

A conceptual framework for educational software on back pain and neck pain management

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Keywords:	Exercise therapy, Low back pain, Neck pain
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A conceptual framework for educational software on back pain and neck pain management

Running title: A Framework for Educational Software on BP & NP

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Abstract

Background and aims: Digital technologies have created many opportunities as part of transformative learning in higher education. The current research aimed to develop a conceptual framework for mobile learning to manage low back and neck pain in physiotherapy students.

Methods: This study was done in three stages. First, the initial model of the system was determined in three main axes through brainstorming sessions and by examining the existing gaps in the training process of physiotherapy students. Second, data content for these three axes was extracted using a literature review. Electronic databases such as Scopus, PubMed, Web of Science, Science Direct, Google Scholar search engine, library resources, and Google Play app store were used for the review. The content obtained in the previous stage was validated in the third stage, and the final conceptual framework was obtained.

Results: The conceptual framework of the system was first designed in the three axes of demographic information, clinical and psychological history, clinical content for training, and features of software and exercises. Then, data content in these three axes was extracted using a literature review. In the first axis, 24 data items were obtained. In the second axis, five main categories included 34, 31, 31, 29, and 39 items, respectively. In the third axis, 36 data items were confirmed. The importance of the data content of this framework was calculated based on the percentages provided by experts. The average axis of demographic information, clinical and psychological history was 4.90, clinical content for training was 4.72, and software features and exercises were 4.90.

Conclusions: The final validated conceptual framework can be a useful solution to improve the education of physiotherapy students to make decisions and help with correct clinical reasoning and the correct method of performing therapeutic exercises.

Keywords: *Exercise therapy, Low back pain, Neck pain, Medical Education, Mobile app*

1 Introduction

Due to the growth of the world population and the increase in life expectancy, humans have experienced a longer life, and non-communicable diseases such as musculoskeletal disorders have become common. Back pain and neck pain are common problems worldwide and are considered the most common cause of disability in societies. Neck pain ranks 21st in terms of the global burden of pain and ranks 4th in problems and disability. Back pain is the third reason for surgery and the fourth reason for hospitalization, and is considered one of the most important reasons for being absent from work after a cold (1). Back pain may be associated with many risk factors that encompass personal, social, and occupational aspects of individuals, such as physical inactivity and catastrophic beliefs about the origin of back pain (2). Identifying these factors is valuable for developing programs aimed at improving the management of this condition. These two disorders are one of the main reasons for visiting physiotherapists of all ages and cause high costs and reduced productivity (3-5).

Managing back pain and neck pain requires the participation of different medical specialties. One of the most important specialties is physiotherapy to eliminate or reduce pain, restore body movements, and educate patients (6-8). Basic strategies have been implemented to promote physiotherapy services in the management of back pain and neck pain, and today, one of these strategies is the use of information technology capabilities. For example, e-health is used to increase clinical reasoning skills, and students' learning in the management of back pain and neck pain treatment (9-14). Using the capabilities of the decision support system and the benefits of electronic health has led to the fulfillment of clinical needs and improvement in the quality of care (12, 15-19). Fortunately, rehabilitation and physical therapy have created a huge opportunity to use e-health and to improve the skill of physical therapy for the development and research of decision support systems (20-24).

Several studies have investigated the use of technology in physiotherapy. Studies conducted by Postolache et al.(18), Olivier et al.(13), Widerström et al.(25), Edirippulige et al.(26), Keengwe et al.(27), Kelly et al.(28), Tan et al.(29), Benditz et al.(30), and Jansen-Kosterink et al.(11) are among those that have investigated the positive impact of this approach or similar approaches. Other studies have also been conducted in Iran, which have recommended this approach as a suitable method for the

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3 1 quality of health and physiotherapy services (30, 31). However, limited studies have investigated the
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5 2 use and effectiveness of technology in the field of physical therapy students' education. It seems
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7 3 necessary to conduct this study on the use of technology in the education of physiotherapy students.
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9 4 Currently, most of the training of physiotherapists is traditional, which includes theoretical and
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11 5 practical learning in the university. The problem is that physiotherapy students learn theory and
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13 6 practical skills, but 1) Their clinical reasoning ability, problem-based management and interaction with
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15 7 patients, etc. are not measured; 2) Students are not familiar with patients' problems and exercises; 3)
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17 8 Traditional training methods for case-based management are not effective enough (13, 28, 32-40).
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20 9 The use of information technology tools, such as applications to enhance clinical reasoning skills
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22 10 and "case-based" decision-making, is helpful for physiotherapy students. For active and meaningful
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24 11 learning, the process needs to be done in three ways: being placed in environmental conditions,
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26 12 problem-based learning, and case-based learning. Using technology to implement different types of
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28 13 learning increases student interaction, creates different scenarios for trial and error, and better
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30 14 performance in managing situations (13, 15, 25, 33, 41-46). Achieving these benefits requires the
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32 15 accurate determination of data elements. It is to implement intelligent systems to ensure that diagnostic
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34 16 and treatment methods are appropriate and useful for student training and patient management (47-49).
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37 17 Despite the abundance of back pain and neck pain applications, there is no evidence-based system
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39 18 to provide guideline-based diagnosis and management for the training of physical therapy students.
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41 19 Since the stated goals cannot be achieved with the currently available applications, and it is not possible
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43 20 to conduct a controlled experiment to validate each one, a system designed by a structured dataset can
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45 21 be useful for students (13, 15, 25, 30, 33, 41, 44). One of the most important steps in designing and
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47 22 creating a good system is determining its content quality. The dataset is known as the minimum dataset,
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49 23 an important component of software content (47-51). The current research was conducted to develop
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51 24 the conceptual framework of the back pain and neck pain management training software for
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53 25 physiotherapy students. Physiotherapy students will be able to strengthen clinical reasoning skills in the
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55 26 diagnosis and management of back pain and neck pain treatment with the help of clinical rules extracted
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57 27 from the guidelines and by benefiting from the case-based capability. Also, students can learn more
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deeply by measuring their knowledge through online tests and watching sports exercises in the form of animation.

Material & methods

This study was conducted in 2022 using a combination of quantitative and qualitative methods to design and develop a conceptual framework for mobile learning in managing back and neck pain in physiotherapy students. The structure of this study was presented using the Template for Intervention Description and Replication (TIDieR) checklist. This checklist is designed for describing interventions and is particularly useful for educational interventions and software. This checklist helps you to fully and clearly describe all the details related to the educational software and its features (52). This study was conducted in three stages, which include 1) Determination of the conceptual model of software, 2) Determination of its data content in three axes, and 3) Validation of the conceptual framework. Figure 1 shows the outline of the research stages.

Figure 1-Outline of research stages

○ Stage one: Determination of the conceptual model of software

The unstructured oral interview was used to collect data about the problems and gaps in the education of physiotherapy students and the workflow process of patient management. It was conducted with two physiotherapists in the physiotherapy clinic of Tehran University of Medical Sciences. Among the questions related to this stage were: Do you think the educational curriculum for managing back pain and neck pain is appropriate for physiotherapy students? What gaps are there in this curriculum? What axes should the data required in the educational software have? What information should be collected in each axis?. The interview began with an explanation of the topic, followed by a discussion and exchange of opinions on questions. Each interview lasted approximately one and a half hours. In the next step, the research team held brainstorming sessions to reach an agreement and create a conceptual model of the software. The team included two physiotherapists (N.N.A., S.H) and two health information management specialists (L.S, Y.F). It was held in the meeting room of the physiotherapy department of the Faculty of Rehabilitation. One of these people participated in the meeting online

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(S.H.). Also, the process of teaching physiotherapy students and their curriculum was examined. As a result of these meetings, the conceptual model of the software was to be prepared in three axes. Those include 1) Required demographic information and clinical and psychological history, 2) Clinical contents for teaching diagnosis, treatment, and sports exercises for low back pain and neck pain, and 3) Required features and exercises for managing low back pain and neck pain.

○ **Stage two: Determination of the data content in three axes**

❖ **Required demographic information and clinical and psychological history**

To determine the data content for this axis, scientific resources were extracted from electronic databases such as Scopus, PubMed, Web of Science, Science Direct, and Google Scholar search engine. The search was carried out with keywords "physical therapy", "neck pain", "low back pain", "pain management", "rehabilitation", "psychologically", "physiotherapy", "lifestyle", "mental health" through operators "AND" and "OR". The inclusion criteria are the types of valid journal articles and conference papers indexed in scientific databases in English & Persian languages from 2000 to 2021. Studies that are in other languages and the form of letters to editors and published theses, reports, or book chapters were excluded from the study.

❖ **Clinical contents for teaching diagnosis, treatment, and sports exercises for low back pain and neck pain**

One of the main educational resources for students is evidence-based clinical guidelines, which can be a good source for correct diagnosis and treatment. For this purpose, the scientific evidence required for the clinical contents for the management of back pain and neck pain was extracted from Scopus, PubMed, Web of Science, Science Direct, Google Scholar search engine, NICE, WHO, and NLM websites. To obtain the best relevant clinical guidelines in the world, a search with the keywords "neck pain guideline", "neck pain pathway", "guideline", "low back pain pathway", "neck pain algorithm", "back pain", "back pain algorithm" was done. Inclusion criteria include clinical guidelines and scientific articles on the management of back

pain and neck pain indexed in a scientific database in English, regardless of time limitation. Guidelines that were presented for specific age groups were excluded from the study. To determine sports exercises, library sources were also used, based on the opinion of the research team and considering that this system is supposed to be used as an educational tool along with reference books, as a result of the book "Low Back and Neck pain: causes and conservative treatment" written by Paul Williams was selected (53). This book is a resource used to teach the management of back pain and neck pain to undergraduate students of physiotherapy in the Faculty of Rehabilitation at Tehran University of Medical Sciences. After extracting the studies obtained from different scientific databases, first, all the duplicated and unrelated articles from the included results were removed based on the conditions of the study, and only the articles that met the inclusion criteria were left. Screening of studies was carried out in two stages, including a title and abstract review stage and a full-text review of the articles by two independent reviewers. The steps for searching for sources and selecting the final sources reviewed were carried out according to the PRISMA flow chart.

❖ Required features and exercises for managing low back pain and neck pain.

To determine the features of the software, the research team used existing applications to identify the features and defects in these applications and to design a new application without existing defects. For this purpose, search the Google Play app store with the keywords "back pain", "neckache", "lumbago", "low back pain", "pains neck", "physiotherapy", "education", "management", "pain". "management" "treatment", "diagnosis" was done. Inclusion criteria include exercise training, availability, no need for an accessory device to perform interventions, updated from 2019 to 2021, and providing therapeutic interventions. Exclusion criteria include specialized applications for pregnant people or patients with a specific condition, providing yoga and relaxation exercises without basic treatments, and paid applications.

