Does a home-based exercise program play any role in the treatment of knee osteoarthritis? A meta-analysis

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Abstract

Background. Knee-osteoarthritis is a very common joint disorder, affecting about 85% of the population worldwide. The effectiveness of home-based exercises is still debatable, with many studies indicating positive outcomes with few side effects, while others find them of limited utility.

Objectives. To assess the role of home-based exercise (HBE) programs in the treatment of knee osteoarthritis.

Materials and methods. Randomized controlled trials were included as per the predefined Population, Intervention, Comparison, Outcomes and Study (PICOS) criteria. Demographic summaries and event data for osteoarthritis therapy in the exercise and control groups were assessed, and comparative efficacy was evaluated using clustered graphs. The RevMan software was used to calculate the odds ratio (OR) and risk ratio of the included studies. The risk of bias was also evaluated and heterogeneity analysis was performed.

Results. Fifteen clinical trials performed from 2000 to 2022, with a total of 2922 osteoarthritis patients, were included in the study, according to the chosen inclusion criteria. We observed a reduction in Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores but a more marked improvement in clinical symptoms in the exercise group. The Knee Injury and Osteoarthritis Outcome Score (KOOS) increased only in the exercise group and not in the control group. We obtained a pooled OR of 0.59 (95% confidence interval (95% CI): 0.36–0.98), T^2 value of 0.88, χ^2 value of 185.41, degrees of freedom (df) value of 14, I^2 value of 92%, and p-value <0.00001. The overall Z effect was 2.04 with a p-value of 0.04. The pooled risk ratio was 0.81 (95% CI: 0.66–0.99) with a T^2 value of 0.14, χ^2 value of 191.53, df value of 14, I^2 value of 93%, and p-value <0.00001.

Conclusions. The data from the studies included in this meta-analysis are in favor of the use of HBEs for the treatment of knee osteoarthritis.

Key words: knee osteoarthritis, home-based exercises, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, knee injury, Knee Injury and Osteoarthritis Outcome Score (KOOS)

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Introduction

Knee osteoarthritis is a very common joint disorder that affects approx. 85% of the population worldwide, mostly adults over 50 years of age.[1] Knee osteoarthritis is a medical condition in which the flexible and slippery articular cartilage of the knee that normally protects the joint becomes degenerated.[2] Due to this degeneration, the joint undergoes friction and impaction, which ultimately leads to pain and stiffness.[3] The main clinical symptoms of knee osteoarthritis are joint stiffness, difficulty walking and swelling. Knee osteoarthritis can be hereditary or caused by increasing age, elevated weight, hormonal disturbances, and athletic injuries.[4] For its treatment, various pain-relieving medications, anti-inflammatory drugs, supporting braces, and exercises can be used. In extreme cases when knee osteoarthritis results from a fall, trauma, accident, or high impact motor vehicle collision, knee injuries occur to one or more tissues that make up the knee joint, including ligaments, cartilage, muscles, or knee bones; a knee replacement surgery is recommended in these cases.[5] Since medications are associated with adverse side effects, such as indigestion and dry mouth, as well as a high cost of supporting braces and complexity of surgical procedures, home-based exercises (HBEs) may be considered an effective alternative to alleviate the symptoms of knee osteoarthritis.[6]

For example, Thomas[7] and Thorstensson et al.[8] reported that exercise can significantly reduce the clinical symptoms associated with knee osteoarthritis. Thorstensson et al. suggested exercises such as one-leg hop, lateral step-up, one-leg semi-squatting, and heel-raising.[8] Similarly, Doi et al. concluded that quadricep strengthening HBEs can effectively improve knee osteoarthritis.[9] Knoop et al. recommend muscle strengthening exercises as an effective method to alleviate the symptoms of knee osteoarthritis.[10] Similarly, Williams et al. support an internet-based exercise training program.[11] Unlike Bennel et al.,[12] Kuntz et al.[13] advocate biomechanically-based yoga exercises. Shellington et al.[14] advocate the so-called square-stepping exercise, and Choi and Lee[15] recommend knee joint traction therapy. Nelligan et al. determined that lower limb strengthening exercise programs, such as seated knee extension, walk squats, hip abduction, and calf raises, are effective treatment methods.[16] Consistent with these studies, in the randomized controlled clinical trials by Allen et al., the authors described the effectiveness of a Stepped Exercise Program for Patients with Knee Osteoarthritis (STEP-KOA).[17] Rewald et al.[18] suggest aquatic cycling exercises and swimming, and Makarm et al.[19] support stretching for the hamstring and quadriceps muscles as effective strengthening HBE programs. Thiengwittayaporn et al.[20] support knee bending exercises, and Gohir et al.[21] mention hamstring and quadricep muscle-strengthening exercise programs as effective ways to reduce the symptoms associated with knee osteoarthritis.

Although there are numerous supporting studies, the effectiveness of HBEs is still debated, as some studies report that they have limited efficacy. Therefore, this study aimed to thoroughly analyze the available randomized controlled trials on the use of HBE programs for the treatment of knee osteoarthritis and to predict the outcome of the analysis.

Objectives

The goal of this meta-analysis was to assess the role of HBE programs in the treatment of knee osteoarthritis.

Materials and methods

We followed the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) normative recommendations in this study with the registration No. SYSU//IRB//2021//554. All procedures performed in this study were according to the institutional and/or national research standards and followed the 1964 Declaration of Helsinki and its later amendments.

