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Original Article

Effectiveness of a Smartphone Application to Improve Home Exercise Adherence in Adults with Knee Osteoarthritis in Saudi Arabia: A Randomized Controlled Trial

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Abstract

Background: Knee osteoarthritis (OA) is a prevalent condition globally, with poor adherence to home exercise programs (HEPs) posing a major barrier to effective management. This study examined the impact of a smartphone-based HEP with motivational text messaging on adherence, pain, and physical function among adults with knee OA in Saudi Arabia. **Methods:** A randomized controlled trial was conducted with 42 participants diagnosed with knee OA, recruited from a clinic at King Fahad Medical City (KFMC). Participants were randomized into two groups: the intervention group (n = 21) received a HEP delivered via WhatsApp with motivational text messages, while the control group (n = 21) received a paper-based HEP. Outcomes included self-reported adherence, pain (measured by visual analogue scale), and physical function (assessed using the Arabic version of the WOMAC physical function subscale). Assessments were conducted at baseline and at 6 weeks by a physical therapist with six years of experience. **Results:** At 6 weeks, the intervention group demonstrated significantly greater adherence (p = 0.001), lower pain scores (p = 0.017), and improved physical function (p = 0.001) compared to the control group. **Conclusion:** Delivering a HEP via a smartphone application with motivational text messaging may significantly improve adherence, reduce pain, and enhance physical function in adults with knee OA.

Keywords Knee Osteoarthritis, Tele Rehabilitation, Exercise Therapy, Smartphone, Mobile Applications, Treatment Adherence and Compliance.

Introduction

In 2019 the World Health Organization (WHO) identified musculoskeletal conditions as the most prevalent condition with them most commonly affecting people from adolescence through to older age(Leumann et al., 2019). A Global Burden of Disease (GBD) report (James et al., 2018) provided

evidence of the impact of musculoskeletal conditions, highlighting the significant disability burden associated with these conditions, with musculoskeletal conditions resulting in the highest level of disability around the world, accounting for 16% of all years lived with disability (Sebbag et al., 2019). The prevalence and impact of musculoskeletal conditions is predicted to rise as the global population ages (James et al., 2018).

One of the most common musculoskeletal conditions is osteoarthritis (OA), which is a highly prevalent and leading cause of chronic disability, WHO reported that more than 40% of the population aged >70 years is diagnosed with knee OA (Leumann et al., 2019). Knee OA can result in pain, decreased physical activity levels, movement limitations and problems performing daily activities which can, in turn, negatively impact on quality of life (Vignon et al., 2006;Colbert et al., 2012; McAlindon et al., 2014; Fransen et al., 2015; Anwer, Alghadir, & Brismée, 2016).

Clinical practice guidelines recommend patient education, strengthening exercises and weight loss for the non-pharmacological management of OA as the first line of management (Tittlemier, Wittmeier, & Webber, 2021). Similarly, the OA Research Society International guidelines (McAlindon et al., 2014) recommend physiotherapy management, self-management and education as first line management strategies (Holden, Haywood, Potia, Gee, & McLean, 2014). However, the success of such exercise programs is reliant on each patient's commitment to their home exercise program (HEP) (Sandra Frances Bassett, 2003). Up to 65% of patients have been shown to be either non-adherent or partially adherent to their HEP, and approximately 10% fail to complete their prescribed program of physiotherapy (Sandra Frances Bassett, 2003). Reduced adherence can result in poorer patient outcomes, including a greater risk of recurrence and progression towards chronic conditions, and increased healthcare costs (Bennell, Dobson, & Hinman, 2014; Marks, 2012; Sandra Frances Bassett, 2003). There are numerous barriers to adherence with a HEP including too many exercises, exercises that are too complex, boring or repetitive, lack of supervision or support, and difficulties contacting care providers to alter or refresh the HEP (Marks, 2012).