○ Stage three: Validation of the conceptual framework

After completing the second stage, a list of the initial data content of the software was extracted, and during the brainstorming session with the research team, it was put in the form of a questionnaire

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3 1 to obtain the experts' opinion about the data content. The questionnaire was designed in three areas. 1)
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5 2 The axis of demographic information and clinical and psychological history (25 elements). 2) The axis
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7 3 of clinical contents for teaching diagnosis, treatment, and sports exercises of back pain and neck pain
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9 4 (165 elements). 3) Axis of features and exercises (36 elements).

11 5 The second part of the questionnaire includes five sections of back pain diagnostic data (35
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13 6 elements), neck pain diagnostic data (31 red flag elements) and neck pain diagnostic data (33 elements),
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15 7 back pain treatment data (30 elements), neck pain treatment data (39 elements) and sports exercises
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17 8 (Eight back pain sports exercises and two neck pain sports exercises). Each of the questions in the
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19 9 questionnaire has five options based on a five-point Likert scale from one to five, in the order of
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21 10 completely disagree (score one) to completely agree (score five).

22 11 In the next step, to determine validity and reliability, the questionnaire based on a three-option
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24 12 scale (one: not necessary, two: useful but not harmful, three: necessary) was given to 10 specialists in
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26 13 physiotherapy and medical informatics. After data collection and analysis of the results, the CVR of
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28 14 each element was calculated. The elements that did not have an acceptable relative coefficient of content
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30 15 were excluded from the study. The reliability of the questionnaire was also obtained with Cronbach's
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32 16 alpha ($\alpha = 0.66$).

33 17 Then, the research team sent the questionnaire to experts for content validity to finalize and gain
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35 18 consensus from the stakeholders of the software. The 12 physiotherapists from the University of
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37 19 Medical Sciences in Iran and the sports medicine research center of Tehran University of Medical
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39 20 Sciences were selected to participate in the research. After collecting the questionnaires, SPSS software
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41 21 version 26 was used for data analysis.

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47 22 **Result**

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50 23 According to the research steps, the findings are divided into three stages.

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52 24 ○ **Stage one: Determination of the conceptual model of software**

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54 25 By examining the opinions of experts in interviews and brainstorming meetings of the research
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56 26 team, the conceptual model of the software was determined in three axes. For this purpose, the relevant
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58 27 findings from the experts' interviews about the process of teaching students in the management of back
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pain and neck pain, and the gaps in the training process were reviewed. According to the discussion on problems in the curriculum, it was concluded that there are three main problems 1) Ineffectiveness of training due to lack of time and resources to improve clinical reasoning and lack of intervention (in diagnosis and treatment of back pain and neck pain) and secondly, the traditionality of the teaching method and thirdly, presenting the instructions for sports exercises on paper form in the book.

○ **Stage two: Determination of the data content in three axes**

The results of this stage are presented in three separate sections according to the conceptual model obtained from the previous stage.

❖ **Demographic information and clinical and psychological history**

The data content of demographic information, and clinical and psychological history of patients that is useful in treatment and diagnosis was extracted from the systematic review of relevant studies. Initially, 35 articles were found. After removing duplicated studies, 30 articles remained. Then, unrelated studies were removed by examining the title and abstract, and finally, 22 articles remained at this stage. In the next step, based on the full-text screening, 14 articles were removed, and only eight articles remained. The screening process is shown in Figure 2.

Figure 2- The process of study screening to extract the first axis

❖ **Clinical content for teaching diagnosis, treatment, and sports exercises for low back pain and neck pain**

Clinical content was extracted based on a systematic review. First, 26 articles were extracted. After removing duplicated studies, 23 articles remained. Then, unrelated studies were removed by examining the title and abstract, and finally, 13 articles remained. In the next step, based on the full-text review of the study, seven articles were removed, and finally, six articles were included. The screening process is shown in Figure 3.

Figure 3- The process of study screening to extract the second axis

The obtained clinical content is shown in Table 1.

Table 1- Clinical content for teaching diagnosis, treatment, and sports exercises for LBP and NP

❖ Features and exercises for managing low back pain and neck pain.

The results showed that there is a limited number of applications for teaching back and neck pain management. Also, there was no application specifically for physiotherapy students to teach and improve the clinical reasoning of back pain and neck pain. In the review process, initially, 10 apps were extracted based on the inclusion criteria of the study. After removing duplications, one app was excluded from the study because it was not free, and two apps whose main focus was on other diseases. Finally, three apps were left to review. These three apps were evaluated from three important aspects (features, quality, and quantity of information). By examining the results of the apps available on the Google Play app store, their good features were used to build a new model. In the evaluated apps, the aspect of strengthening clinical reasoning for the diagnosis and treatment of back pain and neck pain was not included, which was considered in our study. In general, these apps lacked three important aspects, i.e., the use of clinical guidelines for diagnosis and treatment, the use of a decision support system to help make decisions, and the use of animation to teach sports exercises. These three important aspects were used in the current model. In addition to these features, such as patient record management, a dashboard for viewing reports, and a test section, are also built into our model. Other general aspects such as functionality, aesthetics, ease of use, and user experience were also considered.

○ Stage three: Validation of the conceptual framework

Data content was presented to the experts in the form of a questionnaire. The distribution of the frequency of participating experts is summarized in Figure 4.

Figure 4- *Demographic distribution of participation*

The results of the validation of the conceptual framework are shown in the figure 5. The complete table of validation results along with all the items is given in Appendix A (Table 2-4).

Figure 5- The final conceptual framework of educational software

Discussion

The current research was conducted to design a conceptual framework for the educational software of back pain and neck pain management for physiotherapy students. According to the findings of this study, the minimum data content for teaching the management of back pain and neck pain for students includes demographic information, clinical and psychological history, and clinical content for a red flag, diagnosis, and treatment of back pain and neck pain, features, and sports exercises. The results of the survey showed that the data content of the system was agreed upon by the majority of experts.

○ Determination of the conceptual model of software

Before entering the clinical environment and treating patients, physiotherapy students must be able to decide on the appropriate diagnosis and treatment for the patient's problem. Therefore, they should acquire basic knowledge and skills and learn clinical reasoning with different models based on complaints, which are usually multifactorial problems. Since students do not fully understand this skill in theory lessons and have difficulty in recognizing problems and appropriate exercises, to diagnose and treat the cause of neck pain and back pain, using a decision support system plays an important role in students' learning (4). The methodology of this research will lead to the development of a guideline-based software model to meet the educational needs of students.

○ Determination of the data content in three axes

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❖ Demographic information and clinical and psychological history

Demographic information is collected to identify and communicate with patients, which is considered necessary data for identifying, calling, and following up with patients. Demographic, clinical, and psychological history items in this study conform to the NIH Minimum Data Set. The US National Institutes of Health (NIH) introduced the Minimum Data Set for Chronic Low Back Pain (CLBP) in 2014 to increase the use of standardized definitions and criteria and facilitate comparisons in clinical and epidemiological studies. It includes 40 items on demographics, medical history, symptoms, and functions. 17 of these items were derived from the Patient-Reported Outcomes Measurement Information System (PROMIS) short-form instrument. Seven factors out of these 17 items were identified and considered important and necessary for the back pain dataset, which is: 1: pain intensity and interference (six items), 2: history of pain (seven items), 3: medical interventions (five items), 4: depression and psychological state (six items), 5: physical performance (three items), 6: sleep disorder (four items), and 7: lifestyle. These 7 factors have been identified as data sets for chronic back pain (54). The clinical guidelines of the American Medical Association and the American Pain Society for the treatment of back pain have also suggested the history and evaluation of psychosocial risk factors as important criteria for the assessment of chronic back pain (55). In this study, the elements of pain intensity, depression, medical interventions, physical function, and lifestyle were used for the demographic information and clinical and psychological history axis, which, with an average score of more than 4, indicates a high level of agreement among experts.

❖ Clinical content for teaching diagnosis, treatment, and sports exercises for low back pain and neck pain

According to the findings of this study, it should be acknowledged that clinical guidelines for diagnosis and treatment, in addition to being the basics of direct patient care, help the process of education, planning, and research in the field of health care (56). In 2000, a study was conducted by Bekkering et al. The lack of evidence-based guidelines for the physiotherapy treatment of back pain and the need for a specific guideline for physiotherapy for back pain were the reasons for conducting

1 this study. The name of this guideline was Dutch, which presents the diagnostic and therapeutic process
2 of physiotherapy in patients with back pain. The set of data that is used in the process of evaluating
3 patients includes data related to patient referral, history, physical examination, and time to visit a
4 physiotherapist. In the referral of the patient, important data such as the reason for referral, period of
5 disability, participation problems, and information related to diagnostic methods are obtained. In the
6 patient's clinical history, a clear picture of the patient's health problem is obtained. This section contains
7 four sub-sections. (data related to the identification of symptoms at the beginning of the condition, data
8 related to the assessment of the current condition, data related to disease control strategies, data related
9 to other additional information). In the physical examination, daily activities and the patient's
10 participation in doing things are checked. When referring to physical therapy, the physical therapist
11 should consider disabilities and participation problems, and whether the back pain follows a normal or
12 abnormal process, in the process of collecting information from the patient. It should also include signs
13 of an abnormal period, such as (an increased number of daily rest periods, use of accommodation with
14 or without return to activities or participation, etc.) in its investigations. It should also investigate
15 whether physiotherapy intervention improves the patient's condition or not. If the answer to this
16 question is positive, continue the treatment plan and otherwise, refer the patient (57). In the current
17 research, the data content related to history, physical examination, and referral as well as the treatments
18 and drugs used, and the level of participation in the patient's activity and functional level in daily life,
19 is considered as data content based on clinical guidelines. The elements related to the initial assessment
20 of the patient in the axis of clinical history and the elements related to the differential diagnosis of back
21 pain were also used for referral or non-referral in this axis.

22 A study conducted by Petersen et al. in 2017 dealt with the clinical classification of back pain. In
23 this study, the cause of back pain is divided into four categories: intervertebral disc, sacroiliac joint,
24 disc herniation with nerve root involvement, spinal canal stenosis, and vertebral dislocation (58). In this
25 study, the classification of Petersen et al. and the classification of the National Institute for Health and
26 Care Excellence (NICE) (59) were used to diagnose the cause of back pain. According to these two
27 sources, the causes of back pain include cauda equina syndrome, spine fracture, cancer, infection,
28 intervertebral disc, sacroiliac joint, disc herniation with nerve root involvement, spinal canal stenosis,

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vertebral disc herniation, and back pain are divided into non-specific pain. In this research, these classifications have been used to diagnose the cause of back pain, and a set of clinical rules has been presented to diagnose each of these classes. The purpose of these diagnoses is to rule out risk factors to arrive at a diagnosis of non-specific low back pain.

