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Rehabilitation after Total Hip & Total Knee Arthroplasty with Smartphone Applications: a Scoping Exercise using a Systematic Review of Current Applications and Patient Survey

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ABSTRACT

This study aims to assess the quality, user friendliness of current smartphone applications ("apps") available for total hip (THR) and total knee (TKR) arthroplasty patients and identifies patient preferences regarding the content of an ideal rehabilitation app.

The Google® Play and Apple® app stores were systematically searched. The Mobile App Rating Scale (MARS) and the Systematic Usability Scale (SUS) were used for the assessment of apps. A questionnaire was designed and used in a post op orthopaedic clinic at a large tertiary center. 102 patients (52 TKR and 50 THR) completed the questionnaire.

Nine apps were included in the systematic review. On MARS assessment, the mean overall score was 3.55/5. The highest and lowest mean scores were seen in the functionality (3.86/5) and aesthetics (3.44/5) subscales respectively. The mean overall SUS score was 75.3/100 (Grade B) with a range of 51.25 – 95.

Both scales suggested moderate levels of quality and user friendliness of currently available apps, but with significant variation between apps. Patient preferences are not currently ideally matched by available apps.

Keywords: Outcomes Research, Patient Outcome Assessment, Real World Evidence, Technology, Health Care Costs.

INTRODUCTION

The use of smartphones has become extremely common worldwide with the number of smartphone users reaching 5.22 billion by the end of 2020[1]. The influence of portable technology is evident amongst older populations with 65% of over 65-year-olds using a smartphone in a 2020 review[2]. The potential of mobile devices in healthcare to organize appointments, communicate results and provide a source of information and education is massive[3]. Mobile applications are now commonly used by healthcare professionals to communicate both generic and specific information with patients, especially in the monitoring of chronic diseases such as diabetes[4] osteoarthritis[5] asthma[6] and coronary heart disease[7]. Such systems can help obtain accurate and real time data for virtual patient management, in lieu of a traditional face-to-face examination. This decreases the costs of healthcare and gives flexibility to interact at a time and place suitable to both the patient and provider[8-12].

Total hip replacement (THR) and Total knee replacement (TKR) are common operations, with approximately 205,000[13] carried out in the United Kingdom (UK) in 2019. Rehabilitation after such procedures is suitable for self-management[14]. In the UK, no post-operative rehabilitation app is currently recommended by the NHS, leaving individual patients to seek their own source of advice or seek advice from their healthcare provider.

OBJECTIVES

Our study has two main aims, to systematically review the quality of the available smartphone applications in

THR and TKR surgery using the Mobile App Rating Scale (MARS) and System Usability Scale (SUS), and to survey patient opinions and needs regarding the desired content of an ideal postsurgical follow-up app. This data would then be used to further evaluate the content of current generation of mobile health (mHealth) apps and propose design improvements.

METHODS

Systematic Review of Available Applications

A Population Intervention Comparison Outcome (PICO) framework was used to establish the basis for the review. Two authors performed a search to review the apps currently available for patient use in UK between 2nd November 2021 and 14th February 2022 in the Apple® app store and Google Play® app store yielding 1634 results (Figure 1). The search findings were recorded and then screened to remove duplications and irrelevant programs using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology.

Inclusion criteria for Apps:

1. App available to UK based patients
2. App in the English language
3. App designed for use of patient (not clinician).
4. App has specific target of THR/TKR or contains a section targeting THR/TKR
5. App is not game based
6. App can be free of charge or contain a paywall/in app purchasing (patients may be willing to pay for a service of benefit; so, apps that charge a fee were considered).
7. App has had an update within the last 18 months (i.e., the developer is still actively upgrading the product).
8. App has generic basis, so not targeted at one specific clinician (usually surgeon) and their patients. Apps related to a specific prosthesis were considered, as long as the content/advice remained generic
9. App does not involve physiotherapist assessment and bespoke exercise prescription as part of induction process.

A total of 15 applications were included (Table I). Information regarding the apps' development, user numbers, star rating and most recent update were collected and stored for reference.

The following applications were unavailable for review as the developer did not allow access: My Mobility, Bbraun, Velys Patient Path – DePuy, RPM – Corin, My Recovery - Future Health Works, Care4Today Patient Information – Johnson & Johnson

Each app was assessed using the Mobile App Rating Scale (MARS) and the System Usability Scale (SUS) rating scales. The MARS questionnaire[15] consists of 23 items divided into five sections: user engagement, functionality, aesthetics, information quality, and subjective reviewer quality. Previous research evaluating mHealth apps in arthroplasty using MARS has demonstrated excellent inter-rater reliability[16] and shown validity in its effectiveness as a quality assessment tool[17].

