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Original Paper

Evaluating the Quality, Content Accuracy, and User Suitability of mHealth Prenatal Care Apps for Expectant Mothers: Critical Assessment Study

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Abstract

Background: The proliferation of health apps in the digital health landscape has created significant opportunities for health promotion, particularly during pregnancy. However, despite the widespread distribution and popularity of pregnancy mobile apps, there are limited data on their quality and content.

Objective: This study aimed to evaluate the quality, content accuracy, and suitability of the most popular and freely available Persian mobile health (mHealth) apps for prenatal care in expectant mothers.

Methods: Through a systematic search, a total of 199 apps were screened from available app stores using the search term “pregnancy app” until July 2023. Inclusion criteria were apps in the Farsi language, freely available, downloaded more than 10,000 times, and designed for pregnant women. Ultimately, 9 apps met these criteria. These apps were downloaded onto mobile phones and assessed by 2 independent reviewers using the Mobile App Rating Scale (MARS), the Coverage and Depth of Information Checklist, and the Suitability Assessment of Materials (SAM). Statistical analyses explored relationships between app quality metrics and user ratings.

Results: The 9 apps evaluated had an average MARS score of 3.55 (SD 0.61) out of 5. Aesthetics (mean 4.02, SD 0.45) and Functionality (mean 4.11, SD 0.36) scored the highest, followed by Engagement (mean 3.29, SD 0.53) and Information (mean 3.09, SD 0.48). User star ratings did not strongly correlate with MARS scores (r=0.38, P>.05). Regarding health information coverage, 6 out of 9 (66.7%) apps were rated as poor, and 3 (33.3%) as adequate. For SAM, 4 (44.4%) apps were rated as superior and 5 (55.6%) as adequate. No app received a poor score.

Conclusions: The study underscores the need for improved standards in pregnancy app development to enhance educational efficacy and user satisfaction. Health care providers should recommend high-quality pregnancy apps with appropriate content to ensure effective health promotion. These findings contribute to understanding the current landscape of pregnancy apps and highlight areas for future research and regulatory attention.

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KEYWORDS

pregnancy; prenatal care; mobile health apps; mHealth; women's health; health care providers; quality assessment; content evaluation; suitability assessment; digital health; smartphones; eHealth; telehealth; telemedicine; health promotion; technology; functionality; systematic search

Introduction

eHealth represents an innovative approach within the health care sector, using information and communication technology to enhance access to health care services and improve their quality [1]. eHealth encompasses various digital technologies, including telemedicine, mobile health (mHealth) apps (MHAs), electronic health records, and health information systems. These technologies aim to bridge the gap between health care providers and patients by enabling remote access to health care services, improving communication, and enhancing the overall quality of care [2].

MHAs are an integral part of the broader digital health ecosystem, including wearable technologies, virtual reality, telemedicine, and eHealth. These apps significantly enhance the accessibility and delivery of health services, especially with the increasing demand for smartphones and other digital devices driven by rapid technological advancements [3]. These apps empower individuals to participate in symptom control and identification, receive treatment, and obtain personal feedback and motivational support [2,4,5]. Pregnancy apps, in particular, have become popular resources for expectant mothers, offering functionalities ranging from fetal development tracking to health tips and educational content [6,7]. However, the reliability of health recommendations provided by pregnancy apps remains a significant concern. For instance, a study found that 89.7% of Chinese mobile apps for pregnancy and postpartum care did not provide safety statements or supporting evidence, and 68% of US apps similarly lacked evidence-based content [8]. Also, a systematic review of sexual and reproductive health apps revealed that, while a variety of apps exist, only a few meet high-quality design standards or demonstrate effectiveness in real-life settings [9]. These findings emphasize the critical need for research into the usability and evidence-based development of MHAs, particularly those targeting pregnancy care.

It is crucial for these apps to provide accurate and reliable evidence-based content that considers the cultural and linguistic needs of the target audience, including information on cultural practices and traditions related to pregnancy and childbirth [10].

While the quantity and user acceptance of Iranian pregnancy apps have grown significantly, the credibility of the information within these apps remains invalidated. A study conducted in Iran found that only 1.3% of pregnancy-related mobile apps were developed with the participation of obstetricians, and only 5% used reliable information resources [11]. This lack of professional input may affect the accuracy and reliability of the information these apps provide.

Despite the proliferation of pregnancy apps, there is a notable lack of research evaluating Persian-language apps. Existing studies on digital health tools in Persian often overlook the unique challenges faced by expectant mothers, such as the need for culturally relevant information and user-friendly interfaces that accommodate varying levels of comprehension and accessibility requirements specific to their needs [12]. Furthermore, data on the effectiveness of these apps in delivering evidence-based health information and supporting positive health outcomes is scarce [11].

The aim of this study is to assess MHAs for Iranian pregnant women by evaluating them across three key aspects: (1) quality assessment; (2) content accuracy via assessing coverage and depth of information, which assesses how thoroughly the app addresses relevant health topics, including work and rest practices during pregnancy, nutrition education, stress management, interpersonal relationships, and pregnancy care instructions, with significant implications for maternal health and well-being; and (3) user suitability of materials, which examines the quality of the app's content to ensure it is accurate, reliable, and user-friendly. Specifically, this study seeks to answer the following questions:

1. What apps are available?

2. What is the quality of these apps, as measured by the Mobile App Rating Scale (MARS)?

3. How comprehensive is the content provided by these apps?

4. How suitable are these apps for expectant mothers based on their design and cultural relevance?

Methods

Study Design and Protocol Registration

This study used a systematic approach to identify, select, and evaluate Persian-language pregnancy apps available up to July 2023. The methodology was designed to ensure a rigorous and transparent evaluation process. A detailed protocol for the review was developed and registered with the International Prospective Register of Systematic Reviews (PROSPERO; ID CRD42023461605).

Search Strategy and Inclusion Criteria

The app search was conducted between June 1, 2023, and July 31, 2023, focusing on major platforms commonly used by Persian-language app users. Searches were performed on Google Play Store, Cafebazaar App Store, Myket Market, Kandoo, Iran Apps, Avval Market, and Pars Hub. To enhance comprehensiveness, an internet-based search via Google was also conducted as a supplementary measure to identify apps not listed on these platforms.

Given the dynamic nature of search results on the Google Play Store, the search was conducted manually to ensure relevance. The Apple App Store is not officially accessible in Iran due to regional restrictions. However, using a virtual private network is legal in Iran, and Iranian users frequently use virtual private networks to connect to the store and download apps. Apps were identified by sequentially navigating through search results. We

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screened all results until no new eligible apps were identified, which required reviewing up to 10 pages per platform. No web crawler was used, but search results were manually exported by recording app details (eg, name, description, and download count) directly into a predesigned data extraction form.

The search was conducted using a combination of Persian keywords related to pregnancy and their English equivalents. Search terms included were “pregnancy,” “prenatal care,” “motherhood,” “pregnant,” and “mother and baby.” Apps were considered eligible if they met the following criteria: the app must be in Persian, freely available, with or without in-app purchases, compatible with the Android operating system, having more than 10,000 downloads, designed for pregnant women, provided information on at least one of the following topics: work and rest practices during pregnancy, nutrition education, stress management, interpersonal relationships, or pregnancy care instructions.

Apps were excluded from the analysis if they met any of the following criteria: inaccessibility due to dead or broken links, duplication, design as e-books, news sources, magazines, podcasts, blogs, games, or gaming-related content. In addition, apps were excluded if their primary function was monitoring or timing without providing educational content, or if they required paid subscriptions or included freemium content that limited access to essential features.

Screening Process and Data Extraction

In order to determine eligibility, two independent reviewers (FA and SEZ) screened the titles, images, and descriptions of the identified apps during the search. In cases of disagreement, a third senior reviewer (RLR) was consulted to reach a consensus.

Data from eligible apps were extracted systematically by two reviewers (FA and SEZ) who were trained to ensure consistency and accuracy.

Eligible apps were downloaded and tested on a Xiaomi Mi Mix 3 device running Android 12. Extracted data included app name, version, developer, cost, in-app purchases, user rating, number of ratings, and last update date.

App Features and Quality Assessment

Using 3 primary assessment tools, 2 reviewers with expertise in midwifery and reproductive health independently evaluated the apps.

The MARS

MARS evaluates app quality across 4 dimensions including (1) engagement to assess fun, interest, adaptability, interactivity, and target group relevance; (2) functionality to examine performance, usability, navigation, and gestural design; (3) aesthetics to evaluate layout, graphics, and visual appeal; and (4) information quality to review the accuracy, goals, credibility based on the evidence and quality, and quantity of information, including visual information.

Apps were rated using a 5-point scale (1=inadequate to 5=excellent). A mean score was calculated to determine overall quality. Disagreements were resolved by involving a third assessor.

The validity of the Persian (Farsi) version of the MARS questionnaire, translated and culturally adapted from the original scale, was rigorously assessed and confirmed through various psychometric measures. The fit indices demonstrated strong construct validity for each dimension (root-mean-square error of approximation [RMSEA]=0.074, Tucker-Lewis index [TLI]=0.922, comparative fit index [CFI]=0.940, and standardized root-mean-square residual [SRMR]=0.059). Reliability was reported as good to excellent across domains, with Omega coefficients ranging from 0.79 to 0.93, indicating high internal consistency. Furthermore, the instrument exhibited strong interrater reliability, with an intraclass correlation coefficient of 0.82, demonstrating a high level of objectivity [13].

Coverage and Depth of Information Checklist

This researcher-developed tool assessed educational content based on guidelines by Iran’s Ministry of Health [14], which are provided in Multimedia Appendix 1. The checklist used in this study was developed and validated to ensure its reliability and suitability for evaluating MHAs designed for Iranian pregnant women. The development process began with an extensive review of the literature, expert consultations, and adherence to relevant maternal health guidelines to identify key topics and items for inclusion. These topics covered essential domains such as pregnancy care, stress management, nutrition education, and exercise practices during pregnancy. Coverage was scored as follows: correct and sufficient (2 points), partially correct or insufficient (1 point), and incorrect or not addressed (0 points). The total score categorized app content as Superior (41-46 points, 90%-100%), Adequate (23-40 points, 50%-89%), or Poor or Low (<23 points, ≤49%). The resulting checklist was structured with clear, measurable items to evaluate the quality, coverage, and depth of information provided by the apps.

To ensure the checklist was a reliable and effective evaluation tool, it underwent a pilot testing phase. A sample of 5 MHAs was selected for this pilot, chosen to represent a variety of features and content typically found in apps targeting pregnant women. Two independent reviewers with reproductive health specialists having experience in the evaluation of health apps assessed the apps using the checklist. This process served two primary purposes: to evaluate the internal consistency of the checklist items and to measure interrater reliability.

The checklist showed strong internal consistency (Cronbach α=0.85) and substantial interrater reliability (Cohen κ=0.80), confirming its alignment and consistency in measuring information coverage and quality. Minor ambiguities identified during pilot testing were revised, resulting in a robust and validated tool used to evaluate the MHAs comprehensively (Multimedia Appendix 2).

Suitability Assessment of Materials

The authors conducted a suitability assessment of patient education material using the Suitability Assessment of Materials (SAM) tool. Each item was rated as superior (2 points), adequate (1 point), or not suitable (0 points). The SAM consists of 22

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items grouped under four categories: literacy demand, layout and type, learning stimulation and motivation, and cultural appropriateness. Apps featuring content that lacked cultural alignment, such as multimedia showcasing non-Iranian contexts or dietary advice incompatible with local practices, were found to be less effective in addressing user needs. In contrast, apps that included culturally tailored recommendations, such as adherence to Islamic dietary guidelines or the use of culturally familiar imagery, were more favorably received. Scores were categorized as follows: 0%-39% (not suitable), 40%-69% (adequate), and 70%-100% (superior).

A study assessing SAM's interrater reliability for written stroke education materials showed that most individual SAM items had high interrater reliability, with 17 out of 22 items achieving substantial, almost perfect, or perfect weighted κ values (≥0.60), with a total agreement of 96% [15].

Data Analysis

Data analysis was conducted based on the extracted data from the included apps. The extracted data were first tabulated across all studies, and then the collected data were analyzed using IBM SPSS Statistics (version 25.0). Descriptive statistics, including mean and SD, were calculated for the app ratings from the MARS, Coverage and Depth of Information Checklist, and SAM. This analysis provided a comprehensive overview of app quality, content coverage, and suitability. The research team adhered to ethical principles, including honesty and trustworthiness, in data analysis and when presenting the study's findings. To protect the rights of the app developers, the names of the apps were identified by codes in this systematic evaluation.

Ethical Considerations

The research study was approved by the Research Ethics Committees of Mashhad University of Medical Sciences, Mashhad, Iran (IR.MUMS.REC.1400.179). Since the study involved the assessment of publicly available MHAs, no personal data or identifiable participant information were collected. The apps evaluated are commercially available and publicly accessible, ensuring user privacy and confidentiality. No compensation was provided or required for this study as it involved the assessment of publicly available MHAs and not the participation of individuals.