For the treatment of back pain, a study was conducted by Stanton et al. in 2011 to evaluate the classification algorithm. In this study, a comprehensive algorithm was developed to guide clinical decision-making. 2500 patients with acute or subacute low back pain in the United States and Australia were included. Physiotherapists performed standardized assessments of all participants, and researchers used these findings to classify participants into low back pain treatment subgroups. In this algorithm, four treatment methods are considered: 1. Manual treatment, 2. Stabilizing treatment 3. Specific exercises 4. Stretching (60). In this study, this clinical algorithm, which was approved by the research team, was used to classify the patient into one of the diagnosis classes for back pain management.

The American Medical Association and American Pain Society provide guidelines for the evaluation and management of acute and chronic low back pain. In this guideline, seven recommendations are considered for back pain management (55). In this research, the recommendations of this guideline have been used to manage and treat back pain and refer patients to the relevant specialist. The core elements of back pain diagnosis (patient referral in case of severe neurological deficits and suspected underlying diseases) and back pain treatment (self-care, stretching therapy, sports therapy, manual therapy, and stabilizing therapy) have been used in this guideline.

The National Institute for Health and Care Excellence (NICE) guideline was used to detect neck pain red flags. In this guideline, non-specific back pain signs and symptoms, and diagnostic red flags for the cause of neck pain and management of neck pain are classified. Symptoms such as Fever, general neck stiffness, lymphadenopathy, nausea or vomiting, increasing pain, non-stop or disrupting sleep, severe neck sensitivity, Redness, sores or skin discharge, weight loss for no reason, neurological problems (including change in cognitive status - change in muscle tone - ataxia - Babinski's sign, etc.) are among the symptoms that indicate a serious condition of the cause of neck pain (61). In this research, these red flags have been used to identify risk factors for patient referral.

The orthopedic section of the American Physical Therapy Association (APTA) continuously strives to develop evidence-based practice guidelines for the management of orthopedic physical therapy in patients with musculoskeletal disorders based on the World Health Organization's International Classification of Functioning, Disability, and Health (WHO-ICF). In this guide, the diagnosis of types of neck pain is divided into four categories: 1. Neck pain with movement disorder, 2. Neck pain with movement coordination disorder 3. Neck pain with headache 4. Neck pain with radicular pain. Also, it suggests a certain treatment method based on each of the diagnoses made (62, 63). In this research, this guideline has been used to provide a treatment solution for managing all types of neck pain.

The axis of sports exercises is provided to teach students how to properly perform sports exercises with the help of animation. Therapeutic exercises and instructions for patient education are taken from the book (Causes and conservative treatment of Back Pain and Neck Pain by Paul Williams and Dudley Hart and translated by Ansari and Nakhdi) (64).

❖ Features and exercises for managing low back pain and neck pain.

The core of the software's features includes 5 general sections (new patient management, previous patient management, test, report, and general section). The main difference between our model and the reviewed apps was that none of them comprehensively provided the necessary features to increase the learning and teaching of students in an integrated manner. Also, this model has helped to increase the clinical reasoning skills of students with the help of clinical rules extracted from the guidelines in a case-based and interactive way. Among the disorders in physiotherapy, back pain and neck pain have the highest number of referrals, and due to the many differential diagnoses of these two disorders, it has been difficult to decide on the diagnosis and treatment plan.

In a study conducted by Pastora et al. in 2021, they investigated the use of mobile e-learning for physiotherapy students. The findings showed that the use of an electronic educational tool to design a sports training program improves students' learning. Students with high satisfaction reported that their learning improved in sports training (65). The study by Fernández-Lao et al. in 2016, examining the

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effect of mobile learning on physical therapy students' learning, reported the effectiveness of this method (15). In 2010, Tan et al. reported the positive effect of using blogs on clinical reasoning and metacognitive skills of undergraduate physiotherapy students in an educational program (29). Noguera et al. in 2013 reported effective learning of physiotherapy students with the help of computer tools (43). The distinction of the current research is that clinical rules are used to help make decisions about diagnosis and treatment, which strengthens clinical reasoning skills because it allows the student to enter the data of a hypothetical patient. Lirong Xiao's study on the effect of animation on learning concluded that 3D animations in particular significantly improve learning (66). In this research, considering the impact of animation on the learning of students and patients, it is recommended to use Adobe After Effects and Adobe Illustrator software to show back pain and neck pain exercises. Considering that the principles of designing animations are based on evidence and based on book sports exercises, therefore, it is more effective for users than simple images or verbal explanations. Other uses of animation in learning have been proven in studies (67, 68).

○ **Validation of the conceptual framework**

The conceptual framework validation results showed that the data elements were generally agreed upon by the experts. The experts agreed on all the axes, and only 9 elements out of 226 elements were excluded from the study. The first axis is related to demographic information, clinical and psychological history, which experts have given the most importance to, the pain intensity, and progression of the pain, with a score of 4.9. The accepted elements for this axis are in line with the studies that considered the importance of this information for the management of patients (61, 69-71).

The second axis was related to clinical content for teaching diagnosis, treatment, and sports exercises for low back pain and neck pain; most of the rules had an average of more than 4. Only one element, dominant pain in SIJ without tuber area, has an average of 3.8 in the back pain red flags section. The experts assigned a score of five to all sports exercises, which shows their full agreement with these sports exercises. The accepted elements in this axis are in line with the study. They have stated in their study that evidence-based rules should be considered for the management of back pain and neck pain

(69, 71, 72). Also, many studies have pointed out the importance of sports exercises for the management of back and neck pain in physiotherapy (69, 71, 72). The third axis is related to the features and exercises; all of its elements had an average of more than 4.8. These results are in line with the studies that have considered the use of mobile health and decision support systems to be effective for increasing student learning (13, 25, 73, 74). In the current study, several components in the three main axes of the final model are given to increase the knowledge and strengthen the clinical reasoning of the students, which are necessary for the correct management of back pain and neck pain.

Conclusion

According to the findings of this research, the most important data elements and features of the software for the management of back pain and neck pain, and the training of physiotherapy students were presented in three main axes, including 1. Demographic information and clinical and psychological history; 2. Clinical content for teaching diagnosis, treatment, and sports exercises for low back pain and neck pain; 3. Features and exercises for managing low back pain and neck pain. The final approved conceptual model was a useful solution for physiotherapy students (national and international) to improve decision-making and help with correct clinical reasoning and the correct way to perform therapeutic exercises. In addition, this model with online tests helps students to play an active role in the learning process, assess their learning, and use a case-based approach to strengthen their clinical skills.

List of abbreviations

CVR:	Content Validity Ratio
NICE:	National Institute for Health and Care Excellence
AIDS:	Acquired immunodeficiency syndrome
CKS:	Clinical Knowledge Summaries
ROM:	Range of Motion
SLR test:	Straight Leg Raise test
TENS:	Transcutaneous Electrical Nerve Stimulation
NIH:	National Institutes of Health
CLBP:	Chronic Low Back Pain
PROMIS:	Patient-Reported Outcomes Measurement Information System
APTA:	American Physical Therapy Association
ICF:	International Classification of Functioning, Disability, and Health

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- 1 SIJ: Sacro-Iliac Joint
- 2 MARS: Mobile Application Rating Scale
- 3 App: application
- 4 NP: Neck pain
- 5 LBP: Low back pain

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Competing interests

The authors declare that there are no conflicts of interest.

Authors' contributions

Y.F. and L.S. conceived of the presented idea. N.N. managed the clinical and therapeutic part of the research. Y.F. collected data and prepared the draft manuscript. L.S., N.N.A., and S.H. verified the analytical methods and supervised the findings of this work. Y.F. and M.R. participated in writing and editing the English article. All authors reviewed the results and approved the final version of the manuscript.

Consent for publication

We confirm that the manuscript has been read and approved by all named authors and that no other persons have satisfied the criteria for authorship but are not listed. We further confirm that all have approved the order of authors listed in the manuscript.

Appendix

- Table 2- Validation in the axis of demographic information and clinical and psychological history
- Table 3- The results of validation in the axes of Clinical content for teaching diagnosis, treatment, and sports exercises
- Table 4- The results of validation in the axes of features and exercises

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Appendix tables:

Table 2- Validation in the axis of demographic information and clinical and psychological history

Main category	Num	Data elements	Mean	%
Demographic information	1	Name	4.69	91.78
	2	National code	4.74	91.78
	3	Age	5.01	98.33
	4	Gender	4.98	98.37
	5	BMI	4.84	96.70
	6	Education	4.78	91.70
	7	Job	4.90	95.08
Clinical and psychological history	8	Reason for referral and complaint	4.96	96.79
	9	Signs and symptoms of the disease based on the patient's statements	4.78	93.38
	10	Duration of pain (less than two weeks - more than two weeks)	4.95	95.02
	11	Intensity of pain (0-10)	5.01	98.35
	12	The progression of the pain (pain has become very severe - the pain has become relatively intense - the pain has remained unchanged - the pain has improved a little - the pain has improved relatively)	4.99	98.32
	13	What were you doing when you first noticed the symptoms? (Rest – Walking – Driving – Stairs – Pulling or pushing a thing – Lifting an object – Exercise – Other)	4.87	95.08
	14	What condition aggravates your symptoms? (Stairs - Driving - Lifting off the shelf - Exercise - Other)	4.83	95.07
	15	What condition helps to alleviate the symptoms? (Relaxing - bending...)	4.94	95.05
	16	Treatments carried out (exercise exercises - surgical interventions - manual therapies - drug treatments - other therapeutic approaches to physiotherapy - no treatment)	4.93	95.04
	17	Is the patient able to carry out daily tasks? (Almost - but not quite)	4.93	96.77
	18	Is the patient able to execute work-related tasks? (Almost, but not quite.)	4.78	93.39
	19	Depression	4.91	95.08
	20	Anxiety	4.96	96.75
	21	Distress	4.89	96.71
	22	Sleep problems	4.97	95.04
	23	Abuse, both sexual and physical	4.88	95.05
	24	Additional mental health conditions	4.78	93.35
Total Mean			4.90	95.33

Table 3- The results of validation in the axes of Clinical content for teaching diagnosis, treatment, and sports exercises