As MARS does not fully capture user-friendliness, the System Usability Scale (SUS) was also used which is a ten-item Likert scale providing a global measure of perceived usability[18]. It is the most widely applied tool for assessing user-friendliness, having been used in at least 12 studies of health-related apps[19], and has consistently been shown to be reliable[20,21].

Three authors (GD, AA and SH) undertook training in the use of the rating scales using the MARS online training package[22], which uses sample websites to compare the researcher against the creator's rating (to verify inter-rater reliability), and written documentation regarding SUS from the scale's creator[18].

Two authors (GD and AA) independently evaluated each app using both scales on 26 May 2022. Any significant discrepancies between their ratings were resolved through discussion, and unresolved differences were adjudicated by the third author (SH).

PATIENT QUESTIONNAIRE

To complement the systematic review, a patient questionnaire (Appendix 2) was developed to ascertain patient preferences and expectations regarding the content and functionality of an ideal postsurgical follow-up app. The questionnaire included Likert-scale items addressing usability, communication features, educational content, and rehabilitation support. Following trialing, data collection was conducted between 4th May 2022 and 8th June 2022 in the same orthopaedic clinic.

Inclusion criteria for patients:

1. Postoperative primary Total Hip or Total Knee Arthroplasty
2. Between 6 weeks and 6 months following the procedure
3. Can read, understand and write English
4. Owns and can use either a tablet or smartphone device

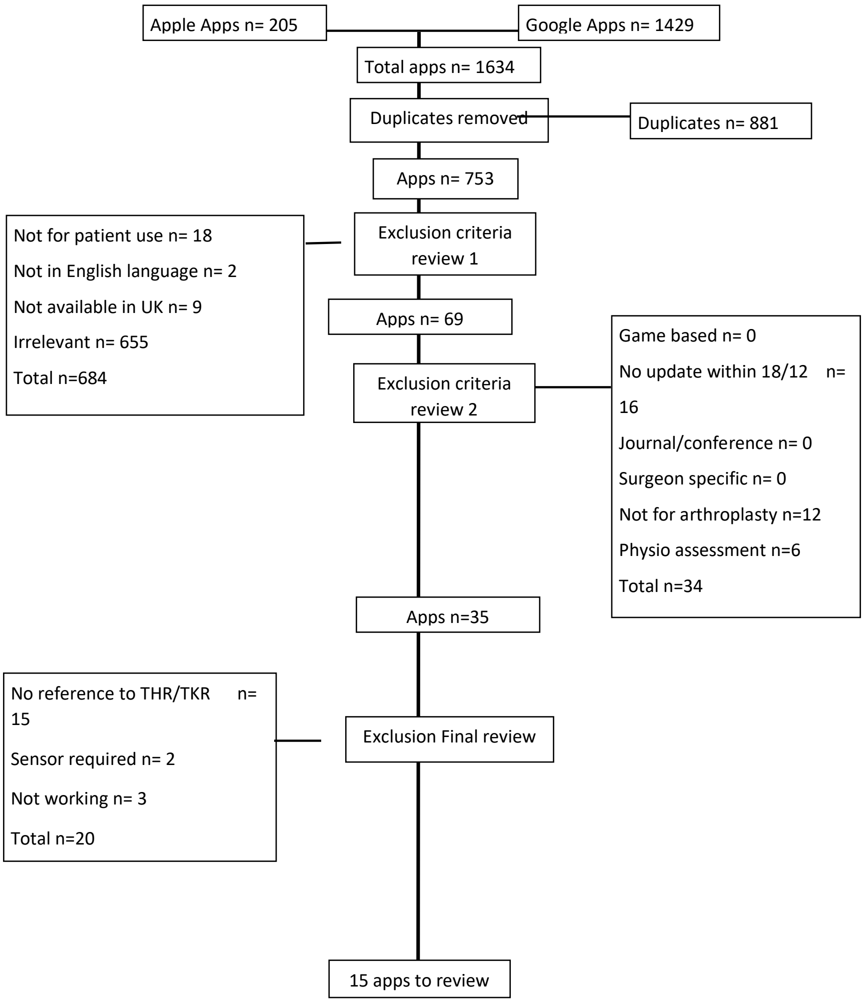

Fig. 1 — PRISMA flow chart.