Results

App Selection Process

The app selection process for this study is outlined in Figure 1. A comprehensive search identified 199 pregnancy-related apps from multiple sources, including internet-based databases, major app stores, and local markets, using the keywords "Pregnancy," "Pregnant," "Pregnancy care," and "Prenatal care." During the initial screening, 146 duplicate entries were removed. For apps found on multiple platforms, the version from the platform with the higher download count was retained for evaluation, ensuring only one version of each app was included. This process left 53 unique apps for further evaluation. These apps were screened for relevance to pregnancy and availability in the Persian language. During this screening process, 27 apps were excluded because they either did not focus on pregnancy or were not available in Persian, leaving 26 apps for further review. The remaining 26 apps were then assessed against the study's predefined inclusion criteria, which considered factors such as app functionality, comprehensiveness of content, and language suitability. In this phase, 9 apps were excluded for failing to meet these criteria. This left 17 apps for a detailed eligibility assessment, during which 8 additional apps were excluded for not fully aligning with the requirements. Ultimately, 9 apps (2 apps were available on the Google Play Store, and 7 apps were available on CaféBazaar) met all criteria and were selected for a comprehensive evaluation regarding their quality, content, and suitability for Persian-speaking pregnant women.

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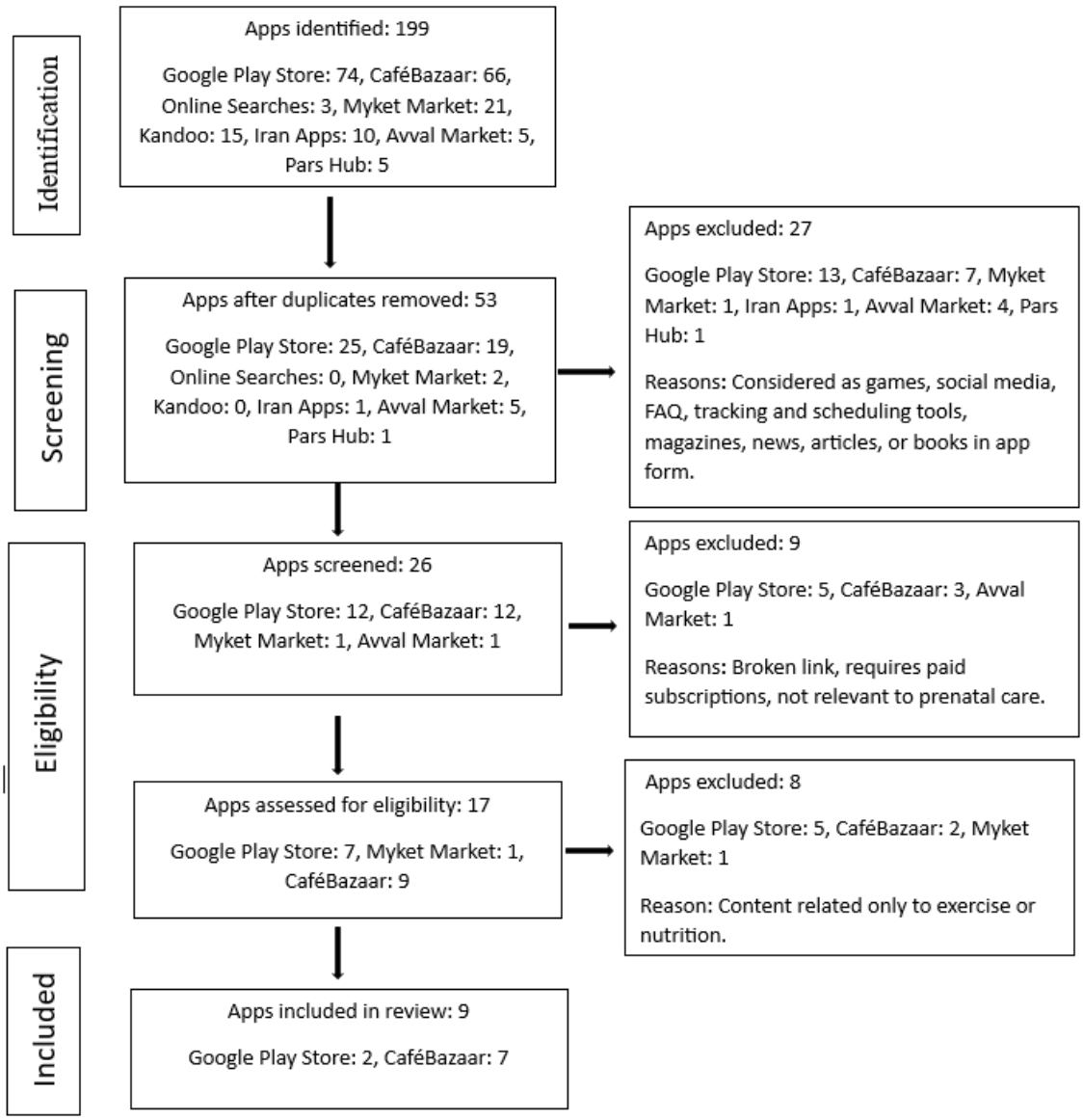
Figure 1. Flow diagram for apps' selection.



Description of the Selected Apps

Of the 9 apps reviewed, 2 were sourced from Google Play and 7 from CaféBazaar. All selected apps were freely available for download. These apps were commercially developed and lacked affiliations with government agencies, academic institutions, or clinical trials. None had associated scientific publications.

A total of 2 apps had substantial user bases with more than 500,000 downloads each, while 3 apps had more modest download numbers of over 10,000. User ratings ranged from 2.9 to 4.7 stars, with most apps (7 out of 9) receiving ratings of 4.2 or higher. We considered the star ratings that appeared on the platform where the app had the highest number of downloads. In these platforms, the star rating system ranges from 1 star (the lowest rating) to 5 stars (the highest rating).

In total, 5 apps required in-app purchases for full functionality. Notable features across the apps included personal profile creation (6 apps), multilingual support (1 app), and offline functionality (2 apps). Only 2 apps provided transparency about their development and scientific teams. Table 1 summarizes these characteristics. Multimedia Appendix 3 provides the original ratings for all included apps.

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Table 1. Summary of app characteristics.

App Code[a]	Downloads	Star rating	In-app purchases	Offline functionality	Language	User interaction	Scientific team
APP N1	>500,000	4.5	Yes	No	Persian	Yes	Yes
APP N2	>500,000	4.7	Yes	No	Persian	Yes	No
APP N3	>10,000	4.2	No	Yes	Persian	No	No
APP N4	>10,000	4.3	Yes	No	Persian	Yes	No
APP N5	>10,000	4.7	Yes	No	Persian	Yes	No
APP N6	>50,000	4.7	No	Yes	Persian	No	No
APP N7	>100,000	2.9	No	No	Persian	Yes	No
APP N8	>100,000	4.5	Yes	No	Persian	Yes	Yes
APP N9	>50,000	4.5	No	No	Persian or English	Yes	No

[a]APP N refers to the app code number (eg, APP N1 refers to app code number 1).

App Quality Assessment

The MARS tool evaluation revealed varying quality levels across the 9 apps. The scores ranged from 2.1 to 3.75 out of 5, with most apps (7 out of 9) scoring above 3. Reviewer-specific scores are presented in Multimedia Appendix 3.

Looking at the subscales, Aesthetics and Functionality emerged as the strongest domains, with median scores of 4. Engagement showed moderate performance, with a median score of 3, while Information quality was generally lower, with a median score of 2.8.

APP N4 demonstrated the strongest performance in three domains (Engagement: 4.2, Functionality: 5, Aesthetics: 4.6), while APP N8 led in Information quality (3.5). The lowest-performing app across most domains was APP N3, as shown in Table 2.

Relationship between app features examining the data qualitatively reveals several patterns. First, apps with higher MARS scores (above 3.5) generally received better user ratings, with most having ratings of 4.5 stars or higher. However, this trend was not consistent for all apps. For instance, APP N2 received high user ratings (4.7 stars) despite having a relatively low score in the information quality domain (2.8).

Second, the two most downloaded apps, with more than 500,000 downloads each, shared specific features. These included in-app purchases, user interaction capabilities, and regular content updates. Nevertheless, a higher number of downloads did not necessarily correlate with higher MARS scores, suggesting that download numbers alone are not a reliable indicator of app quality.

Finally, apps developed by teams with scientific expertise (2 out of 9) tended to score higher in the information quality domain, with scores exceeding 3.2. Conversely, apps with offline functionality (2 out of 9) tended to have lower overall MARS scores compared with apps with internet-based functionality, suggesting that offline accessibility may be associated with compromises in other quality domains such as engagement or information quality.

Table 2. MARS scores for antenatal apps.

App code[a]	Overall MARS score	Engagement	Functionality	Aesthetics	Information
APP N4	3.75	4.2	5	4.6	2.2
APP N2	3.62	3.6	4.1	4	2.8
APP N9	3.62	3.8	4.1	4.1	2.8
APP N1	3.57	3.4	3.8	3.9	3.2
APP N8	3.55	3.6	3.8	4	3.5
APP N5	3.35	3.5	4.2	3.9	1.8
APP N7	3.1	2.9	2.5	3.2	3.5
APP N6	2.27	1.7	2.5	2	2.6
APP N3	2.1	1.6	3	1.3	2

[a]APP N refers to the app code number (eg, APP N1 refers to app code number 1).

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Coverage and Depth of Information

Most apps provided relatively poor coverage and depth of health information. Table 3 summarizes the completeness of the content.

None of the apps addressed all the essential training subjects recommended by the Deputy Minister of Health. A total of 6 apps were rated as poor for coverage and depth of health information and 3 apps were rated as adequate. Topics such as sexual health, oral health, immunization, substance avoidance, stress management, and prenatal classes were either poorly covered or entirely neglected. Furthermore, none of the apps provided references for the educational content, raising concerns about the accuracy and reliability of the information.

Table 3. Coverage and depth of information in apps.

App code[a]	Overall coverage rating	Key topics covered	Missing topics
APP N1	Adequate	Pregnancy changes, fetal growth, physical activity	Sexual health, immunization, stress management
APP N2	Adequate	Nutrition, common complaints, warning signs	Oral health, prenatal classes, substance use
APP N3	Poor	Pregnancy changes, physical activity	Comprehensive information on health subtopics
APP N4	Adequate	Fetal growth, physical activity, nutrition	Sexual health, immunization, substance use
APP N5	Poor	Common complaints, warning signs	Oral health, prenatal classes, stress management
APP N6	Poor	Basic pregnancy changes	Comprehensive coverage on health subtopics
APP N7	Poor	Common complaints	Sexual health, immunization, substance use
APP N8	Adequate	Physical activity, nutrition, common complaints	Sexual health, prenatal classes, stress management
APP N9	Adequate	Pregnancy changes, fetal growth, physical activity	Oral health, immunization, substance use

[a]APP N refers to the app code number (eg, APP N1 refers to app code number 1).

Suitability of Information

The SAM assessment revealed varying levels of content suitability across apps. A total of 4 apps achieved superior ratings (>70%), while 5 were rated as adequate (40%-70%) as shown in Table 4.

In terms of Literacy and Layout, high-performing apps (SAM>70%) consistently showed strong literacy demand scores, with layout quality typically aligning with overall suitability ratings. Learning stimulation emerged as the most challenging domain, being consistently the lowest-scoring area across all apps. Even apps with superior overall performance demonstrated significant room for improvement in user engagement strategies.

Cultural appropriateness presented a particularly interesting dimension, with scores ranging widely from 35% to 95%. Notably, apps with superior overall ratings typically exhibited more refined cultural adaptation, suggesting a strong correlation between cultural sensitivity and overall app quality. Apps with culturally misaligned content, such as multimedia depicting non-Iranian contexts or dietary advice unsuitable for local practices, were noted as less effective in meeting user needs. Conversely, apps incorporating culturally aligned recommendations, such as content adhering to Islamic dietary laws or featuring culturally relevant imagery, were better received.

Diving deeper into the quality patterns, apps with superior SAM ratings (>70%) shared several common characteristics. These apps distinguished themselves through comprehensive content organization, clear visual hierarchies, consistent cultural adaptation, and robust interactive elements. This suggests that successful pregnancy apps go beyond mere information delivery, focusing on user experience and cultural relevance.

Conversely, most apps revealed consistent areas requiring improvement. These included enhancing learning stimulation features, developing original educational media, ensuring cultural consistency, and providing authoritative reference citations. These gaps highlight the potential for future app development in the pregnancy support digital ecosystem, pointing to opportunities for creating more engaging, culturally sensitive, and scientifically grounded mHealth resources.

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Table 4. SAM scores for suitability of app information.

App code[a]	Total score (%)	Literacy demand (%)	Layout and type (%)	Learning stimulation and motivation (%)	Cultural appropriateness (%)
APP N1	81.25% (Superior)	90% (Superior)	85% (Superior)	55% (Adequate)	95% (Superior)
APP N2	75% (Superior)	88% (Superior)	82% (Superior)	50% (Adequate)	80% (Superior)
APP N3	42% (Adequate)	48% (Adequate)	30% (Not suitable)	30% (Not suitable)	60% (Adequate)
APP N4	84.25% (Superior)	92% (Superior)	90% (Superior)	75% (Superior)	80% (Superior)
APP N5	70% (Superior)	85% (Superior)	70% (Superior)	65% (Adequate)	60% (Adequate)
APP N6	44 % (Adequate)	40% (Adequate)	35% (Not suitable)	25% (Not suitable)	35% (Not suitable)
APP N7	48.75 % (Adequate)	75% (Superior)	50% (Adequate)	30% (Not suitable)	40% (Adequate)
APP N8	67.5 % (Adequate)	75% (Superior)	80% (Superior)	50% (Adequate)	65% (Adequate)
APP N9	68.75 % (Adequate)	80% (Superior)	75% (Superior)	55% (Adequate)	65% (Adequate)

[a]APP N refers to the app code number (eg, APP N1 refers to app code number 1).