A relatively new strategy that may help to increase adherence to HEPs is telerehabilitation (Schäfer, Zalpour, Von Piekartz, Hall, & Paelke, 2018). Technology usage reports indicates that 59% of the world's population is using the internet today ("Digital 2021: Global Overview Report — DataReportal – Global Digital Insights," n.d.). Text message platforms such as WhatsApp have shown promise with respect to facilitating exercise adherence and may be one solution to improve adherence to exercise interventions (Nelligan, Hinman, Kasza, & Bennell, 2019). One study that use text messages for 6 weeks, physical activity, self-efficacy for exercise, perceived benefits of exercise and social support significantly increased; reductions were observed in barriers to exercise and pain (Spoelstra et al., 2015). Other study that use internet-delivered exercise education as intervention of OA both groups showed large clinically relevant improvements in pain and function with benefits still evident over 18 months, (Nelligan et al., 2019), the authors of the research proved the possibility of having improved exercise adherence for OA patients in case of applying technology that is personalized to meet the patient`s needs, in addition to the importance of other motivational behavioral solutions. At present, little is known about the use of a text message platform as an intervention modality to improve adherence with a HEP. Currently, there is limited evidence regarding the use of text message–based

platforms as an intervention to enhance adherence to home exercise programs (HEPs). To our knowledge, no studies have specifically evaluated the effectiveness of such an approach in a Saudi population with knee osteoarthritis (OA).

Therefore, to fill this gap, this study aimed to investigate whether delivering a HEP via a smartphone-based application (WhatsApp), supplemented with motivational text messaging, could improve adherence and influence pain and physical function among adults with knee OA.

Methodology

Study Design, Setting, and Participants

A randomized controlled trial was undertaken where participants were randomly allocated to an intervention or control group using a permuted block randomization method (Broglio, 2018).

The study involved a convenience sample of older adults diagnosed with knee OA. Participants were recruited from King Khalid University Hospital and King Fahad Medical City, two general hospitals in the same geographic area that receive large numbers of the target population from all over Riyadh, Saudi Arabia.

Adults aged 45-65 years with a diagnosis of knee OA (unilateral or bilateral, mild to moderate severity), who were prescribed a HEP and familiar with using smartphone text message apps were eligible for inclusion. Exclusion criteria were pre-existing neurological or unstable cardiopulmonary conditions or those on a waiting list for surgical intervention, those deemed unable to undertake self-management without direct supervision were also excluded (e.g. reduced intellectual ability, psychiatric conditions).

All participants provided informed, written consent. Participants were assessed at baseline by the attending physical therapist, using the study outcome measures, and based on this assessment they received general advice and education about their condition, and a daily standardized HEP for knee OA.

The control group received their HEP as a paper hand-out whilst attending the clinic for the baseline assessment. The intervention group received their HEP via WhatsApp and were also sent motivational text messages by a researcher through WhatsApp five times per week for six weeks.

All participants were instructed to contact their physical therapist if the HEP caused any adverse effects.

Outcomes measures

The primary outcome was the level of adherence with the HEP over the six weeks study period. For the intervention group, this was measured by participants completing an online exercise log via the WhatsApp (Hawley-Hague, Horne, Skelton, & Todd, 2016). Control group participants recorded their exercise log and brought it to the clinic by the end of week 6. Adherence was measured as the number of HEP sessions performed per week. Two or less sessions/week was classified as low adherence, while a ≥3 sessions/week was classified as adherent (Hinman, et al., 2020).

Secondary outcomes comprised knee pain and physical function. Knee pain was assessed using a visual analogue scale (VAS; 0 = no pain, 10 = sever pain). The reliability and construct validity of this scale has been shown to be sufficient to measure the level of pain in adults (Hawker, Mian, Kendzerska, & French, 2011).

Physical functional status and pain was assessed using an Arabic version of the Western Ontario and

McMaster Universities OA Index (WOMAC) physical function scale. The WOMAC is a disease-specific self-report instrument with 17 items in physical function, with a score range of 0= not any and a higher score 4= extreme indicating worse function. The WOMAC has been shown to be valid and reliable and is widely recommended and used in studies of people with knee OA (Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988). The Arabic version of WOMAC has been shown to be valid and reliable (Guermazi et al., 2004).

The secondary outcomes of pain and physical function were measured at baseline and after 6 weeks.

