Health Quality Ontario

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ONTARIO HEALTH TECHNOLOGY ASSESSMENT SERIES

Structured Education and Neuromuscular Exercise Program for Hip and/or Knee Osteoarthritis: A Health Technology Assessment

KEY MESSAGES

What Is This Health Technology Assessment About?

Osteoarthritis is a chronic, progressive condition that involves the breakdown of tissues and cartilage and loss of joint function. Symptoms include pain and stiffness, which can lead to movement limitations, reduced physical function, and reduced quality of life. Osteoarthritis is the most common form of arthritis and most often affects the hip and knee. More than 10% of Canadians over the age of 15 have osteoarthritis. There is no cure for osteoarthritis, but treatment options are available. Clinical guidelines recommend nonsurgical treatments be tried first, including patient education, exercise, and weight management.

This health technology assessment evaluates how effective and safe a structured education and neuromuscular exercise program is for the management of hip and/or knee osteoarthritis, if it is good value for money, the budget impact of publicly funding this kind of program in Ontario, and the preferences and values of people with hip and/or knee osteoarthritis.

What Did This Health Technology Assessment Find?

Moderate-quality evidence suggests that, compared with usual care, a structured education and neuromuscular exercise program for hip and/or knee osteoarthritis improves physical function, quality of life, and the ability to perform activities of daily living. Low-quality evidence suggests that, compared with usual care, this type of program improves pain. Low-quality evidence suggests that, compared with patient education, this type of program improves pain and physical function.

A group-based structured education and neuromuscular exercise program consisting of two educational sessions and 24 exercise sessions may be good value for money. We estimated that publicly funding this type of program in Ontario might cost about $21 million in the first year and $92 million in the fifth year, depending on uptake. If the program could be delivered with 12 exercise sessions, the cost might be reduced to $12 million in the first year and $53 million in the fifth year.

People with hip and/or knee osteoarthritis reported positive experiences with a structured education and neuromuscular exercise program, feeling that it had strengthened their muscles and reduced their symptoms of stiffness and pain.

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HEALTH TECHNOLOGY ASSESSMENT AT HEALTH QUALITY ONTARIO

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The statements, conclusions, and views expressed in this report do not necessarily represent the views of the consulted experts.

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ABSTRACT

Background

Osteoarthritis is a chronic disorder and the most common form of arthritis. The joints most commonly affected are the hip and knee. The progression of osteoarthritis results in the breakdown of tissues and cartilage and the loss of joint function, causing symptoms such as pain, stiffness, reduced physical function, and limited movement. Although there is no cure for osteoarthritis, treatment options are available to manage symptoms and optimize quality of life. Clinical guidelines recommend education, exercise, and weight loss (when necessary) as the first line of treatment.

Methods

We conducted a health technology assessment, which included an evaluation of the effectiveness, safety, and cost-effectiveness of a structured education and neuromuscular exercise program for the management of hip and/or knee osteoarthritis. We also assessed the budget impact of publicly funding such a program, and we spoke with people with osteoarthritis to gain an understanding of their preferences and values. We performed a systematic review of the clinical and economic literature published between January 1, 2008, and October 4, 2017. We also performed a grey literature search of health technology assessment websites. We assessed the risk of bias of each study, and we assessed the quality of the body of evidence according to the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) Working Group criteria. To evaluate the cost-effectiveness of a structured education and neuromuscular exercise program for adults with knee osteoarthritis, we conducted a cost–utility analysis from the perspective of the Ontario Ministry of Health and Long-Term Care. We also estimated the budget impact of publicly funding such a program in Ontario over the next 5 years. To contextualize the potential value of this type of program as a treatment option, we spoke with people with hip and/or knee osteoarthritis.

Results

Ten studies met our inclusion criteria for the clinical evidence review. Compared with usual care, a structured education and neuromuscular exercise program showed statistically significant short-term improvements in pain (GRADE low) and physical function (GRADE moderate), as well as statistically significant long-term improvements in performing activities of daily living (GRADE moderate) and in quality of life (GRADE moderate). The short-term improvements in pain and physical function appeared to be sustained into the medium term. Compared with patient education, a structured education and neuromuscular exercise program showed statistically significant short-term improvements in pain (GRADE low) and physical function (GRADE low) and sustained long-term improvement in physical function.

Our primary economic evaluation showed that, compared with usual care, a group-based structured education and neuromuscular exercise program consisting of two educational sessions and 24 exercise sessions for the management of knee osteoarthritis was associated with an incremental cost of $719 (95% confidence interval [CI]: $410–$1,118) and an incremental quality-adjusted survival of 0.03 quality-adjusted life-years (QALYs) (95% CI: −0.006 to 0.06), resulting in an incremental cost-effectiveness ratio (ICER) of $23,967 per QALY gained. The budget impact of publicly funding a group-based structured education and neuromuscular exercise program consisting of two educational sessions and 24 exercise sessions would range from $21.4 million to $91.6 million per year over the next 5 years. The budget impact of publicly funding a program consisting of two educational sessions and

12 exercise sessions would range from $12.4 million to $53.2 million per year over the next 5 years.

People with hip and/or knee osteoarthritis with whom we spoke reported on the negative impact of osteoarthritis on their physical functioning and quality of life. Those with experience of a structured education and neuromuscular exercise program reported favourably on the program, stating they felt that participation in the program had strengthened their muscles and reduced the negative impact of their symptoms. The cost of such programs was reported as a barrier to access.

Conclusions

There is moderate-quality evidence that, compared with usual care, a structured education and neuromuscular exercise program improves physical function, quality of life, and the ability to perform activities of daily living. There is low-quality evidence that, compared with usual care, this type of program improves pain. Low-quality evidence suggests that, compared with patient education, a structured education and neuromuscular exercise program improves pain and physical function.

A group-based structured education and neuromuscular exercise program may be cost-effective for the nonsurgical management of knee osteoarthritis. Publicly funding a group-based structured education and neuromuscular exercise program for hip and/or knee osteoarthritis in Ontario would lead to additional costs to the health system of $21.4 million to $91.6 million per year over the next 5 years. If the program could be delivered with a smaller number of 12 exercise sessions, the budget impact would be reduced to between $12.4 million and $53.2 million over the next 5 years.

Structured education and neuromuscular exercise programs are perceived favourably by people with hip and/or knee osteoarthritis. However, the cost of such programs may be a barrier to access.

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OBJECTIVE

This health technology assessment examines the effectiveness, safety, and cost-effectiveness of a structured education and neuromuscular exercise program for the management of osteoarthritis of the hip and/or knee. It also assesses the budget impact of publicly funding such a program in Ontario and examines the experiences of people with hip and/or knee osteoarthritis and their perspectives on treatment options, including a structured education and neuromuscular exercise program.

BACKGROUND

Health Condition

Osteoarthritis is a chronic disorder and the most common form of arthritis. The joints most commonly affected are the hip and knee. Osteoarthritis leads to abnormal changes within the joint, characterized by the breakdown of tissues and cartilage, bone reshaping, the formation of bony lumps, joint inflammation, and loss of joint function.[1] These changes often cause symptoms such as pain, stiffness, reduced physical function, and limited movement.[2,3]

Nonmodifiable risk factors, such as genetics, sex, and age, as well as modifiable risk factors, such as body mass index, physical inactivity, and previous injury, may increase the likelihood of developing osteoarthritis.[2] Sex and age are the strongest predictors of osteoarthritis.[4] Specifically, the prevalence of knee osteoarthritis is higher in women and elderly populations.[5] Epidemiological studies have shown that 60% of hip osteoarthritis and up to 40% of knee osteoarthritis are attributable to genetic factors.[6] People who are classified as obese and those with a previous knee injury have a significantly increased risk of developing knee osteoarthritis.[7]

Clinical Need and Target Population

Globally, 9.6% of men and 18.0% of women aged 60 years and older are living with symptomatic osteoarthritis.[8,9] Among individuals living with osteoarthritis, 80% experience reduced movement, and 25% are unable to execute major activities of daily living.[10] In Canada the overall prevalence of osteoarthritis is more than 10% among people aged 15 years and older.[11] In 2009, the overall prevalence of knee osteoarthritis was 29.4%, compared to 12.3% for hip osteoarthritis.[12] Specifically, the prevalence of hip osteoarthritis was highest among those aged 50 to 64 years: 47.2% (95% CI: 37.3–57.3). In contrast, the prevalence of knee osteoarthritis was highest in those aged 65 years and older: 48.7% (95% CI: 41.6–55.8).[12] The Global Burden of Disease 2010 Study found that hip and knee osteoarthritis ranked eleventh in terms of years lived with disability and thirty-eighth in terms of disability-adjusted life-years.[3] As the Canadian population ages, the prevalence of osteoarthritis will increase.[13]

Osteoarthritis is associated with both health care– and non–health care–related costs such as loss of productivity, defined as permanent absence from work.[14] The Arthritis Alliance of Canada reports that approximately 30% of the labour force (1 in 3 employees) will experience challenges working as a result of an osteoarthritis diagnosis.[14]

The disease burden for people living with osteoarthritis is shaped by socioeconomic and psychosocial factors.[15] An Ontario study showed that quality of life was 10% to 25% lower among people with osteoarthritis compared with people without osteoarthritis.[8] A cohort study of adults aged 55 years and older living with moderately severe hip or knee osteoarthritis followed prospectively for 3 years found that pain caused depressed mood through its effect on fatigue

and disability, adjusting for patient demographics and psychosocial factors.[16] More specifically, this study concluded that the inability to cope and a social environment characterized by a lack of support negatively influenced the relationship between pain and depression.[16]

Current Treatment Options

Although there is no cure for osteoarthritis, treatment options are available to manage symptoms and optimize quality of life. Clinical guidelines and a Health Quality Ontario quality standard recommend patient education, exercise, and weight loss as the first line of treatment.[15,17-19] Evidence-based treatment for osteoarthritis may include self-management programs that integrates patient education, structured exercise (i.e., aerobic conditioning, strength training, and neuromuscular exercise), physical activity (e.g., walking, biking, swimming, yoga), and weight management.[17,18]

Some people with osteoarthritis may choose to use pharmacological agents, including acetaminophen and nonsteroidal anti-inflammatory drugs (NSAIDs), for pain relief. However, various preparations and doses of pharmacological agents have been demonstrated to be ineffective for the treatment of osteoarthritis.[20]

Health Service Under Review

While there are many conservative management programs available for the treatment of hip and/or knee osteoarthritis, we chose to examine the evidence for a structured program that consists of both patient education and neuromuscular exercise, with a minimum duration of 6 weeks. Other combinations of components in a structured program were beyond the scope of this health technology assessment.

