CURRENT CONCEPTS REVIEW

The Mobile Applications for Low Back and Neck Pain Therapy: App Review

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Abstract

This study aimed to assess mobile applications (apps) designed for physiotherapy targeting low back pain (LBP) and neck pain (NP) using the Mobile Application Rating Scale (MARS). The study employed an evaluation design, in which three reviewers conducted searches in English and Persian on Google Play in October 2024 to identify apps related to LBP and NP. After initial screening, the included apps were downloaded and installed on smartphones for further evaluation. The MARS questionnaire was utilized to evaluate apps. The total score obtained from the MARS questionnaire, along with the rating on the Google Play Store, was used to assess the quality and effectiveness of the apps. Eighteen apps, consisting of eight for NP and ten for LBP, were included in this study. Among LBP apps, the application "Back Pain Relief Exercises at Home" received the highest score (3.79/5). Moreover, the app "Lia – AI Posture Trainer" achieved the highest score among NP apps at 4.25/5. The findings showed that the apps available for NP and LBP are limited and low-quality. Given the increasing number of individuals suffering from these conditions, there is a clear need for up-to-date and high-quality software to provide daily patient support. These apps must be developed based on scientific studies and incorporate user feedback.

Level of evidence: IV

Keywords: Back pain, Digital health, Mobile applications, Neck pain, Software validation

Introduction

The two most common causes of disability worldwide across various countries and age groups are low back pain (LBP) and neck pain (NP). These conditions impose a significant financial burden, including medical expenses, lost productivity, and employment issues.[1-5] Physiotherapists often encounter patients seeking treatment for LBP and NP, with patient education and exercise being commonly recommended based on current guidelines in physiotherapy. Exercise has been proven to be an effective tool for alleviating pain and improving the functional status of individuals with chronic LBP and NP.[6-10] The emergence of new technologies, particularly mobile applications (apps), has revolutionized various industries, including healthcare. A mobile application or app is a computer program or software application designed to run on a mobile device such as a phone, tablet, or watch. These apps have the potential to assist individuals in performing exercises correctly and on time.[1,11,12] Physiotherapists have also embraced information and communication technology (ICT), especially mobile apps, resulting in significant changes in treatment plans.[2,13-15]

As of September 23, 2024, the Google Play Store alone offers more than 1.68 million apps. During the last measured period, there were 36,260 healthcare and medical apps available on the Google Play Store.[16,17] However, the rapid development of technology has made it challenging to assess the quality of these apps. Many apps are developed without input from healthcare professionals and end users, and they often do not align with standard clinical guidelines. Additionally, there is a lack of rules and regulations in this field.[4,12,18-20] Consequently, it is crucial to evaluate the quality of mobile apps using validated measures and compare them to existing best practice

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guidelines.[12,21-23]

To address this need, the Mobile Application Rating Scale (MARS) was developed to assess the quality and performance of health-related mobile apps.[24] The MARS questionnaire was created in 2015 through semantic analysis and synthesis of literature by Stoyanonv et al. Several studies have demonstrated good reliability and validity of the translated versions of the MARS questionnaire, such as MARS-G (German version), MARS-F (French version), MARS-K (Korean version), and the Spanish version.[19,24-31] Recently, the Persian version of the MARS questionnaire has also been translated and approved.[32] The MARS questionnaire evaluates various aspects of mobile app quality, quantity, and performance, specifically relevant to health-related apps. It consists of 29 items grouped into different sections: A-D (engagement, functionality, aesthetics, information quality), E (subjective quality), and F (app-specific).[19,24-31]

This study aims to address two gaps in the existing literature. First, while the quality of LBP apps has been studied extensively, limited research has been conducted on NP apps. Additionally, although most LBP apps also include information related to NP, no previous study has simultaneously evaluated the quality of LBP and NP apps.[1,4,11,33] Second, even though existing LBP and NP apps often include exercise, counseling, and education related to physiotherapy, these aspects have not been evaluated using a comprehensive approach. The main objectives of this study are:

1) Evaluation of mobile apps for physiotherapy interventions targeting LBP and NP using the MARS questionnaire.

2) Assessing the adherence of exercise features in mobile apps to standard guidelines.

Main body

Study design

This study utilized a cross-sectional descriptive-analytical design to evaluate the quality of mobile applications targeting LBP and NP, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline. The researchers developed a search strategy and conducted searches in app stores using the relevant keywords. The primary screening of apps was based on their names and descriptions. Subsequently, the included apps were downloaded and evaluated against predefined inclusion and exclusion criteria. Finally, the eligible apps were assessed by the authors using the MARS questionnaire.[17]

Information sources and search strategy

In October 2024, the researchers reviewed the Google Play Store to identify apps related to LBP and NP. For LBP apps, the search terms used were 'back pain', 'low back pain', and 'lumbago back pain'. For NP apps, the search terms used were 'neck pain', 'cervical pain', 'NP', and 'neckache'. Other words such as physical therapy, exercise, and physiotherapy were also searched separately. These search terms were employed to ensure comprehensive coverage of relevant apps in the respective categories.[34,35]

Eligibility criteria

Preliminary screening to enter the study

During the initial screening of the apps on the Google Play Store, the researchers excluded apps that did not meet certain criteria. The following characteristics resulted in the exclusion of apps from the study: 1) Inconsistency between names or descriptions and the purpose of the study; 2) unavailability in Persian or English languages; and 3) payment requirements for download or use.

After this initial screening, the included apps were downloaded and installed on smartphones for further evaluation. The study's inclusion criteria were as follows: 1) The app must be available to the public; 2) the app should not require additional equipment to perform therapeutic interventions; 3) the app should have been updated between 2019 and 2024; and 4) the app should provide exercise therapy strategies to encourage patients to perform daily activities. On the other hand, the following apps were excluded from the study: 1) Apps providing only anatomical, diagnostic, and preventive information about NP and LBP without exercise recommendations; 2) specialized apps targeting specific conditions such as pregnancy, sciatica, or back pain due to cancer; 3) apps lacking a suggested exercise program; 4) apps containing software bugs or technical issues; and 5) apps solely focusing on yoga, meditation, or relaxation techniques without addressing exercise therapy for LBP and NP.

Selection process

After the initial screening, the apps that met the inclusion criteria were downloaded onto mobile phones with the Android operating system. In the next step, the apps were reviewed by two independent reviewers to assess their compliance with the inclusion and exclusion criteria. In cases where the two reviewers did not reach a consensus, a third researcher was involved to make the final judgment regarding the inclusion or exclusion of the app. This approach ensured a fair and objective evaluation process for the apps.