Sample size

The sample size was estimated based on a previous randomized controlled trial (Alasfour & Almarwani, 2020). In that study, adherence to the home-based exercise program was the primary outcome variable. A sample size of 42 participants (21 per group) was determined through an a priori power analysis using G*Power 3 software (Faul, Erdfelder, Lang, & Buchner, 2007), assuming a power of 0.80, a significance level of 0.05, and accounting for a 15% attrition rate. The adherence score was used as the primary variable for sample size estimation.

Ethical Considerations

The study was approved by the institutional review boards at the College of Medicine at King Saud University and King Fahad Medical City May 30,2022 IRP log number: 21-206E. Informed consent was obtained from all participants prior to their involvement in the study. Data were kept confidential and used solely for research purposes.

Statistical analyses

All statistical analyses were conducted using SPSS software, version 26.0 (IBM Corp., Armonk, NY, USA). Data distribution was assessed to determine normality; parametric tests were applied for normally distributed data. Adherence was calculated as the number of completed home exercise program (HEP) sessions recorded in the adherence log divided by the total number of prescribed sessions. An independent samples t-test was used to compare adherence between the intervention and control groups. Analysis of variance (ANOVA) was employed to compare group differences in adherence rate, pain scores, and physical function outcomes. Statistical significance was set at $p < 0.05$.

Results

Study participants

A total of 50 patients were screened for participation. As shown in Figure 1, 42 met the eligibility criteria and were randomized to the control or intervention group. A Shapiro-Wilk Test of Normality revealed that Baseline demographic data were similar between the two groups (Table 1).

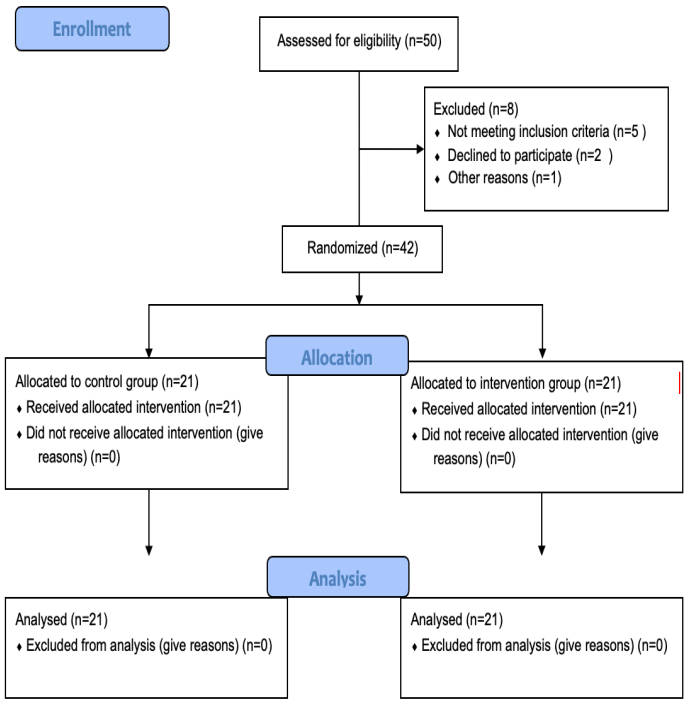

Figure 1. A CONSORT (2010) flow chart depicting the study procedures.

Table 1. Demographic data for the N=42 participants.

Variables	Intervention Group (n=21)	Control Group (n=21)	p-value
Age, years, mean (SD)	53,5(6)	54(5,7)	
Female, number (%)	17 (81)	17 (81)	1.000
Male, number (%)	4 (19)	4 (19)	
Educational level, n (%)			
Not educated	8 (38)	9 (43)	0.105
< High school	5 (24)	0 (0)	
Bachelor degree	3 (14)	6 (29)	
Post-graduate	5 (24)	6 (29)	
Marital status			
Married	17 (81)	20 (95)	1.53
Not married	4 (19)	1 (5)	
Employment status			
Working	8 (38)	17 (81)	1.000
Homemaker	13 (81)	17 (81)	

Main results

Figure 2 depicts the mean number of HEP sessions reported by each group for each week of the six-week study period. At the end of week 6, the mean difference between-groups for the adherence rate were 6,9 sessions in favour of the intervention group, this difference was statistically significant (p= .001) (Figure.2). At week 6 the intervention group remain high adherence to HEP with range of 13-23 sessions per week and the control group were ranged 6-15 sessions per week (Table.2).