At minimum, the educational component of a structured program should include information related to the etiology of osteoarthritis, risk factors, symptoms, treatment options, the importance of exercise, and guidance on coping and self-management techniques.[21] The educational component may be delivered concurrently; for example, when participants receive instruction on neuromuscular exercises.

The purpose of the neuromuscular exercise component of a structured program is to improve sensorimotor control and achieve functional stability.[22-24] This is in contrast to strength training and aerobic exercise, which increase muscle mass and cardiovascular fitness, respectively. Neuromuscular exercises involve multiple joints and muscle groups and are usually performed in both open and closed kinetic chain positions (i.e., lying, sitting, standing). Strength, coordination, balance, and proprioception are integrated in various core stability/postural function, postural orientation, muscle strengthening, and flexibility exercises.[22] Under the supervision of a trained health professional with expertise in musculoskeletal conditions, participants progress through exercises of varying difficulty by increasing the number, direction, and speed of movements in accordance with the quality of their neuromuscular control.[23]

An example of a structured education and neuromuscular exercise program available in Ontario is Good Life with osteoArthritis in Denmark (GLA:D) Canada. In 2016, Bone and Joint Canada collaborated with researchers in Denmark, who had developed the initial GLA:D program, to develop GLA:D Canada.[25]The GLA:D Canada program runs for 8 weeks. Participants receive two weekly patient education sessions delivered by a trained health professional; each session is 60 to 90 minutes in duration.[26] The first session covers information related to the etiology of osteoarthritis, risk factors, symptoms, and treatment options, and the second session addresses

self-management techniques. The neuromuscular exercise component consists of 12 biweekly 60-minute supervised group sessions delivered over 6 weeks. The exercises are targeted to each participant's ability and motor control. Each session consists of a warm-up, a circuit program, and a cool-down. To warm up, participants cycle on an exercise bike for 10 minutes. The circuit program consists of four stations that focus on core stability and postural function, postural orientation, lower extremity muscle strength, and functional exercises. Participants perform two to three sets of 10 to 15 repetitions of each exercise. To cool down, participants walk and perform stretching exercises for 10 minutes.[27]

Ontario Context

Publicly funded physiotherapy services are available at physiotherapy clinics, though availability is limited and many patients experience long waits. To be eligible for publicly funded physiotherapy at these clinics, a person needs a referral from a doctor and must meet at least one of the following criteria:[28]

- ≤19 or ≥ 65 years old, or
- Be receiving benefits under the Ontario Disability Support Program or the Ontario Works program, or
- Have stayed overnight in hospital for a condition that now requires physiotherapy treatment

Where GLA:D Canada programs are offered in Ontario, they are typically paid for by private health insurance or by patients themselves. There are a small number of publicly funded sites offering GLA:D Canada.[29]

CLINICAL EVIDENCE

Research Question

What are the benefits and harms of a structured education and neuromuscular exercise program for the management of hip and/or knee osteoarthritis?

Methods

We developed the research question in consultation with clinical experts.

Literature Search

We performed a literature search on October 2, 2017, to retrieve studies published from January 1, 2008 to the search date. We used the Ovid interface in the following databases: MEDLINE, Embase, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Centre for Reviews and Dissemination Health Technology Assessment Database, and National Health Service Economic Evaluation Database (NHS EED). We used the EBSCOhost interface to search the Cumulative Index to Nursing & Allied Health Literature (CINAHL).

Medical librarians developed the search strategy using controlled vocabulary (i.e., Medical Subject Headings) and relevant keywords. The final search strategy was peer-reviewed using the Peer Review of Electronic Search Strategies (PRESS) Checklist.[30] We created database auto-alerts in MEDLINE, Embase, and CINAHL and monitored them for the duration of the assessment period.

During consultations with our clinical experts, we selected 2008 as the cut-off year for our literature search, as we wanted to focus on the most recent evaluations.

We also performed a targeted grey literature search of health technology assessment agency websites and clinical trial registries.

See Appendix 1 for our literature search strategies, including all search terms.

Literature Screening

A single reviewer conducted an initial screening of titles and abstracts using the DistillerSR management software and then obtained the full text of studies that appeared eligible for the review according to the inclusion criteria. The author then examined the full-text articles and selected studies eligible for inclusion. We report reasons for exclusion of full-text articles in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram (Figure 1).

Inclusion Criteria

Types of Studies

We included English-language full-text publications of studies published between January 1, 2008, and October 2, 2017. We included randomized controlled trials, systematic reviews, meta-analyses, and observational studies.

Participants

We included studies of adults aged 18 years and older with symptoms of hip osteoarthritis, knee osteoarthritis, or both hip and knee osteoarthritis. We included studies of people following any type of usual care for symptom management, waiting to receive total joint replacement, or with a history of total joint replacement that had occurred 2 years or more previously.

Intervention

We included studies of structured programs that consisted of both patient education and neuromuscular exercise.

The educational component of these programs addressed the following topics: etiology of osteoarthritis, risk factors, symptoms, treatment management, exercise, and coping and self-help tools. The educational component could be delivered concurrently; for example, when participants received instruction on how to perform neuromuscular exercises.

The neuromuscular exercise component consisted of core stability and postural function, postural orientation, muscle strengthening, and flexibility exercises designed to improve strength, coordination, balance, and proprioception. Participants were supervised by a trained health professional with expertise in musculoskeletal conditions. The health professional taught exercises of progressive difficulty by increasing the number, direction, and speed of movements in accordance with the quality of participants' neuromuscular control.

Comparators

We included any of the following comparison groups:

- Weight loss management
- Aerobic exercise/aquatic exercise
- Usual care (defined as consultation with a family physician, taking NSAIDs, undergoing physiotherapy or acupuncture, receiving information on the management of osteoarthritis, practising tai chi, or wearing insoles)
- Patient education

We also included observational studies with no control/comparison group.

Outcomes of Interest

We included studies that reported results for at least one of the following outcomes of interest:

- Pain and pain intensity
- Physical function
- Quality of life
- Activities of daily living
- Physical activity
- Safety

Timing

We included studies of structured education and neuromuscular exercise programs with a minimum duration of 6 weeks.

Settings

We included studies of structured education and neuromuscular exercise programs taking place in private, public, community health centre, or hospital physiotherapy clinic settings.

Exclusion Criteria

- Animal and in vitro studies
- Editorials, case reports, and commentaries
- Studies of people with osteoarthritis other than hip or knee osteoarthritis or with rheumatoid arthritis
- Study population less than 18 years of age

Data Extraction

We extracted relevant data on study characteristics and risk-of-bias items using a data form to collect information about the following:

- Source (i.e., citation information)
- Methods (i.e., number of participants, study design, participant allocation, allocation sequence concealment, blinding, participant eligibility, analyses, description of structured education and neuromuscular exercise program, duration of intervention and frequency of sessions)
- Comparison groups
- Outcomes (i.e., outcomes measured, measurement scale, effect size and 95% confidence intervals, minimum detectable change, minimum clinically important improvement, minimum clinically important difference, time points at which outcomes were assessed)
- Study country, setting, and funding

We contacted authors of the studies to provide clarification on missing or incomplete data or published analyses as needed.

Statistical Analysis

We reported the results from each included study. We calculated mean differences, standard errors, and confidence intervals for studies in which authors provided means and standard deviations (Table A9). Results were reported at each follow-up time. Short-term was defined as ≤ 6 months, mid-term as between 6 and 12 months, and long-term as ≥ 12 months. We assessed the clinical relevance of the mean differences from baseline to follow-up by applying clinical thresholds available in the literature. These included the minimum detectable change, minimum clinically important improvement, or minimum clinically important difference. The minimum detectable change is the smallest real difference in an outcome.[31] The minimal clinically important improvement is defined as the smallest change in measurement that is

deemed a meaningful improvement in a patient's symptoms, whereas the minimum clinically important difference provides insight into whether the change experienced by a patient would result in adapting a patient's management.[32] We applied clinical thresholds from knee osteoarthritis populations when population-specific benchmarks for hip osteoarthritis were unavailable.[33]

We did not perform a meta-analysis of study results owing to the heterogeneity in outcome measurement and inconsistent follow-up across studies.

Critical Appraisal of Evidence

For randomized controlled trials, we assessed risk of bias using the Cochrane Risk of Bias Tool (Table A1). For observational studies, we assessed risk of bias using the Risk of Bias Assessment Tool for Nonrandomized Studies (RoBANS) (Table A2).

We evaluated the quality of the body of evidence for each outcome according to the *Grading of Recommendations Assessment, Development, and Evaluation (GRADE) Handbook*.[34] We assessed the body of evidence according to the following considerations: risk of bias, inconsistency, indirectness, imprecision, and publication bias. We determined the overall quality to be high, moderate, low, or very low using a step-wise, structural methodology. The quality score reflects our assessment of the certainty of the evidence.

Expert Consultation

Between August 2017 and February 2018, we consulted with several experts on structured education and neuromuscular exercise programs. Consulted experts included physiotherapists, stakeholders, and research scientists in osteoarthritis. Their role was to review the clinical review plan, contextualize the evidence, provide guidance on the current management of osteoarthritis, and confirm whether the education and exercise components described in the included studies satisfied the intervention criteria.