5. Can use the internet
6. Can understand the terminology used in the questionnaire

Responses were analyzed for correlation and variance using non-parametric tests, including Spearman's rho, Mann–Whitney U, and Kruskal–Wallis[23-25].

Institutional Review Board (IRB) approval was not required for this study as it involved a systematic review of publicly available smartphone applications and an anonymized voluntary patient questionnaire conducted as part of routine clinical service evaluation, in accordance with institutional and national ethical guidelines.

RESULTS

Systematic Review of Available Applications

A total of nine applications met the inclusion criteria and were reviewed for quality and usability. The MARS and SUS scores are presented in Tables II and III, respectively.

Correlation between the overall MARS and SUS scores was assessed using a two-tailed Spearman correlation test. The result was significant ($p = 0.049$), indicating a positive alignment between the scores obtained from both rating scales.

Inter-rater reliability between the two assessors (GD and BH) was evaluated using a two-way mixed effects intraclass correlation coefficient (ICC) model. The ICC for the overall MARS rating was 0.979 (95% confidence interval [CI] 0.906–0.995), and for the SUS rating it was 0.984 (95% CI 0.931–0.996), demonstrating excellent agreement between raters.

The MARS and SUS values reported represent the mean of both reviewers' ratings.

PATIENT QUESTIONNAIRE

A total of 150 patients were invited to participate in the questionnaire survey. Of these, 102 patients completed the questionnaire (52 post-TKR and 50 post-THR). Four patients declined participation, and

Table I. — Hip and knee arthroplasty rehab applications Synchronous(real time video)/Asynchronous(web based application)– Final Cohort.

App Name	App store	THR, TKR or Both	Star Rating /5	No: of users giving star rating	Synchronous or Asynchronous	No: of users	Free /Costs	Last update	Version
Curovate Canada – UK version	Apple & Google	TKR	3.3	187	Synchronous	10,000+	Free trial Subscription from £7.99	1-5-22	1.2.4
Expy Physical therapy USA – UK version	Apple & Google	Both	5	9	Synchronous & Asynchronous	50+	Free. Physio telehealth payments.	6-6-21	2.0.0
My recovery (including joint school app by my recovery) UK	Apple & Google	Both	3.8	303	Synchronous & Asynchronous	10,000+	Free via PIN from institution	30-5-22	4.12.1
ZB (Zimmer Biomet) MyMobility USA – UK version	Apple & Google	Both	3.3	77	Synchronous & Asynchronous	5000+	Free	30-10-21	3.4.1
Corin RPM UK	Apple & Google	Both	None	No reviews	Synchronous & Asynchronous	500+	Free via PIN (for patients with Corin implants)	19-5-22	4.12.0
Velys patient path UK	Apple & Google	Both	None	No reviews	Synchronous & Asynchronous	100+	Free via PIN (for patients with DePuy implants)	19-5-22	5.1.0
For patient app Bbraun Germany – UK version	Apple and Goo-gle	Both	None	No reviews	Synchronous & Asynchronous	100+	Free via PIN (for patients Bbraun implants)	1-3-22	1.2.10
TrackActive me UK	Apple & Google	Both	4.7	13	Synchronous & Asynchronous	1000+	Free trial 7 days. £4.99 month after	27-1-22	1.13.0
Pocket Physio UK	Apple & Google	Both	None	No reviews	Asynchronous	500+	Free	26-11-20	1.0.4

nine were later deemed ineligible (despite initially consenting) due to factors such as not owning a smartphone or computer or lacking internet access. Participant demographics are presented in Table IV.

Patients' preferences for general healthcare app features are summarized in Table S1, while preferences for specific postoperative recovery and rehabilitation features are shown in Table S2.

The influence of gender and age on responses within the THR and TKR groups was assessed using Mann–Whitney Uand Kruskal–Wallis tests. The Mann–Whitney analysis revealed no significant gender differences among TKR patients. In the THR cohort, the only significant finding was that male patients were more likely to use the internet for health-related information than females ($p = 0.031$).

Differences associated with age were more marked. The Kruskal–Wallis test indicated that younger TKR patients demonstrated significantly greater confidence in searching for and downloading an app compared with those over 60 years ($p = 0.041$), a finding mirrored in the THR group ($p = 0.008$).