Main category	Subcategory	Num	Data elements	Mean	%
Back pain red flags	Intervertebral disc	1	Centralization of symptoms	4.63	91.76
		2	No centralization of symptoms	4.33	85.03
	Sacroiliac joint	3	Dominant pain in the SIJ without the tuber area	3.88	76.80
		4	3 positives out of 5 physical examination findings: distraction, compression, thigh thrust, Gaenslen test, sacral thrust	4.79	93.31
	Disc herniation with nerve root involvement	5	Straight leg raises test positive for referred leg pain	4.65	91.77
		6	3 positives out of 4 history or physical examination findings: Dermatomal pain location in concordance with a nerve root, and corresponding sensory deficits, reflexes, and motor weakness	4.86	96.74
		7	Supplementary physical examination findings: Crossed straight leg raise test positive, then disc herniation with nerve root involvement	4.84	95.03
	Spinal stenosis	8	3 positive out of 5 history findings: age more than 48 years. Bilateral symptoms, leg pain more than back pain, pain during walking/standing, or pain relief upon sitting	4.37	86.70
		9	Supplementary physical examination finding: improved walking tolerance with the spine in flexion or relief by forward bending	4.83	95.03
	Spondylolisthesis	10	Intervertebral slip by inspection or palpation	4.81	95.04
		11	Segmental hypermobility by use of manual passive physiological intervention motion test	4.40	88.39
		12	Supplementary physical examination findings in the elderly spondylolisthesis	4.78	93.34
	Cauda equina syndrome	13	Supplementary physical examination finding: improved walking tolerance with the spine in flexion or relief by forward bending	4.61	91.77
		14	Severe or progressive bilateral neurological deficit of the legs, such as major motor weakness with knee extension, ankle eversion, or foot dorsiflexion.	4.80	95.01

Neck pain red flags		15	Recent-onset urinary retention (caused by bladder distension because the sensation of fullness is lost) and/or urinary incontinence (caused by loss of sensation when passing urine).	4.86	95.03
		16	Recent-onset faecal incontinence (due to loss of sensation of rectal fullness).	4.71	93.33
		17	Perianal or perineal sensory loss (saddle anesthesia or paresthesia).	4.71	93.33
		18	Unexpected laxity of the anal sphincter.	4.80	95.09
	Spinal fracture	19	Sudden onset of severe central spinal pain, which is relieved by lying down.	4.90	98.30
		20	A history of major trauma (such as a road traffic collision or fall from a height), minor trauma, or even just strenuous lifting in people with osteoporosis or those who use corticosteroids.	4.72	93.35
		21	Structural deformity of the spine (such as a step from one vertebra to an adjacent vertebra) may be present.	4.88	96.72
		22	There may be a point of tenderness over a vertebral body.	4.63	91.72
	Cancer	23	The person is 50 years of age or older.	4.42	88.35
		24	Gradual onset of symptoms.	4.87	95.02
		25	Severe unremitting pain that remains when the person is supine, aching night pain that prevents or disturbs sleep, pain aggravated by straining (for example, at stool, or when coughing or sneezing), and thoracic pain.	4.44	88.39
		26	Localized spinal tenderness.	4.68	91.73
		27	No symptomatic improvement after four to six weeks of conservative low back pain therapy.	4.67	91.74
		28	Unexplained weight loss.	4.65	91.79
		29	History of cancer — breast, lung, gastrointestinal, prostate, renal, and thyroid cancers are more likely to metastasize to the spine.	4.73	93.39
	Infection	30	Fever	4.75	93.39
		31	Tuberculosis, or a recent urinary tract infection.	4.67	91.76
		32	Diabetes	4.33	86.79
		33	History of intravenous drug use	4.67	91.72
		34	HIV infection, use of immunosuppressants, or the person is otherwise immunocompromised	4.78	93.35
	GENERAL	1	Fever	4.74	93.30
		2	Generalized neck stiffness	4.82	95.08
		3	Lymphadenopathy	4.82	95.05
		4	Nausea or vomiting	4.89	95.00
		5	Pain that is increasing, is unremitting, or disturbs sleep	4.61	91.73
		6	Severe neck tenderness	4.65	91.74
		7	Skin erythema, wounds, or exudate	4.68	91.74
		8	Unexplained weight loss	4.73	93.38
		9	Altered cognitive status	4.65	91.72
		10	Altered muscle tone	4.75	93.31
		11	Ataxia	4.71	93.38
		12	Babinski's sign: up-going plantar reflex, hyper-reflexia, clonus, spasticity	4.69	91.76
		13	Gait disturbance, clumsy or weak hands, or loss of sexual, bladder, or bowel function	4.71	93.32
		14	Hoffman's sign	4.74	93.35
		15	Incontinence	4.73	93.34
		16	Lhermitte's sign: flexion of the neck causes an electric shock-type sensation that radiates down the spine and into the limbs	4.34	85.04
		17	New or severe headache	4.84	96.76
		18	Photophobia or phonophobia	4.66	91.78
			Visual loss	4.44	88.39
		19	Weakness involving more than one myotome or loss of sensation involving more than one dermatome	4.61	91.75
	Age-related factors for people aged under 20 years	20	Altered hair distribution	4.90	95.06
		21	Birthmarks	4.90	95.04
		22	Congenital abnormalities	4.82	95.06
		23	Family history	4.67	91.76
		24	Infections related to substance misuse	4.69	91.73
	Age-related factors for people aged over 50 years	25	Skin tags	4.66	91.74
		26	History of cancer	4.64	91.73
	Other red flag features	27	Vascular disease	4.63	91.71
		28	A history of inflammatory arthritis, cancer, tuberculosis, immunosuppression, drug abuse, AIDS, or other infections	4.68	91.75
		29	A history of violent trauma (for example, a road traffic accident) or a fall from a height or minor trauma in a person at risk of osteoporosis (especially in post-menopausal women)	4.60	90.05
		30	Minor trauma may fracture the spine in people with osteoporosis	4.79	93.34
		31	Risk factors for osteoporosis. For more information, see the CKS topic on Osteoporosis - prevention of fragility fractures	4.72	93.31
		1	Central and/or unilateral neck pain	4.67	91.74

Neck pain diagnosis	Neck pain with mobility deficit	2	Limitation in neck motion that consistently reproduces symptoms	4.61	91.78
		3	Associated shoulder girdle or upper extremity pain may be present	4.76	93.38
		4	Limited cervical ROM	4.84	95.02
		5	Neck pain is reproduced at the end range of active and passive motion	4.70	93.36
		6	Restricted cervical and thoracic segmental mobility	4.76	93.31
		7	Intersegmental mobility testing reveals characteristic restriction	4.78	93.38
		8	Neck and referred pain reproduced with provocation of the involved cervical or upper thoracic segments or cervical musculature	4.75	93.35
		9	Mechanism of onset linked to trauma or whiplash	4.75	93.34
	Neck pain with movement coordination impairment (wad)	10	Associated (referred) shoulder girdle or upper extremity pain	4.64	91.72
		11	Associated with varied nonspecific concussive signs and symptoms	4.79	93.30
		12	Dizziness/nausea	4.64	91.73
		13	Headache, concentration, or memory difficulty, confusion, hyper-sensitivity to mechanical, thermal, acoustic, odor, light stimuli, heightened affective distress	4.64	91.79
		14	Positive cranial cervical flexion test	4.71	93.34
		15	Positive neck flexor muscle endurance test	4.79	93.36
		16	Strength and endurance deficit of the trapezius muscle	4.73	93.39
		17	Neck pain with mid-range motion that worsens with end-range position	4.78	93.39
		18	Point tenderness may include a myofascial trigger point	4.80	93.37
		19	Sensorimotor impairment may include altered muscle activation patterns, proprioceptive deficit, postural balance, or control	4.70	93.33
		20	Neck and referred pain reproduced by provocation of the involved cervical segments	4.73	93.31
	Neck pain with headache (cervicogenic)	21	Noncontinuous, unilateral neck pain and associated headache	4.75	93.40
		22	A headache is precipitated or aggravated by neck movement or sustained position/posture	4.59	90.07
		23	Positive cervical flexion rotation test	4.51	90.06
		24	A headache is reported with provocation of the involved upper cervical segments	4.74	93.37
		25	Limited cervical ROM	4.76	93.36
		26	Restricted upper cervical segmental mobility	4.70	93.37
		27	Strength, endurance, and coordination deficit of the neck muscle	4.76	93.31
	Neck pain with radiation pain (radicular)	28	Neck pain with radiating (narrow band of lancination) pain in the involved extremity	4.72	93.31
		29	Upper extremity dermatomal paresthesia or numbness and myotomal muscle weakness	4.74	93.32
		30	Neck and neck-related radiating pain reproduced or relieved with radiculopathy testing, positive test cluster includes upper limb nerve mobility, Spurling test, cervical distraction, cervical ROM	4.76	93.40
		31	May have upper extremity sensory, strength, or reflex deficits associated with the involved nerve roots	4.67	91.80
Back pain treatment-based algorithm	Nerve compress	1	Does the patient have symptoms distal to the buttock and signs of nerve root compression?	4.55	93.39
		2	Peripheralize with extension movement?	4.71	93.39
	Traction	3	Have a positive SLR test?	4.75	93.30
		4	Peripheralization of symptoms, with no ability to centralize with movement	4.72	93.34
	Specific Exercise	5	Centralized with 2 or more movements in the same direction (ie, flexion or extension)?	4.80	93.36
		6	Centralize with movement in one direction and peripheralize with opposite movements	4.73	93.31
		7	Directional preference for extension or flexion	4.71	93.33
		8	Centralization with motion testing	4.75	93.35
		9	Peripheralization in a direction opposite to centralization	4.71	93.35
		10	Have the duration of symptoms of <16 days?	4.78	88.39
		11	No symptoms distal to the knee?	4.49	93.34
	Manipulation	12	Hip medial (internal) rotation ROM > 35°	4.75	93.31
		13	Hypomobility with testing	4.75	93.31
		14	Average SLR ROM >91°	4.75	93.31
		15	Positive prone instability test?	4.76	91.71
	Stabilization	16	Positive aberrant movements?	4.66	93.32
		17	Age <40 years?	4.71	93.37
		18	Hypomobility with spring testing	4.78	93.34
		19	Increasing episode frequency	4.73	93.34
		20	3 or more prior episodes	4.76	91.78
	Factors traction Against	21	Low back pain only (no distal symptoms)	4.61	93.32
		22	No sign of nerve root compression	4.71	95.04
	Specific exercise factors against	23	Low back pain only (no distal symptoms)	4.89	93.36
		24	Status quo with all movements	4.71	93.31
	Factors against manipulation	25	Symptoms below the knee	4.72	91.77
		26	Increasing episode frequency	4.70	90.07
		27	Peripheralization with motion testing	4.54	90.01
		28	No pain with spring testing	4.59	91.74