The statements, conclusions, and views expressed in this report do not necessarily represent the views of the consulted experts.

Results

Literature Search

The literature search yielded 2,306 citations published between January 1, 2008 and October 2, 2017, after removing duplicates. After the search date, we included another observational study identified by experts.[29] Ten studies from eleven publications met the inclusion criteria. Appendix 3 provides a selected list of studies excluded after full-text review that includes the primary reason for exclusion.

Figure 1 presents the flow diagram for the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) for the clinical literature search.

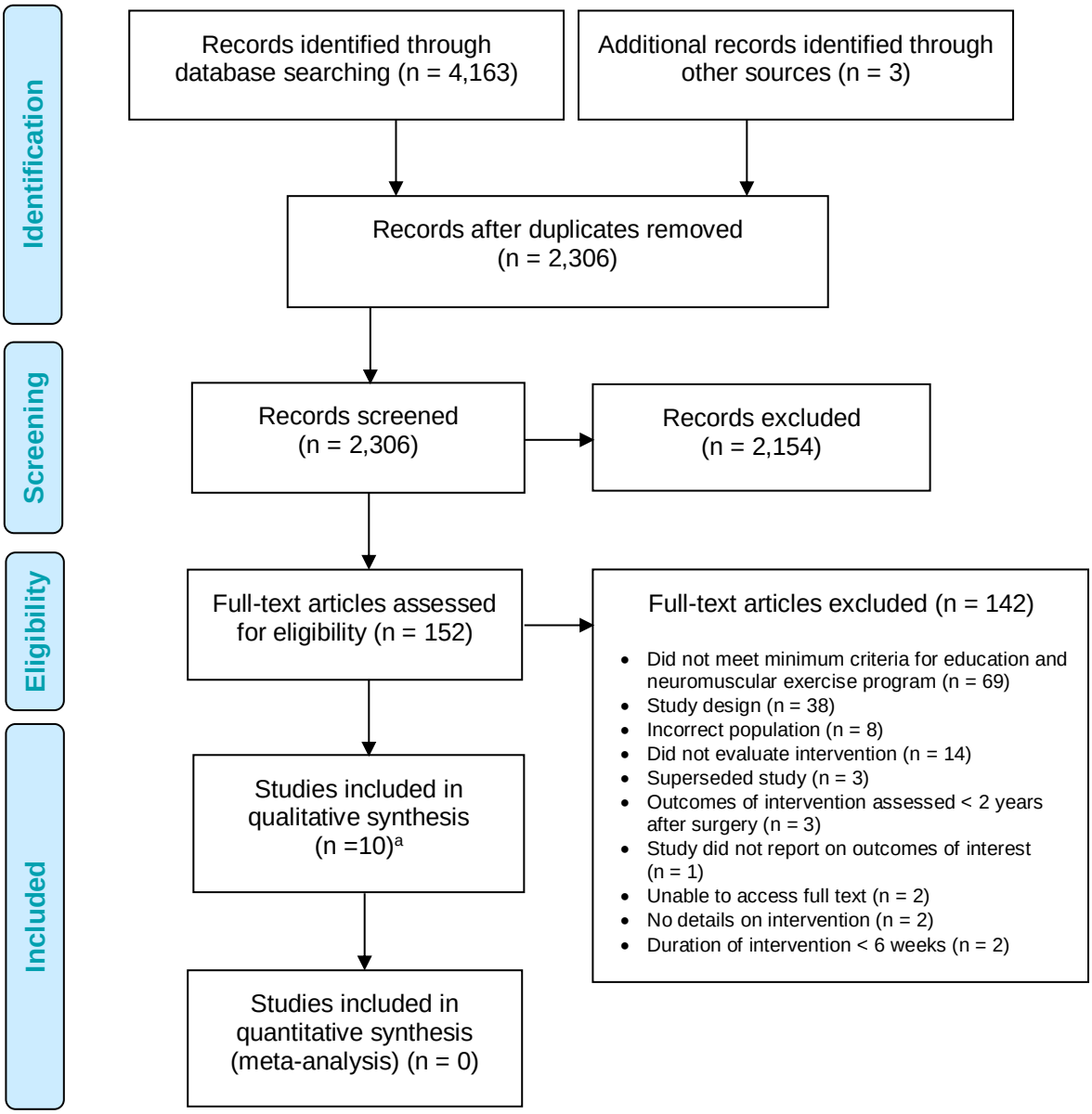

Figure 1: PRISMA Flow Diagram—Clinical Search Strategy

Abbreviation: PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.
[a]Ten studies from 11 publications.
Source: Adapted from Moher et al.[35]

Characteristics of Included Studies

We identified two randomized controlled trials, reported in three publications,[36-38] comparing structured education and neuromuscular exercise programs with usual care, and two randomized controlled trials of structured education and neuromuscular exercise programs versus patient education.[39,40] Usual care was defined as consultation with a family physician, taking NSAIDs, or undergoing physiotherapy. Patient education was defined as information leaflets that provided information on the management of osteoarthritis and the importance of

exercise. We also identified six observational studies of a structured education and neuromuscular exercise program.[21,29,41-44] Table 1 summarizes the characteristics of the included randomized controlled trials, and Table 2 summarizes the characteristics of the included observational studies.

The studies assessed structured education and neuromuscular exercise programs that ranged from 6 to 12 weeks in duration with a frequency of 1 to 2 sessions per week. Although the types of neuromuscular exercise included in each program were consistent across studies, the duration and frequency of sessions and the type of health care professional implementing the program varied. The programs in some studies also included components (e.g., weight loss) in addition to the minimum intervention of structured education and neuromuscular exercise.

The measurement scales (Appendix 4) used to assess outcomes of interest and performance tests for physical function differed between studies. Follow-up across studies also varied, ranging from 6 weeks to 30 months.

These variations resulted in a heterogeneous body of evidence. As a result of the clinical and statistical heterogeneity across studied, we summarized the results for outcomes of interest in a tabular and narrative synthesis.

Table 1: Characteristics of Included Randomized Controlled Trials

Author, Year, Country (N, Intervention/ Control)	Patient Inclusion Characteristics			Intervention (Session Frequency)	Comparator	Outcomes of Interest	Measurement Scale/ Performance Test	Follow-Up
	Joint	Age, Years	Symptom Severity					
da Silva et al, 2015,[39] Brazil (19/22)	Knee	> 18	Moderate to very severe	• Self-management class (without exercise; also given to the control group; 1 90-minute lecture on osteoarthritis) • Supervised collective group exercise[a] program (2 60-minute sessions/week for 8 weeks)	Booster educational leaflets about OA and how to improve quality of life and function	Pain, activities of daily living, physical function, quality of life	Lequesne Index,[b] 30-second chair-stand test, timed up-and-go test, 6-minute walk test	8 weeks
Hurley et al, 2012,[36] United Kingdom (278/140)	Knee	≥ 50	Mild, moderate, severe	Supervised patient education and progressive exercise[a] program (2 60-minute sessions/week for 6 weeks; education: 15–20 minutes/ session; exercise: 35–40 minutes/ session)	Usual care, defined as services or interventions considered appropriate by participants' primary care physicians (e.g., analgesia via NSAIDs)	Pain, physical function	WOMAC[c]	6 weeks; 6, 18, 30 months

Author, Year, Country (N, Intervention/ Control)	Patient Inclusion Characteristics			Intervention (Session Frequency)	Comparator	Outcomes of Interest	Measurement Scale/ Performance Test	Follow-Up
	Joint	Age, Years	Symptom Severity					
Skou et al, 2015,[37] Denmark (47/44); Skou et al, 2016,[38] Denmark (43/46)	Knee	≥ 18	More than mild	• Patient education (2 60-minute sessions) • Neuromuscular training (2 60-minute sessions/week for 12 weeks) • Drug: paracetamol, ibuprofen, pantoprazole • Dietary counselling for participants with a BMI ≥ 25 to reduce body weight by at least 5% (4 60-minute sessions) • Insoles to wear in all shoes	Usual care, defined as two standardized information leaflets (also given to the intervention group); leaflets designed to encourage participants to seek care outside of study <u>Leaflet 1 (4 pages)</u> • Information on knee OA (etiology, symptoms, functional limitations, recommended treatments, symptom management advice) <u>Leaflet 2 (2 pages)</u> • Information on where to seek treatment, how to sustain a healthy lifestyle (focusing on diet, smoking, alcohol intake, physical activity)	Pain, activities of daily living, quality of life, physical function	KOOS,[d] timed up-and-go test, VAS[e]	3, 12 months

Author, Year, Country (N, Intervention/ Control)	Patient Inclusion Characteristics			Intervention (Session Frequency)	Comparator	Outcomes of Interest	Measurement Scale/ Performance Test	Follow-Up
	Joint	Age, Years	Symptom Severity					
Svege et al, 2015,[40] Norway (55/54)	Hip	40–80	Mild to moderate	• Patient education following Hip School[f] format • Supervised exercise[a] program: strengthening, functional, flexibility (2–3 sessions/week for 12 weeks)	Patient education following Hip School format (3 group meetings; first provides information on the etiology of OA, second describes exercise biomechanics, third addresses pain management and coping techniques)	Pain, physical function, physical activity	WOMAC,[b] PASE[g]	4, 10, 16 months

Abbreviations: KOOS, Knee Injury and Osteoarthritis Outcome Score; NSAID, nonsteroidal anti-inflammatory drug; OA, osteoarthritis; PASE, Physical Activity Scale for the Elderly; VAS, Visual Analogue Scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

[a]The exercises described in the study satisfied the definition of neuromuscular exercise; this was confirmed by a clinical expert.

[b]The Lequesne Index comprises 3 dimensions, including pain (5 items), maximum walking distance (2 items), and activities of daily living (function subdomain, 8 items). Each dimension has a maximum total score of 8. The total Lequesne Index score ranges from 0 to 24, with higher scores indicating worse function.

[c]The WOMAC comprises 3 subscales (pain, stiffness, and physical function) and is composed of 24 questions. Scores range from 0 to 100, with higher scores indicating more severe disease.