Discussion

Principal Findings

This study evaluated the quality, content accuracy, and user suitability of 9 popular Persian MHAs designed for prenatal care, using standardized assessment tools. The findings revealed that while the apps generally performed well in aesthetics and functionality, they showed notable deficiencies in information quality and coverage. Only a third of the apps achieved adequate health information standards, and none excelled in this category. Despite moderate user ratings, the results highlight significant gaps in the educational and informational content of these apps, underscoring the need for improved standards in app development to better serve expectant mothers.

App Availability and Characteristics

Based on the results, no apps were found with any background of scientific documents or being based on the evidence, including the results of the clinical trials. All reviewed apps lacked transparency regarding affiliations and were set up to be commercial rather than as an intervention to change health behavior. All included apps were mostly commercial and were not designed by university academics or research staff. In line with the results of our study, Musgrave et al [16] also indicated that, in their review study of pregnancy apps available in Australia, the affiliations and sources of funding information indicated that all apps were commercially developed and the scientific reviewer teams were not introduced. As a result, this is one of the weaknesses of apps because in order to increase their reliability, the scientific staff or resources for training must be specified [17]. This finding is particularly concerning given the critical role of accurate and comprehensive health information in antenatal care. The qualitative study on mothers' views on mHealth in self-care for pregnancy identified the need for reliable and trustworthy information in pregnancy apps [12]. Pregnant women were found to be interested in using apps for self-care, but they required reliable and accurate information to make informed decisions about their health [12]. Research highlights the importance of reliable content in health apps. They report that only 5% of the examined apps used reliable information resources, which is a significant concern given the importance of accurate information for pregnant women [11].

In our study, of the 6 apps scoring highest for quality, only 2, APP N7 and APP N9, did not contain in-app purchases. This finding aligns with another review article investigating nutrition-based pregnancy apps, which reported that highly rated MARS apps often required in-app purchases and could not be operated without internet access [18]. Concurrently, recent data suggest that only 5%-10% of app users are willing to pay for in-app purchases [19]. Furthermore, in our study, most applications could not be used without internet access, with only 2 apps offering plain textual information available offline. Similarly, the study by Musgrave et al [16] identified the lack of access to app content without an internet connection as a limitation of mHealth.

App Quality Assessment

The MARS tool revealed a nuanced quality landscape. With an average score of 3.55 out of 5, the apps demonstrated moderate quality. Aesthetics and Functionality emerged as the strongest domains, while Information quality consistently scored lower. The high user ratings and significant download numbers of apps such as APP N4 and APP N1 reflect their popularity and perceived utility among users. These apps scored well in terms of user engagement, functionality, and aesthetics, as evidenced by their high MARS scores. This aligns with the general trend observed in health app evaluations where engaging, visually appealing, and easy-to-use apps tend to garner higher user satisfaction [20]. For instance, APP N4 excelled in the engagement and functionality domains with scores of 4.2 and 5, respectively. This suggests that users value interactive and well-designed interfaces that enhance their overall experience. This finding is consistent with studies noting that apps with high engagement features often receive favorable user feedback and higher ratings, even if their informational content is not comprehensive [21].

However, despite their high user ratings, these apps often fall short of delivering thorough educational content. This discrepancy between user satisfaction and content quality highlights a critical issue in the design and development of health apps [22]. Users may prioritize user experience and

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accessibility over the depth and accuracy of information, which can lead to gaps in the provision of comprehensive health education [23].

Content Comprehensiveness

Our study found significant deficiencies in the coverage and depth of information provided by most apps. Despite their high engagement scores, many apps scored poorly in the information domain of MARS and lacked comprehensive coverage of essential pregnancy-related topics. For example, none of the apps covered all the crucial educational topics outlined by the Deputy Minister of Health, and several key areas, such as sexual health and prenatal classes, were consistently neglected. Also, the lack of verifiable sources for the educational content in the reviewed apps further exacerbates this issue, as it raises questions about the accuracy and credibility of the information disseminated to users.

While some apps offered a higher percentage of educational content coverage needed for pregnancy, they were inadequate or neglectful in more than half of the apps on topics such as sexual health, immunization, stress management, and introducing prenatal classes. This observation aligns with findings from another review, which reported that only 16 (31.4%) apps contained information on appropriate pregnancy weight gain as defined by the Institute of Medicine guidelines [18].In addition, a previous study by Tinius et al [24] on apps related to physical activity during pregnancy found that none of the included apps incorporated goal-setting in alignment with the American College of Sports Medicine (ACSM) and American College of Obstetricians and Gynecologists (ACOG) guidelines. The most frequently covered topics in the apps were changes during pregnancy, fetal growth, physical activity, nutrition, common complaints, and warning signs, consistent with other reviews [25]. Overall, reviewers noted that nearly half of all apps were poor or inadequate for recommending to others.

Suitability and Cultural Relevance

The evaluation of the apps using the SAM tool revealed mixed results regarding the suitability of health information. While 4 out of 9 apps (APP N1, APP N2, APP N4, and APP N5) were rated as superior in terms of suitability, the majority were merely adequate, and none were found to be unsuitable. This suggests that while some apps do meet the basic requirements for suitable health information materials, there is substantial room for improvement.

Notably, APP N1 and APP N4 received the highest scores in the SAM evaluation, reflecting their superior suitability for the intended audience. These apps likely benefited from their engaging and user-friendly design, which aligns with findings from previous studies indicating that well-designed health information materials are more likely to be effective [12].

Although many apps were evaluated as good to excellent on the SAM score across dimensions such as literacy demand, layout, and type, they received lower scores in the areas of graphics and illustrations and learning stimulation motivation. Similarly, a review of apps for infant feeding reported that 42% of the apps were rated as superior, 54% as adequate, and 3% as unsuitable [26]. However, Cheng et al [26] noted lower scores for readability and cultural appropriateness, which contrasts with our results. Our study determined that most programs were culturally appropriate for Iranian users. This discrepancy may be attributed to the fact that many of the apps in the study by Cheng et al [26] were developed outside of Australia, specifically in America, the United Kingdom, and the European Union, where cultural differences are expected. In contrast, the apps examined in our study were all designed by Iranian teams, which likely contributed to their relative cultural appropriateness.

A unique strength was the cultural appropriateness of these Iranian-developed apps. Unlike international apps that may struggle with cultural adaptation, these apps demonstrated a strong understanding of local user needs. However, areas for improvement included original educational media and interactive elements. These insights underscore the need for app developers to focus on comprehensive design and cultural considerations to enhance both the quality and user experience of pregnancy apps [27].

The study reveals a critical gap between app popularity and quality. High download numbers and user ratings do not guarantee comprehensive or reliable health information. This underscores the urgent need for rigorous content development standards, transparent scientific affiliations, comprehensive educational coverage, and enhanced user engagement strategies.

Strengths and Limitations

The study had several strengths. It used a comprehensive evaluation framework using 2 independent reviewers, which enhanced the reliability of the assessments. Concentrating on Persian MHAs for prenatal care, the study filled a significant gap in the literature and highlighted areas for improvement, particularly regarding the coverage and depth of health information. However, our study had several limitations. The evaluation was restricted to apps available on Android Play stores available in Iran, potentially excluding other resources on different platforms or less accessible databases. In addition, a key limitation is the rapidly evolving MHA market. Some apps included in this review may no longer be available, and new apps may have emerged since the data collection, which could affect the relevance of our findings. Our study also did not explore the long-term user engagement or the impact of these apps on user health outcomes, which could provide deeper insights into their effectiveness.

Implications of Findings

The implications of these findings are significant for both app developers and health care providers. High user engagement and aesthetic appeal are crucial for attracting users, but the ultimate value of antenatal apps lies in their ability to deliver reliable, comprehensive health education. Given the increasing reliance on digital tools for health information, ensuring that apps provide accurate, well-rounded educational content is essential. Our study underscores the need for more rigorous standards and oversight in the development and evaluation of health apps to ensure they meet the informational and usability needs of their users. For health care providers, these results

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suggest caution when recommending apps to expectant mothers. Providers should consider not only the popularity and user ratings of an app but also its content quality and the credibility of the information it provides.

Future Research Directions

Future research should expand the scope to include a wider range of platforms and perhaps a broader geographic scope to capture a more comprehensive view of available antenatal apps. Further studies should also look into the longitudinal impact of these apps on maternal health outcomes and user behavior. In addition, exploring user feedback and integrating it into apps' evaluation could provide a more nuanced understanding of app performance and areas for improvement. Given the rapid evolution of digital health tools, continuous monitoring and evaluation are necessary to keep up with emerging trends and ensure that these tools remain relevant and useful for their intended audiences.

Conclusion

A systematic evaluation of MHAs for prenatal care in Iran revealed a critical need for stricter quality control. While numerous pregnancy apps exist, many lack the quality and comprehensive content mandated by the Ministry of Health. Furthermore, the accuracy of educational content is questionable due to the absence of reliable references or involvement of health care professionals. This research highlights the importance of evaluating app quality and suitability for user navigation while also emphasizing the need to assess the use of behavioral change techniques like goal setting and self-monitoring. By identifying these gaps and deficiencies, researchers can recommend improvements and integrate evidence-based strategies to enhance the effectiveness of pregnancy apps in promoting healthy behaviors and ultimately improving maternal and infant health outcomes.

Acknowledgments

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Data Availability

All data generated or analyzed during this study are included in this published article and its supplementary information files.

Authors' Contributions

FA and RLR contributed to conceptualization and methodology. FA and SEZ performed data curation. FA conducted formal analysis. RLR performed project administration and supervision. FA assisted with writing-original draft. FA, RLR, and SEZ contributed to investigation and writing-review and editing.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Clinical Standards and Guidelines by Iran's Ministry of Health.
[PDF File (Adobe PDF File), 751 KB - apinj_v9i1e66852_app1.pdf]

Multimedia Appendix 2
Checklist for Evaluating Mobile Health Applications for Pregnant Women.
[DOCX File , 17 KB - apinj_v9i1e66852_app2.docx]

Multimedia Appendix 3
Original ratings for mobile health app evaluation.
[DOCX File , 27 KB - apinj_v9i1e66852_app3.docx]

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Abbreviations

ACOG: American College of Obstetricians and Gynecologists
ACSM: American College of Sports Medicine
CFI: comparative fit index
MARS: Mobile App Rating Scale
MHA: mobile health app
mHealth: mobile health
PROSPERO: International Prospective Register of Systematic Reviews
RMSEA: root-mean-square error of approximation
SAM: Suitability Assessment of Materials
SRMR: standardized root-mean-square residual
TLI: Tucker-Lewis index

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Pediatric Sleep Quality and Parental Stress in Neuromuscular Disorders: Descriptive Analytical Study

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Abstract

Background: Neuromuscular disorders (NMDs) constitute a heterogeneous group of disorders that affect motor neurons, neuromuscular junctions, and muscle fibers, resulting in symptoms such as muscle weakness, fatigue, and reduced mobility. These conditions significantly affect patients' quality of life and impose a substantial burden on caregivers. Spinal muscular atrophy (SMA) is a relatively common NMD in children that presents in various types with varying degrees of severity.

Objective: This study aimed to evaluate the sleep quality of children with NMDs, particularly SMA types 1, 2, and 3 and assess the stress levels experienced by their parents.

Methods: A descriptive analytical study was conducted from February to October 2023, in selected hospitals and dystrophy associations in Tehran and Isfahan, Iran. A total of 207 children aged 1 - 14 years with various NMDs were included in the study. Data were collected using a web-based questionnaire with 3 parts: demographic information, the Children's Sleep Habits Questionnaire to assess children's sleep, and the Stress Response Inventory to measure parental stress. Statistical analyses were performed using SPSS version 22, with an α level of .05.

Results: Significant differences in sleep quality were found among SMA types, with mean scores of 74.76 (SD 7.48) for SMA type 1, 76.4 (SD 7.29) for SMA type 2, 72.88 (SD 6.73) for SMA type 3, and 75.87 (SD 5.74) for other NMDs (P=.02). A correlation was found between sleep and length of hospital stay (r=0.234, P<.001)and between sleep and the child's sex (r=−0.140, P=.04). Parental stress scores averaged 95.73 (SD 32.12). There was not a statistically significant difference in parental stress scores among the 4 groups (P=.78). This suggests that parental stress levels were similar across different NMD groups.

Conclusions: Sleep disorders are prevalent among children with NMDs, especially SMA. Parents experience high levels of stress that can affect the care they provide. Therefore, interventions to improve children's sleep and address parental stress are crucial. Regular screening, counseling, and tailored support are recommended to enhance the well-being of children with NMDs and their families.

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KEYWORDS

spinal muscular atrophy; neuromuscular disorders; sleep quality; pediatrics; parental stress; children; parents; muscular atrophy; muscular disorders

Introduction

Neuromuscular disorders (NMDs) are a diverse group of disorders that affect motor neurons, neuromuscular junctions, and muscle fibers, resulting in various disease onsets, presentations, and prognoses. Examples of NMDs include spinal muscular atrophy (SMA), Charcot-Marie-Tooth disease, congenital myasthenia gravis, and Duchenne muscular dystrophy [1,2]. Children with NMDs can also develop central nervous system disorders such as cerebral palsy and spinal cord injury [3]. Common symptoms of NMDs include muscle weakness, fatigue, reduced mobility, and decreased physical performance. Additionally, these patients may experience orthopedic, cardiac, infectious, and respiratory problems, which can negatively impact their quality of life [4].