	Stabilization Factors against	29	Discrepancy in SLR ROM	4.64	93.40
NECK pain treatment	Neck pain with mobility deficit	Acute			
		1	Thoracic manipulation	4.76	93.36
		2	Cervical mobilization or manipulation	4.77	93.36
		3	Cervical ROM, stretching, and isometric strengthening exercise	4.79	93.36
		4	Advice to stay active, plus home cervical ROM, and isometric exercise	4.77	93.38
		5	Supervised exercise: including cervico-scapulothoracic and upper extremity stretching, strengthening, and endurance training	4.77	93.38
		6	General fitness training (stay active)	4.72	95.01
		Subacute			
		7	Cervical mobilization or manipulation	4.76	93.30
		8	Thoracic manipulation	4.85	93.39
		9	Cervical ROM, stretching, and isometric strengthening exercise	4.78	93.38
		Chronic			
		10	Thoracic manipulation	4.72	95.04
		11	Cervical mobilization	4.78	91.73
		12	Combined cervico-scapulothoracic exercise plus mobilization	4.83	95.06
		13	Mixed exercise for cervico-scapulothoracic Regime - neuromuscular exercise: coordination, proprioception, and postural training, stretching, strengthening, Endurance training, aerobic conditioning, and cognitive affective element	4.68	95.01
		14	Supervised individual exercise	4.86	91.79
	15	Stay active with lifestyle approaches	4.86	93.33	
	16	Dry needling, low-level laser, Pulsed or high-power ultrasound, intermittent mechanical traction, repetitive brain stimulation, TENS, Electrical muscle stimulation	4.67	93.31	
	17	Thoracic manipulation	4.79	95.03	
	Neck pain movement coordinate impairment (WAD)	Acute			
		18	Education: Advise to remain active, act as usual	4.70	95.02
		19	Home exercise: pain-free cervical ROM and postural element	4.85	93.33
		20	Monitor for acceptable progress	4.85	90.07
		21	Minimize collar use	4.76	91.71
		Subacute			
		22	Education: Activation and counseling	4.52	93.31
		23	Combined exercise: active cervical ROM and isometric low-load strengthening, plus manual therapy (cervical mobilization), plus physical agent: Ice, heat, TENS	4.65	96.76
		24	Supervised exercise: active cervical ROM or stretching, strengthening, endurance, neuromuscular coordination, and stabilization elements	4.76	91.78
		Chronic			
		25	Education: prognosis. Encouragement, reassurance, and pain management	4.89	93.30
	26	Cervical mobilization plus individual progressive exercise: low-load cervico-scapulothoracic strengthening, Endurance, flexibility, functional training using cognitive behavioral therapy principles, vestibular rehabilitation, eye, head, neck coordination, and neuromuscular coordination elements	4.69	93.36	
	Neck pain with headache (cervicogenic)	Acute			
		27	Exercise c1-2 self-SANG	4.74	91.71
		Subacute			
		28	Cervical manipulation and mobilization	4.71	91.73
		29	Exercise:c1-2 self-SANG	4.62	91.71
		Chronic			
		30	Cervical manipulation	4.66	91.75
		31	Cervical and thoracic manipulation	4.73	93.31
32		Exercise for cervical and scapulothoracic region: strengthening and endurance exercise with neuromuscular training, including motor control and biofeedback elements	4.82	95.03	
33		Combined manual therapy(mobilization or manipulation) plus exercise (stretching, strengthening, and endurance training elements)	4.74	93.31	
Neck pain with radiation pain (radicular)	Acute				
	34	Exercise: mobilization and stabilization elements	4.72	93.34	
	35	Low-level laser	4.78	93.34	
	36	Possible short-term collar use	4.88	95.05	
	Chronic				
	37	Combined exercise: stretching and strengthening elements plus manual therapy for the cervical and thoracic regions: mobilization or manipulation	4.77	93.32	
	38	Educational counseling to encourage participation in occupational and exercise activities	4.76	93.31	
39	Intermittent traction	4.81	96.79		
		Total mean		4.72	92.76

Table 4- The results of validation in the axes of features and exercises

Category	Num	Data elements	Mean	%
Register a new patient	1	Registering data related to the national code and name, and other important items	4.83	96.72
	2	Registration of demographic information, clinical and psychological records (optional)	4.87	95.07
	3	Presenting red flags of back pain and neck pain using rules (if-then) to train students	4.86	96.75
	4	Using rules (if-then) for decision support systems	4.96	98.33
	5	Providing guidance messages to continue the management or referral process	4.88	96.73
	6	The possibility of creating two separate cases based on the type of disorder (back pain and neck pain)	4.82	96.73
	7	Using animation to show sports exercises	4.82	96.79
	8	Text and audio file to explain how to do the exercises	4.94	98.35
	9	Playing background music while doing exercises	5.00	98.34
Management patient	10	Record information related to diagnosis and treatment	4.85	96.79
	11	Recording information about the patient's condition at the onset of pain	4.97	98.37
	12	Record information about pain intensity	4.92	98.31
	13	The possibility of changing the diagnosis and treatment if needed	4.84	96.78
	14	Record a note to schedule an appointment and provide additional information	4.96	98.36
Exam	15	Providing specialized questions separately	4.84	96.73
	16	Providing multiple-choice questions to challenge students' knowledge	4.98	98.38
	17	Recording test results based on the number of correct and incorrect answers, and providing a report card	4.91	98.35
Reports	18	Providing a report on the number of patients according to the type of selected back pain treatment	4.84	96.79
	19	Providing a report on the number of patients according to the type of selected neck pain diagnosis	4.82	96.72
	20	Providing a report on the number of patients according to the number of patients with back pain and neck pain	4.88	96.77
	21	Willingness to report the number of patients by gender	4.82	96.72
	22	Providing a report on the number of patients by age	4.94	98.32
General	23	Access to the application with username and password	4.95	98.32
	24	Provide the username and password to students via SMS	4.90	96.74
	25	Bilingual application	5	100
Title		Description	Mean	%
Exercise	26	Back pain exercise 1 Strengthen the less-used abdominal muscles .	5	100
	27	Back pain exercise 2 Simultaneous stretching of muscles and nerves & Painless walking & Strong and short stretching of the low back muscles, & Improving the range of motion towards the front of the waist.	5	100
	28	Back pain exercise 3 Strong contraction of the abdominal muscles	5	100
	29	Back pain exercise 4 Stretch on the bar & Increase the forward range of motion of the pelvis - Reduce the deflection of the front of the pelvic plate	5	100
	30	Back pain exercise 5 Strengthen the weak serine muscles (A group of three muscles that make up the buttocks)	5	100
	31	Back pain exercise 6 Strengthen the muscles of the legs with special emphasis on the muscles of the front of the thighs (quadriceps muscles), & Strengthen the muscles (buttocks) of the serine	5	100
	32	Back pain exercise 7 Strong and short low back muscles stretch & improve the forward range of motion of the waist.	5	100
	33	Back pain exercise 8 Strengthen leg muscles with special emphasis on front thigh muscles (quadriceps muscles) & Strengthen the serine muscles	5	100
	34	Neck pain exercise 1 Lying on the back and moving the neck	5	100
	35	Neck pain exercise 2 Sitting on a chair and hanging the neck forward, and moving the head to the sides	5	100
	36	Neck pain exercise 3 Sit on all fours and move your head to the sides in a hanging position	5	100
Total mean			4.90	98.20

Table 1- Clinical content for teaching diagnosis, treatment, and sports exercises for LBP and NP

Subcategory of this axis	Data content	NICE guideline	Dutch Guideline	Algorithm by Stannon et al	Guideline of AMA & AAPM ^{**}	Guideline of neck pain of APTA ^{**}	The book by Paul Williams ⁽¹⁾
Low back pain red flags	Intervertebral disc				+		
	Sacroiliac joint				+		
	Disc herniation				+		
	spinal stenosis				+		
	Spondylosis				+		
	cauda equina syndrome	+			+		
	Spinal fracture	+			+		
	cancer	+			+		
	infection	+			+		
	Non-specific back pain	+			+		
Neck pain red flags	Common signs of neck pain					+	
	Common red flags of neck pain under 20 years old	+				+	
	General red flags of neck pain over 20 years	+				+	
	Other red flags	+				+	
Diagnosis of different types of neck pain	Neck pain with mobility impairment					+	
	Neck pain with impaired movement coordination					+	
	Neck pain with headache					+	
	Painful neck pain					+	
Low back pain treatment	Acceptance factors of stretching therapy		+	+	+		
	Acceptance factors for sports therapy		+	+	+		
	Acceptance factors of manual therapy		+	+	+		
	Acceptance factors for stabilization therapy		+	+	+		
	Factors rejecting traction therapy		+	+			
	Factors rejecting exercise therapy		+	+			
	Factors rejecting manual therapy		+	+			
	Factors rejecting stabilization therapy						
Neck pain treatment	Neck pain with chronic-acute-subacute mobility disorder					+	
	Neck pain with chronic-acute-subacute movement coordination disorders					+	
	Neck pain with headache-chronic-acute-subacute					+	
	Neck pain with chronic-acute-subacute radicular pain distribution					+	
Sports exercises	Back pain exercises						+
	Neck pain exercises						+
** American Medical Association and the American Academy of Pain Medicine ** American Physical Therapy Association							

- Williams PC. Low back and neck pain: causes and conservative treatment: Charles C Thomas Pub Limited; 1974.