The mean of the intervention group was 18 sessions in the week 6 indicated as 3,6 sessions\week which is classified as adherent on the other hand mean of the control group was 11.1 in week 6 indicated as 2 which classified as low adherence.

For VAS pain the mean difference between-groups was not significant at baseline (p = 0.42) but was significant at week 6 (p = 0.017) (Figure 3). There was a significant reduction in VAS pain scores for the intervention group over time.

Figure 2. Box-plot of HEP sessions performed per week for the intervention and control groups.

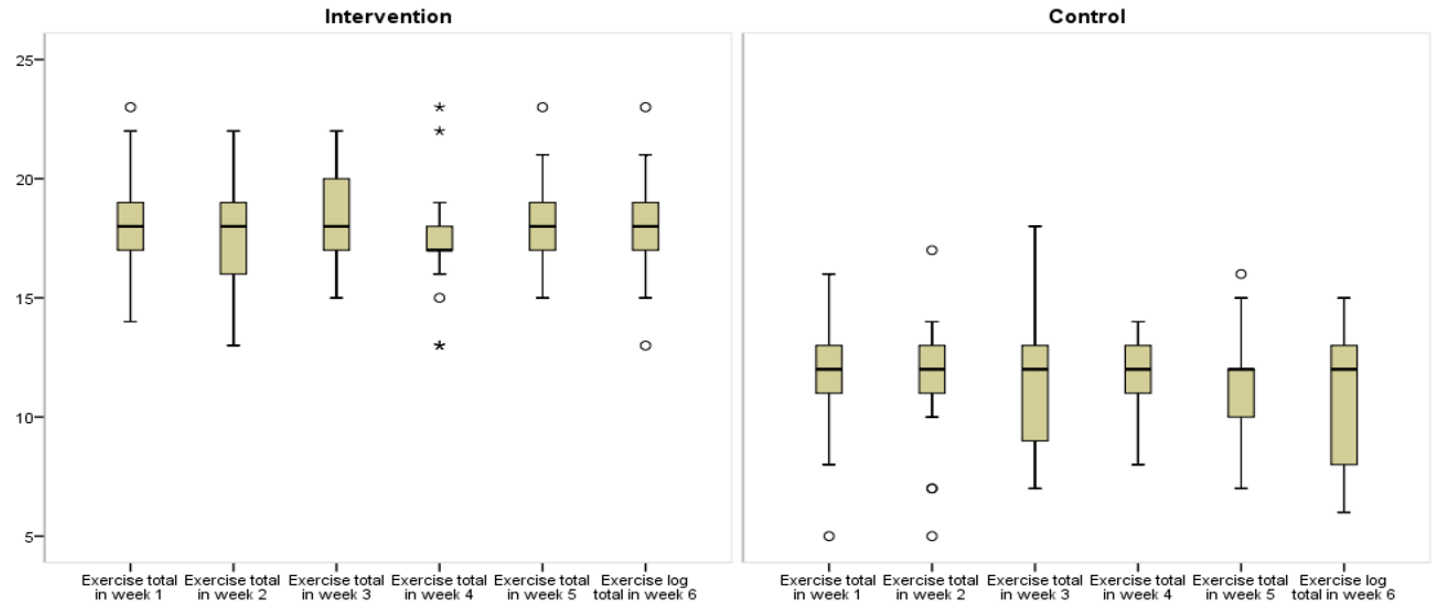

Table 2. The number of home-exercise sessions performed per week among the study groups of Adults with Knee Osteoarthritis