The global prevalence of neuromuscular diseases, as estimated through a systematic reviews of studies, ranges from 16 per 10,000 to 25.1 per 100,000 individuals and affects people of all ages [5]. The most common autosomal recessive disorder in children with NMDs is SMA, and it affects approximately 1 in 10,000 individuals and has a carrier frequency of 1 in 50 in certain populations [4]. Despite this, there have been no comprehensive epidemiological studies conducted on children with NMDs, particularly SMA, in Iran. Only one study in Iran

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identified Duchenne muscular dystrophy as the most prevalent NMD, with no comprehensive data available on SMA or other NMDs [6].

Many NMDs, including SMA, cause progressive muscle weakness that affects the respiratory system, leading to reduced upper airway function, impaired coughing and secretion clearance, and weakened chest wall support [7]. As a result, children with NMDs, particularly SMA, are at high risk for upper airway obstruction, pulmonary aspiration, frequent respiratory infections, sleep-disordered breathing (SDB), hypoventilation, and respiratory failure [8,9].

SDB is a prevalent complication in children with advanced NMDs [10]. It occurs intermittently due to partial or complete upper airway obstruction, leading to disrupted sleep patterns and ventilation [11]. The prevalence of SDB in healthy children is approximately 1%, while up to 70% of children with NMDs experience it [12]. The common issues faced by these children include sleep disturbance, drowsiness, night sweats, nausea, morning headaches, fatigue, and poor academic performance. Therefore, effective management of SDB is crucial to reduce complications and enhance the quality of life for children with NMDs [13,14]. According to research, sleep disorders in children can result in sleep problems for their parents. When children struggle to fall asleep, their parents also have difficulty sleeping, which can cause stress and lead to missed workdays [15]. In a recent study, the mental health of parents of a child with a NMD was assessed using the Psychological Adaptation Scale questionnaire, which revealed high levels of mental health problems among parents [16].

Stress and anxiety among parents and caregivers can also have negative effects on children, potentially leading to a lack of support from mothers. Confusion in parental behavior, particularly from mothers, can be harmful to their children [17]. Furthermore, research has indicated that changes in a mother's psychological functioning, such as increased stress and anxiety, can influence her perception of her child's sleep problems [18]. Despite numerous studies highlighting the association between parental stress and sleep quality in children with NMDs, comprehensive research specifically focusing on a large cohort of patients with SMA remains limited. Globally, existing studies have primarily concentrated on genetic, laboratory, and epidemiological aspects with small sample sizes and a restricted focus on a few NMDs [6,12,19].

This study aimed to bridge this knowledge gap by examining various aspects of sleep in Iranian children with NMDs, with a particular emphasis on SMA. Using child-specific sleep assessment tools, this study sought to identify the correlation between sleep disturbances and parental stress in this population. The findings of this study can increase our understanding of the sleep experiences of children with NMDs and their parents' stress levels. Eventually, these findings can be used to formulate approaches that enhance the well-being of such children and minimize emotional strain on parents in various cultural environments.

Methods

Study Design and Participants

This descriptive analytical study was conducted as part of a larger study in selected hospitals in Tehran and Isfahan, as well as the dystrophy association of these centers, from February to October 2023, in Iran. The study included a sample of 207 children diagnosed with a NMD, with inclusion criteria of having any muscular dystrophy with an unknown cause and being between preschool and school age (1 to 14 years old). The exclusion criterion was an incomplete questionnaire.

Data Collection

A cross-sectional web-based survey was conducted using the SurveyHeart platform [20] to collect data from caregivers of children with NMDs. Participants were recruited through convenience sampling at selected hospitals and centers in Tehran and Isfahan, Iran. To optimize participation, caregivers were informed about the aims of the study and the significance of sleep for children with NMDs. Data were gathered using a 3-part web-based questionnaire. The initial section captured the demographic information using closed-ended questions. Subsequently, children's sleep habits and parental stress levels were assessed using the Children's Sleep Habits Questionnaire (CSHQ) and the Stress Response Inventory (SRI), respectively, and both used Likert scale items.

Web-Based Questionnaire

Demographic Characteristics

The demographic data examined in this study included the child's sex and age, number and length of hospitalizations, use of specific medications for treatment, parents' educational levels, parents' job, recruitment organization (military or civilian), and number of children in the family.

Children's Sleep Habits Assessment

The CSHQ, which was reviewed and designed by Owens et al [21], was created to assess the sleep habits of 623 preschool- and school-aged children. They showed that the CSHQ was an effective tool for evaluating sleep quality in children. The questionnaire consisted of 35 statements rated on a 3-choice Likert scale across 8 categories: sleep resistance, sleep anxiety, parasomnia, breathing disorders during sleep, waking up at night, sleepiness during the day, sleep duration, and sleep onset delay. Statements 1, 2, 9, 10, and 28 were scored in reverse order. The total score ranged from 33 to 99, with a higher score indicating poorer sleep quality (score ≥41) [21]. In a previous study, the homogeneity of the questionnaire was determined to have a Cronbach α of 0.8 [22]. The validity of the children's sleep habits questionnaire was assessed based on content validity, and its internal consistency has been found to be 0.82 [15]. In another study, the Cronbach α was 0.816 [23].

Parental Stress Assessment

To assess parental stress levels, the SRI scale developed by Koh et al [24] was used. This questionnaire was designed to explore the emotional, physical, cognitive, and behavioral aspects of stress responses. It was a self-reported measure, requiring

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participants to indicate the extent to which they experience each symptom on a 5-point Likert scale ranging from “not at all” (0 points) to “completely” (4 points). The stress response questionnaire consisted of 39 items and 7 subscales: tension (6 items), aggression (4 items), somatization (3 items), anger (6 items), depression (8 items), fatigue (5 items), and frustration (7 items). The following points were assigned to calculate the score for each tension subscale: 16 for aggression, 12 for somatization, 24 for anger, 32 for depression, 20 for fatigue, and 28 for frustration. The minimum and maximum scores were 0 and 156, respectively. The reliability of the SRI tool was examined, resulting in a Cronbach α of 0.97, with a 3-week interval between assessments [24]. The validity of the Persian version of the SRI tool in Iran was confirmed, with an α coefficient of 0.963. Validity was further assessed through factor analysis using the principal parts method and Varimax rotation [25]. In the present study, the Cronbach α for this tool was 0.941.

Ethical Considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The study protocol was approved by the Ethics Committee of the Baqiyatullah University of Medical Sciences (code IR. BMSU. BAQ. REC.1401.129). Written informed consent was obtained from the guardian or legal guardian of each child participant. Participants (or their legal representatives) had the right to withdraw from the study at any time without any consequences. All data collected during this study was anonymized to ensure participant privacy.

Statistical Analysis

For statistical analyses, mean tests with SDs and nonparametric tests (Spearman, Kendall τb, and Kruskal-Wallis) were used to measure qualitative and quantitative variables and determine their relationship with the types of dystrophy, respectively. All analyses were considered statistically significant at an α level of .05. The statistical data were analyzed using SPSS version 22 (IBM Corp).

Results

Demographic Characteristics

This study aimed to investigate the demographic and clinical characteristics of children with NMDs. Of the 207 children enrolled, 50 (24.2%) had SMA type 1, 95 (45.9%) had SMA type 2, 54 (26.1%) had SMA type 3, and only 8 (3.9%) had other NMDs. Specifically, 4 children had Duchenne muscular dystrophy and 4 children had Becker muscular dystrophy. Regarding sex, 114 participants (55.1%) were boys and 93 (44.9%) were girls. Those with SMA type 1 included 20 boys (9.7%) and 30 girls (14.5%). The children with SMA type 2 group included 50 boys (24.2%) and 45 girls (21.7%), and those with SMA type 3 included 36 boys (17.4%) and 18 girls (8.7%). Additionally, for children with other NMDs, there were 8 boys (3.9%). The mean age of the children was 7.14 (SD 4.41) years. Additionally, out of 207 families, 49 (23.7%) were military, while 158 (76.3%) were civilians (Tables 1 and 2).

Furthermore, we examined the clinical characteristics of these children. Children with SMA type 1 had the longest average length of hospitilization and the highest average number of hospitalizations among the 4 groups. There were significant differences in both the length of stay and number of hospitalizations among the 4 NMD groups (P<.001). Conversely, no significant correlations were found between the other demographic variables and the different NMD groups, suggesting that the length of hospital stay varied significantly (Table 2). Additionally, this study assessed the use of specific medications to treat these children. Of the children enrolled in the study, 70% (35/50) with SMA type 1, 63% (60/95) with SMA type 2 (63%), 52% (28/54) with SMA type 3, and 50% (4/8) with other NMDs received disease-specific treatment.

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Table . Demographic characteristics of the study participants (n=207).

Characteristics	SMA[a] type 1	SMA type 2	SMA type 3	Other NMD[b]	Total
NMD of the child, n (%)	50 (24.2)	95 (45.9)	54 (26.1)	8 (3.9)	207 (100)
Father's education, n (%)					
Less than a diploma	18 (8.7)	16 (7.7)	19 (9.2)	0 (0)	53 (25.6)
Diploma	16 (7.7)	31 (15)	17 (8.2)	6 (2.9)	70 (33.8)
Bachelor's degree	12 (5.8)	26 (12.6)	13 (6.3)	2 (1)	53 (25.6)
Graduate	4 (1.9)	18 (8.7)	5 (2.4)	0 (0)	27 (13)
No answer	0 (0)	4 (1.9)	0 (0)	0 (0)	4 (1.9)
Mother's education, n (%)					
Less than a diploma	12 (5.8)	24 (11.6)	22 (10.6)	0 (0)	58 (28)
Diploma	26 (12.6)	33 (15.9)	24 (11.6)	2 (1)	85 (41.1)
Bachelor's degree	10 (4.8)	29 (14)	8 (3.9)	4 (1.9)	51 (24.6)
Graduate	2 (1)	9 (4.3)	0 (0)	2 (1)	13 (6.3)
Father's job, n (%)					
Recruitment	14 (6.8)	30 (14.5)	24 (11.6)	4 (1.9)	72 (34.8)
Part-time	21 (10.1)	38 (18.4)	14 (6.8)	4 (1.9)	77 (37.2)
Home	0 (0)	2 (1)	0 (0)	0 (0)	2 (1)
Unemployed	13 (6.3)	10 (4.8)	15 (7.2)	0 (0)	38 (18.4)
Vacation	2 (1)	15 (7.2)	1 (0.5)	0 (0)	18 (8.7)
Mother's job, n (%)					
Recruitment	2 (1)	20 (9.7)	5 (2.4)	2 (1)	29 (14)
Part-time	0 (0)	10 (4.8)	2 (1)	0 (0)	12 (5.8)
Home	44 (21.2)	57 (27.5)	43 (20.8)	6 (2.9)	150 (72.5)
Unemployed	2 (1)	0 (0)	0 (0)	0 (0)	2 (1)
Vacation	2 (1)	6 (2.9)	4 (1.9)	0 (0)	12 (5.8)
Recruitment organization, n (%)					
Military	11 (5.3)	23 (11.1)	13 (6.3)	2 (1)	49 (23.7)
Civilian	39 (18.8)	71 (34.3)	41 (19.8)	6 (2.9)	158 (75.8)
Number of children in the family, n (%)					
1	17 (8.2)	44 (21.2)	17 (8.2)	4 (1.9)	82 (39.6)
2	21 (10.1)	34 (16.4)	22 (10.6)	4 (1.9)	81 (39.1)
3	12 (5.8)	15 (7.2)	13 (6.3)	0 (0)	40 (19.3)
4	0 (0)	2 (1)	2 (1)	0 (0)	4 (1.9)

[a]SMA: spinal muscular atrophy.

[b]NMD: neuromuscular disorder.

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Table . Demographic characteristics of the study participants.

Variable	SMA[a] type 1, mean (SD)	SMA type 2, mean (SD)	SMA type 3, mean (SD)	Other NMD[b], mean (SD)	*P* value[c]
Sleep score[d]	74.76 (7.48)	76.40 (7.29)	72.88 (6.73)	75.87 (5.74)	.03
Parental stress score[e]	94.72 (28.83)	98.81 (30.76)	94.89 (33.69)	91.25 (45.03)	.78
Length of stay (days)	1.76 (0.71)	1.03 (0.19)	1.58 (0.69)	1 (0.00)	<.001
Number of hospitalizations	2.16 (0.87)	1.55 (0.83)	2.09 (0.87)	1 (0.00)	<.001
Age of the child (years)	4.32 (3.65)	9.75 (4.86)	6.25 (4.62)	8.25 (4.62)	.02

[a]SMA: spinal muscular atrophy.

[b]NMD: neuromuscular disorder.

[c]Kruskal-Wallis test.

[d]Total sleep score: mean 74.37, SD 7.14.

[e]Total stress score: mean 95.73, SD 32.12.

Sleep Habits of Children

The mean sleep score for each group was 74.76 (SD 7.48) for SMA type 1, 76.4 (SD 7.29) for SMA type 2, 72.88 (SD 6.73) for SMA type 3, and 75.87 (SD 5.74) for other NMDs. There was a statistically significant difference in the sleep scores among the 4 groups (P=.02). This indicated that at least 1 group had a significantly different mean sleep score than the other groups (Table 2). Pediatric sleep was influenced by various demographic variables, some of which had significant correlations while others did not. A significant positive correlation was observed between sleep score and the length of hospital stay (r=0.234, P<.001), suggesting that longer hospital stays were associated with a decrease in the quality of pediatric sleep. Furthermore, a significant negative correlation was found between sleep and sex (r=−0.140, P=.04), suggesting that sex differences affected pediatric sleep patterns. However, the correlations between sleep and NMD (r=0.121, P=.08) and the father's education (r=−0.119, P=.08) were weak and nonsignificant. Similarly, the correlation between sleep and the number of children (r=.025, P=.72) was very weak and nonsignificant, indicating little to no association (Table 3).