Data collection process

Two reviewers evaluated the apps downloaded from the Google Play Store using the MARS questionnaire.[33] To record the evaluation data of the apps, Microsoft Excel (2019) was used. The process involved entering the MARS questionnaire items into separate Excel sheets. Each author then evaluated the apps based on each question, providing their ratings or responses. This method allowed for systematic and organized data entry, making it easier to analyze and compare the evaluations of different apps. Excel's spreadsheet capabilities also provide flexibility in data manipulation and calculation, facilitating further analysis of the evaluation results.

Quality assessment

The MARS questionnaire was applied to assess the quality of the included apps. This questionnaire consists of 29 items grouped into six dimensions. Dimensions A-D (Quality Ratings) include (A) engagement (five items: fun, interest, individual adaptability, interactivity, and target group); (B) functionality (four items: performance, usability, navigation, and gestural design); (C) aesthetics (three items: layout,

graphics, and visual appeal); (D) information quality (seven items: the accuracy of app description, goals, quality of information, quantity of information, quality of visual information, credibility, evidence-based).

Dimension E is the subjective quality, which contains four questions that address user experience with the app. These questions inquire about offering the application to others, the number of times the application is used, willingness to pay, and the rating of the application.

Dimension F contains six questions that address the impact of the app on users' attitudes (i.e., knowledge, attitude, intention to change, help-seeking, and behaviour change).[12,19,28,36]

Data synthesis and analysis

In this study, descriptive statistics (mean and standard deviation) were used to assess and compare the ratings of the applications. In addition, Pearson correlation was used to examine the relationship between Google Play ranking and MARS overall quality score. Moreover, for measuring the quality of information, we used the National Institute for Health and Care Excellence (NICE) Neck Pain: Revision. Credibility scoring was performed on app descriptions. Additionally, Google, Google Scholar, and PubMed were searched to identify the legal sources to measure their credibility. Furthermore, the scoring criterion for the evidence-based item was the presence or absence of a clinical trial.

Quality of information

All medical guidelines recommend exercise therapy for the management of chronic LBP. However, there is significant variability in these exercises, which include water exercises, stretching, back schools, the McKenzie exercise approach, yoga, and tai chi.[37] NICE was updated in December 2020.[38] It recommends three exercise groups including biomechanical, aerobic, mind-body, or a combination of these approaches for patients with LBP. Moreover, the Neck Pain: Revision 2017 guideline offers different exercise programs such as stretching, strengthening, endurance training, aerobic conditioning, and cognitive-affective elements for different types of NP.[39] This study divided exercise programs into five categories: Strengthening, stretching, flexion-extension exercises, endurance training, and aerobics. The exercises used in these apps were placed in one of these categories.

Credibility

We assessed the credibility of the information source by reviewing the descriptions of the apps. In addition, to identify the legal license, a search was conducted based on the names of the apps in Google, Google Scholar, and PubMed.

Evidence-based score

As mentioned, applications should be assessed using effective evaluation studies to ensure reliable use. In this study, we used the websites "Clinical Trials" as well as "PubMed" and "Google Scholar" to identify supporting evidence. Therefore, if a clinical trial was conducted for an application, we assigned an evidence-based score to it.

Safety and privacy

The safety and privacy of the applications were also evaluated. However, this section is only used for a descriptive questionnaire and has no impact on the overall MARS score. Notably, the MARS questionnaire also includes an item related to this topic: "Does the app use password options to improve privacy?"

Overview of apps

In this study, the researchers identified a total of 277 apps related to LBP and 271 apps related to NP on the Google Play Store. After a screening process at different stages, eight NP apps and ten LBP apps met the inclusion and exclusion criteria and were selected for further evaluation. To assess the quality of the selected apps, the researchers utilized the MARS questionnaire. This questionnaire allowed them to evaluate various dimensions of the apps, including engagement, functionality, aesthetics, information quality, subjective quality, and app-specific quality.

As shown in Figure 1, the PRISMA flow diagram outlines the selection process of the apps. This diagram provides a visual representation of the screening stages and the number of apps that were included or excluded at each stage. It helps to ensure transparency and clarity in the app selection process, which follows the PRISMA guidelines for systematic reviews and meta-analyses. [Figure 1]

Overall, this study aimed to identify and evaluate a subset of LBP and NP apps using the MARS questionnaire, providing valuable insights into the quality and usability of these apps for individuals with LBP and NP.

LBP and NP applications on the Google Play Store were extracted based on inclusion and exclusion criteria. First, all unrelated and duplicate apps were removed from the obtained results, leaving only apps that met the inclusion criteria. The final selection included 18 applications, of which 10 were for LBP and 8 for NP. The basic characteristics of apps are shown in [Table 1]. As can be observed, all the included apps were commercially developed. The applications "Back Pain Relief Exercises at Home", "Neck & Shoulder Pain Relief Exercises, Stretches", and "6 Minute Back Pain Relief" had the highest number of installations and user reviews on Google Play Store, respectively. Moreover, the highest ratings of apps registered on Google Play belonged to ''Neck and Shoulder Pain Relief Exercises, Stretches'' (4.7/5), "Neck & Shoulder Workout (30-Day Workout Plan)" (4.6/5), "Back Pain Relief Exercises" (4.7/5), and ''Back Pain Relief Exercises at Home'' (4.7/5).

MARS questionnaire: app classification

The target section in the MARS questionnaire is divided into 12 categories. By evaluating each of the apps, the best option was selected among these categories. The results of this evaluation were as follows: Increases happiness/well-being (n = 8), mindfulness/meditation/relaxation (n = 6), reduces negative emotions (n = 5), depression (n = 0), anxiety/stress (n = 6), anger (n = 0), behavior change (n = 4), alcohol/substance abuse (n = 0), goal setting (n = 12), entertainment (n = 14), relationships (n = 0), and physical health (n = 18).