DISCUSSION

Quality and Usability of Existing Applications

Overall apps scored higher on functionality and information content than engagement and aesthetics. A significant correlation between quality and usability was observed ($p=0.049$) supporting the complementary use of MARS and SUS for evaluation.

SUS scores varied between apps, ranging from scores out of 100 of 95 (Healthzone Fife) down to 51.25

Table II. — MARS scores for assessed apps.

App Name	MARS A Engagement	MARS B Functionality	MARS C Aesthetics	MARS D Information	MARS E Subjective Quality	MARS Mean score A+B+C+D
1. Curovate	4	3.5	4.17	4.17	4	3.96
2. Expy PT	3.4	4.25	4.5	3.33	3	3.87
3. Health Zone NHS Fife	2.6	4.63	3.67	4.5	3.25	3.85
4. Patient Journey	2.8	4.25	3.33	4	2.75	3.60
5. My Recovery Joint school	3.4	4	3	3.8	2.5	3.55
6. Pocket Physio	2.7	4	3	4.1	2.75	3.45
7. Track Active Me	3.8	3	3.33	3.6	3	3.43
8. GPEP	2.6	4	3	3.4	2.5	3.25
9. RecovAware	3.4	3.13	3	2.6	1.75	3.03
Cumulative mean 1-9	3.19	3.86	3.44	3.72	2.83	3.55

Table III. — SUS scores for assessed apps.

App Name	Mean SUS score	Mean SUS grade
1. Health Zone NHS Fife	95	A+
2. Pocket Physio	83.75	A
3. Curovate	82.5	A
4. Patient Journey	80	A-
5. Expy PT	80	A-
6. GPEP	77.5	B+
7. My Recovery Joint school	65	C
8. Track Active Me	62.5	D
9. RecovAware	51.25	F
Cumulative Mean 1-9	75.3	B

Table IV. — Baseline characteristics of included patients.

	THR	TKR	Total
Number of respondents	50	52	102
Number of Males	17	34	51
Number of Females	33	18	51
Number of patients at 6 week review	38	33	71
Number of patients at 6 month review	12	19	31
Modal age group	60-79	60-79	N/A
Number owning smartphone	46	47	93
No. owning Tablet computer	18	19	37
No. owning Laptop computer	22	26	48
No. owning desktop computer	10	15	25
No. owning 2 or more devices	34	33	67
No owning smartphone only	12	9	28

(RecovAware). Three apps score below the generally accepted threshold of 80 (RecovAware, TrackActive Me, My Recovery). The five above this threshold were: Expy, Curovate, Patient Journey, Pocket Physio, Healthzone Fife. The mean SUS score across all apps was 75.3 (B grade on the Sauro-Lewis curved grading scale)[26], indicating performance was above 'average' but below 'good'. Higher MARS scores tended to align with higher SUS scores, reinforcing the relationship between quality and usability.

Public star ratings in app stores (Table S3) showed no correlation with MARS or SUS results, there was wide variance in the volume of users giving app ratings (1-303 ratings per app) with two apps having no available rating.

Regulatory oversight remains limited. None of the reviewed apps possessed United Kingdom Conformity Assessed (UKCA) accreditation. The Medicines and Healthcare Products Regulatory Agency (MHRA) provide guidance defining when an app qualifies as a medical device[27]. Apps incorporating patient questionnaires or clinical measurements may require such classification and marking. Additionally, the National Institute for Health and Care Excellence (NICE) has introduced evidence standards for digital health technologies[28] to guide developers, funders, and commissioners integrating digital tools into the UK healthcare system. NICE approval and UKCA marking could improve both safety and market acceptance for mHealth apps intended for NHS integration.

Despite these findings, none of the reviewed apps demonstrated patient input in their design—a key element for usability and adoption. This study represents the second comprehensive review of postoperative THR and TKR applications, following the work of Bahdori et al[16]. Since then, progress towards patient-centered app design has been limited. The small body of literature that has emerged, demonstrates patient co-design in mHealth apps for knee arthritis[17] and elective orthopaedics[29] has successfully incorporated personalized exercises, video calling and message supporting thereby enhancing engagement. Current THR and TKR apps do provide valuable features—such as range of motion measurement, step count, patient-reported outcome measures (PROMs), goal setting, and telehealth options—which facilitate home-based rehabilitation and real-time data collection. However, these apps generally lack personalization, local pathway integration, and an evidence-based foundation.