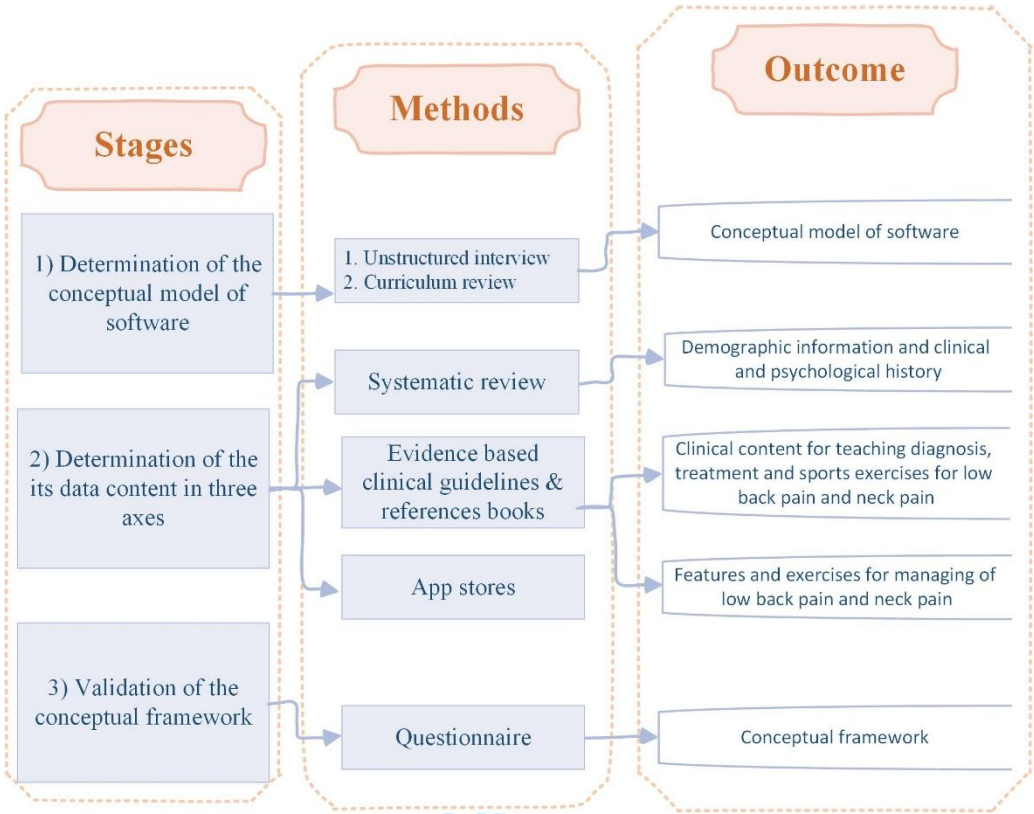


Figure 1-Outline of research stages

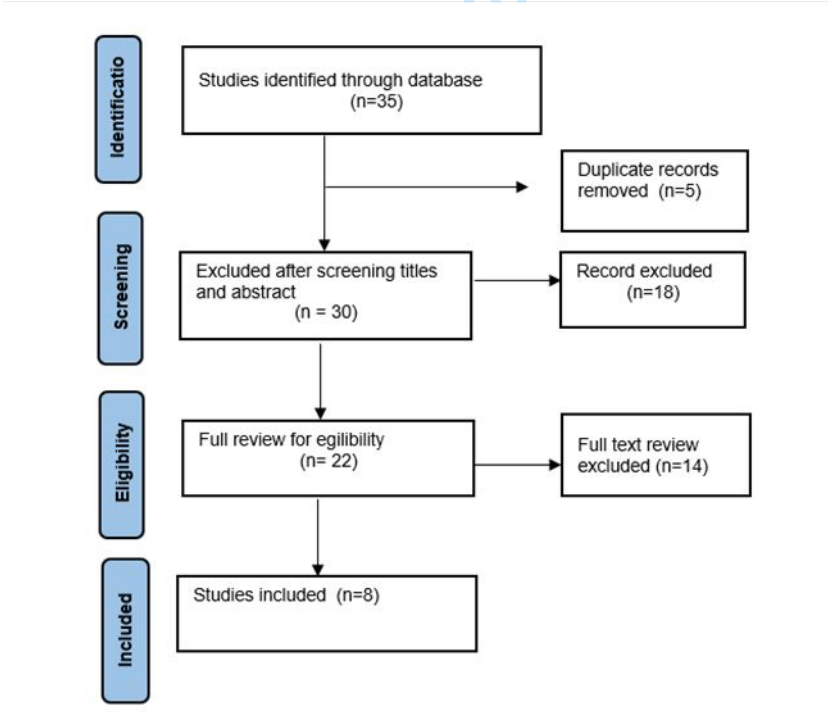


Figure 2- The process of study screening to extract the first axis

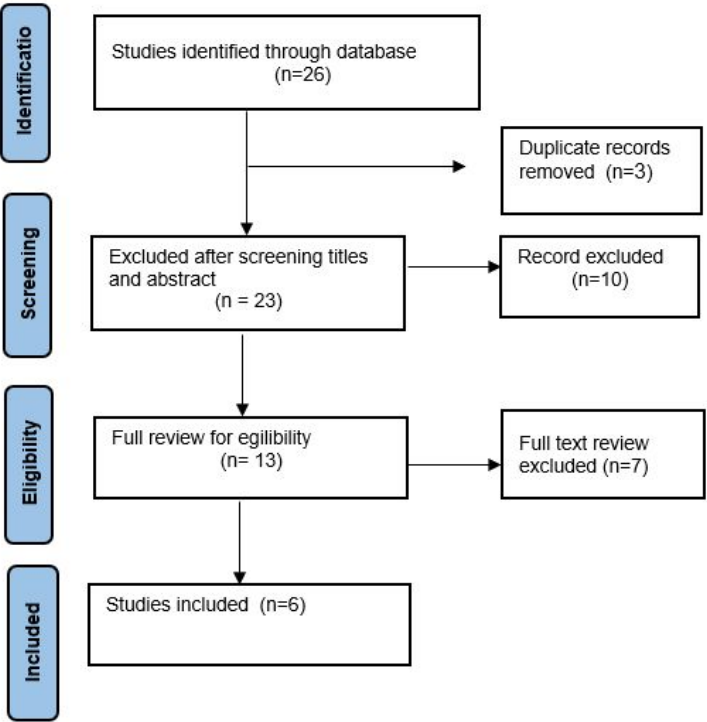


Figure 3- The process of study screening to extract the second axis

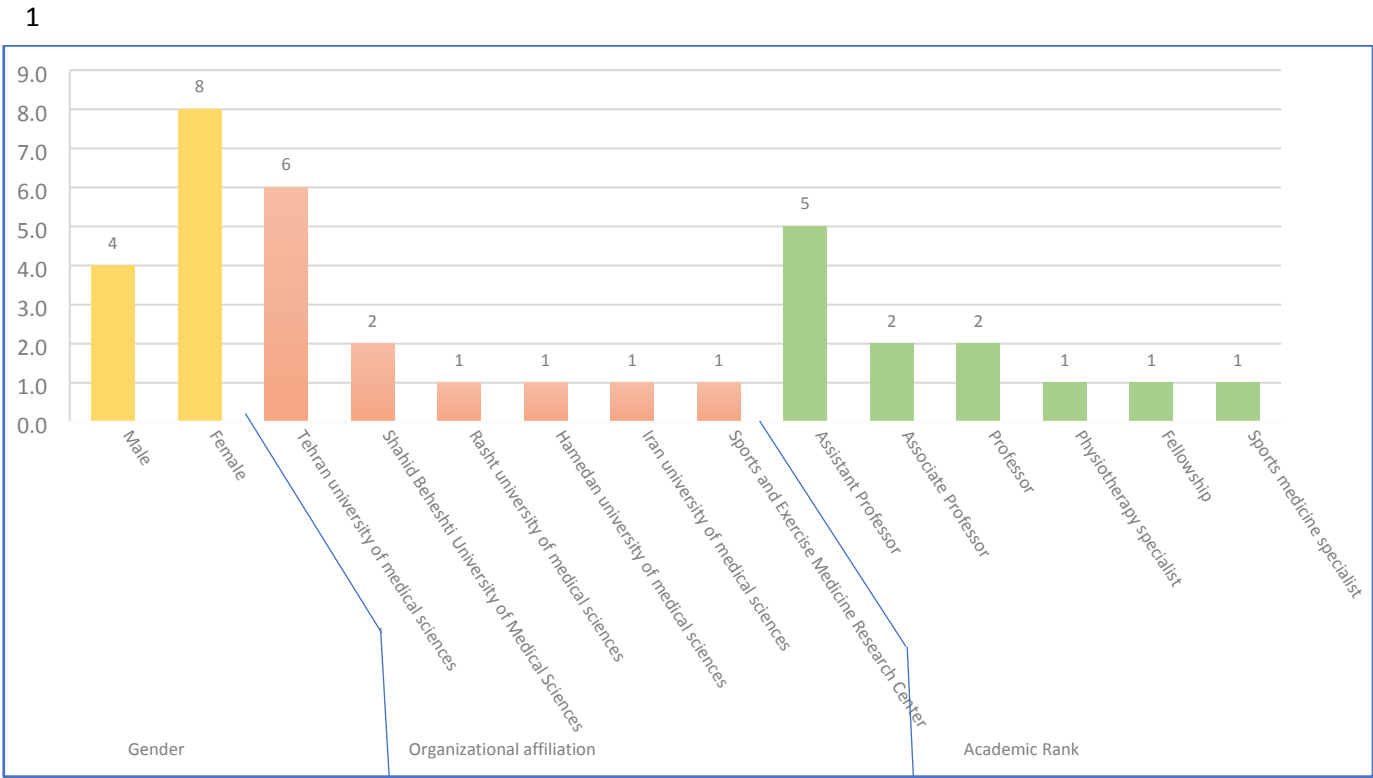


Figure 4- Demographic distribution of participation

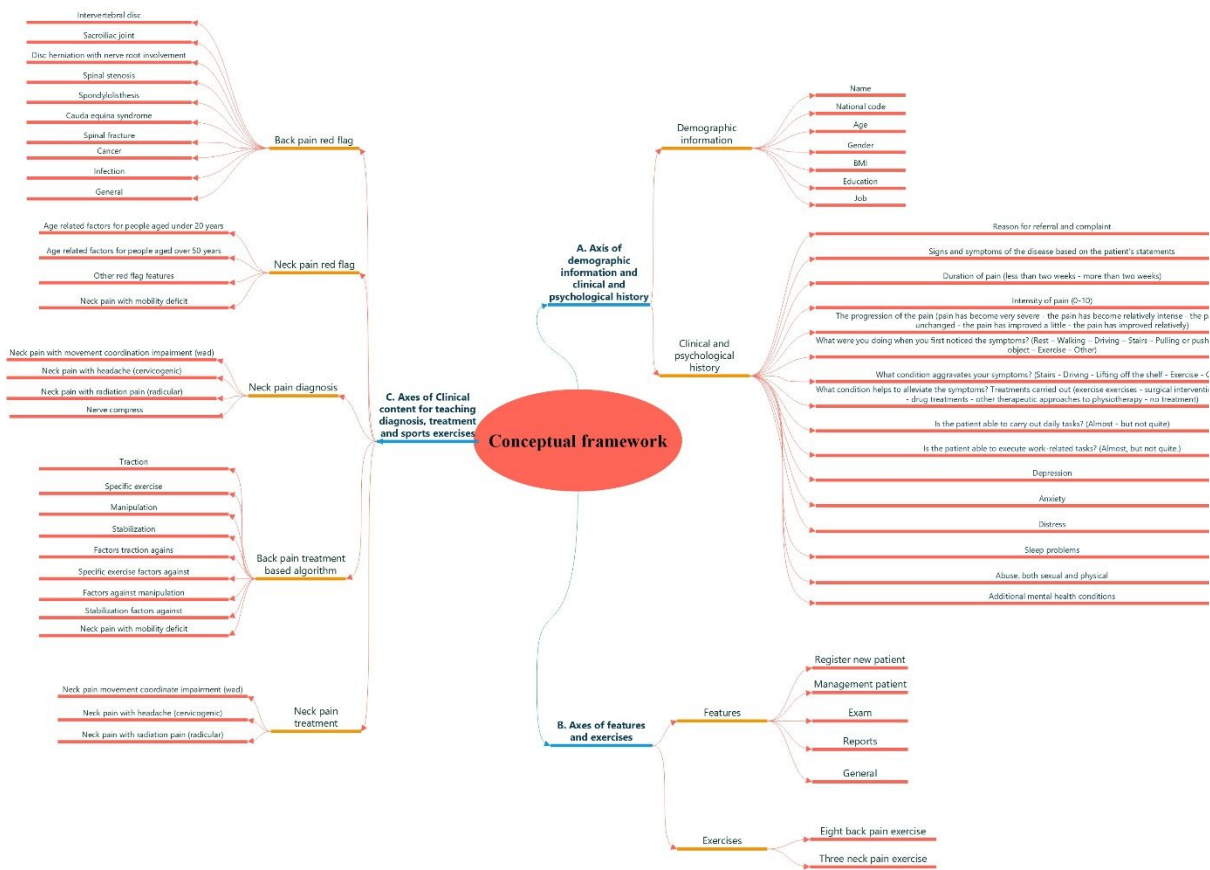


Figure 5- The final conceptual framework of educational software

Appendix tables:

Table 1- Validation in the axis of demographic information and clinical and psychological history

Main category	Num	Data elements	Mean	%
Demographic information	1	Name	4.69	91.78
	2	National code	4.74	91.78
	3	Age	5.01	98.33
	4	Gender	4.98	98.37
	5	BMI	4.84	96.70
	6	Education	4.78	91.70
	7	Job	4.90	95.08
Clinical and psychological history	8	Reason for referral and complaint	4.96	96.79
	9	Signs and symptoms of the disease based on the patient's statements	4.78	93.38
	10	Duration of pain (less than two weeks - more than two weeks)	4.95	95.02
	11	Intensity of pain (0-10)	5.01	98.35
	12	The progression of the pain (pain has become very severe - the pain has become relatively intense - the pain has remained unchanged - the pain has improved a little - the pain has improved relatively)	4.99	98.32
	13	What were you doing when you first noticed the symptoms? (Rest – Walking – Driving – Stairs – Pulling or pushing a thing – Lifting an object – Exercise – Other)	4.87	95.08
	14	What condition aggravates your symptoms? (Stairs - Driving - Lifting off the shelf - Exercise - Other)	4.83	95.07
	15	What condition helps to alleviate the symptoms? (Relaxing - bending...)	4.94	95.05
	16	Treatments carried out (exercise exercises - surgical interventions - manual therapies - drug treatments - other therapeutic approaches to physiotherapy - no treatment)	4.93	95.04
	17	Is the patient able to carry out daily tasks? (Almost - but not quite)	4.93	96.77
	18	Is the patient able to execute work-related tasks? (Almost, but not quite.)	4.78	93.39
	19	Depression	4.91	95.08
	20	Anxiety	4.96	96.75
	21	Distress	4.89	96.71
	22	Sleep problems	4.97	95.04
	23	Abuse, both sexual and physical	4.88	95.05
	24	Additional mental health conditions	4.78	93.35
Total Mean			4.90	95.33

Table 2- The results of validation in the axes of Clinical content for teaching diagnosis, treatment, and sports exercises

Main category	Subcategory	Num	Data elements	Mean	%
Back pain red flags	Intervertebral disc	1	Centralization of symptoms	4.63	91.76
		2	No centralization of symptoms	4.33	85.03
	Sacroiliac joint	3	Dominant pain in the SIJ without the tuber area	3.88	76.80
		4	3 positives out of 5 physical examination findings: distraction, compression, thigh thrust, Gaenslen test, sacral thrust	4.79	93.31
	Disc herniation with nerve root involvement	5	Straight leg raises test positive for referred leg pain	4.65	91.77
		6	3 positives out of 4 history or physical examination findings: Dermatomal pain location in concordance with a nerve root, and corresponding sensory deficits, reflexes, and motor weakness	4.86	96.74
		7	Supplementary physical examination findings: Crossed straight leg raise test positive, then disc herniation with nerve root involvement	4.84	95.03
	Spinal stenosis	8	3 positive out of 5 history findings: age more than 48 years. Bilateral symptoms, leg pain more than back pain, pain during walking/standing, or pain relief upon sitting	4.37	86.70
		9	Supplementary physical examination finding: improved walking tolerance with the spine in flexion or relief by forward bending	4.83	95.03
	Spondylolisthesis	10	Intervertebral slip by inspection or palpation	4.81	95.04
		11	Segmental hypermobility by use of manual passive physiological intervention motion test	4.40	88.39
		12	Supplementary physical examination findings in the elderly spondylolisthesis	4.78	93.34
	Cauda equina syndrome	13	Supplementary physical examination finding: improved walking tolerance with the spine in flexion or relief by forward bending	4.61	91.77
		14	Severe or progressive bilateral neurological deficit of the legs, such as major motor weakness with knee extension, ankle eversion, or foot dorsiflexion.	4.80	95.01

Neck pain red flags		15	Recent-onset urinary retention (caused by bladder distension because the sensation of fullness is lost) and/or urinary incontinence (caused by loss of sensation when passing urine).	4.86	95.03
		16	Recent-onset faecal incontinence (due to loss of sensation of rectal fullness).	4.71	93.33
		17	Perianal or perineal sensory loss (saddle anesthesia or paresthesia).	4.71	93.33
		18	Unexpected laxity of the anal sphincter.	4.80	95.09
	Spinal fracture	19	Sudden onset of severe central spinal pain, which is relieved by lying down.	4.90	98.30
		20	A history of major trauma (such as a road traffic collision or fall from a height), minor trauma, or even just strenuous lifting in people with osteoporosis or those who use corticosteroids.	4.72	93.35
		21	Structural deformity of the spine (such as a step from one vertebra to an adjacent vertebra) may be present.	4.88	96.72
		22	There may be a point of tenderness over a vertebral body.	4.63	91.72
	Cancer	23	The person is 50 years of age or older.	4.42	88.35
		24	Gradual onset of symptoms.	4.87	95.02
		25	Severe unremitting pain that remains when the person is supine, aching night pain that prevents or disturbs sleep, pain aggravated by straining (for example, at stool, or when coughing or sneezing), and thoracic pain.	4.44	88.39
		26	Localized spinal tenderness.	4.68	91.73
		27	No symptomatic improvement after four to six weeks of conservative low back pain therapy.	4.67	91.74
		28	Unexplained weight loss.	4.65	91.79
		29	History of cancer — breast, lung, gastrointestinal, prostate, renal, and thyroid cancers are more likely to metastasize to the spine.	4.73	93.39
	Infection	30	Fever	4.75	93.39
		31	Tuberculosis, or a recent urinary tract infection.	4.67	91.76
		32	Diabetes	4.33	86.79
		33	History of intravenous drug use	4.67	91.72
		34	HIV infection, use of immunosuppressants, or the person is otherwise immunocompromised	4.78	93.35
	GENERAL	1	Fever	4.74	93.30
		2	Generalized neck stiffness	4.82	95.08
		3	Lymphadenopathy	4.82	95.05
		4	Nausea or vomiting	4.89	95.00
		5	Pain that is increasing, is unremitting, or disturbs sleep	4.61	91.73
		6	Severe neck tenderness	4.65	91.74
		7	Skin erythema, wounds, or exudate	4.68	91.74
		8	Unexplained weight loss	4.73	93.38
		9	Altered cognitive status	4.65	91.72
		10	Altered muscle tone	4.75	93.31
		11	Ataxia	4.71	93.38
		12	Babinski's sign: up-going plantar reflex, hyper-reflexia, clonus, spasticity	4.69	91.76
		13	Gait disturbance, clumsy or weak hands, or loss of sexual, bladder, or bowel function	4.71	93.32
		14	Hoffman's sign	4.74	93.35
		15	Incontinence	4.73	93.34
		16	Lhermitte's sign: flexion of the neck causes an electric shock-type sensation that radiates down the spine and into the limbs	4.34	85.04
		17	New or severe headache	4.84	96.76
		18	Photophobia or phonophobia	4.66	91.78
			Visual loss	4.44	88.39
		19	Weakness involving more than one myotome or loss of sensation involving more than one dermatome	4.61	91.75
	Age-related factors for people aged under 20 years	20	Altered hair distribution	4.90	95.06
		21	Birthmarks	4.90	95.04
		22	Congenital abnormalities	4.82	95.06
		23	Family history	4.67	91.76
		24	Infections related to substance misuse	4.69	91.73
	Age-related factors for people aged over 50 years	25	Skin tags	4.66	91.74
		26	History of cancer	4.64	91.73
	Other red flag features	27	Vascular disease	4.63	91.71
		28	A history of inflammatory arthritis, cancer, tuberculosis, immunosuppression, drug abuse, AIDS, or other infections	4.68	91.75
		29	A history of violent trauma (for example, a road traffic accident) or a fall from a height or minor trauma in a person at risk of osteoporosis (especially in post-menopausal women)	4.60	90.05
		30	Minor trauma may fracture the spine in people with osteoporosis	4.79	93.34
		31	Risk factors for osteoporosis. For more information, see the CKS topic on Osteoporosis - prevention of fragility fractures	4.72	93.31
		1	Central and/or unilateral neck pain	4.67	91.74