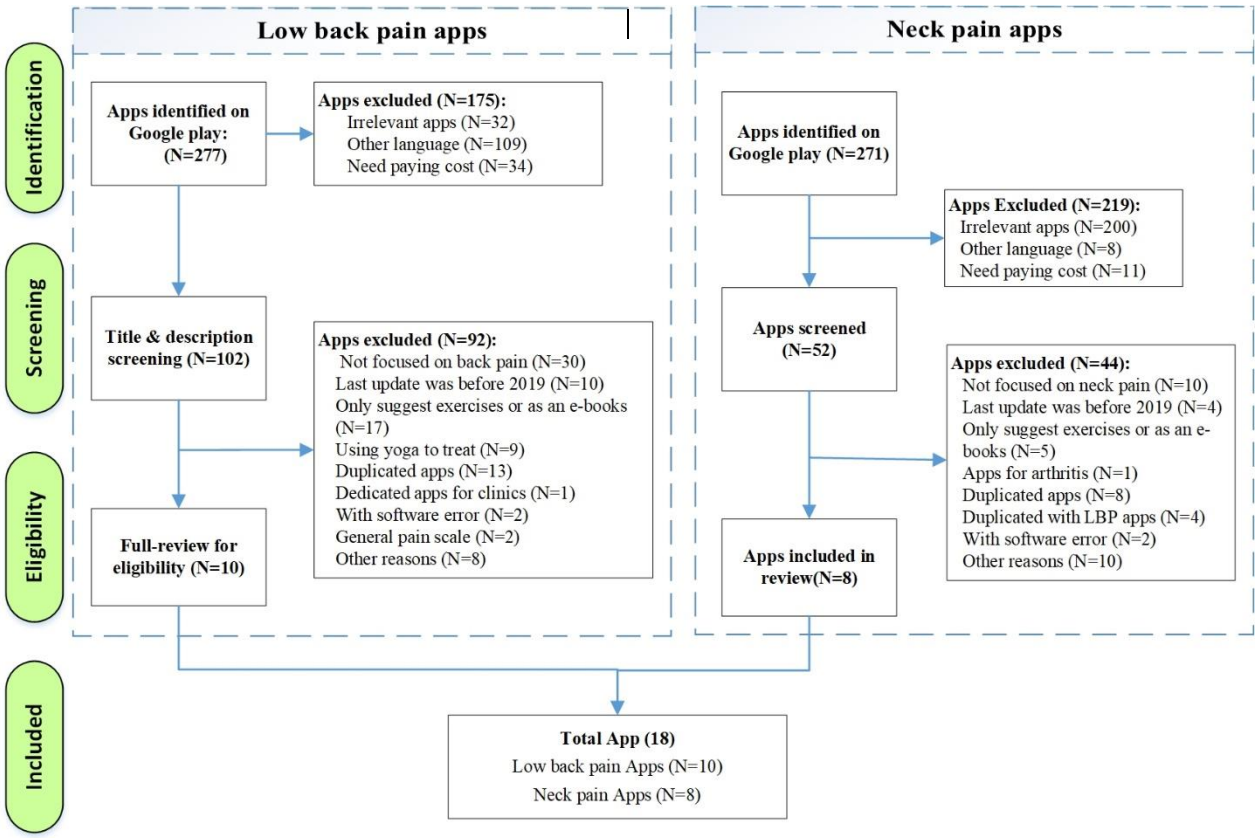

Figure 1. The process of app selection

Table 1. Characteristics of applications

	Rate on Google Play	Developer	Affiliations	N version	Last Update	Privacy link	Reviewer on Google Play	Installs	Brief Description
App name- Neck pain									
Neck & Shoulder Workout (30 days Workout Plan)	4.6	Game Master's	Commercial	1.5	2020	-	54	1,000+	This strengthening shoulder pain exercise relieves your pain in the shoulder and neck.
Neck & Shoulder Pain Relief Exercises, Stretches	4.6	OHealthApps Studio	Commercial	1.4	2020	-	1317	100,000+	Neck and Shoulder Pain Exercises, back of NP exercises and NP stretching exercise
Neck Stretches & Exercises	3.7	Steveloper	Commercial	1.3	2020	-	28	10,000+	The app demonstrates stretching and strengthening exercises you can do that may reduce NP.
Neck Pain Relief Exercises	3.4	1Bestofall LTD	Commercial	1.5	2020	✓	48	10,000+	This application contains six exercises that proven by doctors can help relieve your NP.
My neck	4.2	appdevelopers.ru	Commercial	1	2019	✓	253	10,000+	This is a simple application that at the right time reminds you to do exercises to reduce pain in the neck.

Table 1. Continued

Relieve Neck Pain	3.8	Therefreshbay	Commercial	1.5	2020	-	137	10,000+	Relieve NP provides relief to people who tend to sit long hours in front of the computer or play tech devices
Lia – AI Posture Trainer	-	Smart Spinal Solutions, Inc	Commercial	1.0.0.8	2023	-	-	1K+	Lia's smart wearable and app diagnose and correct bad posture, helping reduce neck, shoulder, and back pain with physiotherapist-designed workouts.
Neck Exercises	-	geozor	Commercial	1.3	2024	-	-	500+	Neck stretching and strengthening exercises. Stretch daily and strengthen 2-3 times a week.
App name- Back pain									
Back pain relief exercises at home	4.7	Vladimir Ratsev	Commercial	1.0.98	2020	✓	10,293	500,000+	With this application, you will be able to engage in the treatment and prevention of diseases of the back and neck at home.
Lower Back Pain and Sciatica Relief Exercises	4.4	App4Life dev	Commercial	4.2.4	2020	-	179	10,000+	These lower back strengthening exercises are a great way to strengthen your lower back and your core in general.
Back Pain Relief Exercises	4.7	1Bestofall LTD	Commercial	1.2	2021	✓	20	10,000+	With this application, you will be able to engage in the treatment and prevention of diseases of the back and neck at home.
Lower Back Pain Exercises	3.4	1Bestofall LTD	Commercial	1.1	2021	-	71	10,000	Lower Back Pain Exercises is a daily training application to remove back pain that contains nine proven exercises by doctors to relieve LBP.
low back pain relief exercises	3.4	the apps	Commercial	3.7.0.1.1	2019	-	51	10,000	About the application: waist exercises -LBP exercise - LBP relief- lumbago
6 Minute Back Pain Relief	4.5	Round1Fight	Commercial	3.7	2019	-	1,595	100,000+	Our goal is to help people who suffer from mild back pain, stiff neck, shoulders, or other discomfort created due to sitting for long periods.
Back Pain Exercises 2	-	ANIJ	Commercial	5	2020	-	-	100+	The set of exercises presented in this app is suitable for people suffering from LBP (Lumbar herniated disc, etc.).
Back pain relief exercises at home	4.2	Gym Fitness Technology	Commercial	1.0.2	2021	-	15	5,000+	The application contains a set of complete workouts: - lower back workouts; - thoracic spine workouts, - neck workouts.
Back Pain Relieving Exercises	-	Dr.Kavin Khatri	Commercial	1.3	2023	-	-	1K+	The app aims to help those with recurrent back pain and prevent future episodes.
Pain Relief Exercises	4/5	Healure Technology	Commercial	2.0.014	2024	-	224	10K+	Over 1000 personalized exercises for joint and muscle pain. custom workout plans by physiotherapists.