Table . Correlation analysis between pediatric sleep, parental stress, and demographic variables.

Variable	NMD[a]	Length of stay	Parental stress	Father education	Sex	Child number
Pediatric sleep						
r[b]	0.121	0.234	0.454	–0.119	–0.140	0.025
P value	.08	<.001	.53	.08	.04	.72
Parental stress						
r	0.231	–0.049	—	–0.061	–0.017	0.032
P value	.46	.48	—	.38	.80	.65

[a]NMD: neuromuscular disorder.

[b]Spearman rank correlation coefficient.

Parental Stress

The parents of children with SMA type 2 reported the highest mean stress score of 98.81 (SD 30.76), followed by the parents of children with SMA type 3 (mean 94.89, SD 33.69), SMA type 1 (mean 94.72, SD 28.83), and other NMDs (mean 91.25, SD 45.03). There was not a statistically significant difference in parental stress scores among the 4 groups (P=.78). This suggests that parental stress levels were similar across the different NMD groups (Table 2). No significant correlations were found between parental stress and the demographic variables examined (Table 3).

Discussion

Principal Findings

This study found that children with NMDs, especially those with SMA, had significantly lower sleep quality according to the CSHQ. Frequent sleep disturbances in children with NMDs can significantly increase the overall disease burden for patients and their caregivers [26]. As a result, parents of children with NMDs can experience high levels of stress. However, sleep disorders in people with NMDs, especially in children with SMA, have not been well studied. Therefore, it is necessary to evaluate sleep in patients with NMDs [27,28]. Our study is the first to examine a large group of children with NMDs, particularly SMA, in Iran. One notable difference between our

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study and others [29-33] was the number of patients with SMA. In this study, we assessed the sleep of 199 children with SMA using the CSHQ. The results of our study, demonstrating reduced sleep quality in children with SMA, align with those of Chiang et al [33], who reported significantly lower mean sleep scores in this population compared to healthy controls [34]. These findings are consistent with those of a study on children with SMA type 1 [35], a study of 85 children with SMA type 1 and 2 in Italy [29], a study on 31 children with SMA type 1, 2, and 3 [30], and a study on children with myotonic dystrophy [36].

Furthermore, the results of our study showed that the mean score of sleep disorders in children with SMA type 2 was higher than that of other types of NMDs, although there was not a statistically significant relationship between individual and family factors. However, in contrast to the study by Pera et al [29], sleep disorders were reported more frequently in children with SMA type 2 compared to other children. Additionally, Chacko et al [30] reported fewer sleep disorders in children with SMA type 3. This discrepancy may be attributed to sample size, as the studies done by Chacko et al [30] and Pera et al [29] included only 9 and 13 children with SMA type 3, respectively. Another difference between our study and the aforementioned studies was the use of a sleep assessment tool. Chacko et al [30] used polysomnography, whereas Pera et al [29] used the Sleep Disturbance Scale for Children. However, further research and evaluation are necessary to gain a better understanding of the sleep disorders in children with NMDs.

Sleep problems are common in childhood and adolescence and are related to various factors, such as learning, memory, and emotional and behavioral problems [37-39]. This study aimed to investigate the individual and family factors that influence children's sleep. The study examined the child's age, the number and duration of hospitalizations, the parents' education and occupation, their employing organization, and the number of children in the family. In this study, no significant relationship was found between parents' education and their children's sleep. However, a study on children with NMDs found that higher levels of parental education and income were associated with a reduced care burden for parents. This, in turn, led to improved sleep quality and a better overall quality of life for their children [40]. Furthermore, a study conducted on healthy children showed that children whose parents had a university education were more prone to experiencing sleep issues than children whose parents did not graduate from high school [41].

The child's age was taken into consideration when studying childcare outcomes. This is because as a child with a NMD ages, parents' caregiving responsibilities become more challenging due to the progression of the disease. For example, a study conducted in Brazil examined 31 caregivers of children with Duchenne and found that older boys were more likely to be better understood by their caregivers in terms of their needs and care [42].

Another result of this study was the difference among various groups of patients with NMDs in terms of sleep examination, age, duration, and number of hospitalizations. The results of Chacko et al [30] also corroborate our findings in a sleep study of children with SMA types 1, 2, and 3. They demonstrated that sleep quality was lower in children with SMA type 1 than those with SMA type 2 and SMA type 3 [30]. The length of stay and number of hospitalizations varied among children with different types of SMA and NMDs in general. The findings of Lin et al [43] also support the results of this study. In terms of hospitalization, Chan et al [44] revealed that patients with SMA type 1 had more than 10 visits per year, patients with SMA type 2 had 8 - 23 visits, and patients with SMA type 3 had 12 - 28 visits annually. Regarding hospital stays, the average stay length for patients with SMA type 2 was longer than patients with SMA type 3 but shorter than patients with SMA type 1. The results from Chan et al [44] also confirmed the difference in the duration and number of hospitalizations among these children. Additionally, there was a significant relationship between the duration of hospitalization and sleep in children. When children are hospitalized, they tend to sleep less and have lower quality sleep [42]. A study also found that children admitted to general pediatric and intensive care units slept an average of 2 hours less than they did at home before hospitalization, according to their parents' reports [42]. It is important to note that admitting a child to a hospital is a stressful experience that can increase parental anxiety.

Parents of a child with a chronic disease often experience significant stress that impacts various aspects of their lives [45]. This study aimed to investigate the stress levels of parents of children NMDs by using 7 subscales: tension, aggression, somatization, anger, depression, fatigue, and frustration. The results indicated that parents of children with NMDs experience varying levels of stress, with parents of children with SMA type 2 experiencing higher levels. This aligns with a study that found no significant difference in stress levels among parents of children with NMDs such as Williams syndrome, Down syndrome, and autism spectrum disorder [46]. This study also stated that the similarity in parental stress levels across different NMD groups suggests that the specific type of disorder may not be the main cause of stress [46]. Additionally, a study reported that parents of children with NMDs experienced high levels of stress, with no significant difference between mothers and fathers [47]. Another study examined emotional distress symptoms among mothers of sons with Duchenne and Becker muscular dystrophy, comparing them to a control group of women matched for sex and age. The study found that these mothers reported a lower quality of life and more emotional distress, depression, stress, and clinical anxiety symptoms compared to the women in the control group [48]. Given the consistent reports of higher stress levels among parents of children with NMD, it is crucial to focus on implementing adaptive strategies for families and parents. Screening and intervention measures for families of children with NMDs are essential steps to support these families. NMD associations that provide assistance to these patients should consider implementing measures to screen and support parents of these families. It would also be beneficial to identify centers that offer mental health services and refer families based on their health insurance coverage.

In addition, we expected to observe a significant correlation between children's sleep and parents' stress levels. However,

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this relationship was not statistically significant, despite several studies indicating a connection between children's sleep and parents' stress [18,49,50]. Perhaps this difference can be attributed to the numerous and diverse factors that impact the sleep of children with NMDs and the stress experienced by their parents. Additionally, the intermittent nature of medication administration, frequently resulting from drug supply constraints, can further compromise the sleep quality in this patient population.

Another study aimed to assess the level of stress experienced by parents of children who were hospitalized. The study included 352 parents whose children were hospitalized, and it was found that these parents generally experienced mild-to-moderate levels of stress. Interestingly, the study also revealed that parents who reported lower stress levels tended to feel more satisfied. This study identified several factors that predicted higher levels of stress among parents. These factors included having a low level of education, having a child hospitalized for more than 14 days, and having a child who had visited the hospital frequently in the past [51]. These findings can be generalized to other children with neurodevelopmental disorders because parents of such children often experience higher levels of stress, due to the frequent hospitalizations that their children require. As the duration of their child's hospitalization increases, parents are more likely to report higher levels of stress.

This study, along with others that emphasize sleep disturbances in children with NMDs and the stress experienced by their parents, highlight the urgent need for comprehensive interventions. In this context, studies by Bedi et al [52] and Mellies et al [53] demonstrated that noninvasive ventilation normalizes nocturnal gas exchange and improves diurnal gas exchange, respiratory disturbance index, arousals from sleep, nocturnal heart rate, sleep architecture, and overall quality of life in children with NMDs by reducing symptoms and enhancing daily functioning. However, adherence to noninvasive ventilation, especially in rapid eye movement–related SDB, remains unclear. For instance, nocturnal bilevel positive airway pressure treatment has been shown to help individuals with limb-girdle muscular dystrophies return to their usual daily activities [54]. In addition to noninvasive ventilation, other interventions such as pharmacological treatments, behavioral strategies, and sleep health literacy are also important [55-57]. Implementing these interventions can be challenging; however, they are crucial for improving sleep quality and overall health. It is essential to understand which patients are at a higher risk of developing sleep dysfunction and should be actively monitored. Moreover, more rigorously designed studies are needed to evaluate the long-term benefits and cost-effectiveness of various sleep interventions for children with NMD.

Limitations

One limitation of this study was its methodology. The findings reported here were correlational, not causal, and they do not imply causality. Data were collected using self-reported web-based questionnaires. The extensive sample size necessitated the use of this method; however, it limited control over response conditions, thereby introducing potential biases and reducing the reliability of the findings. Our current methodology does not thoroughly evaluate various factors, such as environmental, psychological, physiological, and social influences on sleep quality. Future research should employ a multidimensional approach, incorporating objective sleep measurements and detailed clinical evaluations to gain a more comprehensive understanding of the sleep disorders in this population.

Conclusions

The results of our study indicate that sleep disorders, particularly SMA, are common in children with NMD. Furthermore, our examination of parental stress levels revealed a high level of stress among these parents, which can affect the quality of care for their children. Therefore, interventions should be implemented to improve the sleep of these children. Additionally, due to the high level of stress experienced by parents, it is necessary to implement measures for screening, identification, and referral for counseling. These families should be regularly evaluated and supported, and interventions should be tailored based on the intensity of their stress.

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Conflicts of Interest

None declared.

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Abbreviations

CSHQ: Children’s Sleep Habits Questionnaire
NMD: neuromuscular disorder
SDB: sleep-disordered breathing
SMA: spinal muscular atrophy
SRI: Stress Response Inventory

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Original Paper

Disparities in Clinical and Experimental Pain Between Non-Hispanic White and Asian American Individuals With Knee Osteoarthritis and the Role of Pain Catastrophizing: Pilot Study in Florida

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Abstract

Background: Although a few studies have delineated the disparities in knee osteoarthritis (KOA) pain between non-Hispanic White and Asian American individuals, a significant research gap persists in elucidating the mechanisms underlying these differences.

Objective: This pilot study aims to examine psychological factors, specifically pain catastrophizing and negative affect, as potential explanatory mechanisms for these dissimilarities.

Methods: A cross-sectional design was used. Forty community-dwelling participants aged 50-70 years with self-reported KOA pain, including 20 non-Hispanic White and 20 Asian American individuals, were recruited in North Central Florida. Clinical KOA pain intensity was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the 4 subscales of the Short-Form McGill Pain Questionnaire-2. Quantitative sensory testing was conducted to measure experimental sensitivity to heat- and mechanically induced pain, including heat pain, pressure pain threshold, and punctate mechanical pain, as well as inhibitory pain processes through conditioned pain modulation. Pain catastrophizing was evaluated using the Coping Strategies Questionnaire-Revised Pain Catastrophizing subscale, while negative affect was assessed using the Positive and Negative Affect Schedule. Bayesian mediation analyses were used to examine both direct and indirect effects (mediation) between variables.

Results: Asian American individuals exhibited higher pain catastrophizing scores than non-Hispanic White individuals. Pain catastrophizing, at high levels, contributed to WOMAC and Short-Form McGill Pain Questionnaire-2, which measured clinical pain. Race had no direct effects on these pain scores but exerted significant indirect effects via pain catastrophizing (WOMAC pain: 0.96, 95% CI 0.03-2.16; continuous pain: 0.84, 95% CI 0.18-1.70; intermittent pain: 0.78, 95% CI 0.03-1.71; neuropathic pain: 0.43, 95% CI 0.03-0.95; and affective pain: 1.05, 95% CI 0.24-1.99); thus, pain catastrophizing likely fully mediated the relationship between race and these pain measures. While Asian American individuals reported greater experimental pain sensitivity (heat pain, pressure pain threshold, and punctate mechanical pain) than non-Hispanic White individuals, these racial effects were not mediated by pain catastrophizing. Asian American individuals reported higher negative affect scores compared with non-Hispanic White individuals; however, negative affect did not mediate the relationship between race and any pain measures.

Conclusions: The results demonstrate the contribution of pain catastrophizing to clinical pain in Asian American individuals with KOA and identify it as a potential mechanism underlying group differences in KOA pain between non-Hispanic White and Asian American individuals. However, caution is warranted due to the exploratory nature of this study and the treatment of Asian

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American individuals as a monolithic sample. Hence, future replication with larger and more diverse samples is necessary. Additionally, the lack of mediation effects of pain catastrophizing in the relationship between race and experimental pain suggests the need to explore other factors, such as biological, genetic, social, and environmental influences. Moreover, further research is essential to clarify the role of negative affect.