Search strategy

This meta-analysis was based on an extensive search conducted in the databases of MEDLINE (via PubMed), CINAHL (via EBSCO), Scopus, and Web of Science, and covered the years 2000–2022. The following key words were used for searching the relevant studies: [knee osteoarthritis], [joint disorder], [home-based exercises], [randomized controlled trial], [WOMAC score], [and KOOS score]. All the included articles were selected following the PRISMA guidelines. The studies were selected randomly irrespective of the language, publication status or type of study (prospective, retrospective or clinical trial). A demographic summary of the patients with event data extracted from the included studies is summarized in Table 1.[7–21]

To assess the efficacy and safety of HBEs for the treatment of mild to moderate knee osteoarthritis in comparison with various pain relievers, data from randomized controlled trials were extracted. In these studies, patients from different age groups were treated with different exercises or control treatments; their Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Knee Injury and Osteoarthritis Outcome Score (KOOS) were measured, and changes in clinical symptoms were observed. Statistical parameters, such as diagnostic odds ratio (OR) and risk ratio with 95% confidence intervals (95% CIs), were calculated with the help of RevMan software (Cochrane, London, UK), and their respective forest plots were drawn.

Two authors (JW and DX) separately scanned the relevant sources for related studies. The full-text articles of the sources were collected when possible, while abstracts were used only if they provided sufficient information for the meta-analysis. Obsolete references were excluded, and

Table 1. Demographic summary of the included studies

Study and year	Journal	Type of study	Sample size	Age of patients [years]	Gender F/M	Duration of study	Improvement of assessment parameter	Exercise group			Control group		
								inter-vention arm	pre-treatment score	post-treatment score	control arm	pre-treatment score	post-treatment score
Thomas 2002	*British Medical Journal*	randomized controlled trial	786	50–70	126/74	24 months	WOMAC	78/199	11.96 ±3.54	6.96 ±3.54	121/199	13.06 ±3.44	7.04 ±3.67
Thorstensson et al. 2005	*BMC Musculoskeletal Disorders*	randomized controlled trial	69	36–65	31/30	6 weeks	KOOS	31/61	60 ±18	61.8 ±18	30/61	64 ±19	62.7 ±19
Doi et al. 2008	*American Journal of Physical Medicine & Rehabilitation*	randomized controlled trial	142	50–80	90/31	8 weeks	WOMAC	58/121	22.85 ±16.79	13.69 ±13.47	63/121	25.95 ±15.88	18.59 ±16.38
Knoop et al. 2013	*Osteoarthritis and Cartilage*	randomized controlled trial	159	55–70	97/62	12 weeks	WOMAC	79/159	25.2 ±11.8	17.4 ±11.6	80/159	27.1 ±12.7	19.3 ±11.4
Williams et al. 2015	*BMC Musculoskeletal Disorders*	randomized controlled trial	350	>60	–	4 months	WOMAC	70/350	6.5 ±17.5	6.1 ±17.5	280/350	6.5 ±17.5	6.75 ±17.5
Bennell et al. 2016	*Arthritis Care & Research*	randomized controlled trial	222	52–70	89/60	52 weeks	WOMAC	74/149	34.3 ±7.2	18.1 ±11.2	75/149	35.0 ±7.4	21.30 ±9.8
Kuntz et al. 2018	*PLOS ONE*	randomized controlled trial	59	55–80	31 F	12 weeks	KOOS	10/31	48.8 ±12.4	70.3 ±12.8	21/31	52.0 ±17.9	49.9 ±24.7
Shellington et al. 2019	*Canadian Journal on Aging*	pilot randomized controlled trial	22	60–70	15/7	24 weeks	WOMAC	10/22	32.5 ±5.7	30.0 ±5.7	12/22	24.7 ±6.7	22.6 ±6.7
Choi and Lee 2019	*The Journal of Korean Physical Therapy*	randomized controlled trial	30	60–72	15/15	4 weeks	WOMAC	15/30	47.20 ±1.65	25.33 ±2.38	15/30	44.13 ±2.29	35.26 ±2.76
Nelligan et al. 2019	*BMC Musculoskeletal Disorders*	randomized controlled trial	206	>45	–	24 weeks	WOMAC	102/206	6.3 ±11.5	2.3 ±11.5	104/206	6.5 ±11.5	5.5 ±10.5
Allen et al. 2019	*BMC Musculoskeletal Disorders*	randomized controlled trial	345	>40	–	9 months	WOMAC	300/345	6.5 ±17.5	5.2 ±17.5	336/345	6.5 ±17.5	6.1 ±17.5
Rewald et al. 2020	*Archives of Physical Medicine and Rehabilitation*	randomized controlled trial	111	50–70	–	12 weeks	KOOS	47/111	56.96 ±12.96	63.55 ±15.33	55/111	57.89 ±15.26	57.24 ±19.16
Makarm et al. 2021	*Egyptian Rheumatology and Rehabilitation*	randomized controlled clinical study	210	40–65	161/49	6 months	VAS	104/210	58.29 ±17.4	41.4 ±14.2	106/210	61.2 ±13.7	60.9 ±14.7
Thiengwittayaporn et al. 2021	*Archives of Orthopaedic and Trauma Surgery*	randomized controlled trial	106	40–80	73/9	4 weeks	KOOS	40/82	67.3 ±13.3	70.7 ±11.0	42/82	65.3 ±4.1	62.0 ±5.2
Gohir et al. 2021	*JAMA Network Open*	randomized clinical trial	105	>45	71/34	6 weeks	WOMAC	48/103	8.0 ±3.9	5.1 ±3.8	57/103	7.8 ±3.7	6.0 ±3.7

WOMAC – Western Ontario and McMaster Universities Arthritis Index; KOOS – Knee Injury and Osteoarthritis Outcome Score; VAS – Visual Analogue Scale.

useful studies were included as per the inclusion criteria. Event data with useful variables were collected independently by 2 researchers (ZC and ML).