Exercise sessions	Group N=42						p-value
	Intervention			Control			
	Mean	SD	Range	Mean	SD	Range	
Exercise log total in week 1	18.2	2.1	14-23	11.6	2.7	5-16	.001*
Exercise log total in week 2	17.9	2.6	13-22	11.5	2.7	5-17	.001*
Exercise log total in week 3	18.3	1.9	15-22	11.9	3.0	7-18	.001*
Exercise log total in week 4	17.5	2.4	13-23	11.9	1.7	8-14	.001*
Exercise log total in week 5	18.3	1.8	15-23	11.1	2.4	7-16	.001*
Exercise log total in week 6	18.0	2.1	13-23	11.1	2.6	6-15	.001*

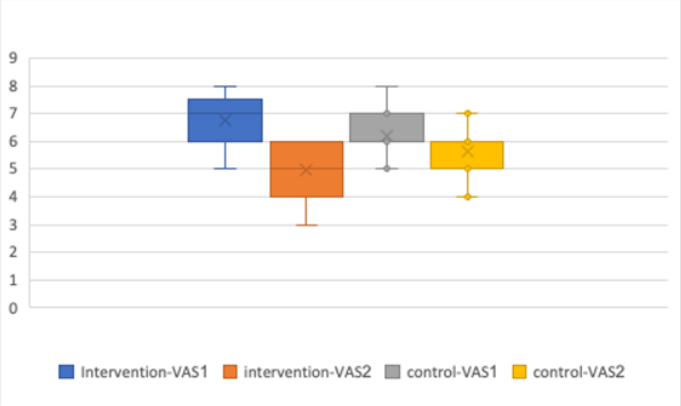

Figure 3. Box-plot of VAS scores for the intervention and control groups (N=42). The results for the pain subscale of the WOMAC are summarized in Table 3. among study groups showed a significant reduction in pain scores after week 6 for the intervention group in pain at rest (*p*=.001) and in pain on weight bearing (*p*=.004) as it shown in Table 3. WOMAC total pain score after week 6 was statistically significant (*p*=.001**)** (Table 4).

Table 3. Pain subscale of the WOMAC for the intervention and control groups (N=42).

Variables	Intervention group		Control group		p value
	Baseline	Week 6	Baseline	Week 6	
Resting pain, n (%)					
None	0 (0)	2 (10)	0 (0)	0 (0)	
Slight	0 (0)	9 (43)	0 (0)	0 (0)	
Moderate	10 (48)	10 (47)	8 (38)	12 (57)	0.001
Very severe	7 (33)	0 (0)	12 (57)	9 (43)	
Extremely severe	4 (19)	0 (0)	1 (5)	0 (0)	
Weight bearing pain, n (%)					
None	0 (0)	1 (5)	0 (0)	0 (0)	
Slight	0 (0)	9 (43)	0 (0)	0 (0)	0.004
Moderate	8 (38)	7 (33)	10 (47)	12 (57)	
Very severe	8 (38)	4 (19)	11 (53)	9 (43)	
Extremely severe	5 (24)	0 (0)	0 (0)		

Table 4. Physical function subscale of WOMAC among study groups of Adults with Knee Osteoarthritis, using exact probability test (N=42).