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KEYWORDS

Asian American; non-Hispanic White; osteoarthritis; pain; pain catastrophizing

Introduction

Background

Symptomatic knee osteoarthritis (KOA), characterized by pain, disability, and diminished quality of life, is a prevalent joint disorder in middle-aged and older adults [1]. Traditional perspectives have primarily linked KOA pain to structural joint changes; however, the weak correlation between radiographic findings and clinical symptoms suggests that structural abnormalities alone do not comprehensively account for the pain experienced by sufferers [2-5]. This indicates that additional factors, including psychosocial influences, may significantly impact the severity and perception of OA-related pain [6].

The prevalence of symptomatic KOA is projected to increase in racially and ethnically marginalized groups [7]. Although significant disparities in clinical and experimental pain have been reported across racial and ethnic groups with KOA, relevant studies have predominantly compared non-Hispanic White with African American individuals [8]. Asian American individuals, a rapidly growing minority, have been underrepresented in pain research despite emerging evidence indicating that they experience greater KOA-related pain than non-Hispanic White individuals [9], challenging cultural stereotypes of stoicism. To date, no studies have delineated the mechanisms underlying the differences between non-Hispanic White and Asian American individuals.

The biopsychosocial model of pain recognizes the importance of various psychological factors in pain [10]. One such factor, pain catastrophizing—cognitive and affective pain appraisal characterized by the tendency to address and magnify the threat value of painful stimuli and feel helpless owing to pain—is reportedly significantly correlated with increased knee pain severity in both clinical and experimental settings [11-13]. Notably, Asian American individuals have been reported to exhibit higher levels of pain catastrophizing, possibly influenced by acculturative stress and cultural practices affecting pain perception and response [14]. The greater use of pain catastrophizing among racial and ethnic minorities can also be attributed to health disparities resulting from structural and systemic barriers to adequate pain treatment and biased health care interactions [15,16], possibly promoting negative perceptions regarding pain management and the belief that their pain cannot be controlled and is likely to worsen. Considering the association between higher levels of pain catastrophizing and increased KOA pain, pain catastrophizing plausibly mediates the racial disparities observed in KOA pain between non-Hispanic White and Asian American individuals.

In addition to specific pain-related factors, broader elements, such as depression and negative affect, influence knee pain experiences, and this prevails in situations involving clinical and experimentally induced pain [17-19]. Ahn et al [20] found higher levels of depression to occur in Asian American individuals with self-reported KOA pain compared with those in age- and sex-matched non-Hispanic White individuals, and such variations in depression evidently mediated racial group differences in clinical and experimental pain. Negative affect, a general predisposition to experiencing aversive mood states, has been associated with racial discrimination and psychological distress among Asian American individuals [21]. Daily microaggressions contribute to higher levels of mental health symptoms and negative affect among Asian American individuals [22-24] and specific Asian American groups [25]. To date, the role of negative affect in racial disparities in KOA pain between non-Hispanic White and Asian American individuals has not yet been investigated.

Objectives

This pilot study aims to investigate psychological factors, specifically pain catastrophizing and negative affect, as potential explanatory mechanisms underlying group differences in KOA pain between non-Hispanic White and Asian American individuals. Elucidating these mechanisms may inform the development of targeted interventions that improve KOA pain management in the understudied Asian American population and help address pain disparities across racial groups.

Methods

Study Participants

This cross-sectional analysis used baseline data from the randomized controlled trial registered at ClinicalTrials.gov (NCT02512393) to examine the efficacy of transcranial direct current stimulation on KOA pain. Detailed selection criteria and enrollment procedures have been documented previously [26]. In summary, at baseline, 40 participants with KOA pain (20 non-Hispanic White and 20 Asian American individuals) were recruited in North Central Florida between September 2015 and August 2016 through local advertisements. Participants were eligible if they were aged 50-70 years, had self-reported unilateral or bilateral KOA pain as per American College of Rheumatology criteria, could speak and read English, and were willing and able to provide written informed consent before enrollment. In our sample of Asian American individuals, detailed information on subgroup ethnicities, languages, cultural backgrounds, and demographic characteristics was not gathered during data collection and is therefore unavailable in this study.

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Exclusion criteria ensured participants did not have concurrent medical conditions that could confound osteoarthritis-related outcomes or coexisting diseases that could impede protocol completion, including (1) prosthetic knee replacement or nonarthroscopic surgery on the affected knee; (2) serious medical illness, such as uncontrolled hypertension, heart failure, or recent history of acute myocardial infarction; (3) peripheral neuropathy; (4) systemic rheumatic disorders, such as rheumatoid arthritis, systemic lupus erythematosus, and fibromyalgia; (5) alcohol or substance abuse; (6) cognitive impairment (ie, Mini-Mental Status Examination score≤23); (7) history of brain surgery, tumor, seizure, stroke, or intracranial metal implantation; (8) pregnancy or lactation; and (9) hospitalization for psychiatric illness within the past year.

Measurement

The collected basic characteristics included age, sex, BMI (kg/m^2), Kellgren-Lawrence radiographic grade, employment status, marital status, educational attainment, and household income.

Clinical KOA Pain

The Western Ontario and McMaster Universities Osteoarthritis Index Pain Subscale.

Average knee pain for the past 48 hours was measured by the pain subscale of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), which consisted of 5 items on a 0-4 Likert scale measuring the pain severity during walking, climbing stairs, sleeping, resting, and standing [27]. The participants' responses to each pain question were summed up to derive an aggregated score for pain intensity (range: 0-20). The subscales in WOMAC demonstrate reliability and validity in evaluating patients with KOA [28,29].

Short Form McGill Pain Questionnaire-2

The Short Form McGill Pain Questionnaire-2 (SF-MPQ-2) has been validated and widely used to assess the multidimensional qualities of pain [30]. It consists of 4 subscales, including continuous pain (6 items: throbbing pain, cramping pain, gnawing pain, aching pain, heavy pain, and tender), intermittent pain (6 items: shooting pain, stabbing pain, splitting pain, electric-shock pain, and piercing), neuropathic pain (6 items: hot-burning pain, cold-freezing pain, pain caused by light touch, itching, tingling or pins and needles, and numbness), and affective description of pain (4 items: tiring-exhausting, sickening, fearful, and punishing-cruel). Each subscale score was computed as the average of answered items, with higher scores indicating greater pain intensity.

Quantitative Sensory Testing

A multimodal Quantitative Sensory Testing (QST) battery was used to assess pain sensitivity using precisely controlled protocols that elicit pain with thermal and mechanical stimuli, as well as inhibitory pain processes. This includes heat pain (ie, threshold and tolerance), pressure pain threshold (PPT), punctate mechanical pain (PMP), and conditioned pain modulation (CPM). The sequence of heat and mechanical testing was randomized and counterbalanced, while CPM was always administered last to minimize any potential carryover effects. The same researcher performed QST on each participant throughout the study, and all participants were provided with standardized recorded instructions to prevent bias during data collection and to enhance the reliability of the results.

Thermal Testing Procedures

All thermal stimuli were delivered using a computer-controlled TSA-II NeuroSensory Analyzer (Medoc Ltd) to measure heat pain thresholds and heat pain tolerances on both the index knee and the ipsilateral ventral forearm using an ascending method of limits. At each body site, the thermode position was moved between trials to prevent sensitization or habituation of cutaneous receptors. Starting from a baseline of 32 °C, the thermode temperature increased at a rate of 0.5 °C per second until participants responded by pressing a button on a handheld device. Participants were instructed to press the button when heat first becomes painful to assess the heat pain threshold, and when they could no longer tolerate the heat pain to assess heat pain tolerance. Three trials of heat pain threshold were conducted at the first test site, followed by 3 trials of heat pain tolerance were conducted. Then, 3 trials each at the second test site were conducted, with a 5-minute rest period between sites. The average of the 3 trials was calculated for each individual, providing overall heat pain threshold and tolerance temperatures for analysis.

Mechanical Testing Procedures

Mechanical pain response was measured via 2 approaches. First, PPT was assessed by applying blunt mechanical pressure to deep tissues (ie, muscle and joint) via a handheld digital pressure algometer (Wagner). Increasing pressure was applied at a constant rate of 0.3 kgf/cm^2 per second to measure the PPT at 4 sites—the medial and lateral aspects of the index knee, ipsilateral quadriceps, and trapezius. The order of testing sites was counterbalanced and randomized. For assessing PPT, participants were instructed to inform the experimenter when the sensation "first becomes painful" occurred, and the pressure was recorded. The results of the 3 trials at each body site were averaged for each site, and then these PPTs at 4 sites were averaged to derive an overall measure of PPT. Second, PMP stimuli evaluated cutaneous mechanical sensitivity on both the index patella and the back of the ipsilateral hand. We used calibrated nylon monofilament that delivered a target force of 300 g to obtain verbal ratings of the pain intensity on a scale of 0 (no pain sensation) to 100 (the most intense pain sensation imaginable) following 10 contacts at the rate of 1 contact per second. An overall score for each site was computed by averaging across 2 trials.

Conditioned Pain Modulation

Ten minutes after assessing the thermal or mechanical pain, the CPM was evaluated. CPM reflects the endogenous pain inhibitory pathway (ie, descending pain inhibition) also known as the "pain inhibits pain" paradox [31]. CPM was assessed by determining the change in PPT on the trapezius, immediately following the immersion of the contralateral hand up to the wrist in the cold-water bath (12 °C) for 1 minute. The initial preimmersion PPT measurement was conducted just before placing the hand in the water. Thirty seconds after hand

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immersion, participants were asked to rate the cold pain intensity (0-100) from the immersed hand followed by the second PPT measurement, and were informed to keep their hand in the water bath for as long as tolerable up to 1 minute. After the removal of the hand, the final PPT measurement was taken. This temperature was chosen based on prior experience with middle-aged and older adults with KOA, where 12 °C was found to produce moderate yet tolerable pain for most participants. Water was continually circulated and maintained at a constant temperature by a refrigeration unit (Neslab). An increase in PPT following cold water immersion demonstrated pain inhibition.

Pain Catastrophizing

The Coping Strategies Questionnaire-Revised measures the use of strategies for coping with pain by assessing 6 domains—distraction, catastrophizing, ignoring pain sensations, distancing from pain, coping self-statements, and praying. Participants rate how often they use specific strategies on a 7-point Likert scale from 0=never to 6=always, with higher scores indicating greater usage for each domain. This study used the 6-item catastrophizing subscale, with scores calculated as the mean of the responses. The reliability and validity of the Coping Strategies Questionnaire-Revised subscales have previously been shown to be acceptable [32,33].

Negative Affect

The Positive and Negative Affect Schedule includes 20 items that evaluate the frequency of both pleasant and unpleasant emotions individuals experience [31]. The inventory is divided into 2 subscales, each with 10 items for positive and negative emotions. Negative affect is calculated from the sum of 10 items (afraid, ashamed, distressed, guilty, hostile, irritable, jittery, nervous, scared, and upset), rated on a 5-point scale from 1=very slightly or not at all to 5=extremely. A lower total negative score indicates less negative affect (range: 10-50). The Positive and Negative Affect Schedule has been validated and demonstrates reliability, with an α coefficient range of .84 to .87 for negative affect [34].

Statistical Analyses

Descriptive statistics were used to characterize the study participants. Chi-square or Fisher exact test for categorical variables and the 2-tailed *t* test for continuous variables were used to compare participant characteristics between the groups. Composite measures for QST were created by calculating *z* scores for the heat pain threshold and tolerance at the arm and knee; PPT at the medial and lateral aspects of the index knee, ipsilateral quadriceps, and trapezius; and PMP at the index patella and hand. The *z* scores for each pain measure were subsequently averaged across the body sites to yield overall heat pain threshold, heat pain tolerance, PPT, and PMP values for the analyses.

Separate path analytical models were estimated to assess the indirect effects (mediation) of ethnicity (coded 0 for non-Hispanic White and 1 for Asian American individuals) via pain catastrophizing or negative affect on each clinical and experimental pain measure. The path models facilitated the examination of both direct and indirect effects. Model fit, path coefficient estimates, and 95% highest posterior density CIs ("credibility" in Bayesian terms) for parameter estimates were generated using the Bayesian estimation method in Mplus (version 8.8; Muthén & Muthén). Bayesian estimation is advantageous in that it precludes the necessity of the normality assumption in the sampling distribution of estimates and potentially provides more accurate parameters in small-sample cases [35]. Model fit was evaluated using the criteria and methods recommended by Muthén and Asparouhov [36]. Where 95% CIs did not overlap with zero, the effect was considered significant.

Ethical Considerations

The institutional review board (IRB) of the University of Arizona (UA) considers investigators engaged in research if they (1) interact with participants for research purposes, (2) have access to identifying study information, (3) obtain informed consent from research participants, or (4) the UA directly receives part of federal funds for the study (ie, UA is the prime awardee). If none of the earlier are true, then the researchers would not need IRB approval. Thus, this secondary analysis of deidentified data from an existing randomized controlled trial does not need any IRB approval. The original study (NCT04016272) received appropriate ethical approval, and written informed consent was obtained.