Patient Preferences and App Adoption

The patient survey (n = 102) indicated that user-friendliness is the most highly valued feature of a healthcare app (Table S1). Regular internet use correlated strongly with confidence in using apps, prior healthcare app experience, and willingness to adopt an app for postoperative recovery ($p < 0.01$).

Variance was observed between TKR and THR patients. TKR patients with high internet and app use did not necessarily prefer app-based treatment, suggesting continued reliance on in-person physiotherapy and consultant reviews ($p = 0.83$ & 0.48). However, TKR patients willing to engage with technology were more likely to share data with third-party providers ($p < 0.05$). THR patients demonstrated more pronounced relationships: those confident with technology expressed a willingness to use apps in lieu of healthcare professional visits ($p < 0.05$) and believed apps could reduce treatment costs ($p < 0.05$). Patients preferring apps over physiotherapy similarly preferred them over consultant or GP visits ($p < 0.01$).

Patients' app feature preferences (Table S1) focused on practical recovery tools, ranking exercise videos, practical advice, and contact information highest. Lower-ranked but beneficial features include photo upload, inclinometer, telemedicine, and pedometer functions. Lifestyle tools such as weight management and smoking cessation were least valued, likely reflecting prioritization of immediate postoperative recovery over long-term health management. Apps that were free of charge were consistently preferred.

Pain following TKR persists for at least three months in more than 20% of patients[30], with risk factors including female sex, younger age, and higher preoperative pain levels. This may explain the greater desire for ongoing clinical support among TKR patients compared to THR patients.

Age also influenced technology engagement: patients under 60 reported higher confidence and greater use of technology, consistent with prior research[31]. Gender had minimal impact, aside from males being more likely to seek health information online ($p = 0.031$). However, overall, procedure type (THR vs. TKR) had a greater influence on technology adoption than demographic variables.

Integration of Findings and Implications

Taken together, these results highlight a mismatch between app quality and patient expectations. While several apps offer functional tools for rehabilitation, they often lack features that patients value most, such as personalized guidance, local pathway integration, and clear evidence-based content. Access to accurate information via technology can increase patient engagement with rehabilitation programs[32], while direct interaction with healthcare professionals for individualized support can further improve satisfaction, clinical outcomes[33], and self-efficacy[34].

Incorporating patient input into app design is therefore essential to enhance usability, engagement, and adoption. Proper integration of mHealth apps into postoperative care could facilitate cost-effective, home-based rehabilitation, real-time PROMs collection, and enhanced patient satisfaction.

Data security and confidentiality are also critical considerations. Prior studies indicate that up to 80% of healthcare apps fail to meet appropriate security standards[35], highlighting the need for regulatory oversight and standardized quality assessment to ensure safe implementation in clinical practice.

Limitations

The primary limitation of this study is that participants were recruited from a single clinic within a tertiary center and therefore may not be representative of broader populations. Additionally, completing the survey required the ability to read and understand the questionnaire, which may have introduced bias related to ethnicity, culture, or socioeconomic status. Consistent with previous research, older patients were less likely to engage with technology compared with those under 60 years of age[31].

CONCLUSION

This study represents the first attempt to combine a systematic review of THR and TKR apps with patient qualitative evaluation to assess usability, quality, and patient preferences. Overall, apps demonstrated moderate quality, performing better in functionality and information than engagement or aesthetics. None incorporated patient input, and regulatory oversight was limited, highlighting gaps in patient-centered design.

Patients prioritized usability, practical recovery tools, and personalized guidance. THR patients were more willing to use apps in place of in-person follow-up, while TKR patients often preferred ongoing clinical support. Age and digital literacy influenced adoption.

Current apps are unlikely to fully meet patient needs. Incorporating patient co-design, evidence-based content, and integration with local care pathways is essential for enhancing engagement, supporting home rehabilitation, and improving patient satisfaction.