[d]The KOOS consists of 42 items in five separately scored subscales: pain, symptoms, function in activities of daily living, sport and recreation function, and knee-related quality of life. A Likert scale is used; all items have five answer options scored from 0 (no problems) to 4 (extreme problems). Each of the five scores is calculated as the sum of the items included. Scores are transformed into a 0–100 scale, with 0 representing extreme knee problems and 100 representing no knee problems.

[e]The VAS score is determined by measuring the distance (in mm) on a 10-cm line between a "no pain" anchor and the patient's mark, providing a range of scores from 0 to 100, with higher scores indicating greater pain intensity. The VAS was used in Skou et al, 2016.[38]

[f]In Hip School, participants attend a group session in which they are encouraged to ask questions, are provided an educational presentation, and receive written information on therapeutic exercises. Participants are also offered an individual follow-up session after 2 months.[45]

[g]The PASE consists of 24 questions on physical activity, the total score of which expresses overall physical activity level. Scores range from 0 to 315, with 0 indicating complete inactivity and 315 indicating an extremely high level of activity.

Table 2: Characteristics of Included Observational Studies

Author, Year Country (N)	Patient Inclusion Characteristics			Intervention (Session Frequency)	Outcomes of Interest	Measurement Scale/ Performance Test	Follow-Up
	Joint	Age, Years	Symptom Severity				
Al-Khlaifat et al, 2016,[41] United Kingdom (19)	Knee	Not reported	Moderate, severe (participants had definite osteophytes)	• Self-management education and exercise[a] program (1 80-minute session/week for 6 weeks; education: 20 minutes/session; exercise: 60 minutes/session)	Pain, activities of daily living	KOOS[b]	6 weeks
Davis et al, 2018,[29] Canada (59)	Hip or knee	≥ 30	Not reported	• Patient education (2 60-minute sessions) • Neuromuscular exercise program (2 sessions/week for 6 weeks)	Pain intensity, pain, activities of daily living, quality of life, physical function	HOOS[c] or KOOS,[b] 30-second chair-stand test, 40-metre walk test	3 months
Patel et al, 2010,[42] United Kingdom (72)	Knee	Not reported	Mild to moderate	• Education and exercise[a] program (2 60-minute sessions/week for 6 weeks)	Pain, physical function	WOMAC[d]	12 months
Skou et al, 2012,[43] Denmark (36)	Hip, knee, or both hip and knee	Not reported	Not reported	• Patient education (2–3 sessions over 2 weeks) • Supervised neuromuscular exercise program (2 sessions/week for 6 weeks)	Pain, physical function	VAS,[e] 30-second chair-stand test	3 months
Skou et al, 2014,[44] Denmark (82)	Hip, knee, or both hip and knee	Not reported	Not reported	• Patient education (2–3 sessions over 2 weeks) • Supervised neuromuscular exercise program (2 sessions/week for 6 weeks)	Pain	VAS[e]	3, 12 months
Skou and Roos, 2017,[21] Denmark (9,825)	Hip or knee	Not reported	Not reported	• Patient education (2–3 sessions over 2 weeks) • Supervised neuromuscular exercise program (2 sessions/week for 6 weeks)	Pain, physical function, joint-related quality of life, physical activity	VAS,[e] self-report questionnaire for physical activity, 40-metre fast-paced walk, 30-second chair-stand test	3, 12 months

Abbreviations: HOOS, Hip Disability and Osteoarthritis Outcome Score; KOOS, Knee Injury and Osteoarthritis Outcome Score; VAS, Visual Analogue Scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

[a]The exercises described in the study satisfied the definition of neuromuscular exercise; this was confirmed by a clinical expert.

[b]The KOOS consists of 42 items in five separately scored subscales: pain, symptoms, function in activities of daily living, sport and recreation function, and knee-related quality of life. A Likert scale is used; all items have five answer options scored from 0 (no problems) to 4 (extreme problems). Each of the five scores is calculated as the sum of the items included. Scores are transformed into a 0–100 scale, with 0 representing extreme knee problems and 100 representing no knee problems.

[c]The HOOS comprises 5 subscales: pain, symptoms, activities of daily living, sport and recreation function, and hip-related quality of life. Scores range from 0 to 100, with higher scores indicating fewer to no symptoms and lower scores indicating severe symptoms.

[d]The WOMAC comprises 3 subscales (pain, stiffness, and physical function) and is composed of 24 questions. Scores range from 0 to 100, with higher scores indicating more severe disease.

[e]The VAS score is determined by measuring the distance (in mm) on a 10-cm line between a "no pain" anchor and the patient's mark, providing a range of scores from 0 to 100, with higher scores indicating greater pain intensity.

Pain

Randomized Controlled Trials

Four randomized controlled trials (reported in five publications) reported data on pain (Table 3).[36,38-40,46]

Structured Education and Neuromuscular Exercise Program Versus Usual Care

Two publications on the same trial reported data on pain in people with knee osteoarthritis.[37,38] Pain and pain intensity were measured via the Knee Injury and Osteoarthritis Outcome Score (KOOS) pain subscale and the Visual Analog Scale, respectively. Both publications reported that, compared with those in the control group, participants in the structured education and neuromuscular exercise group experienced greater improvement in pain at a 12-month follow-up compared to baseline and greater improvements in peak pain intensity and pain intensity during function at a 3-month follow-up compared to baseline; these results were statistically significant.[37,38] However, a minimum detectable change of 13.4 points for the KOOS pain subscale, based on available literature,[47] was not met.[37,38]

Hurley et al measured pain via the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscale.[36] They found a statistically significant initial improvement in pain in participants with knee osteoarthritis at 6 weeks post-intervention compared to baseline, and sustained improvement at a 30-month follow-up.[36] A minimum detectable change for the WOMAC pain subscale was not available in the literature.

Structured Education and Neuromuscular Exercise Program Versus Patient Education

Svege et al measured pain in people with hip osteoarthritis using the WOMAC pain subscale.[40] The study authors found no significant difference in mean self-reported pain scores between baseline and follow-ups at 4, 10, 16, and 29 months when the intervention was compared with patient education.[40]

The randomized controlled trial by da Silva et al measured pain in people with knee osteoarthritis via the Lequesne algofunctional index of pain.[39] This study demonstrated a statistically significant improvement in pain at the 8-week follow-up in the structured education and neuromuscular exercise group compared with patient education.

Observational Studies

Six single-group observational studies assessing people with hip and knee osteoarthritis who received a structured education and neuromuscular exercise program reported data on the outcome of pain (Table 4).[21,29,41-44] Of these, two included participants with knee osteoarthritis,[41,42] two included participants with either hip or knee osteoarthritis,[21,29] and two included participants with hip, knee, or both hip and knee osteoarthritis.[43,44]

The two studies that included participants with both hip and knee osteoarthritis demonstrated improvement in pain at 3 and 12 months.[43,44] These results suggest that a structured education and neuromuscular exercise program may provide both short- and long-term benefits.

Davis et al provided subgroup results for hip osteoarthritis and knee osteoarthritis for the outcomes of pain.[29] Pain for hip and knee osteoarthritis was measured via the Hip Disability and Osteoarthritis Outcome Score (HOOS) and the KOOS pain subscales, respectively, and pain

intensity was measured via the Numeric Pain Rating Scale.[29] A minimal clinically important difference of two points[48] was found for pain intensity from baseline to 3 months.[29] Similarly, a statistically significant improvement from baseline to 3 months was observed for pain (as measured via the KOOS pain subscale for knee osteoarthritis and the HOOS pain subscale for hip osteoarthritis)[29]; however, a minimum detectable change of 13.4 points[48] was not met for the KOOS pain subscale scores.[29]

Patel et al[42] and Al-Khlaifat et al[47] both observed a reduction in pain in participants with knee osteoarthritis from baseline to follow-up, Patel et al via the WOMAC pain subscale[42] and Al-Khlaifat et al via the KOOS pain subscale.[47] However, Patel et al did not report a 95% confidence interval for their study result.[42]

For structured education and neuromuscular exercise compared to usual care, the overall quality of the body of evidence for pain was assessed as low (Appendix 2, Table A3). The quality of the body of evidence was downgraded because of concerns with risk of bias due to loss of more than 20% of participants in the intervention group at the 30-month follow-up. There was potential for imprecision due to the width of the 95% confidence intervals.

For structured education and neuromuscular exercise compared to patient education, the overall quality of the body of evidence for pain was assessed as low (Appendix 2, Table A3). The quality of the body of evidence was downgraded because of risk of bias as participants lost to follow-up prior to 29 months underwent total hip replacement, which may bias the pain outcomes. There was potential for imprecision due to the width of the 95% confidence intervals.