Results

Table 1 presents the characteristics of the participants by race. The groups differed in terms of age (*P*=.001), BMI (*P*=.001), and Kellgren-Lawrence radiographic grade (*P*=.01). The mean age of non-Hispanic White individuals was 65.1 (SD 7.05) years, whereas the mean age of Asian American individuals was 54.8 (SD 7.36) years. The BMI for non-Hispanic White and Asian American individuals was 28.0 (SD 3.12) kg/m² and 25.0 kg/m² (SD 3.41) kg/m², respectively. Out of 20 Asian American individuals, most (n=11, 55%) were classified as grade 0. In contrast, grades 3 and 4 were predominant among non-Hispanic White individuals, with 7 out of 20 (35%) participants falling into these categories. Additionally, grade 2 was more common among non-Hispanic White individuals (8/20, 40%) compared with Asian American individuals (2/20, 10%). There were no significant differences between the groups in sex proportion, employment status, marital status, educational attainment, and household income.

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Table 1. Basic characteristics of the participants (N=40)a.

Characteristic	Non-Hispanic White (n=20)	Asian American (n=20)	*P* value
Age (years), mean (SD)	65.1 (7.05)	54.8 (7.36)	*.001*
Sex, n (%)	8 (40)	13 (65)	.21
Male	12 (60)	7 (35)	
Female	8 (40)	13 (65)	
BMI (kg/m^2), mean (SD)	28.0 (3.12)	25.0 (3.41)	*.001*
Kellgren-Lawrence radiographic grade, n (%)			*.010* [b]
0	2 (10)	11 (55)	
1	3 (15)	5 (25)	
2	8 (40)	2 (10)	
3	6 (30)	2 (10)	
4	1 (5)	0 (0)	
Employment status, n (%)			.28
Yes	9 (47)	12 (71)	
No	10 (53)	5 (29)	
Marital status, n (%)			.13[b]
Married or partnered	13 (65)	18 (90)	
Nonmarried or unpartnered	7 (35)	2 (10)	
Educational attainment, n (%)			.50
2-year college degree or less	8 (40)	5 (25)	
4-year college degree of higher	12 (60)	15 (75)	
Household income (US $), n (%)			.52
More than 50,000	11 (58)	8 (42)	
50,000 or less	8 (42)	11 (58)	

[a]Significant results are indicated in italics.

[b]Fischer exact test.

Descriptive statistics for variables used in the path models are presented in Table 2. Figure 1 shows the mediation path (race → mediator → pain). Fit for each of the models was acceptable, with all 95% CIs for the difference between observed and replicated chi-square values encompassing 0, all posterior predictive values >.45, and convergence of posterior parameter trace plots. Tables 3 and 4 provide results of the path analysis, including direct and indirect effects and the 95% highest posterior density CIs for each of the pain measure models.

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Table 2. Descriptive statistics for pain-related outcomes, pain catastrophizing, and negative affect among non-Hispanic White and Asian American individuals (N=40).

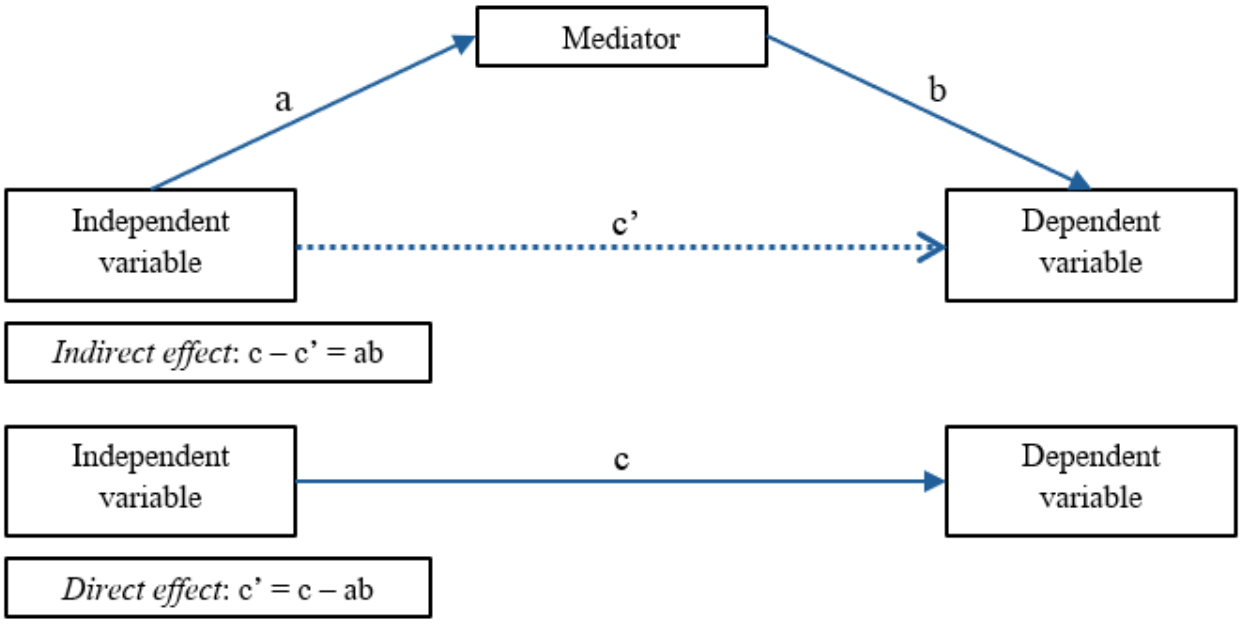
Pain measures	Non-Hispanic White (n=20)	Asian American (n=20)
WOMAC[a] pain (range: 0-20), mean (SD)	4.90 (2.55)	4.40 (2.67)
SF-MPQ-2[b] continuous pain (range: 0-10), mean (SD)	1.78 (1.94)	1.98 (1.37)
SF-MPQ-2 intermittent pain (range: 0-10), mean (SD)	1.28 (2.19)	1.47 (1.83)
SF-MPQ-2 neuropathic pain (range: 0-10), mean (SD)	0.67 (0.93)	1.07 (1.24)
SF-MPQ-2 affective pain (range: 0-10), mean (SD)	0.79 (1.83)	1.46 (1.66)
Heat pain threshold[c], mean (SD)	0.49 (0.82)	–0.49 (0.74)
Heat pain tolerance[c], mean (SD)	0.51 (0.76)	–0.51 (0.73)
Pressure pain threshold[c], mean (SD)	0.45 (0.86)	–0.45 (0.61)
Punctate mechanical pain[c], mean (SD)	–0.62 (0.56)	0.62 (0.76)
Conditioned pain modulation, mean (SD)	1.29 (1.14)	1.16 (0.71)
Pain catastrophizing (range: 0-6), mean (SD)	0.31 (0.74)	1.33 (1.25)
Negative affect (range: 10-50), mean (SD)	14.00 (4.29)	20.15 (9.02)

[a]WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

[b]SF-MPQ-2: Short-Form McGill Pain Questionnaire-2.

[c]Average *z* score.

Figure 1. Mediation path model. For clinical pain measures, we measured WOMAC pain and SF-MPQ-2 pain. To produce composite QST measures, average z scores were computed for heat pain threshold and heat pain tolerance measurements at the arm and knee; PPT measurements at the medial and lateral aspect of the index knee, ipsilateral quadriceps, and trapezius; and PMP measurements at the patella and hand. a = direct effect of race on the mediator; b = direct effect of the mediator on pain measures after controlling for race; ab = indirect effect of race on pain measures operating through the mediator; c' = direct effect of race on pain measures after controlling for the mediator; c = total effect of race on pain measures without accounting for the mediator. Due to the small sample size, we analyzed each mediating effect (ie, pain catastrophizing and negative affect) separately. PMP: punctate mechanical pain; PPT: pressure pain threshold; QST: quantitative sensory testing; SF-MPQ-2: Short-Form McGill Pain Questionnaire-2; WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.



In each model (Table 3), the direct effect of race on pain catastrophizing (Figure 1; a = direct effect of race on the mediator) indicated that Asian American individuals had significantly higher pain catastrophizing scores than non-Hispanic White individuals (mean difference 1.03; 95% CI 0.29-1.70). Additionally, as shown in Table 4, in each model, the direct effect of race on negative affect indicated that Asian American individuals yielded significantly higher negative affect scores than non-Hispanic White individuals (mean difference 6.15; 95% CI 1.11-10.80).

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Table 3. Estimated direct and indirect effects with 95% CI (N=40; pain catastrophizing as a mediator)[a,b].

Pain outcomes (R^2)	Direct effects		Indirect effect, ab (95% CI)
	c' (95% CI)	b (95% CI)	
WOMAC[c] pain (0.179)	–1.53 (–3.39 to 0.25)	1.00 (0.21-1.81)	0.96 (0.03-2.16)
SF-MPQ-2[d] continuous pain (0.283)	–0.67 (–1.78 to 0.40)	0.85 (0.38-1.34)	0.84 (0.18-1.70)
SF-MPQ-2 intermittent pain (0.187)	–0.64 (–2.07-0.73)	0.81 (0.20-1.43)	0.78 (0.03-1.71)
SF-MPQ-2 neuropathic pain (0.215)	–0.06 (–0.83 to 0.67)	0.45 (0.12-0.78)	0.43 (0.03-0.95)
SF-MPQ-2 affective pain (0.410)	–0.41 (–1.47 to 0.60)	1.06 (0.61-1.52)	1.05 (0.24-1.99)
Heat pain threshold[e] (0.284)	–1.07 (–1.67 to –0.50)	0.08 (–0.17 to 0.34)	0.07 (–0.20 to 0.39)
Heat pain tolerance[e] (0.304)	–0.94 (–1.52 to –0.39)	–0.07 (–0.32 to 0.18)	–0.06 (–0.38 to 0.19)
Pressure pain threshold[e] (0.259)	–0.96 (–1.54 to –0.41)	0.06 (–0.19 to 0.31)	0.05 (–0.23 to 0.34)
Punctate mechanical pain[e] (0.462)	1.09 (0.58-1.57)	0.15 (–0.07 to 0.37)	0.14 (–0.09 to 0.43)
Conditioned pain modulation (0.168)	–0.49 (–1.70 to 0.16)	0.36 (0.07-0.65)	0.34 (0.00-0.79)

[a]Significant results are indicated in italics.

[b]c' = direct effect of race on pain measures after controlling for pain catastrophizing; b = direct effect of pain catastrophizing on pain measures after controlling for race; ab = indirect effect of race on pain measures operating through pain catastrophizing.

[c]WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

[d]SF-MPQ-2: Short-Form McGill Pain Questionnaire-2.

[e]Average *z* score.

Table 4. Estimated direct and indirect effects with 95% CI (N=40; negative affect as a mediator)[a,b].

Pain outcomes (R^2)	Direct effects		Indirect effect, ab (95% CI)
	c' (95% CI)	b (95% CI)	
WOMAC[c] pain (0.091)	–1.05 (–2.92 to 0.83)	0.09 (–0.03 to 0.22)	0.50 (–0.23 to 1.59)
SF-MPQ-2[d] continuous pain (0.094)	–0.17 (–1.36 to 1.04)	0.06 (–0.02 to 0.14)	0.34 (–0.13 to 1.04)
SF-MPQ-2 intermittent pain (0.155)	–0.45 (–1.83 to 0.95)	0.11 (0.02-0.20)	0.59 (–0.04 to 1.48)
SF-MPQ-2 neuropathic pain (0.186)	0.04 (–0.70 to 0.80)	0.06 (0.01-0.11)	0.34 (–0.03 to 0.80)
SF-MPQ-2 affective pain (0.108)	0.32 (–0.93 to 1.59)	0.06 (–0.02 to 0.14)	0.32 (–0.17 to 1.04)
Heat pain threshold[e] (0.274)	–1.01 (–1.58 to –0.43)	0.00 (–0.03 to 0.04)	0.02 (–0.25 to 0.27)
Heat pain tolerance[e] (0.297)	–1.01 (–1.56 to –0.45)	–0.00 (–0.04 to 0.04)	–0.00 (–0.25 to 0.26)
Pressure pain threshold[e] (0.255)	–0.94 (–1.49 to –0.38)	0.01 (–0.03 to 0.04)	0.03 (–0.22 to 0.29)
Punctate mechanical pain[e] (0.453)	1.13 (0.65-1.62)	0.02 (–0.01 to 0.05)	0.09 (–0.10 to 0.36)
Conditioned pain modulation (0.039)	–0.15 (–0.85 to 0.56)	0.01 (–0.04 to 0.05)	0.02 (–0.31 to 0.33)

[a]Significant results are indicated in italics.

[b]c' = direct effect of race on pain measures after controlling for pain catastrophizing; b = direct effect of pain catastrophizing on pain measures after controlling for race; ab = indirect effect of race on pain measures operating through pain catastrophizing.

[c]WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index.

[d]SF-MPQ-2: Short-Form McGill Pain Questionnaire-2.

[e]Average *z* score.

Direct Effect of Race on Pain Measures After Controlling Pain Catastrophizing

The direct effect of race on the heat pain threshold (c'=–1.07), heat pain tolerance (c'=–0.94), and PPT (c'=–0.96) indicated that Asian American individuals had lower mean scores on these experimental pain measures than non-Hispanic White individuals after controlling for pain catastrophizing. The direct effect of race on PMP (c'=1.09) indicated that Asian American individuals generated higher mean scores on this pain measure than non-Hispanic White individuals after controlling for pain catastrophizing. After controlling for pain catastrophizing, Asian

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American and non-Hispanic White participants yielded similar mean scores for clinical pain measures.