REFERENCES

1. Finances Online – Reviews for Business. Number of Smartphone and Mobile Phone Users Worldwide in 2022/2023: Demographics, Statistics, Predictions. Copyright©2022. [Accessed 19th April 2022]. Available from: https://www.financesonline.com/number-of-smartphone-users-worldwide
2. Statista. Do you personally use a smartphone? - by age. 15th June 2021. [Accessed 19th April 2022]. Available from https://www.statista.com/statistics/300402/smartphone-usage-in-the-uk-by-age
3. Market Data Forecast. Global mhealth market/Mobile Health Market Size, Share, Trends, Growth & COVID 19 Impact Analysis Report – Segmented by Type, Services, Application & Region – Industry Forecast (2022-2027). January 2022. [Accessed 19th April 2022]. Available from https://www.marketdataforecast.com/market-reports/mobile-health-market
4. Su D, Michaud TL, Estabrooks P, Schwab RJ, Eiland LA, Hansen G et al. Diabetes Management Through Remote Patient Monitoring: The Importance of Patient Activation and Engagement with the Technology. Telemed J E Health. 2019; 25(10): 952-59: https://doi.org/10.1089/tmj.2018.0205
5. Pelle T, Bevers K, van der Palen J, van den Hoogen FHJ, van den Ende CHM. Effect of the Dr. Bart application on healthcare use and clinical outcomes in people with osteoarthritis of the knee and/or hip in the Netherlands; a randomized controlled trial. Osteoarthritis Cartilage. 2020; 28(4): 418-27: https://doi.org/10.1016/j.joca.2020.02.831
6. O'Connor A, Tai A, Carson-Chahhoud K. Isn't There an App for That? The Role of Smartphone and Tablet Applications for Asthma Education and Self-Management in Adolescents. Children. 2021; 8: 786: https://doi.org/10.3390/children8090786
7. Eckardt I, Buschhaus C, Nickenig G, Jansen F. Smartphone-guided secondary prevention for patients with coronary artery disease. J Rehabil Assist Technol Eng. 2021; 8: 1-9: https://doi.org/10.1177/2055668321996572
8. Bini SA, Mahajan J. Clinical outcomes of remote asynchronous telerehabilitation are equivalent to traditional therapy following total knee arthroplasty: A randomized control study. J Telemed Telecare. 2017; 23(2): 239-47: https://doi.org/10.1177/1357633X16634518
9. Chughtai M, Kelly JJ, Newman JM, Sultan AA, Khlopas A, Sodhi N et al. The Role of Virtual Rehabilitation in Total and Unicompartmental Knee Arthroplasty. J Knee Surg. 2019; 32(1): 105-10: https://doi.org/10.1055/s-0038-1637018
10. Tousignant M, Moffet H, Nadeau S, Mérette C, Boissy P, Corriveau H et al. Cost analysis of in-home telerehabilitation for post-knee arthroplasty. J Med Internet Res. 2015; 17(3): e83: https://doi.org/10.2196/jmir.3844
11. Hardt S, Schulz MRG, Pfitzner T, Wassilew G, Horstmann H, Liodakis E et al. Improved early outcome after TKA through an app-based active muscle training programme—a randomized-controlled trial. Knee Surg Sports Traumatol Arthrosc. 2018; 26: 3429-37: https://doi.org/10.1007/s00167-018-4918-2
12. Wolfstadt JI, Soong C, Ward SE. Improving patient outcomes following total joint arthroplasty: is there an app for that? BMJ Qual Saf. 2019; 28: 775–77: https://doi.org/10.1136/bmjqs-2019-009571
13. National Joint registry (NJR). National Joint Registry 18th Annual Report for England, Wales and Northern Ireland. 2021.
14. National Institute For Health and Care Excellence. Joint replacement (primary): hip, knee and shoulder. Evidence review for outpatient hip and knee postoperative rehabilitation. NG157 [Internet]. London: NICE; June 2020 [Accessed 10th May 2022]. Available from https://www.nice.org.uk/guidance/ng157/evidence
15. Stoyanov SR, Hides L, Kavanagh DJ, Zelenko O, Tjondronegoro D, Mani M. Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps. JMIR mHealth uHealth. 2015; 3(1): e27: https://doi.org/10.2196/mhealth.3422
16. Bahadori S, Wainwright TW, Ahmed OH. Smartphone apps for total hip replacement and total knee replacement surgery patients: a systematic review. Disabil Rehabil. 2018; 42: 7: 983-88. https://doi.org/10.1080/09638288.2018.1514661
17. Terhorst Y, Philippi P, Sander LB, Schultchen D, Paganini S, Bardus M, et al. Validation of the Mobile Application Rating Scale (MARS). PLoS ONE. 2020; 15(11): e0241480. https://doi.org/10.1371/journal.pone.0241480
18. Brooke J. SUS: A "quick and dirty" usability scale. In Usability