For structured education and neuromuscular exercise programs with no comparator, the overall quality of the body of evidence for pain was assessed as very low (Appendix 2, Table A3). The quality of the body of evidence was downgraded because of concerns with selection bias and indirectness due to lack of generalizability of the results. There was potential for imprecision due to the width of the 95% confidence intervals.
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Table 3: Randomized Controlled Trials—Mean Differences in Pain Scores for Structured Education and Neuromuscular Exercise Programs Versus Usual Care or Patient Education

Author, Year	Measurement Scale	Follow-Up					
		6–8 weeks	3–4 months	6–8 months	10–12 months	16–18 months	29–30 months
		Mean Difference Between Intervention and Control (95% CI)					
Structured Education and Neuromuscular Exercise Program Versus Usual Care							
Hurley et al, 2012[36,a]	WOMAC	6 weeks −1.70 (−2.08 to −1.32)[b]	—	6 months −0.60 (−1.06 to −0.14)[b]	—	18 months −0.50 (−0.99 to −0.01)[b]	—
Skou et al, 2015[37]	KOOS	—	—	—	12 months −9.7 (−16.1 to −3.3)[b] −9.0 (−15.0 to −3.0)[b,c]	—	—
Skou et al, 2016[38]	VAS	—	3 months 15.4 (2.6–28.2)[b,d] 32.6 (18.1–45.0)[b,e]	—	—	—	—
Structured Education and Neuromuscular Exercise Program Versus Patient Education							
da Silva et al, 2015[39]	Lequesne Index	8 weeks −1.9 (−2.98 to −0.76)[b] −1.6 (−2.6 to −0.5)[b,f]	—	—	—	—	—
Svege et al, 2015[40]	WOMAC	—	4 months −4.7 (−11.4 to 1.9)[b]	—	10 months −6.6 (−13.9 to 0.8)[b]	16 months −6.5 (−14.3 to 1.3)[b]	29 months −5.9 (−14.2 to 2.4)[b]

Abbreviations: CI, confidence interval; KOOS, Knee Injury and Osteoarthritis Outcome Score; VAS, Visual Analog Scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[a]The mean differences and corresponding 95% confidence intervals were calculated by the author of clinical evidence portion of the health technology assessment.
[b]A positive improvement.
[c]Adjusted analyses for follow-up (baseline; 3, 6, and 12 months), site (Farsø, Frederikshavn), baseline values, and interaction between follow-up and treatment arm.
[d]Peak pain intensity.
[e]Pain intensity during function.
[f]Adjusted for baseline values. The mean differences and corresponding 95% confidence intervals were calculated by the author of the health technology assessment.

Table 4: Observational Studies—Mean Differences in Pain Scores Between Baseline and Follow-Up

Author, Year	Measurement Scale	Follow-Up					
		6–8 weeks	3–4 months	6–8 months	10–12 months	16–18 months	29–30 months
		Mean Difference Between Baseline and Follow-Up (95% CI)					
Al-Khlaifat et al, 2015[41]	KOOS	6 weeks[a] 51.5 (47.0 to 62.5)	–	–	–	–	–
Davis et al, 2017[29]	NPRS	–	3 months Hip −1.9 (−2.9 to −0.9)[b] Knee −2.1 (−2.7 to −1.5)[b]	–	–	–	–
	HOOS		Hip 8.8 (4.7–12.9)[b]				
	KOOS		Knee 9.0 (5.4–12.5)[b]				
Patel et al, 2010[42]	WOMAC	–	–	–	12 months −1.6 (95% CI not reported)[b]	–	–
Skou et al, 2012[43]	VAS	–	3 months −15.9 (−24.1 to −7.8)[b]	–	–	–	–
Skou et al, 2014[44]	VAS	–	3 months −12.7 (−18.9 to −6.5)[b]	–	12 months −10.5 (−16.4 to −4.6)[b]	–	–
Skou and Roos, 2017[21]	VAS	–	3 months 12.4 (11.8–13.1)[b] 12.3 (11.7–13.0)[a–c]	–	12 months 13.7 (12.6–14.9)[b] 12.0 (10.8–13.2)[b,c]	–	–

Abbreviations: CI, confidence interval; HOOS, Hip Disability and Osteoarthritis Outcome Score; KOOS, Knee Injury and Osteoarthritis Outcome Score; NPRS, Numeric Pain Rating Scale; VAS, Visual Analog Scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[a]Median (range).
[b]A positive improvement.
[c]Adjusted analyses for baseline scores, gender, age, and body mass index. Excludes individuals reporting to have undergone a total joint replacement during follow-up.

Physical Function

Randomized Controlled Trials

Four randomized controlled trials reported data on physical function (Table 5).[36,37,39,40]

Structured Education and Neuromuscular Exercise Program Versus Usual Care

Among participants with knee osteoarthritis, Hurley et al found a statistically significant initial improvement in physical function (measured via the WOMAC subscale for physical function) from baseline to 6 weeks among those in the structured education and neuromuscular exercise program compared with usual care.[36] The authors found sustained improvement over the course of 30 months' follow-up[36]; however, the minimum detectable change of 9.1 points on the WOMAC physical function subscale[49] was not met at any of the follow-up times.

Similarly, Skou et al reported improvement in physical function, as measured by mean change in time (in seconds) recorded for the timed up-and-go test between baseline and 12 months, among those in the structured education and neuromuscular exercise program versus those receiving usual care[37]; however, the crude and adjusted improvement was not statistically significant and did not meet the minimum detectable change of 2.49 seconds.[33]

Structured Education and Neuromuscular Exercise Program Versus Patient Education

Svege et al assessed physical function in participants with hip osteoarthritis via the WOMAC physical function subscale.[40] The authors found a statistically significant improvement in self-reported physical function between baseline and 16 months (P = .011), and between baseline and 29 months (P = .004) for participants in the structured education and neuromuscular exercise program versus those receiving patient education.[40] However, the minimum detectable change of 9.1 points on the WOMAC physical function subscale[49] was met at 16 months.[40]

Da Silva et al reported a statistically significant improvement in physical function (measured via the timed up-and-go test and the 6-minute walk test) from baseline to an 8-week follow-up in favour of those in the structured education and neuromuscular exercise program compared with those receiving patient education.[39] The minimum detectable change for the 6-minute walk test (61.34 metres)[33] was met; however, the minimum detectable change for the timed-up-and-go test (2.49 seconds)[33] was not.[39]

Observational Studies

Four single group observational studies assessing people with hip and knee osteoarthritis who received a structured education and neuromuscular exercise program reported data on physical function (Table 6).[21,29,42,43]

Two studies investigated participants with hip, knee, or both hip and knee osteoarthritis. In 2017, Skou and Roos reported a significant improvement in physical function as measured by the 30-second chair-stand test and 40-metre fast-paced walk test at a 3-month follow-up,[21] and the minimum clinically important improvements of 2.1 seconds for the 30-second chair-stand test [50] and 0.2 seconds for the 40-metre fast-paced walk test [50] were met. However, the 2012 Skou et al study, which used a smaller sample size , found a significant improvement in physical function as measured by the 30-second chair-stand test,[43] but this result did not meet the clinical threshold for minimum clinically important improvement.[50]

Davis et al provided subgroup results for hip and knee osteoarthritis participants for the 30-second chair-stand test and the 40-metre walk test.[29] The study demonstrated statistically significant improvement from baseline to 3 months, and the minimum clinically important improvement for the 30-second chair-stand test[51] was met for hip osteoarthritis.[29]

Patel et al found an improvement in physical function from baseline to follow-up at 12 months; however, the authors did not provide a 95% confidence interval.[42]

For structured education and neuromuscular exercise compared to usual care, the overall quality of the body of evidence for physical function was assessed as moderate (Appendix 2, Table A4). The quality of the body of evidence was downgraded because of concerns with risk of bias as more than 20% of participants in the intervention group at 30 months were lost to follow-up.

For structured education and neuromuscular exercise compared to patient education, the overall quality of the body of evidence for physical function was assessed as low (Appendix 2, Table A4). The quality of the body of evidence was downgraded because of risk of bias as participants lost to follow-up prior to 29 months underwent total hip replacement, which may bias the physical function outcomes. There was a potential for imprecision due to the width of the 95% confidence intervals.

For structured education and neuromuscular exercise programs with no comparator, the overall quality of the body of evidence for physical function was assessed as very low (Appendix 2, Table A3). The quality of the body of evidence was downgraded because of concerns with selection bias and indirectness due to lack of generalizability of the results. There was a potential for imprecision due to the width of the 95% confidence intervals.

Table 5: Randomized Controlled Trials—Mean Differences in Physical Function Scores for Structured Education and Neuromuscular Exercise Programs Versus Usual Care or Patient Education

Author, Year	Measurement Scale/Performance Test	Follow-Up: 6–8 weeks	3–4 months	6–8 months	10–12 months	16–18 months	29–30 months
		Mean Difference Between Intervention and Control (95% CI)					
Structured Education and Neuromuscular Exercise Program Versus Usual Care							
Hurley et al, 2012[36,a]	WOMAC	6 weeks −5.8 (−7.1 to −4.5)[b]	—	6 months −1.6 (−3.2 to 0.0)[b]	—	18 months −2.3 (−3.9 to −0.7)[b]	30 months −1.4 (−3.2 to 0.4)[b]
Skou et al, 2015[37]	Timed up-and-go test	—	—	—	12 months 0.3 (−0.3 to 1.0)[b] 0.4 (−0.1 to 1.0)[b,c]	—	—
Structured Education and Neuromuscular Exercise Program Versus Patient Education							
da Silva et al, 2015[39,b]	30-second chair-stand test	8 weeks 2.8 (0.72–4.9)[b] 3.5 (1.8–5.2)[b,d]	—	—	—	—	—
	Timed up-and-go-test	−2.1 (−3.1 to −1.0)[b] −1.8 (−2.7 to –0.9)[b,d]					
	6-minute walk test	68.3 (24.4–112.1)[b] 56.4 (28.2–84.6)[b,d]					
Svege et al, 2015[40]	WOMAC	—	4 months −4.6 (−10.7 to 1.6)[b]	—	10 months −8.4 (−15.2 to −1.6)[b]	16 months −9.2 (−16.5 to −1.9)[b]	29 months −6.4 (−14.2 to −1.3)[b]

Abbreviations: CI, confidence interval; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[a]The mean differences and corresponding 95% confidence intervals were calculated by the author of the clinical evidence portion of the health technology assessment.
[b]A positive improvment.
[c]Adjusted analyses for follow-up (baseline; 3, 6, and 12 months), site (Farsø, Frederikshavn), baseline values, and interaction between follow-up and treatment arm.
[d]Adjusted for baseline values.