Inclusion and exclusion criteria

Studies were included if they reported the safety and efficacy of HBEs for the treatment of patients with mild to moderate knee osteoarthritis. Studies were selected within the timeframe from 2000 to 2022 and abstracts were utilized only when they had provided the sufficient information for meta-analysis, while studies with insufficient data, studies reporting only the use of medicines and surgeries (without exercises), and studies published before 2000 were excluded, as shown in Fig. 1.

Evaluation of the analytical standard

Two reviewers (JW and DX) separately evaluated the methodological validity of the included studies and calculated the heterogeneity of the included experiments. One author (BC) was responsible for resolving any disagreements between the authors. To evaluate heterogeneity, Cochran's Q statistic and the I^2 index in a random bivariate model were calculated with the help of RevMan software. The Deeks' funnel plot for publication bias was drawn with the help of MedCalc software (MedCalc Software Ltd., Ostend, Belgium). A risk of bias summary and a graph for the assessment of the risk of bias were made using RevMan software. To compare the changes in WOMAC and KOOS scores pre- and post-treatment with the exercise and control strategies, clustered bar graphs were plotted.

Sources of heterogeneity

The investigated heterogeneity sources included the use of full-text publications compared to abstracts, randomized controlled trials compared to retrospective studies, varied age groups and different numbers of patients, variable duration of treatment, different scales of analysis, and the comparison of HBEs with different control treatment methods.