Variables	Intervention group		Control group		p value
	Baseline	Week 6	Baseline	Week 6	
Getting in / out of car, n (%)					
None	0 (0)	0 (0)	0 (0)	0 (0)	
Slight	0 (0)	10 (47)	0 (0)	2 (10)	
Moderate	7 (33)	9 (43)	8 (38)	11 (52)	0.010*
Very severe	12 (57)	2 (10)	13 (62)	8 (38)	
Extremely severe	2 (10)	0 (0)	0 (0)	0 (0)	
Going shopping, n (%)					
None	0 (0)	0 (0)	0 (0)	0 (0)	
Slight	0 (0)	8 (38)	0 (0)	2 (10)	0.027*
Moderate	8 (38)	12 (57)	9 (43)	13 (62)	
Very severe	11 (52)	1 (5)	12 (57)	6 (28)	
Extremely severe	2 (10)	0 (0)	0 (0)	0 (0)	
Walking on flat surface, n (%)					
None	0 (0)	0 (0)	0 (0)	0 (0)	
Slight	0 (0)	10 (47)	1 (5)	3 (15)	0.044*
Moderate	8 (38)	8 (38)	10 (47.5)	10 (47)	
Very severe	11 (52)	3 (15)	10 (47.5)	8 (38)	
Extremely severe	2 (10)	0 (0)	0 (0)	0 (0)	
Getting in/out of bath, n (%)					
None	0 (0)	0 (0)	0 (0)	0 (0)	
Slight	1 (5)	11 (53)	0 (0)	2 (10)	0.007*
Moderate	8 (38)	10 (47)	10 (47)	17 (80)	
Very severe	11 (52)	0 (0)	11 (53)	2 (10)	
Extremely severe	1 (5)	0 (0)	0 (0)	0 (0)	
Sitting, n (%)					
None	0 (0)	1 (5)	0 (0)	0 (0)	
Slight	0 (0)	8 (38)	0 (0)	0 (0)	0.001*
Moderate	11 (53)	12 (57)	11 (53)	10 (47)	
Very severe	10 (47)	0 (0)	10 (47)	11 (53)	
Extremely severe	0 (0)	0 (0)	0 (0)	0 (0)	
Getting on/off toilet, n (%)					
None	0 (0)	0 (0)	0 (0)	0 (0)	
Slight	0 (0)	7 (33)	0 (0)	0 (0)	0.005*
Moderate	8 (38)	12 (57)	12 (57)	13 (62)	
Very severe	11 (53)	2 (10)	9 (43)	8 (38)	
Extremely severe	2 (10)	0 (0)	0 (0)	0 (0)	
Heavy domestic duties, n (%)					
None	0 (0)	1 (5)	0 (0)	0 (0)	
Slight	0 (0)	8 (38)	0 (0)	0 (0)	0.006*
Moderate	7 (33)	9 (42)	11 (53)	12 (57)	
Very severe	13 (62)	3 (15)	10 (47)	9 (43)	
Extremely severe	1 (5)	0 (0)	0 (0)	0 (0)	
Light domestic duties, n (%)					
None	0 (0)	0 (0)	0 (0)	0 (0)	
Slight	0 (0)	9 (43)	0 (0)	0 (0)	0.001*
Moderate	9 (43)	10 (47)	8 (38)	9 (43)	
Very severe	11 (52)	2 (10)	13 (62)	12 (57)	
Extremely severe	1 (5)	0 (0)	0 (0)	0 (0)	

P: Exact probability test ** P < 0.05 (significant)*

Table 5. WOMAC subscale among study groups of Adults with Knee Osteoarthritis, using an Independent samples t-test (N=42).

WOMAC subscale	Intervention group		Control group		p value
	Baseline	Week 6	Baseline	Week 6	
	Mean, SD, Range	Mean, SD, Range	Mean, SD, Range	Mean, SD, Range	
Pain scores	13.7, 2, 10-18	8, 2.1, 4-12	13.2, 1.5, 11-17	11.6, 1.5, 9-15	0.001*
WOMAC total physical function score	72,8, 9.7 44-89	27.8, 3.7 21-34	77.1, 5, 67-85	36.4, 2.8, 32-41	0.001*
WOMAC total score	92, 11 59-110	38.7, 5 28-48	96.4, 5.4 86-105	53.7, 3.7 46-61	0.001*

* P < 0.05 (significant)

As shown in Table 3, there were no significant differences between-groups for the WOMAC physical function scores at baseline. However, by week 6 significant differences between-groups were seen for all items with the intervention group showing better physical function than the control group. Similarly, as shown in Table 4, the intervention group demonstrated significantly lower values for pain scores, total physical function scores and total scores for the WOMAC than the control group, representing less pain and better physical function.

Table 5 presents the comparison of WOMAC subscale scores between the intervention and control groups at baseline and after 6 weeks. At baseline, there were no significant differences in pain, physical function, or total WOMAC scores between the groups. However, after 6 weeks, the intervention group showed a statistically significant improvement across all WOMAC domains.

Specifically, the pain scores in the intervention group decreased markedly from a mean of 13.7 ± 2 (range: 10–18) at baseline to 8 ± 2.1 (range: 4–12), compared to a more modest reduction in the control group from 13.2 ± 1.5 (range: 11–17) to 11.6 ± 1.5 (range: 9–15). This difference was statistically significant (p = 0.001).