In the MARS questionnaire, there is a section related to theoretical background/strategies. The results of this section showed that information/education (N = 16), strengths-based (N = 14), feedback (N = 10), advice/tips/skill training (N = 12), and assessment (N = 9) strategies were the most used strategies to motivate behavior change.

Additionally, in the section on the technical aspects of the apps, the most prevalent technical components were enabling content sharing (N = 9) and sending reminders (N = 10), which were highly beneficial in encouraging users to continue regular exercise.

MARS questionnaire: App quality ratings

The scores obtained from the MARS questionnaire for each application are shown in [Table 2]. In general, the results obtained from the evaluation of apps are mentioned in the following sections.

Overall, the mean score of the MARS questionnaire was moderate (2.56). By section, the mean scores of engagement, functionality, aesthetic, and information were 2.67, 3.34, 2.48, and 2.52, respectively, and only functionality had a higher and acceptable score. Moreover, the comparison of NP and LBP apps revealed that NP apps had a marginally better score (3.29 vs. 2.55).

Table 2. Results of evaluation of neck pain and back pain apps with MARS questionnaire

	A. Engagement	B. Functionality	C. Aesthetics	D. Information	App quality mean score (A-D)	E. App subjective quality	F. APP-specific
App name- Neck pain							
Neck & Shoulder Workout (30 days Workout Plan)	3.10	3.88	3.67	3.67	3.58	4.25	4.00
Neck & Shoulder Pain Relief Exercises, Stretches	2.50	3.50	3.67	3.50	3.29	3.25	3.08
Neck Stretches & Exercises	3.10	3.50	3.00	2.92	3.23	3.38	3.58
Neck Pain Relief Exercises	2.90	3.38	3.17	2.92	3.19	3.25	4.00
My neck	2.20	3.38	2.17	2.25	2.50	3.00	3.67
Relieve Neck Pain	2.50	3.25	2.17	2.75	2.67	3.13	3.33
Neck Exercises	3.40	3.75	3.44	2.20	3.20	3.63	3.20
Lia – AI Posture Trainer	4.80	2.53	0.07	3.00	4.27	4.25	4.30
Mean	**3.06**	**3.39**	**2.67**	**2.90**	**3.29**	**3.39**	**3.52**
App name- Back pain							
Back pain relief exercises at home	3.90	4.00	3.83	3.43	3.79	4.50	4.25
Lower Back Pain and Sciatica Relief Exercises	1.50	3.00	1.63	1.90	2.01	2.38	1.92
Back Pain Relief Exercises	3.80	3.75	3.44	3.44	3.52	3.63	3.50
Lower Back Pain Exercises	1.40	1.50	1.13	2.00	1.51	1.88	2.08
low back pain relief exercises	2.10	3.00	1.75	2.00	2.21	2.63	2.67
6 Minute Back Pain Relief	2.50	3.50	3.00	3.00	3.00	2.75	3.33
Back Pain Exercises 2	2.90	3.50	1.88	2.10	2.59	3.38	3.08
Back pain relief exercises at home	2.50	3.38	1.84	2.50	2.55	2.75	3.25
Back Pain Relieving Exercises	2.20	4.00	3.00	2.40	2.90	1.75	1.40
Pain Relief Exercises	3.90	3.75	3.31	2.40	3.34	2.63	2.80
Mean	**2.67**	**3.38**	**2.48**	**2.51**	**2.55**	**2.82**	**2.82**
Total Mean	**2.67**	**3.34**	**2.48**	**2.52**	**2.56**	**3.23**	**3.19**

Among NP apps, "Lia – AI Posture Trainer" received the highest score with a mean value of 4.25/5, and "Back Pain Relief Exercises at Home" received the highest score among LBP apps with a mean value of 3.79/5. "My Neck" with a mean value of 2.50/5 had the lowest score among NP apps, and "Lower Back Pain Exercises" with an average value of 1.51/5 received the lowest score among LBP apps. In NP and LBP apps, the highest score in all three sections of engagement, functionality, and aesthetics was obtained by the app "Back Pain Relief Exercises at Home" (3.90/5, 4/5, and 3.83/5, respectively). In the information section, "Neck & Shoulder Workout (30-Day Workout Plan)" received the highest score (3.67/5).

MARS questionnaire: Subjective quality score

In all apps, the subjective quality had a moderate score (3.23). In addition, the comparison of NP and LBP apps showed that NP apps had a marginally better score (3.39 vs. 2.82) in this section. "Neck and Shoulder Workout (30-Day Workout Plan)" and "Lia – AI Posture Trainer" received the highest score among NP apps with a mean value of 4.25/5.

Moreover, “Back Pain Relief Exercises at Home” received the highest score among LBP apps with a mean value of 4.5/5. “My Neck” received the lowest score among NP apps with a mean value of 3.00/5. Furthermore, “Back Pain Relieving Exercises” received the lowest score among LBP apps with a mean value of 1.75/5.

App-specific score

In all apps, the app-specific quality had a moderate score (3.19). Moreover, the comparison of NP and LBP apps revealed that NP apps had a marginally better score (3.52 vs. 2.82) in the subjective quality section. “Lia – AI Posture Trainer” received the highest score among NP apps with a mean value of 4.30/5. "Back Pain Relief Exercises at Home" scored the highest among LBP apps with a mean of 4.25/5. "Neck and Shoulder Pain Relief Exercises, Stretches" received the lowest score among NP apps with a mean value of 3.08/5. “Back Pain Relieving Exercises” scored the lowest among LBP apps with a mean value of 1.40/5.