Table 6: Observational Studies—Mean Differences in Physical Function Scores Between Baseline and Follow-Up

Author, Year	Measurement Scale	Follow-Up					
		6–8 weeks	3–4 months	6–8 months	10–12 months	16–18 months	29–30 months
		Mean Difference Between Baseline and Follow-Up (95% CI)					
Davis et al, 2017[29]	30-second chair-stand test	–	3 months Hip 4.1 (P < .0001)[b] Knee 2.7 (P < .0001)[b]	–	–	–	–
	40-metre walk test		Hip 0.3 (0.2–0.4)[b] Knee 0.2 (0.1–0.2)[b]				
Patel et al, 2010[42]	WOMAC	–		–	12 months −8.0 (95% CI not reported)[b]	–	–
Skou et al, 2012[43]	30-second chair-stand test	–	3 months 1.4 (0.3–2.4)[b]	–	–	–	–
Skou and Roos, 2017[21]	30-second chair-stand test	–	3 months 2.3 (2.2–2.4)[b] 2.3 (2.2–2.4)[a,b]	–	–	–	–
	40-metre walk test		2.5 (2.3–2.7)[b] 2.5 (2.3–2.6)[a,b]				

Abbreviations: CI, confidence interval; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[a]Adjusted analyses for baseline scores, gender, age, and body mass index. Excludes individuals reporting to have undergone a total joint replacement during follow-up.
[b]A positive improvement.

Quality of Life

Randomized Controlled Trials

Structured Education and Neuromuscular Exercise Program Versus Usual Care

Two randomized controlled trials reported on quality-of-life outcomes in people with knee osteoarthritis.[37,39] Skou et al compared a structured education and neuromuscular exercise program with usual care,[37] and da Silva et al compared a structured education and neuromuscular exercise program with patient education.[39]

Skou et al measured quality of life with the KOOS quality-of-life subscale.[37] The authors reported a statistically significant between-group difference of −13.5 (95% CI: −19.8 to −7.1) in favour of the structured education and neuromuscular exercise program versus usual care between baseline and a 12-month follow-up.[37] However, this mean difference did not meet the minimal detectable change threshold of 21.1 units.[47]

Similarly, the between-group difference of −10.9 (95% CI: −16.8 to −5.8), measured via the KOOS quality-of-life subscale score and adjusted for follow-up, location of intervention, baseline values, and interaction between follow-up and treatment arms, was statistically significantly in favour of the structured education and neuromuscular exercise program versus usual care but did not meet the minimal detectable change criterion.[37]

Structured Education and Neuromuscular Exercise Program Versus Patient Education

Da Silva reported on quality of life in the context of 8 domains of the 36-item Short-Form Health Survey (SF-36): physical function, role physical, bodily pain, general health, vitality, social function, role emotional, and mental health.[39] However, physical and mental component summary measures were not provided.[39] The crude improvements for the SF-36 domains of physical function, role physical, general health, vitality, role emotional, and mental health were statistically significantly improved in the education and neuromuscular group compared with patient education[39]:

- Physical function: 17.66 (95% CI:5.42–29.90)
- Role physical: 60.00 (95% CI: 37.23–82.77)
- General health: 16.93 (95% CI: 3.88–29.98)
- Vitality: 12.00 (95% CI: 0.63–23.37)
- Role emotional: 35.67 (95% CI: 12.98–58.36)
- Mental health: 17.33 (95% CI: 3.11–31.55)

Similarly, the adjusted improvements for the SF-36 domains of physical function, role physical, bodily pain, general health, vitality, and role emotional were statistically significantly improved in the education and neuromuscular group compared with patient education[39]:

- Physical function: 18.01 (95% CI: 9.06–26.96)
- Role physical: 53.05 (95% CI: 30.24–75.86)
- Bodily pain: 12.82 (95% CI: 1.95–23.69)
- General health: 13.57(95% CI: 3.20–23.94)
- Vitality: 15.99 (95% CI: 6.62–25.31)
- Role emotional: 32.85 (95% CI: 11.26–54.44)

The crude improvement for the SF-36 domain of bodily pain (16.33 [95% CI: −6.17 to 28.92]) and the adjusted improvement for the SF-36 domain of mental health (5.22 [95% CI: −6.37 to 16.81]) were not statistically significant for people in the structured education group and between neuromuscular exercise groups compared to patient education.[39] Similarly, the crude and adjusted improvements for the SF-36 domain of social function were not statistically significant for people in the structured education group or the neuromuscular exercise group when compared to patient education.[39]

Observational Studies

Two single group observational studies assessing people with hip and knee osteoarthritis who received a structured education and neuromuscular exercise program reported on quality of life.[21,29]

Skou and Roos observed an improvement in quality of life as measured by the HOOS (for hip) or KOOS (for knee) joint-related quality-of-life subscale.[21] The authors conducted crude and adjusted analyses for baseline scores, gender, age, and body mass index.[21] From baseline to 3 months, in participants with hip and knee osteoarthritis, the crude and adjusted mean improvement for those who had not undergone total joint replacement was statistically significant, with a HOOS or KOOS subscale score of 5.4 (95% CI: 5.0–5.9).[21]

For participants with hip osteoarthritis, there was an adjusted mean improvement of 4.6 points using the HOOS quality-of-life subscale.[21] In those with knee osteoarthritis, there was an adjusted mean improvement from baseline to 3 months of 6.2 points using the KOOS quality-of-life subscale.[21] This result did not meet the minimum detectable change threshold of 21.1 points.[47] From baseline to 12 months, in participants with hip and knee osteoarthritis, the crude and adjusted mean difference of 9.4 (95% CI: 8.6–10.2) was statistically significant for the HOOS and KOOS quality-of-life subscale. The adjusted mean difference for participants who had not undergone total joint replacement was 8.2 (95% CI: 7.3–9.0).[21] This result did not meet the minimum detectable change threshold of 21.1 points.[47]

Davis et al presented subgroup results for quality of life for participants with hip or knee osteoarthritis on the HOOS (for hip) or KOOS (for knee) quality-of-life subscale.[29] The authors found a statistically significant mean improvement from baseline to 3 months of 11.7 (95% CI: 3.7–19.8) and 7.3 (95% CI: 2.9–11.6), for hip osteoarthritis and knee osteoarthritis respectively.[29] The minimum detectable change threshold for the KOOS quality-of-life subscale was not met for either hip or knee osteoarthritis.[29]

For structured education and neuromuscular exercise compared to usual care, the overall quality of the body of evidence for quality of life was assessed as moderate (Appendix 2, Table A5). The quality of the body of evidence was downgraded due to the potential for imprecision in the width of the 95% confidence intervals.

For structured education and neuromuscular exercise compared to patient education, the overall quality of the body of evidence for quality of life was assessed as low (Appendix 2, Table A5). The quality of the body of evidence was downgraded because of risk of bias due to more than 20% of participants lost to follow-up at 8 weeks in the intervention group. There was potential for imprecision due to the width of the 95% confidence intervals.

For structured education and neuromuscular exercise with no comparator, the overall quality of the body of evidence for quality of life was assessed as very low (Appendix 2, Table A5). The

quality of the body of evidence was downgraded because of concerns with selection bias and indirectness due to lack of generalizability of the results. There was potential for imprecision due to the width of the 95% confidence intervals.

Activities of Daily Living

Randomized Controlled Trials

Two randomized controlled trials examined function in activities of daily living; both assessed participants with knee osteoarthritis, with one comparing against usual care[37] and one comparing against patient education.[39]

Using usual care as the comparator, Skou et al reported a statistically significant between-group difference of −13.2 (95% CI: −19.9 to −6.6) from baseline to a 12-month follow-up, which is an improvement based on the KOOS activities of daily living subscale.[37] When adjusted for follow-up, location of intervention, baseline values, and interaction between follow-up and treatment arms, the between-group difference of –11.2 (95% CI: −17.1 to −5.4), was a statistically significant improvement.[37]

Using patient education as the comparator, da Silva et al found a crude mean difference of −0.9 (95% CI: −1.9 to 0.1) and a statistically significant adjusted mean difference for baseline values of −1.1 (95% CI: −1.9 to −0.2) from baseline to follow-up at 8 weeks.[39]

Observational Studies

Two single group observational studies assessing people with hip and knee osteoarthritis who received a structured education and neuromuscular exercise program reported on function in activities of daily living.[29,41]

Al-Khlaifat et al examined people with knee osteoarthritis and reported a statistically significant improvement on the KOOS activities-of-daily-living subscale at a 6-week follow-up, with a median of 55.5 (range: 46.75–74.25) compared to the baseline median of 39.0 (range: 28.25–45.25).[41]

Davis et al provided subgroup results for participants with hip or knee osteoarthritis, measured via the HOOS (for hip) or KOOS (for knee) activities-of-daily-living subscale.[29] The study authors found a statistically significant mean change improvement between baseline and a 3-month follow up for hip and knee osteoarthritis of 12.0 (95% CI: 6.3−17.8) and 6.8 (95% CI: 2.3–11.3), respectively.[29]

For structured education and neuromuscular exercise compared to usual care, the overall quality of the body of evidence for activities of daily living was assessed as moderate (Appendix 2, Table A6). The quality of the body of evidence was downgraded because of the potential for imprecision due to the width of the 95% confidence intervals.

For structured education and neuromuscular exercise compared to patient education, the overall quality of the body of evidence for activities of daily living was assessed as moderate (Appendix 2, Table A6). The quality of the body of evidence was downgraded because of risk of bias as more than 20% of participants in the intervention group were lost to follow-up at 8 weeks.

For structured education and neuromuscular exercise programs with no comparator, the overall quality of the body of evidence for activities of daily living was assessed as very low (Appendix 2, Table A6). The quality of the body of evidence was downgraded because of concerns with selection bias and indirectness due to lack of generalizability of the results. There was potential for imprecision due to the width of the 95% confidence intervals.