For the WOMAC physical function score, the intervention group demonstrated a substantial decline from 72.8 ± 9.7 (range: 44–89) at baseline to 27.8 ± 3.7 (range: 21–34) at week 6. In contrast, the control group decreased from 77.1 ± 5.0 (range: 67–85) to 36.4 ± 2.8 (range: 32–41), also with a statistically significant difference (p = 0.001).

The total WOMAC score also followed a similar trend, with the intervention group improving from 92 ± 11 (range: 59–110) to 38.7 ± 5 (range: 28–48), whereas the control group improved from 96.4 ± 5.4 (range: 86–105) to 53.7 ± 3.7 (range: 46–61). The between-group difference at 6 weeks was statistically significant (p = 0.001).

These findings suggest that the intervention was effective in significantly reducing pain and improving physical function and overall knee-related health status in adults with knee osteoarthritis.

Discussion

This randomized controlled trial investigated the effect of using a smartphone-based intervention, including a HEP and text messaging via the WhatsApp application, on adherence to the HEP, pain and physical function among adults with knee osteoarthritis. Using the WhatsApp intervention resulted in significantly better rates of adherence with the HEP, reduced pain and improved physical function compared to the control group.

Our finding of improved rates of adherence with the HEP for the intervention group is important and may be explained by the ease of communication that the use of WhatsApp enabled between the participant and therapist. These results are similar to those reported previously where, for example, a web-based exercise program improved exercise adherence compared with usual clinical practice for adults with musculoskeletal conditions (Bennell et al., 2019). A recent systematic review evaluated the use of eHealth as an intervention for patients with knee OA, with the eHealth including components such as education, counselling, encouragement, found it resulted in improved adherence to a HEP, reduced pain and improved physical function in patients with knee OA (Schäfer et al., 2018). However, our finding contrasts that of a study by Nelson (2017) who found that an online intervention to facilitate rehabilitation following total knee or hip replacement was less successful because their older sample of patients felt less comfortable in using the required technology, and preferred using booklets to guide their HEP.

An important point to raise is that some Saudi women find it difficult to adhere to HEPs due to social barriers such as responsibilities in taking care of the family, difficulty with transportation, lack of time, household responsibilities, and the commitment to social duties that overrule their need to take care of themselves (Al-Eisa, 2010). Using smartphone-based technology may be a particularly effective method to overcome such barriers in this setting.

Limitations

This study had several important limitations. First, the relatively small sample size limits the generalizability of the findings. Second, the sample was predominantly female, which may introduce gender bias and limit applicability to the broader knee osteoarthritis (OA) population. Third, the follow-up period was relatively short, restricting insights into the long-term sustainability of the intervention's effects. Additionally, adherence to the home exercise program (HEP) was self-reported—a method commonly used in previous studies, but one with uncertain reliability. Therefore, future studies should aim to include larger, more diverse samples with longer follow-up periods and objective adherence measures.

Future Implications

Despite these limitations, the findings suggest that integrating smartphone-based platforms, such as WhatsApp, into clinical practice may offer a practical and scalable approach to improving adherence to HEPs. Primary care physicians and physiotherapists could incorporate such tools into first-line interventions. Moreover, future iterations of digital health tools may incorporate features that enable real-time monitoring and engagement, potentially enhancing long-term participation and outcomes.

Conclusion

This study demonstrated that delivering a home exercise program via a smartphone application with motivational text messaging may effectively enhance adherence, reduce pain, and improve physical function in older adults with knee OA. These findings support the potential role of mobile health technologies in musculoskeletal rehabilitation strategies.

Author Contributions

All authors significantly contributed to the work reported, including conception, study design, execution, data acquisition, analysis, and interpretation. They actively participated in drafting, revising, or critically reviewing the manuscript, provided final approval of the version

to be published, agreed on the journal submission, and accepted accountability for all aspects of the work.

Data Availability Statement

The authors will transparently provide the primary data underpinning the findings or conclusions of this article, without any unjustified reluctance. If need from editorial team.

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Conflicts of Interest

The authors declare no potential conflicts of interest related to the research, writing, or publication of this work.

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