Quality of information, credibility, and evidence-based

In Table 3, the apps are evaluated based on the quality of information, credibility, and evidence base. The results showed that the total mean values of information quality (3.26/5) and credibility (2.92/5) in all apps were moderate and, the mean values of quality of information in NP and LBP apps were 3.33/5 and 3.20/5, respectively. In addition, the mean values of credibility in NP and LBP apps were 2.85/5 and 3.00/5. No clinical trials were found for any of the apps; therefore, the evidence-based column for all apps was marked as “none”. Most apps include a warning message in their description advising users to "consult your doctor before doing exercises". The legal owners of the apps are generally not well-known institutions and some do not even have a website. Moreover, none of the apps contain scientific data based on clinical trials. In addition, as can be seen, all apps focussed on stretching, except for "Neck & Shoulder Workout (30-Day Workout Plan)”, “Neck Stretches & Exercises”, “Neck Pain Relief Exercises”, “Neck Exercises”, “Lia – AI Posture Trainer”, “Back Pain Relieving Exercises”, “Pain Relief Exercises”, and “Lower Back Pain Exercises", which also include strengthening exercises.[Table 3]

Table 3. Mean Scores of questions quality of information, credibility, evidence base and types of exercice

Num	App name- Neck pain	Quality of information score	Credibility score	Evidence- base score	Types of exercise	Details of Exercise
1	Neck and Shoulder Workout (30 days Workout Plan)	3	4	None	Strengthening and stretch	Neck Flexion, Scapular Retraction, Shoulder Roll
2	Neck and Shoulder Pain Relief Exercises, Stretches	3	4	None	Stretching	Neck Flexion, Shoulder Shrug, Towel Stretch, Neck Roll, Neck Rotation For Back Pain: Cobra Pose, Bridge Pose, Knee to Chest Stretch
3	Neck Stretches and Exercises	3.5	4	None	Strengthening and stretch	Superman, Wall Angels, Chin Tuck, Neck Retraction, Shoulder Shrugs
4	Neck Pain Relief Exercises	2.5	2.5	None	Strengthening and stretch	Neck Flexion, Neck Retraction, Shoulder Stretch
5	My Neck	3	2	None	Stretching	Neck Tuck, Shoulder Stretch, Neck Roll
6	Relieve Neck Pain	3	2	None	Stretching	Bend forward & backward Shoulder shrug
7	Neck Exercises	3	2	None	Relaxation, strengthening and stretch	Neck Rotation, Chin Tuck, Shoulder Blade Pull
8	Lia – AI Posture Trainer	5	2	None	Strengthening and stretch	Thoracic Spine Extension, Neck Bend, Chin Tuck, Seated Thoracic Extension
	Mean	**3.33**	**2.85**	-	-	-
Num	**App name- Back pain**	**Quality of information score**	**Credibility score**	**Evidence- base score**	**Types of exercise**	**Details of Exercise**
1	Back pain relief exercises at home	4	4	None	Stretching	Seated Hamstring Stretch, Knee Hug, Cobra Pose, Child’s Pose

Table 3. Continued

2	Lower Back Pain and Sciatica Relief Exercises	3	3	None	Stretching	Piriformis Stretch, Knee to Chest Stretch, Cat-Cow, Cobra Pose, Bridge Pose, Hamstring Stretch	
3	Back Pain Relief Exercises	4	3.5	None	Stretching	Lie Back arms, Lie Back head, Lie Back legs, Lie Back hands	
4	Lower Back Pain Exercises	2	3	None	Strengthening and stretch	Knee hugs, Rotation, Abdominal sides, Abdominal exercise	
5	Low Back Pain Relief Exercises	3	3	None	Stretching	Posterior pelvic tilt Half Shuttle, Thesis in bodies Both sequences, attract the knee Straight leg lift, Half Cobra Movement Bridge	
6	6 Minute Back Pain Relief	4	4	None	Stretching	Knee Rolls, Child's Pose, Cat-Cow Pose, Hamstring stretch	
7	Back Pain Exercises 2	3	3	None	Stretching	Stretching the body, Double knee to chest stretch, Pelvic lift, Crunches, Leg cycle	
8	Back pain relief exercises at home	3	3	None	Stretching	Childs pose, cow pose, downward facing dog, seated spinal twist left	
9	Back Pain Relieving Exercises	3	2	None	Strengthening and stretch	Pron position, Press ups, Back arching, Leg raises	
10	Pain Relief Exercises	3	2	None	Strengthening and stretch	Cat-Cow Pose, Seated Hamstring Stretch, Knee Hugs, Hip Rotations	For Neck Pain: Towel Stretch, Neck Roll, Shoulder Shrug, Forward Bend
	Mean	**3.20**	**3.00**	**-**	**-**	**-**	
	Total Mean	**3.26**	**2.92**	**-**	**-**	**-**	

Principal findings

This study identified several new key aspects of information in NP and LBP apps, which had not been examined previously. The results showed that most of the apps were developed by non-profit organizations and did not follow FDA instructions related to the design of health-related mobile apps.[40] A significant concern is that users often base their selection of apps on Google Play ratings, and many are unaware of the standard criteria for apps. The ratings on Google Play are not a reliable scale for the quality of an app. This issue is especially important in medical applications, where the smallest error in advice will have irreparable consequences.

Overall, the mean scores of the apps in all four main sections of the MARS questionnaire were within the moderate range (2.67, 3.34, 2.48, and 2.52). According to the results, the lowest total MARS score (1.51/5) among LBP apps belonged to "Lower Back Pain Activities", and the lowest score among NP apps (2.5/5) was related to the app "My Neck". The highest MARS score among NP apps belonged to "Back Pain Relief Exercises at Home" with a score of 3.79/5. This app contains 100 practices for the strength of the back, abdomen, shoulders, legs, pelvis, and neck muscles. Each exercise includes a video demonstration and instructions. In addition, the user can track the number of exercises through audio, without needing to look at the phone screen. For NP apps, the highest obtained score was 4.27/5, which was assigned to the app "Lia – AI Posture Trainer". Lia combines a smart wearable and app to diagnose and correct poor posture, helping reduce neck, shoulder, and back pain with physiotherapist-designed workouts.

In addition, the scores of subjective quality and app-specific section (perceived impact of the apps on the user's knowledge, attitudes, intentions to change, and the likelihood of change in the target health behaviour) were marginally above moderate (3.23/5 and 3.19/5, respectively). In the app-specific section, NP apps had significantly higher scores than LBP apps (3.52 vs. 2.82). Overall, the apps were of low quality, especially in the items of engagement, aesthetics, and information, with LBP apps performing slightly worse in these items.

Similar to previous research, this study found that the information quality of apps for LBP and NP is low and unreliable. However, previous studies have neither evaluated LBP and NP disorders concurrently nor considered the physiotherapy approach.[1,4,11,12] We assessed both LBP and NP since most related apps include them simultaneously. Several reviews have found no significant correlation between consumer ratings on Google Play and MARS scores. It has also been reported that the "app store rating" is not a good indicator of the quality of the apps.[9,10]

Quality of information, credibility and evidence-based

We divided the exercises proposed by the apps into five categories: Strengthening, stretching, flexion-extension exercises, endurance training, and aerobics. The exercises were placed in one of these categories. As mentioned, the results showed that most of the apps included only strengthening and stretching exercises. To ensure that

appropriate exercises are included for each disorder, developers should produce apps in collaboration with experts (i.e., health professionals and medical informatics specialists).