Physical Activity

Randomized Controlled Trial

One randomized controlled trial assessed the outcome of physical activity in participants with hip osteoarthritis, comparing a structured education and neuromuscular exercise program with patient education.[40]

Svege et al assessed physical activity using the Physical Activity Scale for the Elderly (PASE).[40] The mean differences between the structured education and neuromuscular exercise program and patient education groups demonstrated an improvement in physical activity in favour of the structured education and neuromuscular exercise program. Differences between baseline and 4, 10, 16, and 29 month follow-up were 3 (95% CI: −15.5 to 21.5), 1 (95% CI: −21.2 to 23.3), −1 (95% CI: −25.0 to 23.0), and −10 (95% CI: −35.6 to 15.6), respectively.[40] These differences were not statistically significant.[40]

Observational Studies

Two single group observational studies assessing people with hip and knee osteoarthritis who received a structured education and neuromuscular exercise program reported results for the outcome of physical activity.[21,29]

The studies conducted by Skou and Roos[21] and by Davis et al[29] required participants to self-report the number of days per week they completed at least 30 minutes of moderately intense physical activity. Skou and Roos found that participants who had participated in a structured education and neuromuscular exercise program reported an 18% increase in physical activity at 3 months compared to baseline (odds ratio: 1.18 [95% CI: 1.10–1.27]).[21] At 12 months, a 10% increase in physical activity was found compared to baseline (odds ratio: 1.10 [95% CI: 0.99–1.27]).[21]

Similarly, Davis et al found that 22.7% (95% CI: 0.10–0.43) of participants with hip osteoarthritis and 24.2% (95% CI: 0.13–0.41) of participants with knee osteoarthritis self-reported increased physical activity at a 3-month follow-up.[29]

For structured education and neuromuscular exercise compared to patient education, the overall quality of the body of evidence for activities of daily living was assessed as low (Appendix 2, Table A7). The quality of the body of evidence was downgraded because of risk of bias as participants lost to follow-up prior to 29 months underwent total hip replacement, which may bias the outcomes. There was imprecision due to the width of the 95% confidence intervals

For structured education and neuromuscular exercise programs with no comparator, the overall quality of the body of evidence for activities of daily living was assessed as very low (Appendix 2, Table A7). The quality of the body of evidence was downgraded because of concerns with selection bias and indirectness due to lack of generalizability of the results. There was potential for imprecision due to the width of the 95% confidence intervals.

Adverse Events

Of the studies reviewed, one randomized controlled study assessed adverse events.[37]

Skou et al defined serious adverse events as those having the potential to significantly compromise clinical outcomes; be life-threatening; prolong hospital care; result in significant disability, incapacity, or death; or require inpatient or outpatient hospital care. Non-serious events were considered to comprise all other adverse events, such as pain, swelling, subjective instability, decreased range of motion, and joint distortion.[37]

The authors reported no statistically significant differences in serious adverse events incurred between participants randomized to the structured education and neuromuscular exercise program and those randomized to usual care (P = .22).[37] Similarly, there were no statistically significant differences in non-serious adverse events between treatment groups (P = .46).[37]

Da Silva et al did not assess adverse events but did state that the exercises used in their study were simple and safe.[39]

For structured education and neuromuscular exercise compared to usual care, the overall quality of the body of evidence for adverse events was assessed as high (Appendix 2, Table A8).

For structured education and neuromuscular exercise compared to usual care, the overall quality of the body of evidence for adverse events was assessed as high (Appendix 2, Table A8).

Discussion

A structured education and neuromuscular exercise program is one type of conservative management for hip and/or knee osteoarthritis. While this type of program could include different combinations of components, an assessment of such program variations was beyond the scope of this health technology assessment.

Among the primary studies included with the comparator of usual care, results from the structured education and neuromuscular exercise group found short-term[36,38] and sustained long-term[36,37] improvements in the outcomes of pain and physical function. Compared with usual care, a structured education and neuromuscular exercise program found long-term improvements in quality of life[37] and function in activities of daily living.[37]

When compared with patient education, a structured education and neuromuscular exercise program showed a short-term improvement in pain[40] and ability to perform activities of daily living.[39] Physical function also improved in both the short and long term.[40]

Of the various measurement scales and performance tests used across the included studies to assess physical function when the comparator was patient education, the timed up-and-go test was associated with statistically significant short-term results,[39] and the WOMAC physical function subscale reported statistically significant mid-term[40] and long-term results.[40]

We assessed the clinical importance of results for the measurement scales and performance tests for which thresholds for minimal detectable change, minimal clinically important improvement, or minimal clinically important difference were available in the literature.[47,48,51]

In the absence of available population-specific clinical thresholds, we applied benchmarks from other populations. While the studies reported statistically significant improvements from baseline to follow-up, these studies did not meet the minimal detectable change thresholds for the outcomes of pain, quality of life, and activities of daily living.[21,29,37] The observational study by Davis et al, which assessed the effect of a structured education program and neuromuscular exercise on pain intensity in participants with hip or knee osteoarthritis using the Numeric Pain Rating Scale, did meet the threshold for minimal clinically important difference and minimal clinically important improvement for the 30-second chair-stand test indicating a clinically meaningful change had occurred.[29]

Limitations

We identified several limitations in the included studies.

Five studies reported outcome results for more than one follow-up time, with follow-ups ranging from 6 weeks to 30 months.[21,36,37,40,44] Most studies provided long-term follow-up results for 12 months, which helped us assess whether the improvements observed for outcomes of interest were maintained beyond the duration of treatment with a structured education and neuromuscular exercise program. In studies in which participants were observed and assessed at multiple follow-ups, it is possible that the reported results were influenced by the Hawthorne effect, in which participants alter their behaviour as a result of being observed.

Second, the design of the structured education and neuromuscular exercise program in one randomized controlled trial (reported in two publications) conducted on people with knee osteoarthritis included additional components.[37,38] The intervention was composed of education and neuromuscular exercise (the minimum criteria required for inclusion in this review), as well as a 12-week dietary weight-loss program for participants with a BMI of 25 or more at baseline, custom orthotics, and pain medications offered at the discretion of the orthopedic surgeon involved in the trial. This 12-week intervention entailed 24 supervised exercise sessions in addition to an 8-week transition period following the intervention in which physiotherapists telephoned participants monthly to support the continuation of exercise. Further, a dietician was available for support via two telephone consultations. Therefore, the improvements in pain, physical function, quality of life, and ability to perform activities of daily living observed in this trial may not be solely attributable to an intervention consisting only of education and neuromuscular exercise.

Third, although adjusted analyses were conducted for some studies,[21,36,37,39] residual confounding may have biased the outcome results. For example, people with higher levels of completed education may be more likely than those with less education to apply the principles taught in the educational component and to understand the benefits of engaging in physical activity. Such people may thus be more likely to experience improvements in their pain, physical function, and quality of life. Although a priori power calculations were calculated for randomized controlled trials, loss to follow-up exceeded 20% and is a concern for risk of bias.[36,39,40]

Last, the outcome of physical activity was self-reported by participants in the study by Svege et al[40] using a questionnaire with poor construct validity and only moderate reliability.[52] Thus, the results reported may not be accurate owing to potential response bias and overestimation of outcomes. Although the Lequesne Index used in the study by da Silva et al[39] has satisfactory internal consistency (Cronbach's $\alpha = 0.84$), the objective of the study did not satisfy one of the stated aims of this index, which is to measure outcomes in randomized controlled trials involving

emerging drugs for the management of hip osteoarthritis.[53] Therefore, these results should be interpreted with caution.

Further, it is unclear if a trained outcome assessor administered all questionnaires and performance tests in the studies by Al-Khlaifat et al[41] and by Patel et al[42]; thus, we cannot be assured of a standardized delivery and collection of outcomes.

The included observational studies may overestimate the effect of a structured education and neuromuscular exercise program, given the lack of a control group. The results from six observational studies demonstrated short-term and long-term improvements in pain, physical function, the ability to perform activities of daily living, quality of life, and physical activity. However, the potential selection bias identified limits the generalizability of these findings.

Conclusions

Our conclusions are based on the best-quality evidence available from the included randomized controlled trials.

Compared with usual care, a structured education and neuromuscular exercise program improves the following:

- Pain (GRADE low)
- Physical function (GRADE moderate)
- Quality of life (GRADE moderate)
- Ability to perform activities of daily living (GRADE moderate)

Compared with patient education, a structured education and neuromuscular exercise program improves the following:

- Pain (GRADE low)
- Physical function (GRADE low)
- Quality of life (GRADE low)
- Ability to perform activities of daily living (GRADE moderate)
- Physical activity (GRADE low)

ECONOMIC EVIDENCE

Research Question

What is the cost-effectiveness of a structured education and neuromuscular exercise program for the management of hip and/or knee osteoarthritis?

Methods

Economic Literature Search

We performed an economic literature search on October 4, 2017, for studies published from January 1, 2008, to the search date. To retrieve relevant studies, we developed the search using the clinical search strategy with an economic and costing filter applied.

We created database auto-alerts in MEDLINE, Embase, and CINAHL, which we monitored for the duration of the health technology assessment.

We performed a targeted grey literature search of health technology assessment agency websites, clinical trial registries, and the Tufts Cost-Effectiveness Analysis Registry. See Clinical Evidence, Literature Search, above, for further details on the methods used. See Appendix 1 for the literature search strategies, including all search terms.

Literature Screening

A single reviewer reviewed titles and abstracts, and, for those studies likely to meet the eligibility criteria, we obtained full-text articles and performed further assessment for eligibility.

Inclusion Criteria

- Studies on structured education and neuromuscular exercise programs for the management of hip and/or knee osteoarthritis
- English-language, full-text publications
- Studies published between January 1, 2008, and October 4, 2017
- Cost–utility, cost-effectiveness, cost–benefit, or cost-minimization analyses

Exclusion Criteria

- Reviews (systematic and narrative) and study protocols
- Conference abstracts, editorials, case reports, and commentaries
- Cost-of-illness studies

Outcomes of Interest

- Costs
- Quality-adjusted life-years or other measures of effectiveness
- Incremental costs and incremental effectiveness
- Incremental costs per quality-adjusted life-year (or other health outcomes) gained

Data Extraction

We extracted relevant data on the following:

- Source (i.e., name, location, year)
- Population
- Intervention and comparator
- Outcomes (i.e., health outcomes, costs, incremental cost-effectiveness ratios)

Study Applicability

We determined the usefulness of each identified study for decision-making by applying a modified applicability checklist for economic evaluations originally developed by the National Institute for Health and Care Excellence (NICE) in the United Kingdom to inform the development of NICE's clinical guidelines.[54] We retained questions from the NICE checklist related to study applicability and modified the wording of the questions to remove references to guidelines and to make it Ontario specific. Appendix 6 provides a summary of the studies judged to be directly applicable, partially applicable, or not applicable to the research question.