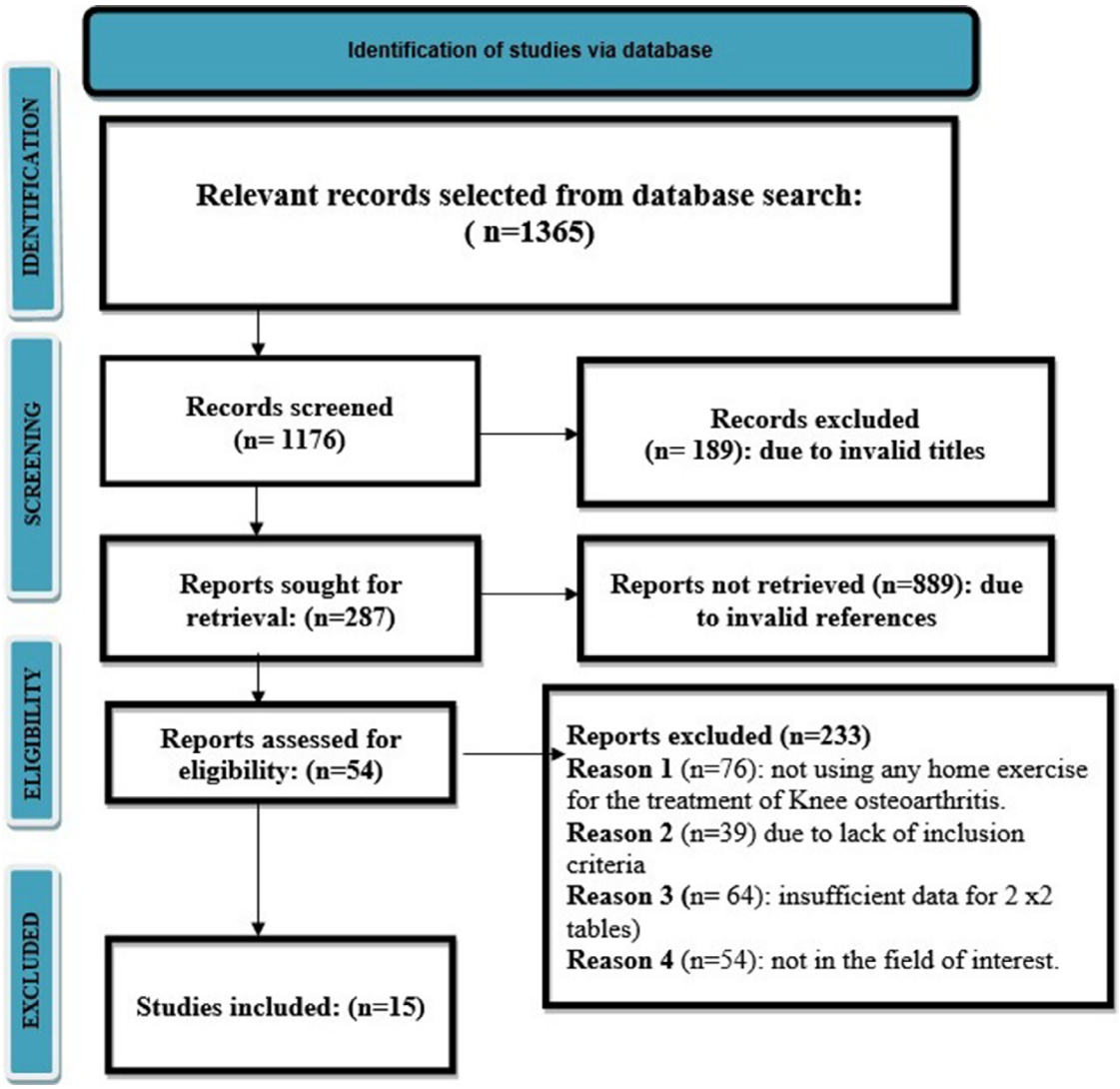


Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram of the study group

Statistical analyses

The diagnostic OR and relative risk were calculated using the DerSimonian–Laird technique. For this, a 2×2 table was created, and a meta-analysis was conducted using RevMan software. The pooled diagnostic OR value and pooled relative risk value were calculated with 95% CIs and respective forest plots. The heterogeneity of the studies was calculated in terms of the T^2 value, χ^2 value, Z value, and p-value using the Mantel–Haenszel method with random effects with RevMan software. The Deeks' funnel plot was constructed to assess the publication bias using MedCalc software, and the p-value was determined using Begg's test and Egger's test. The risk of bias summary and the risk of bias graph were assessed with RevMan software. To compare the changes in WOMAC and KOOS of patients who use either HBEs or any of the control methods, clustered bar graphs were plotted.

Results

Literature search results

A total of 1365 studies were found in the databases. Among these studies, we excluded 189 studies by reading their titles and abstracts, and thus 1176 records remained to be screened. Due to invalid references and duplicity, further 889 studies were excluded, leaving only 287 studies for the final screening. Of these 287 studies, 233 more were excluded: 76 on the basis of inadequate evidence, 39 due to the lack of inclusion criteria, 64 due to insufficient data, and 54 due to inappropriate data. Then, 2×2 tables were created for review. The eligibility of the remaining 54 studies was assessed further. Finally, 15 eligible studies that fulfilled the inclusion criteria (i.e., the use of different HBEs compared to control strategies) were used for the meta-analysis, as shown in Fig. 1.

Demographic details

The demographic details of the studies included in this meta-analysis are shown in Table 1. It provides the author of the study, year of publication, journal of publication, duration of the study, total sample size, age of the patients, gender of the patients, positive outcomes in the exercise and control groups, and mean values of pre- and post-treatment WOMAC and KOOS, along with their standard deviations (SDs). Fifteen randomized controlled clinical trials encompassing a total of 2922 knee osteoarthritis patients were included according to the inclusion criteria for the years 2000–2022. The included studies enrolled adult patients of different age groups who were chosen randomly and treated with either HBEs or control methods, such as placebo, pain relieving medications or joint supporters.

Risk of bias analysis

The meta-analysis was performed using RevMan software. The risk of bias for the included studies was assessed and is shown in Table 2. This study has a low risk of bias, as evident from the risk of bias graph shown in Fig. 2, and the resulting risk of bias is summarized in Fig. 3. The summarized values are suggestive of a random sampling of data and the use of categorical study variables. This meta-analysis has a low risk of publication bias, as apparent from the Deeks' funnel plot (Fig. 4). We obtained a significance level or p-value of 0.3 for Begg's test and 0.5 for Egger's test, indicating no evidence of publication bias.

Statistical parameters and heterogeneity

The OR was calculated using RevMan software to assess the effect of HBEs on knee osteoarthritis patients compared to the outcomes of standard control methods. The forest plot of the ORs and heterogeneity of the data are

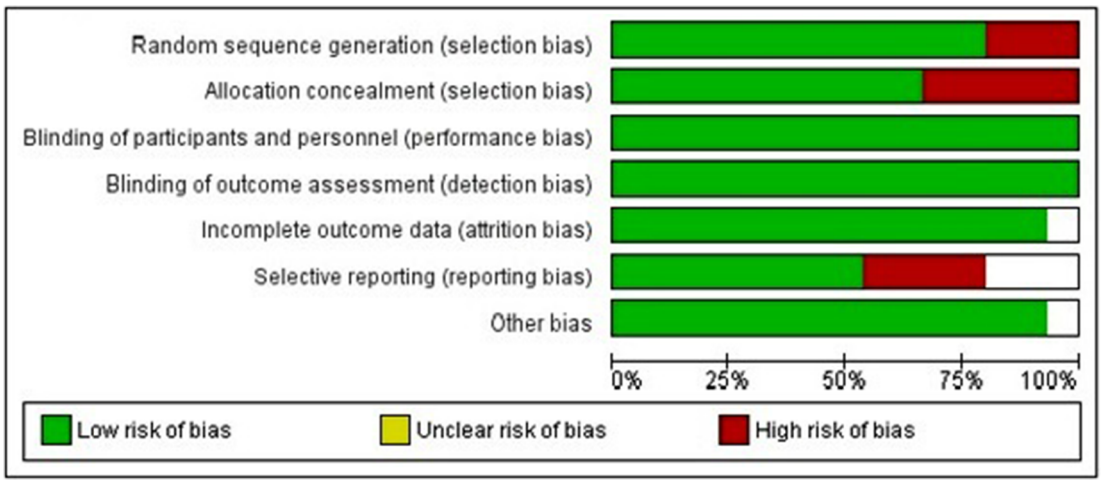


Fig. 2. Risk of bias summary

Table 2. Risk assessment for the included studies

Question	Thomas 2002	Thorstensson et al. 2005	Doi et al. 2008	Knoop et al. 2013	Williams et al. 2015	Bennell et al. 2016	Kuntz et al. 2018	Shellington et al. 2019	Choi and Lee 2019	Nelligan et al. 2019	Allen et al. 2019	Rewald et al. 2020	Makarm et al. 2021	Thiengwittayaporn et al. 2021	Gohir et al. 2021
Was the sample of enrolled patients consecutive or random?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Did the study avoid inappropriate exclusions?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Did all patients receive the same reference standard?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were all patients included in the analysis?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Was the sample frame appropriate to address the target population?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were study participants sampled in an appropriate way?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were the study subjects and the setting described in detail?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were valid methods used for the identification of the condition?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was the condition measured in a standard, reliable way for all participants?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Was an appropriate statistical analysis conducted?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