Direct and Indirect Effect of Pain Catastrophizing on Pain Measures

Pain catastrophizing exhibited positive direct effects, while race exerted positive indirect effects through pain catastrophizing on WOMAC (b=1.00, ab=0.96), SF-MPQ-2 continuous (b=0.85, ab=0.84), SF-MPQ-2 intermittent (b=0.81, ab=0.78), SF-MPQ-2 neuropathic (b=0.45, ab=0.43), and SF-MPQ-2 affective (b=1.06, ab=1.05) pain. These results indicate that participants with higher pain catastrophizing scores tend to have higher values on these pain measures after controlling for race. Considering that race had no direct effects on these pain scores but exerted indirect effects via pain catastrophizing, the effects of race were likely fully mediated through pain catastrophizing for these measures. After controlling race, we did not identify any direct effects of pain catastrophizing on the heat pain threshold, heat pain tolerance, PPT, and PMP. Surprisingly, pain catastrophizing exhibited positive direct effects on CPM (b=0.36).

Direct Effect of Race on Pain Measures After Controlling for Negative Affect

Based on the direct effect of race on the heat pain threshold (c'=–1.01), heat pain tolerance (c'=–1.01), and PPT (c'=–0.91), Asian American individuals yielded lower mean scores on these experimental pain sensitivity measures than non-Hispanic White individuals after controlling for negative affect. The direct effect of race on PMP (c'= 1.13) indicated that Asian American individuals had higher mean scores on this pain measure than non-Hispanic White individuals after controlling for negative affect. Race had no direct effect on CPM. After controlling for negative affect, Asian American and non-Hispanic White participants were found to have similar mean scores for all clinical pain measures.

Direct and Indirect Effects of Negative Affect on Pain Measures

We exclusively detected direct effects of negative affect on SF-MPQ-2 intermittent (b=0.11) and SF-MPQ-2 neuropathic (b=0.06) pain after controlling for race. Race exerted no indirect effects on pain measures via negative affect in any of the path models.

Discussion

Principal Findings

This study investigated whether variations in pain catastrophizing and negative affect explain group differences in clinical and experimental pain between non-Hispanic White and Asian American individuals with KOA. Our main finding suggests that Asian American individuals show higher levels of pain catastrophizing than non-Hispanic White individuals and that it plays a relevant role in greater clinical pain in Asian American individuals. The results additionally indicate that participants with higher pain catastrophizing scores tended to have higher WOMAC- and SF-MPQ-2-measured clinical pain. Furthermore, Asian American individuals exhibited greater sensitivity to experimental pain compared with non-Hispanic White individuals; however, this difference was not due to pain catastrophizing. Asian American individuals also reported experiencing more negative affect than non-Hispanic White individuals, yet this did not seemingly influence the relationship between race and any pain measures.

Comparison With Prior Work

Disparities in pain catastrophizing based on race and ethnicity have been documented in individuals with KOA [13,37-39] and various other pain-related medical conditions [40-43]; notably, individuals who self-identify as minorities, including Black and Hispanic or Latinx groups, are reported to engage in pain catastrophizing as a pain coping strategy more frequently than their non-Hispanic White peers. Increasing evidence also suggests that catastrophizing is a significant mediator of race differences in clinical pain. A recent study by Fullwood et al [39] found that pain catastrophizing mediated the relationship between race (Black vs non-Hispanic White individuals) and WOMAC pain in adults with KOA. Similar findings were reported in the study by Lane et al [43] on individuals with chronic spinal pain receiving physical therapy and the study by Fabian et al [44] in healthy pain-free samples. Our study expands on previous investigations by identifying pain catastrophizing as a significant contributor to group differences in clinical pain between non-Hispanic White and Asian American individuals.

Extensive prior research has demonstrated that pain catastrophizing is associated with undesirable pain outcomes, including more frequent pain experiences or greater pain intensity [11-13]. However, our finding that Asian American individuals have higher clinical pain scores with increasing levels of pain catastrophizing represents a novel contribution to the field. The exact reasons underlying the significantly higher pain catastrophizing scores among Asian American individuals compared with non-Hispanic White individuals remain unclear. A possible explanation is the relationship between acculturative stress and pain catastrophizing in Asian American individuals. Ahn et al [14] suggest that chronic stress contributes to increased pain perception, potentially owing to its physical impact from chronically high levels of sympathetic activation and subsequent physiologic exhaustion; this, in turn, may reduce one's ability to cope with the added stress of pain [45]. They further note that a major source of chronic stress for immigrants could be the process of acculturation [46,47]. In addition, higher pain catastrophizing scores among Asian American individuals could be attributed to a cultural emphasis on pain-related stoicism in Asian communities, which may discourage openly expressing chronic pain to avoid burdening others [48,49]. This cultural disposition causes Asian American individuals to suffer silently, thus amplifying their mental agony. Furthermore, Asian cultural communication styles often prioritize indirectness and subtlety, which can result in less effective communication with health care providers from different cultural backgrounds regarding pain experiences [50]. This communication gap may hinder effective pain management and perpetuate a cycle of unexpressed and poorly managed KOA pain, thereby contributing to higher levels of pain catastrophizing compared to non-Hispanic White individuals. Furthermore, immigrants' experiences with the health care system and the challenges they

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encounter in accessing adequate pain treatment may lead to poorer pain outcomes. This may foster negative thinking about their pain and may leave Asian American patients feeling that their pain is unmanageable and will inevitably worsen.

Asian American individuals reported greater experimental pain sensitivity (heat pain, PPT, and PMP) than non-Hispanic White individuals, replicating previous findings on middle-aged and older adults with KOA [9] and similar reports on younger Asian American individuals [51]. Furthermore, heightened sensitivity occurred at both the affected knee and unaffected body sites, suggesting increased central sensitization. However, pain catastrophizing could not explain the racial group differences in any measures of experimental pain in this study. This contradicts previous studies wherein pain catastrophizing was found to influence racial group differences in QST measures among nonclinical samples [52-55] and patients with chronic low back pain [41]. Several explanations can be proposed for such findings. First, Meints et al [55] found that racial group differences in cold pain tolerance (non-Hispanic White vs African American individuals) were mediated by the rumination component of pain catastrophizing but not by the magnification or helplessness components, examining the mediatory effects of different pain catastrophizing components may yield varied results. Second, other critical factors, such as biological, genetic, social, and environmental mechanisms, may also influence the observed differences. For instance, Rowell et al [51] found that differences in endogenous pain regulatory mechanisms, such as mean arterial pressure and heart rate, potentially play a role in the differences in experimental pain sensitivity between young non-Hispanic White and Asian American individuals. Based on earlier evidence, genetic links to pain phenotypes differ according to racial or ethnic group, potentially generating dissimilarities in pain sensation. For example, pain sensitivity has been associated with variations in the catechol-O-methyltransferase [56] and μ-opioid receptor genes [57]. Moreover, frequency differences in the alleles of pain-related gene polymorphisms may contribute to racial and ethnic disparities in pain responses [58]. Furthermore, studies have suggested a role for nutritional supplement status [59], lower sociodemographic resources [60], and racial discrimination [61] in accounting for individual or racial and ethnic differences in experimental pain sensitivity—all of which potentially contributed to the observed differences but require further evaluation in the future.

Asian American individuals had significantly higher negative affect scores than non-Hispanic White individuals. Although higher negative affect scores were strongly correlated with both intermittent and neuropathic pain (measured using the SF-MPQ-2), negative affect did not seem to influence the relationship between race and any pain measures. Various negative affect-related constructs are important to pain; nevertheless, they differ in specificity and are conceptually distinct; some constructs are general, such as anxiety, depression, and negative affect, whereas others are more specifically pain-related, such as fear of pain, pain anxiety, and pain catastrophizing [62]. Overall, our preliminary findings suggest that pain-specific variables (ie, pain catastrophizing) should be prioritized over general negative affect to minimize pain disparities between non-Hispanic White and Asian American individuals. However, further studies involving larger sample sizes are necessary to confirm our findings. In fact, a study by Ahn et al [9], which established that higher depression levels in Asian American than in non-Hispanic White individuals explained racial group differences in clinical and experimental pain, included 50 participants per group. Additionally, we could not account for covariates, such as sex, age, and pain-related medication, owing to the small sample sizes in the path models, which might have affected the results.

Strengths and Limitations

Our study is the first to highlight the crucial role of pain catastrophizing in explaining disparities in clinical KOA pain between non-Hispanic White and Asian American individuals, contributing to the growing body of literature on racial group differences in pain among individuals with KOA and its associated psychological conditions. Further, the study's strength was upheld by its comprehensive examination of pain in Asian American individuals using a wide range of pain measures, focusing on a population that has received limited attention in studies assessing and managing KOA pain.

This study has certain limitations. First, the findings may not be generalizable as they are based on a convenience sample from a specific region. Moreover, the Asian American participants in the study were limited to English speakers. These limitations introduce challenges in interpreting the findings, underscoring the need for samples from other regions and a more diverse group of Asian American individuals for cross-validation. Second, as previously mentioned, a key limitation of this study is the lack of information about potential commonalities or differences within our broadly categorized, monolithic Asian American sample. Therefore, caution is warranted when interpreting our conclusions. Furthermore, although we use the term "Asian American" when referring to the prior works, we acknowledge the significant heterogeneity within this population, including the diverse countries of origin of participants in individual studies and the considerable variation across "Asian American" cohorts in different studies. Thus, our discussion on racial and ethnic differences should be carefully interpreted. Third, this pilot study had a small sample size. Consequently, statistical analyses were constrained, and data outliers were more likely to skew the results, highlighting the need for a larger sample size. Furthermore, the combination of the small sample size and the lack of subgroup information on the Asian American sample limited the study's capacity to be specifically designed or sufficiently powered to explore variations within smaller subgroups of Asian American individuals. Fourth, the cross-sectional design hindered our ability to discern the directionality of the relationships between variables. Indeed, evidence suggests that pain catastrophizing may not be a characterological trait but a complex phenomenon that can both affect and be affected by pain [39]. Kim et al [48] argue that as clinical pain scores increase, a sense of helplessness or an inability to control chronic knee pain may develop, contributing to higher levels of pain catastrophizing in Asian American individuals. These important relationships warrant further investigation in future studies. Furthermore, previous studies have evaluated pain catastrophizing over a longitudinal

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period to better understand its influence on pain over time in adults with KOA [39]. Similar studies should also be conducted in Asian American samples. Finally, we acknowledge that the term "pain catastrophizing" can considered pejorative and stigmatizing, conflicting with patient-centered care approaches [63]. Labeling patients in this manner potentially leads to blame and stereotyping, adversely affecting decision-making and care quality. Recent analyses have proposed that "pain-related worrying" and "pain-related distress" may better capture the essence of what is measured by pain-catastrophizing items [64].

Future Directions

This pilot study's findings provide a crucial foundation for future research and clinical practice. Considering the limited sample size, we analyzed each mediatory effect separately. Future studies including larger samples may use more sophisticated models to concurrently examine a broader range of factors, thereby more comprehensively elucidating the mechanisms underlying racial disparities in pain between non-Hispanic White and Asian American individuals; in addition to pain catastrophizing and negative affect, as previously discussed, future research should investigate biological, genetic, and other psychological variables essential to understanding chronic KOA pain and evaluate them as explanatory mechanisms to develop more tailored interventions.

Additionally, it is important to acknowledge that the lumping of Asian American groups together in the current study is problematic, as it obscures the tremendous diversity and complexity within and across these groups. This approach may have excluded individuals with varying levels of pain catastrophizing and negative affect or overlooked how acculturative stress and cultural practices—factors that can vary greatly between Asian American subgroups—may influence pain perception and response. Therefore, future studies should account for the demographic and social construction of the Asian American category and its implications in KOA pain research to ensure nuanced and culturally informed analyses.

Finally, our findings underscore the need to systematically assess and treat pain catastrophizing in Asian American individuals in health care settings to ensure effective pain management. Interventions targeting this maladaptive cognitive style among Asian American individuals may help mitigate racial disparities in clinical pain. In particular, the interventions should be culturally sensitive and tailored by further scrutinizing the factors influencing pain catastrophizing in Asian American individuals. If acculturative stress influences pain catastrophizing, then therapy for pain catastrophizing (eg, cognitive behavioral therapy) could be enhanced by focusing on culturally sensitive stress management techniques. In addition, a better understanding of differences in pain experiences based on race, sociocultural background, and experiences with the health care system—such as Asian communities facing structural and systemic barriers that influence pain—may help reduce disparities in pain management.

Conclusions

This pilot study examined psychological factors, specifically pain catastrophizing and negative affect, as potential explanatory mechanisms behind racial group differences in clinical and experimental pain between non-Hispanic White and Asian American individuals with KOA pain. Apparently, pain catastrophizing is essential to addressing racial disparities in clinical KOA pain; however, further research is warranted to verify our findings and elucidate unresolved mechanisms.

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Data Availability

The datasets generated during and/or analyzed during this study are available from the corresponding author on reasonable request.

Authors' Contributions

CL and CKK were responsible for the conception or design of the work. LP and HA contributed to the acquisition of the data. CL and CKK were involved in the analysis and interpretation of the data, as well as drafting the work. JP and HA revised the manuscript critically for important intellectual content. All authors gave final approval of the version to be published and agreed to be accountable for all aspects of the work.

Conflicts of Interest

HA is the Editor-in-Chief of Asian/Pacific Island Nursing.

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Abbreviations

CPM: conditioned pain modulation
IRB: institutional review board
KOA: knee osteoarthritis
PMP: punctate mechanical pain
PPT: pressure pain threshold
QST: quantitative sensory testing
SF-MPQ-2: Short-form-McGill Pain Questionnaire-2
UA: University of Arizona
WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

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