Several studies have shown that the majority of LBP apps suggested improving engagement and information, but did not use a specific approach to evaluate the quality of information.[41] Other studies have demonstrated that the quality of NP apps is significantly low when considering subjective and app-specific quality.[4] Similarly in the current study, it was observed that app quality is low in all sections of the MARS questionnaire.[4,11,18]

Due to the increasing demand for health applications and minimal regulation over their content, users do not wait for research to confirm the validity of the applications. Other studies have shown that the content of apps is of low quality and originates from unreliable sources.[14,42] In line with these findings, this study showed that the credibility of the apps was not adequate.[12,43]

In the evidence-based section, none of the apps were clinically tested. However, the development of apps in universities and research centers can contribute to this important aspect.[18] In addition, encouraging mobile health app developers and educational institutions to collaborate may help overcome some of these challenges. These findings were consistent with those of other studies on pain-focused mobile health apps, which have revealed a notable shortage of scientific evidence to justify the usage of available apps.[37,42] Similar studies have shown that there are many apps available for LBP and NP. It was found that the majority of the evaluated apps lacked empirical support and guideline-based therapies.[1,33]

Safety and privacy

Only one app, "Pain Relief Exercises", features a login option. However, privacy links are included in some apps. For example, among NP apps, "My Neck", "Pain Relief Exercises", and "Neck Pain Relief Exercises" have privacy links containing tips on protecting the patient's personal information and other relevant rules.

Regarding data management, some applications may collect specific types of data, such as device identifiers and location information, and may also share personal user information. Users should be aware that data in some of these applications are not encrypted, although there is an option to request data deletion. In contrast, some other applications do not collect or share any data at all and may encrypt data in transit. These types of applications assure their users that their information is not at risk and that they have enhanced control over their data.

Overall, it is essential for users to pay attention to the privacy and security policies of applications and to take advantage of features such as encryption and data deletion requests to protect their privacy.

A lack of privacy could compromise patient data. Therefore, ensuring the safety and privacy of patient data is an essential consideration in designing and developing apps or updating them.[44]

According to a recent study, the majority of apps infringe upon instructions and best practices, threatening user privacy. Another study found no risk-free apps.[44] As suggested by multiple authors, studies should address the need to enhance the credibility, security, and privacy of apps.[18] The above-mentioned studies indicated the privacy concerns of m-health apps.

In a study by Lalloo et al., it was concluded that most apps violate safety guidelines and threaten user privacy.[42] Moreover, some studies have suggested the need to increase app credibility, security, and privacy.[18] However, another study contradicted this view and claimed that none of the apps posed any risk to privacy.[44] The above-mentioned studies demonstrate the privacy concerns of m-health applications.

Evidence-based criteria, validity, and quality of information should be well considered during software development. The results of this study can be used by three groups including mobile application developers, patients, and physiotherapists. Application developers can use the results of this study to develop or update applications. The need for communication between application developers and experts is evident in this study. If application scores are high in terms of user interface and user experience, but weak in terms of content and evidence, the application will not achieve the desired result. Medical informatics and health information technology bridge the gap between the medical and technology industries. Patients can also benefit from the findings of this study. Based on the results, it was determined that higher app ratings do not necessarily correlate with higher app quality. This study also helps physiotherapists choose the appropriate app for their patients. A high-quality app should integrate all necessary factors so that experts can safely recommend it to their patients. Hence, the evaluation of existing apps using the MARS questionnaire can provide experts with a relative understanding of the quality of various available apps.

Limitations

The present study had some limitations that should be considered. The first limitation is the lack of evaluation of App Store apps due to the unavailability of the iOS operating system, as only apps available on the Google Play Store were included, potentially limiting the generalizability of the findings to iOS users. Another limitation is the exclusion of apps that require payment. This exclusion could lead to potential bias since paid apps might have different features and qualities compared to free apps or organizational accounts. Although this limitation may affect the comprehensiveness of the results, it provides practical insight into the situation of Iranian users and other countries facing this challenge.

Additionally, this study only included apps in English and Persian, which could limit the representation of apps in other languages. It is important to acknowledge that most applications are primarily available in English. Despite these limitations, the current study utilized the MARS questionnaire, which is a comprehensive tool for assessing

the quality of health apps. This questionnaire covers various dimensions, providing a detailed evaluation of the apps' engagement, functionality, aesthetics, information quality, subjective quality, and app-specific quality. This allows for a comprehensive assessment of the included apps in multiple aspects related to their quality and usability.[24,29,35,45] A potential limitation of the MARS questionnaire is that some of its questions assess subjective evaluation and user experience, which introduces a possibility of bias in the answers. It is worth mentioning that subjective opinions may vary between individuals, which can influence the overall evaluation of the apps.

In addition, assessing the quality of information, evidence base, and credibility of the apps is necessary, especially considering that many existing apps provide treatment methods for LBP and NP. Evaluating the effectiveness of these apps is crucial to ensure that they are reliable and trustworthy sources of information and can potentially be integrated into healthcare practices.

Future research should consider incorporating methods to assess the information quality and effectiveness of health apps. This could involve conducting clinical trials or user studies to evaluate the impact of the apps on health outcomes, as well as assessing the accuracy and evidence base of the information provided within the apps. This would provide a more comprehensive understanding of the apps' effectiveness and help guide their inclusion in healthcare practices. By addressing these aspects, researchers and healthcare professionals can ensure that the evaluated apps are not only user-friendly but also provide reliable and evidence-based information to support the management of LBP and NP.

Conclusion

The findings of the present study indicate that there is a limited number of apps designed for NP and LBP, and these apps are generally low in quality based on the MARS tool. Given the increasing number of individuals suffering from these conditions, it is crucial to have up-to-date and high-quality software that can provide daily support to patients. To ensure the development and availability of reliable and effective apps, these apps must be created based on scientific studies and with the input of users. Therefore, app developers should conduct research, gather user feedback, and publish the results to demonstrate the effectiveness and user satisfaction of their apps. Furthermore, it is essential to evaluate and publish information regarding the quality, credibility, functionality, privacy, and usability of health apps. This would provide transparency and allow users, healthcare professionals, and regulatory organizations to make informed decisions about which apps to use or recommend.