presented in Fig. 5. We obtained a pooled OR value of 0.59 (95% CI: 0.36–0.98), T^2 value of 0.88, χ^2 value of 185.41, degrees of freedom (df) value of 14, I^2 value of 92%, and p-value <0.00001. The overall Z effect was 2.04, with a p-value of 0.04. A value of $p < 0.05$ indicates the statistical significance of the data, and a value of OR < 1 is indicative of the protective exposure of an HBE program for the treatment of knee osteoarthritis compared to control strategies; thus, it can be determined that HBEs are a worthwhile treatment method with minimal side effects.

The risk ratio of the included studies was also calculated using RevMan software, and the respective forest plot is shown in Fig. 6. The pooled risk ratio was 0.81 (95% CI: 0.66–0.99) with a T^2 value of 0.14, χ^2 value of 191.53, df value of 14, I^2 value of 93%, and p-value <0.00001. The overall Z effect was 2.06, with a p-value of 0.04. A risk ratio value of less than 1 proves that the use of different HBEs is associated with low risk and is very protective and safe.

An I^2 value above 90% for both the OR and risk ratio is suggestive of substantial heterogeneity of the included studies with low bias. A value of $p < 0.05$ indicates a statistical significance and reflects the high treatment efficacy of HBEs for knee osteoarthritis.

Comparative efficacy of exercise compared to control methods

The patients were randomized into 2 arms: the exercise group and the control group. In both groups, the changes