Neck pain diagnosis	Neck pain with mobility deficit	2	Limitation in neck motion that consistently reproduces symptoms	4.61	91.78
		3	Associated shoulder girdle or upper extremity pain may be present	4.76	93.38
		4	Limited cervical ROM	4.84	95.02
		5	Neck pain is reproduced at the end range of active and passive motion	4.70	93.36
		6	Restricted cervical and thoracic segmental mobility	4.76	93.31
		7	Intersegmental mobility testing reveals characteristic restriction	4.78	93.38
		8	Neck and referred pain reproduced with provocation of the involved cervical or upper thoracic segments or cervical musculature	4.75	93.35
		9	Mechanism of onset linked to trauma or whiplash	4.75	93.34
	Neck pain with movement coordination impairment (wad)	10	Associated (referred) shoulder girdle or upper extremity pain	4.64	91.72
		11	Associated with varied nonspecific concussive signs and symptoms	4.79	93.30
		12	Dizziness/nausea	4.64	91.73
		13	Headache, concentration, or memory difficulty, confusion, hyper-sensitivity to mechanical, thermal, acoustic, odor, light stimuli, heightened affective distress	4.64	91.79
		14	Positive cranial cervical flexion test	4.71	93.34
		15	Positive neck flexor muscle endurance test	4.79	93.36
		16	Strength and endurance deficit of the trapezius muscle	4.73	93.39
		17	Neck pain with mid-range motion that worsens with end-range position	4.78	93.39
		18	Point tenderness may include a myofascial trigger point	4.80	93.37
		19	Sensorimotor impairment may include altered muscle activation patterns, proprioceptive deficit, postural balance, or control	4.70	93.33
		20	Neck and referred pain reproduced by provocation of the involved cervical segments	4.73	93.31
	Neck pain with headache (cervicogenic)	21	Noncontinuous, unilateral neck pain and associated headache	4.75	93.40
		22	A headache is precipitated or aggravated by neck movement or sustained position/posture	4.59	90.07
		23	Positive cervical flexion rotation test	4.51	90.06
		24	A headache is reported with provocation of the involved upper cervical segments	4.74	93.37
		25	Limited cervical ROM	4.76	93.36
		26	Restricted upper cervical segmental mobility	4.70	93.37
		27	Strength, endurance, and coordination deficit of the neck muscle	4.76	93.31
	Neck pain with radiation pain (radicular)	28	Neck pain with radiating (narrow band of lancination) pain in the involved extremity	4.72	93.31
		29	Upper extremity dermatomal paresthesia or numbness and myotomal muscle weakness	4.74	93.32
		30	Neck and neck-related radiating pain reproduced or relieved with radiculopathy testing, positive test cluster includes upper limb nerve mobility, Spurling test, cervical distraction, cervical ROM	4.76	93.40
		31	May have upper extremity sensory, strength, or reflex deficits associated with the involved nerve roots	4.67	91.80
Back pain treatment-based algorithm	Nerve compress	1	Does the patient have symptoms distal to the buttock and signs of nerve root compression?	4.55	93.39
		2	Peripheralize with extension movement?	4.71	93.39
	Traction	3	Have a positive SLR test?	4.75	93.30
		4	Peripheralization of symptoms, with no ability to centralize with movement	4.72	93.34
	Specific Exercise	5	Centralized with 2 or more movements in the same direction (ie, flexion or extension)?	4.80	93.36
		6	Centralize with movement in one direction and peripheralize with opposite movements	4.73	93.31
		7	Directional preference for extension or flexion	4.71	93.33
		8	Centralization with motion testing	4.75	93.35
		9	Peripheralization in a direction opposite to centralization	4.71	93.35
		10	Have the duration of symptoms of <16 days?	4.78	88.39
		11	No symptoms distal to the knee?	4.49	93.34
	Manipulation	12	Hip medial (internal) rotation ROM > 35°	4.75	93.31
		13	Hypomobility with testing	4.75	93.31
		14	Average SLR ROM >91°	4.75	93.31
		15	Positive prone instability test?	4.76	91.71
	Stabilization	16	Positive aberrant movements?	4.66	93.32
		17	Age <40 years?	4.71	93.37
		18	Hypomobility with spring testing	4.78	93.34
		19	Increasing episode frequency	4.73	93.34
		20	3 or more prior episodes	4.76	91.78
	Factors traction Against	21	Low back pain only (no distal symptoms)	4.61	93.32
		22	No sign of nerve root compression	4.71	95.04
	Specific exercise factors against	23	Low back pain only (no distal symptoms)	4.89	93.36
		24	Status quo with all movements	4.71	93.31
	Factors against manipulation	25	Symptoms below the knee	4.72	91.77
		26	Increasing episode frequency	4.70	90.07
		27	Peripheralization with motion testing	4.54	90.01
		28	No pain with spring testing	4.59	91.74

	Stabilization Factors against	29	Discrepancy in SLR ROM	4.64	93.40
NECK pain treatment	Neck pain with mobility deficit	Acute			
		1	Thoracic manipulation	4.76	93.36
		2	Cervical mobilization or manipulation	4.77	93.36
		3	Cervical ROM, stretching, and isometric strengthening exercise	4.79	93.36
		4	Advice to stay active, plus home cervical ROM, and isometric exercise	4.77	93.38
		5	Supervised exercise: including cervico-scapulothoracic and upper extremity stretching, strengthening, and endurance training	4.77	93.38
		6	General fitness training (stay active)	4.72	95.01
		Subacute			
		7	Cervical mobilization or manipulation	4.76	93.30
		8	Thoracic manipulation	4.85	93.39
		9	Cervical ROM, stretching, and isometric strengthening exercise	4.78	93.38
		Chronic			
		10	Thoracic manipulation	4.72	95.04
		11	Cervical mobilization	4.78	91.73
		12	Combined cervico-scapulothoracic exercise plus mobilization	4.83	95.06
		13	Mixed exercise for cervico-scapulothoracic Regime - neuromuscular exercise: coordination, proprioception, and postural training, stretching, strengthening, Endurance training, aerobic conditioning, and cognitive affective element	4.68	95.01
		14	Supervised individual exercise	4.86	91.79
	15	Stay active with lifestyle approaches	4.86	93.33	
	16	Dry needling, low-level laser, Pulsed or high-power ultrasound, intermittent mechanical traction, repetitive brain stimulation, TENS, Electrical muscle stimulation	4.67	93.31	
	17	Thoracic manipulation	4.79	95.03	
	Neck pain movement coordinate impairment (WAD)	Acute			
		18	Education: Advise to remain active, act as usual	4.70	95.02
		19	Home exercise: pain-free cervical ROM and postural element	4.85	93.33
		20	Monitor for acceptable progress	4.85	90.07
		21	Minimize collar use	4.76	91.71
		Subacute			
		22	Education: Activation and counseling	4.52	93.31
		23	Combined exercise: active cervical ROM and isometric low-load strengthening, plus manual therapy (cervical mobilization), plus physical agent: Ice, heat, TENS	4.65	96.76
		24	Supervised exercise: active cervical ROM or stretching, strengthening, endurance, neuromuscular coordination, and stabilization elements	4.76	91.78
		Chronic			
	25	Education: prognosis. Encouragement, reassurance, and pain management	4.89	93.30	
	26	Cervical mobilization plus individual progressive exercise: low-load cervico-scapulothoracic strengthening, Endurance, flexibility, functional training using cognitive behavioral therapy principles, vestibular rehabilitation, eye, head, neck coordination, and neuromuscular coordination elements	4.69	93.36	
	Neck pain with headache (cervicogenic)	Acute			
		27	Exercise c1-2 self-SANG	4.74	91.71
		Subacute			
		28	Cervical manipulation and mobilization	4.71	91.73
		29	Exercise:c1-2 self-SANG	4.62	91.71
		Chronic			
		30	Cervical manipulation	4.66	91.75
		31	Cervical and thoracic manipulation	4.73	93.31
Neck pain with radiation pain (radicular)	Neck pain with headache (cervicogenic)	32	Exercise for cervical and scapulothoracic region: strengthening and endurance exercise with neuromuscular training, including motor control and biofeedback elements	4.82	95.03
		33	Combined manual therapy(mobilization or manipulation) plus exercise (stretching, strengthening, and endurance training elements)	4.74	93.31
		Acute			
		34	Exercise: mobilization and stabilization elements	4.72	93.34
	Neck pain with radiation pain (radicular)	35	Low-level laser	4.78	93.34
		36	Possible short-term collar use	4.88	95.05
		Chronic			
		37	Combined exercise: stretching and strengthening elements plus manual therapy for the cervical and thoracic regions: mobilization or manipulation	4.77	93.32
38		Educational counseling to encourage participation in occupational and exercise activities	4.76	93.31	
		39	Intermittent traction	4.81	96.79
		Total mean		4.72	92.76

Table 3- The results of validation in the axes of features and exercises

Category	Num	Data elements	Mean	%
Register a new patient	1	Registering data related to the national code and name, and other important items	4.83	96.72
	2	Registration of demographic information, clinical and psychological records (optional)	4.87	95.07
	3	Presenting red flags of back pain and neck pain using rules (if-then) to train students	4.86	96.75
	4	Using rules (if-then) for decision support systems	4.96	98.33
	5	Providing guidance messages to continue the management or referral process	4.88	96.73
	6	The possibility of creating two separate cases based on the type of disorder (back pain and neck pain)	4.82	96.73
	7	Using animation to show sports exercises	4.82	96.79
	8	Text and audio file to explain how to do the exercises	4.94	98.35
	9	Playing background music while doing exercises	5.00	98.34
Management patient	10	Record information related to diagnosis and treatment	4.85	96.79
	11	Recording information about the patient's condition at the onset of pain	4.97	98.37
	12	Record information about pain intensity	4.92	98.31
	13	The possibility of changing the diagnosis and treatment if needed	4.84	96.78
	14	Record a note to schedule an appointment and provide additional information	4.96	98.36
Exam	15	Providing specialized questions separately	4.84	96.73
	16	Providing multiple-choice questions to challenge students' knowledge	4.98	98.38
	17	Recording test results based on the number of correct and incorrect answers, and providing a report card	4.91	98.35
Reports	18	Providing a report on the number of patients according to the type of selected back pain treatment	4.84	96.79
	19	Providing a report on the number of patients according to the type of selected neck pain diagnosis	4.82	96.72
	20	Providing a report on the number of patients according to the number of patients with back pain and neck pain	4.88	96.77
	21	Willingness to report the number of patients by gender	4.82	96.72
	22	Providing a report on the number of patients by age	4.94	98.32
General	23	Access to the application with username and password	4.95	98.32
	24	Provide the username and password to students via SMS	4.90	96.74
	25	Bilingual application	5	100
Title		Description	Mean	%
Exercise	26	Back pain exercise 1 Strengthen the less-used abdominal muscles .	5	100
	27	Back pain exercise 2 Simultaneous stretching of muscles and nerves & Painless walking & Strong and short stretching of the low back muscles, & Improving the range of motion towards the front of the waist.	5	100
	28	Back pain exercise 3 Strong contraction of the abdominal muscles	5	100
	29	Back pain exercise 4 Stretch on the bar & Increase the forward range of motion of the pelvis - Reduce the deflection of the front of the pelvic plate	5	100
	30	Back pain exercise 5 Strengthen the weak serine muscles (A group of three muscles that make up the buttocks)	5	100
	31	Back pain exercise 6 Strengthen the muscles of the legs with special emphasis on the muscles of the front of the thighs (quadriceps muscles), & Strengthen the muscles (buttocks) of the serine	5	100
	32	Back pain exercise 7 Strong and short low back muscles stretch & improve the forward range of motion of the waist.	5	100
	33	Back pain exercise 8 Strengthen leg muscles with special emphasis on front thigh muscles (quadriceps muscles) & Strengthen the serine muscles	5	100
	34	Neck pain exercise 1 Lying on the back and moving the neck	5	100
	35	Neck pain exercise 2 Sitting on a chair and hanging the neck forward, and moving the head to the sides	5	100
	36	Neck pain exercise 3 Sit on all fours and move your head to the sides in a hanging position	5	100
Total mean			4.90	98.20