This research recommends that organizations take responsibility for approving health applications. These organizations could be either public or private and could have a structure similar to ISO certificates, which ensure that products and services meet specific quality standards. This type of certification or approval process for health apps would help users identify trustworthy and reliable apps and promote their widespread use. In summary, this study highlights the need for up-to-date and high-quality software to support individuals with NP and LBP. It emphasizes the importance of conducting research, involving users in the development process, and publishing the results. Additionally, evaluating and publishing information about the quality, credibility, functionality, privacy, and usability of health apps is crucial. This study recommends having organizations responsible for approving health apps, similar to ISO certificates, to ensure the reliability and effectiveness of these apps.

List of abbreviations

MARS: Mobile Application Rating Scale
App: application
NP: Neck pain
LBP: Low back pain
ICT: Information and communication technology
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
NICE: The National Institute for Health and Care Excellence

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References

1. Coe-O'Brien R, Joseph L, Kuisma R, Paungmali A, Sitilertpisan P, Pirunsan U. Outcome measures used in the smartphone applications for the management of low back pain: a systematic scoping review. Health Inf Sci Syst. 2020;8(1):1-12. doi:10.1007/s13755-019-0097-x.
2. Kazeminasab S, Nejadghaderi SA, Amiri P, et al. Neck pain: global epidemiology, trends and risk factors. BMC Musculoskelet Disord. 2022;23(1):26. doi: 10.1186/s12891-021-04957-4.
3. Maher C, Ferreira G. Time to reconsider what Global Burden of Disease studies really tell us about low back pain. Ann Rheum Dis. 2022;81(3):306-308. doi: 10.1136/annrheumdis-2021-221173.
4. Marques J, Borges L, Andias R, Silva AG. Characterisation and assessment of the most popular mobile apps designed for neck pain self-management: A systematic search in app stores. Musculoskeletal Care.2022;20(1):192-199. doi: 10.1002/msc.1581.
5. Aghazadeh A, Mansour Sohani S, Salehi R, Parnianpour M. Translation, Cross-Cultural Adaptation and Psychometric Properties of the Persian Version of Patient-Specific Functional Scale in Patients with Chronic Low Back Pain. The Archives of Bone and Joint Surgery. 2025;13(1):47–53. doi: 10.22038/abjs.2024.76731.3546
6. Sterling M, de Zoete RMJ, Coppieters I, Farrell SF. Best Evidence Rehabilitation for Chronic Pain Part 4: Neck Pain. J Clin Med. 2019;8(8):1219. doi: 10.3390/jcm8081219.
7. Taylor NF, Dodd KJ, Shields N, Bruder A. Therapeutic exercise in physiotherapy practice is beneficial: a summary of systematic reviews 2002–2005. Aust J Physiother. 2007;53(1):7-16. doi: 10.1016/s0004-9514(07)70057-0.
8. van Middelkoop M, Rubinstein SM, Kuijpers T, et al. A systematic review on the effectiveness of physical and rehabilitation interventions for chronic non-specific low back pain. Eur Spine J. 2011;20(1):19-39. doi: 10.1007/s00586-010-1518-3.
9. Wang X-Q, Zheng J-J, Yu Z-W, et al. A meta-analysis of core stability exercise versus general exercise for chronic low back pain. PLoS One. 2012;7(12):e52082. doi: 10.1371/journal.pone.0052082.
10. Ghasemi Dehcheshmeh F, Nourbakhsh MR, Amini Farsani Z, Bazrgari B, Arab AM. Kinematic Analysis of Pelvic and Lower Limb Joints during Stand-to-sit Movement in Individuals with Chronic Low Back Pain: A cross-sectional study. The Archives of Bone and Joint Surgery. 2024;12(8):587–596. doi: 10.22038/abjs.2024.76840.3551
11. Didyk C, Lewis LK, Lange B. Availability, content and quality of commercially available smartphone applications for the self-management of low back pain: a systematic assessment. Disabil Rehabil. 2022;44(24):7600-7609. doi: 10.1080/09638288.2021.1979664.
12. Machado G, Pinheiro M, Lee H, et al. Smartphone apps for the self-management of low back pain: A sytematic review. Best Pract Res Clin Rheumatol. 2016;30(6):1098-1109. doi: 10.1016/j.berh.2017.04.002.
13. Hoy D, Brooks P, Blyth F, Buchbinder R. The epidemiology of low back pain. Best Pract Res Clin Rheumatol. 2010;24(6):769-81. doi: 10.1016/j.berh.2010.10.002.
14. Postolache G, Oliveira R, Postolache O. Designing digital tools for physiotherapy.in: Interactivity, game creation, design, learning, and innovation. 1th ed. Brooks AL, Brooks E, Vidakis E, eds. Springer; 2016.
15. Ramey L, Osborne C, Kasitinon D, Juengst S. Apps and Mobile Health Technology in Rehabilitation: The Good, the Bad, and the Unknown. Phys Med Rehabil Clin N Am. 2019;30(2):485-497. doi: 10.1016/j.pmr.2018.12.001.
16. L Ceci. Number of mHealth apps available in the Google Play Store from 1st quarter 2015 to 2nd quarter 2024. Available at: https://www.statista.com/statistics/779919/health-apps-available-google-play-worldwide/. Accessed June 29, 2021.
17. Tangari G, Ikram M, Ijaz K, Kaafar MA, Berkovsky S. Mobile health and privacy: cross sectional study. BMJ. 2021:373:n1248. doi: 10.1136/bmj.n1248.
18. Escriche-Escuder A, De-Torres I, Roldán-Jiménez C, et al. Assessment of the Quality of Mobile Applications (Apps) for Management of Low Back Pain Using the Mobile App Rating