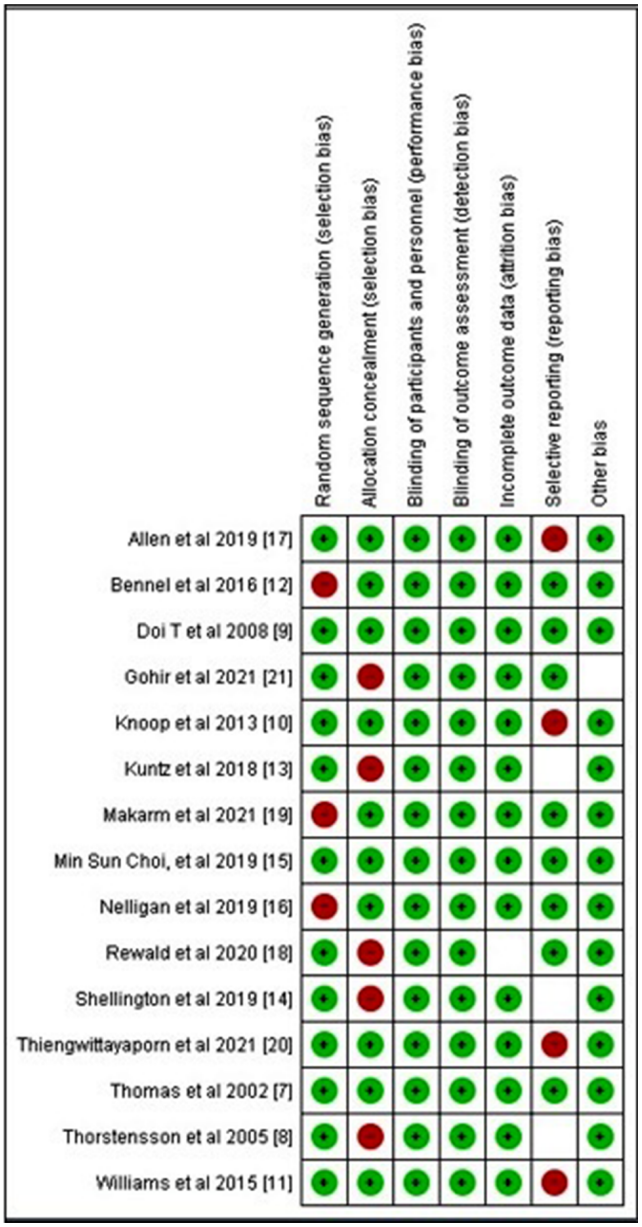


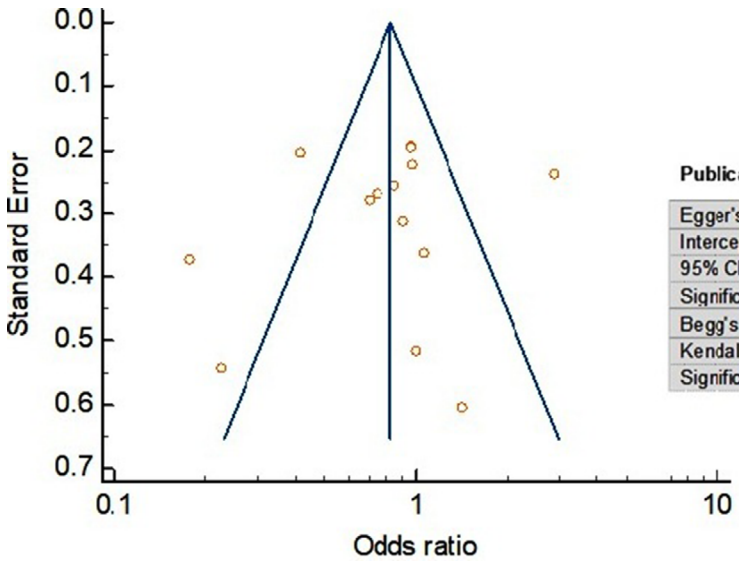
Fig. 3. Risk of bias graph

in KOOS and reductions in WOMAC were calculated, and comparative clustered graphs were designed. A low KOOS indicates extreme difficulty due to knee osteoarthritis, while a high KOOS represents no problems due to knee osteoarthritis. The clustered graph for KOOS (Fig. 7) showed that the score increased in the exercise groups but decreased in the control groups. This proves that exercise improves the pain and other clinical symptoms of knee osteoarthritis more effectively than control methods. Similarly, the clustered graph for reduced WOMAC scores (Fig. 8) showed a reduction in WOMAC scores in both groups, but the reduction was more pronounced in the exercise group. The higher the WOMAC score, the worse the pain, joint stiffness and functional ability limitations. When patients start performing a suitable HBE program, their WOMAC scores decrease (i.e., their pain and stiffness subside and their mobility improves). As shown in these plots, HBEs provide rapid and effective recovery from knee osteoarthritis, with minimal adverse side effects.

Combining all these results, it is clear that HBEs are safe, affordable and highly successful treatment strategies for knee osteoarthritis. Since they can reduce WOMAC scores and increase KOOS scores significantly, this study highly recommends the use of HBEs for the treatment of knee osteoarthritis.

Discussion

Knee osteoarthritis is a very common medical ailment affecting most of the adult population between 40 and 70 years of age. Due to an increased work stress and unhealthy lifestyles, weight gain and hormonal imbalances are common, leading to knee osteoarthritis or other joint disorders. This results in issues such as joint stiffness, difficulty walking and pain during movements. For



Publication bias

Egger's test	
Intercept	-1.3246
95% CI	-5.3767 to 2.7275
Significance level	P = 0.4925
Begg's test	
Kendall's Tau	-0.1923
Significance level	P = 0.3177

Fig. 4. Funnel plot for publication bias

95% CI – 95% confidence interval.

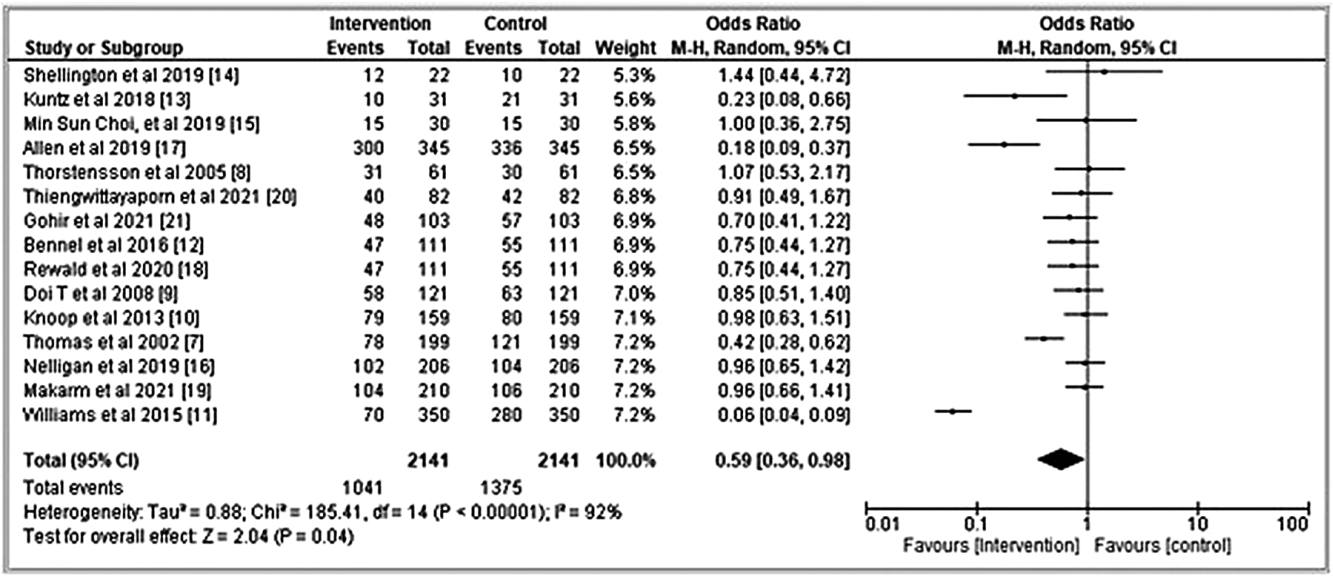


Fig. 5. Forest plot OR

OR – odds ratio; 95% CI – 95% confidence interval; M–H – Mantel–Haenszel method.