Evaluation in Industry, Jordan PW, Thomas B, Weerdmeester BA, McClelland AL (Eds.). 1996. London: Taylor and Francis
19. Azad-Khaneghah P, Neubauer N, Cruz AM, Liu L. Mobile health app usability and quality rating scales: a systematic review, Disabil Rehabil Assist Technol. 2021; 16(7): 712-21: https://doi.org/10.1080/17483107.2019.1701103
20. Lewis JR, Utesch BS, Maher DE, 2015. Measuring perceived usability: the SUS, UMUX-LITE, and AltUsability. Int J Hum-Comput Interact. 2015; 31: 496–505: https://doi.org/10.1080/10447318.2015.1064654
21. Bangor A, Kortum PT, Miller JT. An empirical evaluation of the System Usability Scale. Int J Hum-Comput Interact. 2008; 24(6): 574-94: https://doi.org/10.1080/10447310802205776
22. YouTube.com [Internet]. MARS training video. 15th June 2016 [Accessed 24th May 2022]. Available from https://www.youtube.com/watch?v=25vBwJQIOcE
23. Sauro J, Lewis JR. Standardized Usability Questionnaires. In Sauro J, Lewis JR. Quantifying the User Experience, Practical Statistics for User Research. 2nd edition. Burlington Massachusetts: Morgan Kaufmann; 2016. p. 185-248
24. Mathews SC, McShea MJ, Hanley CL, Ravitz A, Labrique AB, Cohen AB. Digital health: a path to validation. NPJ Digit Med. 2019; 2: 38: https://doi.org/10.1038/s41746-019-0111-3
25. Sedholm, R., McShea, M.J., Cohen, A.B, Webster JA, Mathews SC. Mobile app validation: a digital health scorecard approach. NPJ Digit Med. 2021; 4: 111: https://doi.org/10.1038/s41746-021-00476-7
26. Miller SA, Forrest JL. Enhancing your practice through evidence-based decision making: PICO, learning how to ask good questions. J Evid Base Dent Pract. 2001; 1(2): 136-41: https://doi.org/10.1016/S1532-3382(01)70024-3
27. Medicines and Healthcare products Regulatory Agency. Guidance: Medical device stand-alone software including apps (including IVDMDs). Updated July 2021 [Accessed 10th May 2022]. Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/999908/Software_flow_chart_Ed_1-08b-IVD.pdf
28. National Institute For Health and Care Excellence. Evidence standards framework for digital health technologies. ECD7 [Internet]. London: NICE; 23rd April 2021 [Accessed 10th May 2022]. Available from https://www.nice.org.uk/corporate/ecd7
29. Robinson A, Slight RD, Husband AK, Slight SP. Designing the Optimal Digital Health Intervention for Patients' Use Before and After Elective Orthopaedic Surgery: Qualitative Study. J Med Internet Res. 2021; 8: 23(3): e25885: https://doi.org/10.2196/25885
30. Lewis GN, Rice DA, McNair PJ, Kluger M. Predictors of persistent pain after total knee arthroplasty: a systematic review and meta-analysis. Br J Anaesth. 2015; 114(4): 551-61: https://doi.org/10.1093/bja/aeu441
31. Eze CE, West BT, Dorsch MP, Coe AB, Lester CA, Buis LR et al. Predictors of Smartphone and Tablet Use Among Patients With Hypertension: Secondary Analysis of Health Information National Trends Survey Data. J Med Internet Res. 2022; 24(1): e33188: https://doi.org/10.2196/33188
32. Alokozai A, Bernstein DN, Samuel LT, Kamath AF. Patient engagement approaches in total joint arthroplasty: A review of two decades. J Patient Exp. 2021; 8: https://doi.org/10.1177/23743735211036525
33. Van Kasteren Y, Freyne J, Hussain MS. Total Knee Replacement and the Effect of Technology on Cocreation for Improved Outcomes and Delivery: Qualitative Multi-Stakeholder Study. J Med Internet Res. 2018; 20(3): e95: https://doi.org/10.2196/jmir.7541
34. Wang Q, Hunter S, Lee RL-T, Wang X, Chan, SW-C. Patients' needs regarding rehabilitation services delivered via mobile applications after arthroplasty: A qualitative study. J Clin Nurs. 2021; 00: 1–12: https://doi.org/10.1111/jocn.16152
35. BBC News. Most healthcare apps not up to NHS standards. 16th February 2021. [Accessed 10th May 2022]. Available from https://www.bbc.co.uk/news/technology-56083231

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