Scale (MARS). Int J Environ Res Public Health. 2020;17(24):9209. doi: 10.3390/ijerph17249209.
19. Stoyanov S, Hides L, Kavanagh D, Zelenko O, Tjondronegoro D, Mani M. Mobile app rating scale: a new tool for assessing the quality of health mobile apps. JMIR Mhealth Uhealth. 2015;3(1):e27. doi: 10.2196/mhealth.3422.
20. Portelli P, Eldred C. A quality review of smartphone applications for the management of pain. Br J Pain.2016;10(3):135-40. doi: 10.1177/2049463716638700.
21. Dunphy E, Hamilton FL, Spasić I, Button K. Acceptability of a digital health intervention alongside physiotherapy to support patients following anterior cruciate ligament reconstruction. BMC Musculoskelet Disord. 2017;18(1):471. doi: 10.1186/s12891-017-1846-0.
20. Frontera W, Bean J, Damiano D, et al. Rehabilitation research at the National Institutes of Health. Neurorehabil Neural Repair. 2017;31(4):304-314. doi: 10.1177/1545968317698875.
22. Haynes R, Wilczynski N. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: Methods of a decision-maker-researcher partnership systematic review. Implement Sci. 2010:5:12. doi: 10.1186/1748-5908-5-12.
24. Terhorst Y, Philippi P, Sander LB, et al. Validation of the Mobile Application Rating Scale (MARS). PLoS One. 2020;15(11):e0241480. doi: 10.1371/journal.pone.0241480.
25. Creber RMM, Maurer MS, Reading M, Hiraldo G, Hickey KT, Iribarren S. Review and analysis of existing mobile phone apps to support heart failure symptom monitoring and self-care management using the Mobile Application Rating Scale (MARS). JMIR Mhealth Uhealth. 2016;4(2):e74. doi: 10.2196/mhealth.5882.
26. Hee Ko KK, Kim SK, Lee Y, Lee JY, Stoyanov SR. Validation of a Korean version of mobile app rating scale (MARS) for apps targeting disease management. Health Informatics J. 2022;28(0):14604582221091975. doi: 10.1177/14604582221091975.
27. Knitza J, Tascilar K, Messner E-M, et al. German Mobile Apps in Rheumatology: Review and Analysis Using the Mobile Application Rating Scale (MARS). JMIR Mhealth Uhealth. 2019;7(8):e14991. doi: 10.2196/14991.
28. Martin-Payo R, Fernandez-Álvarez MM, Blanco-Díaz M, Cuesta-Izquierdo M, Stoyanov SR, Llaneza Suárez E. Spanish adaptation and validation of the Mobile Application Rating Scale questionnaire. Int J Med Inform. 2019:129:95-99. doi: 10.1016/j.ijmedinf.2019.06.005.
29. Messner E, Terhorst Y, Barke A, et al. The German version of the mobile app rating scale (MARS-G): development and validation study. JMIR Mhealth Uhealth. 2020;8(3):e14479. doi: 10.2196/14479.
30. Roberts AE, Davenport TA, Wong T, Moon H-W, Hickie IB, LaMonica HM. Evaluating the quality and safety of health-related apps and e-tools: Adapting the Mobile App Rating Scale and developing a quality assurance protocol. Internet Interv. 2021:24:100379. doi: 10.1016/j.invent.2021.100379.
31. Saliasi I, Martinon P, Darlington E, et al. Promoting Health via mHealth Applications Using a French Version of the Mobile App Rating Scale: Adaptation and Validation Study. JMIR Mhealth Uhealth. 2021;9(8):e30480. doi: 10.2196/30480.
32. Barzegari S, Sharifi Kia A, Bardus M, Stoyanov SR, GhaziSaeedi M, Rafizadeh M. The Persian Version of the Mobile Application Rating Scale (MARS-Fa): Translation and Validation Study. JMIR Form Res. 2022;6(12):e42225. doi: 10.2196/42225.
33. Machado GC, Pinheiro MB, Lee H, et al. Smartphone apps for the self-management of low back pain: a systematic review. Best Pract Res Clin Rheumatol. 2016;30(6):1098-1109. doi: 10.1016/j.berh.2017.04.002.
34. Tinius R, Polston M, Bradshaw H, Ashley P, Greene A, Parker AN. An Assessment of Mobile Applications Designed to Address Physical Activity During Pregnancy and Postpartum. Int J Exerc Sci. 2021;14(7):382-399. doi: 10.70252/AQIG9215.
35. Stoyanov S, Hides L, Kavanagh D, Wilson H. Development and Validation of the User Version of the Mobile Application Rating Scale (uMARS). JMIR Mhealth Uhealth. 2016;4(2):e72. doi: 10.2196/mhealth.5849.
36. LeBeau K, Huey LG, Hart M. Assessing the quality of mobile apps used by occupational therapists: evaluation using the user version of the mobile application rating scale. JMIR Mhealth Uhealth. 2019;7(5):e13019. doi: 10.2196/13019.
37. Salazar A, de Sola H, Failde I, Moral-Munoz JA. Measuring the Quality of Mobile Apps for the Management of Pain: Systematic Search and Evaluation Using the Mobile App Rating Scale. JMIR Mhealth Uhealth. 2018;6(10):e10718. doi: 10.2196/10718.
38. Low back pain and sciatica in over 16s: assessment and management.Available at: https://www.nice.org.uk/guidance/ng59. National Institute for Health and Care Excellence (NICE). Accessed April 18, 2021.
39. Blanpied PR, Gross AR, Elliott JM, et al. Neck Pain: Revision 2017. J Orthop Sports Phys Ther. 2017;47(7):A1-A83. doi: 10.2519/jospt.2017.0302.
40. Shuren J, Patel B, Gottlieb S. FDA Regulation of Mobile Medical Apps. JAMA. 2018;320(4):337-338. doi: 10.1001/jama.2018.8832.
41. Escriche-Escuder A, De-Torres I, Roldán-Jiménez C, et al. Assessment of the Quality of Mobile Applications (Apps) for Management of Low Back Pain Using the Mobile App Rating Scale (MARS). Int J Environ Res Public Health. 2020;17(24):9209. doi: 10.3390/ijerph17249209.
42. Lalloo C, Shah U, Birnie KA, et al. Commercially Available Smartphone Apps to Support Postoperative Pain Self-Management: Scoping Review. JMIR Mhealth Uhealth. 2017;5(10):e162. doi: 10.2196/mhealth.8230.
43. Psihogios AM, Stiles-Shields C, Neary M. The Needle in the Haystack: Identifying Credible Mobile Health Apps for Pediatric Populations during a Pandemic and beyond. J Pediatr Psychol. 2020;45(10):1106-1113. doi: 10.1093/jpepsy/jsaa094.
44. Nurgalieva L, O'Callaghan D, Doherty G. Security and privacy of mHealth applications: a scoping review. IEEE Access. 2020;8:104247 68. doi: 10.1109/ACCESS.2020.2999934.
45. Domnich A, Arata L, Amicizia D, et al. Development and validation of the Italian version of the Mobile Application Rating Scale and its generalisability to apps targeting primary prevention. BMC Med Inform Decis Mak. 2016:16:83. doi: 10.1186/s12911-016-0323-2.