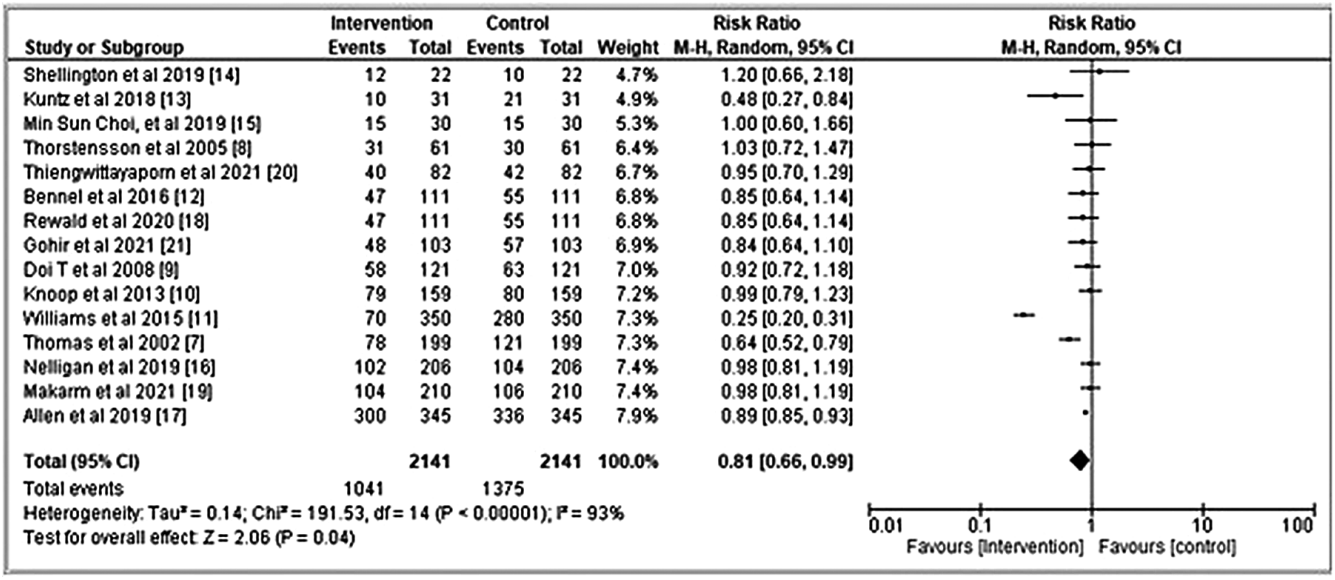
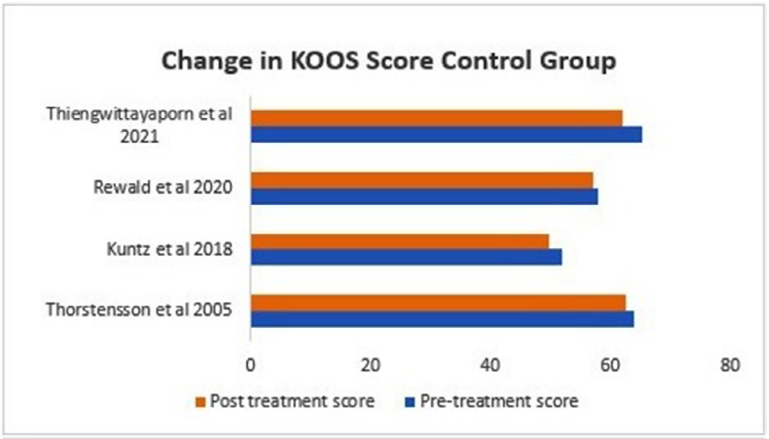


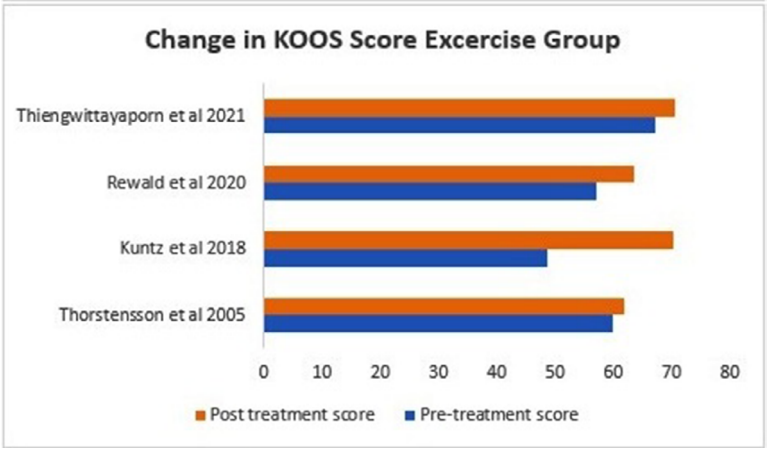
Fig. 6. Forest plot risk ratio

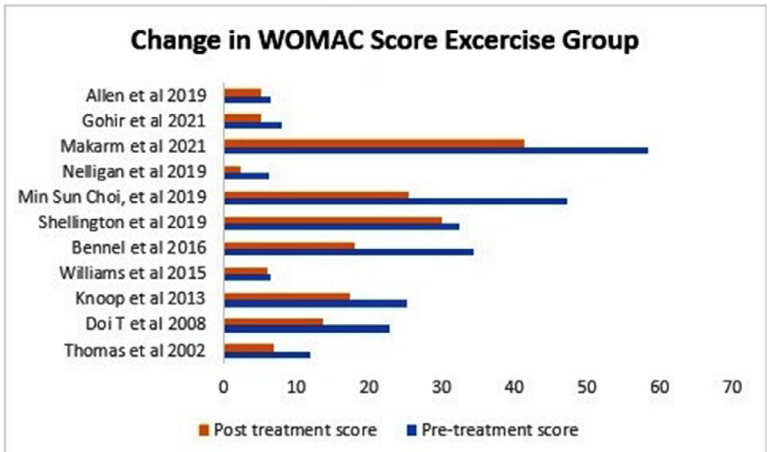
95% CI – 95% confidence interval; M–H – Mantel–Haenszel method.

the treatment of clinical symptoms associated with osteoarthritis, pain-relieving medications to alleviate pain, anti-inflammatory drugs to reduce swelling, and support braces for comfortable walking are available[22]; however, these can be expensive and may be associated with side effects.

Home-based exercise programs, including muscle strengthening and weight loss exercises, are safe, affordable and effective ways to substantially reduce the clinical symptoms of knee osteoarthritis. In a review published in 2005, Roddy et al. reported that home-based quadricep strengthening exercises and aerobic walking are the best treatment methods to reduce the pain and disability of knee osteoarthritis.[23] Similarly, in their systematic review and meta-analysis, Li et al. preferred HBEs as an effective treatment strategy.[24] Swimming and pool exercises are considered highly advantageous for patients with knee osteoarthritis. However, in contrast to these supporting studies, Messier et al. in their randomized controlled trial reported that high-intensity muscle strengthening exercises did not reduce knee pain effectively.[25] In 2009, Bosomworth reported the potential benefits and hazards of HBEs, and asserted that patients with knee osteoarthritis should not perform activities that put extensive strain on their joints, such as running, jumping, and sports like tennis and basketball.[26]







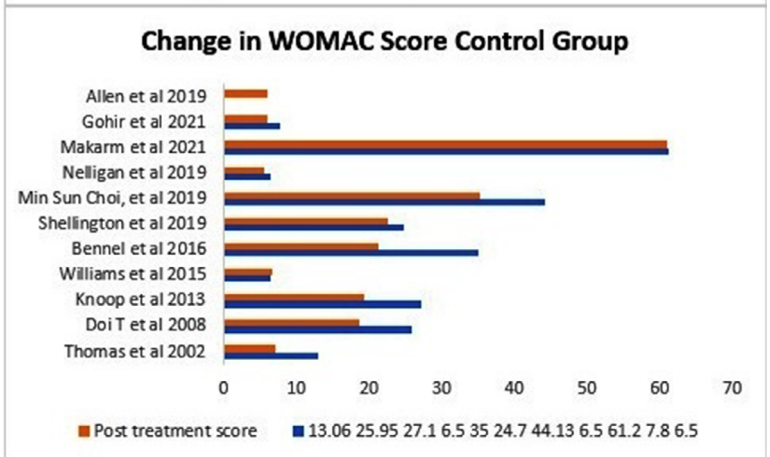


Fig. 7. Change in Knee Injury and Osteoarthritis Outcome Score (KOOS) pre- and post-treatment

To resolve these conflicting conclusions regarding the use of HBE programs for the treatment of knee osteoarthritis, this meta-analysis analyzed the available literature and performed a statistical meta-analysis. We obtained a pooled OR value of 0.59 (95% CI: 0.36–0.98), T^2 value of 0.88, χ^2 value of 185.41, df value of 14, I^2 value of 92%, and p-value <0.00001. The overall Z effect was 2.04, with a p-value of 0.04. The pooled risk ratio was 0.81 (95% CI: 0.66–0.99) with a T^2 value of 0.14, χ^2 value of 191.53, df value of 14, I^2 value of 93%, and p-value <0.00001. The overall Z effect was 2.06, with a p-value of 0.04. All these values are statistically significant. A value of $p < 0.05$ reflects the high treatment efficacy of HBEs for knee osteoarthritis. Similarly, the clustered graphs comparing the changes in WOMAC and KOOS scores also prove the superiority of exercise over the control treatment strategies.

Thus, based on the statistically significant meta-analysis results, this study highly recommends the use of HBE programs for the treatment of knee osteoarthritis. However, in the case of post-traumatic and severe knee damage, the knee replacement therapy is the most suitable option.

Limitations

There are certain limitations to this study. The first is the variability of exercises and control methods used for the treatment of knee osteoarthritis, which in turn skews the results. Similarly, the observation of WOMAC scores and clinical symptoms by different analytical tests performed by different people also increases the risk of false-negative results. Many studies do not report on the efficacy of exercise compared with a conventional pain reliever or anti-inflammatory drug; this may also affect the analysis to some extent. Data from other relevant studies that affirm the efficacy of HBEs in comparison with different medications could also include more results to guide their use more precisely. To observe the variability, detailed data on the case history of the patient, physical examination and pathological tests could further explain the results in order to recommend HBE programs as effective treatment for knee osteoarthritis.

Fig. 8. Change in Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score pre- and post-treatment

Conclusions

Surgery, pain relievers and anti-inflammatory drugs are some of the standard treatment strategies available for knee osteoarthritis; however, each strategy has its complexities and adverse effects. Since exercise has no adverse side effects, HBEs may be considered the best treatment strategy for knee osteoarthritis. Regular exercises can significantly improve the clinical symptoms, reduce the WOMAC scores and significantly increase the KOOS scores of knee osteoarthritis patients. Therefore, they can be considered a preferred, safe and inexpensive treatment method. In this study, we obtained an OR value of 0.59 and a risk ratio value of 0.81. Since both values are less than 1, it suggests that HBEs are safe and effective, and can reduce the clinical symptoms associated with knee osteoarthritis, without any adverse effects. We found substantial improvements in the KOOS and WOMAC scores of patients who performed HBEs for knee osteoarthritis. Based on our statistically significant meta-analysis results ($p < 0.05$) and a low risk of bias, we strongly support the use of HBEs for adults with knee osteoarthritis.

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