Results

Literature Search

The literature search yielded 182 citations published between January 1, 2008, and October 4, 2017, after removing duplicates. We excluded a total of 181 articles based on information in the title and abstract. We then obtained the full text of one potentially relevant article for further assessment, which met our inclusion criteria.[55] Figure 2 presents the PRISMA flow diagram for the economic literature search.

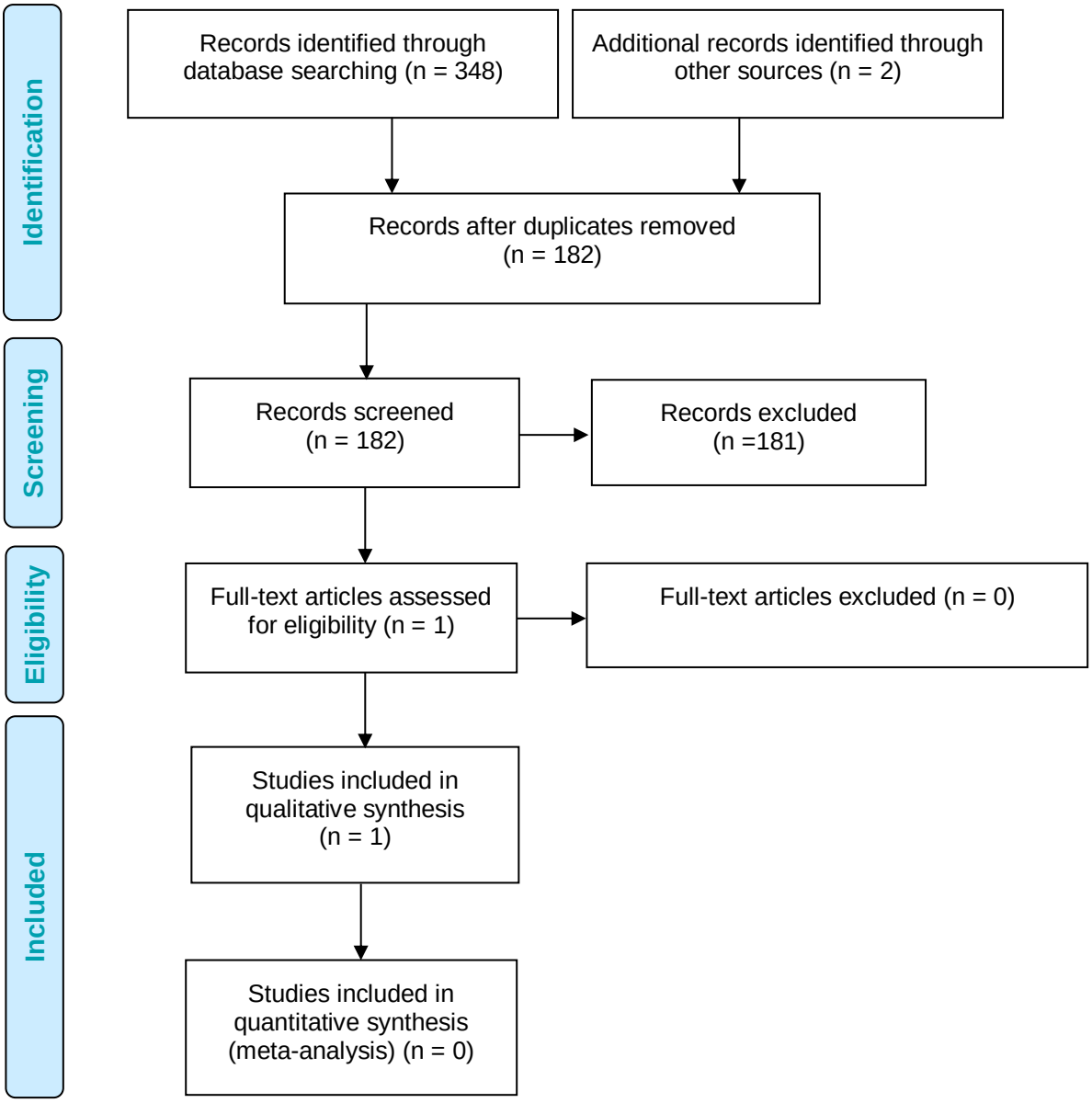

Figure 2: PRISMA Flow Diagram—Economic Evidence Review

Abbreviation: PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-analyses.
Source: Adapted from Moher et al.[35]

Review of the Included Economic Study

Table 7 provides a summary of the included study. Fernandes et al conducted a randomized controlled trial of people with hip or knee osteoarthritis scheduled to receive total hip or total knee replacement surgery.[55] Participants were randomized to receive either an 8-week supervised preoperative education and neuromuscular exercise program (the intervention group) or a preoperative educational package (the control group).[55] The educational package consisted of information on the surgical procedure, expected postoperative progression, and a leaflet on various exercises.[55] The education and neuromuscular exercise program was offered in groups of 6 to 12 patients and consisted of two sessions per week; each session was 1 hour long.[55] Following the intervention, participants underwent surgery. Health outcomes, measured

via the HOOS (for hip osteoarthritis) and KOOS (for knee osteoarthritis), and general health status, measured via the EQ-5D, were assessed at baseline, 8 weeks' post-intervention, and then at 15, 21, and 61 weeks' post-surgery.[55]

The mean baseline utility was 0.63 in the intervention group and 0.57 in the control group.[55] The longitudinal utility associated with the groups at 8 weeks' post-intervention and at 15 and 21 weeks' post-surgery was not reported. Hence, it is unclear whether the beneficial effect of the intervention was sustained over time.

The authors assessed the cost of providing the intervention, the cost of physician services, and the costs of inpatient, outpatient, and emergency department visits.[55] There was no statistically significant difference in health services use or corresponding costs incurred by patients in the intervention or control group (−€132 [95% CI: −€3,942 to €3,679]).[55] Compared with control, the intervention was associated with a statistically significant gain of 0.04 quality-adjusted life-years (QALYs) (95% CI: 0.01–0.07).[55] At a willingness-to-pay of €40,000, the probability of the supervised preoperative education and neuromuscular exercise program being cost-effective was 84%.[55]

Table 7: Results of Economic Literature Review—Summary

Author, Year, Location	Study Design and Perspective	Population	Intervention and Comparator	Results		
				Health Outcome, QALYs (SE)	Costs, 2012 € (SE)	Cost-Effectiveness
Fernandes et al, 2017, Denmark[55]	• Type of economic analysis: Individual-level cost–utility analysis • Study design: Randomized controlled trial • Perspective: Publicly funded health care system (Denmark) • Time horizon: 12 months • Discounting: Not applicable	• Adults aged ≥ 18 years scheduled for total hip or knee replacement surgery • Total N: 165 • Mean age (SD): Intervention, 67.9 (8.6) years; control, 66.9 (8.3) years • % Female: Intervention 52%; control 50%	• Intervention: Supervised preoperative education and neuromuscular exercise program (n = 84) • Comparator (control): Preoperative educational package (n = 81)	• Intervention vs. control: 0.66 (0.04) vs. 0.61 (0.04) • Mean difference: 0.04 (95% CI: 0.01–0.07)	• Average intervention cost: €326 (€12.9) • Total costs, intervention vs. control: €16,181 (€1,174) vs. €16,313 (€1,374) • Incremental cost of intervention: −€132 (95% CI: −€3,942 to €3,679)	• At a willingness-to-pay of €40,000, the intervention has an 84% probability of being cost-effective

Abbreviations: CI, confidence interval; SD, standard deviation; SE, standard error.

Applicability of the Included Study

Table A10 presents the results of the applicability checklist for economic evaluations applied to the included study. We considered the study by Fernandes et al[55] to be not applicable to our decision problem because this study was conducted in Denmark using the local health care payer perspective in people with severe osteoarthritis undergoing total joint replacement.

Discussion

Fernandes et al performed a cost–utility analysis of a supervised preoperative education and neuromuscular exercise program compared with a preoperative education package in people with hip or knee osteoarthritis scheduled for total joint replacement.[55] The preoperative education and neuromuscular exercise program was found to be cost-effective at a country-specific willingness-to-pay of €40,000 per QALY gained.[55]

The study population consisted of people with severe hip and/or knee osteoarthritis scheduled to receive total joint replacement. Therefore, the study findings cannot be directly applied to people with less severe disease, people who are not candidates for surgery, or people who choose not to undergo surgery.

Within the literature, there is a lack of cost-effectiveness analyses on structured education and neuromuscular exercise programs in people with hip and/or knee osteoarthritis who undergo nonsurgical management.

Conclusions

We identified one economic study suggesting that a supervised education and neuromuscular exercise program may be cost-effective compared with an education package. However, this study was conducted from the perspective of Denmark's public health system and was not applicable to the Ontario setting.

PRIMARY ECONOMIC EVALUATION

Although the published economic evaluation that we identified in the literature review addressed the intervention of interest, it did not take a Canadian or Ontario-specific perspective. Owing to these factors, we conducted a primary economic evaluation focusing on the nonsurgical management of hip and/or knee osteoarthritis using Ontario-specific costs.

The clinical evidence review section of this report suggests that a structured education and neuromuscular exercise program may improve quality of life for people with knee osteoarthritis.[37]

There is a lack of evidence regarding changes in health state utility following a structured education and neuromuscular exercise program in adults with hip osteoarthritis. Therefore, we limited our primary economic evaluation to people with knee osteoarthritis undergoing nonsurgical management for their symptoms.

Research Question

What is the cost-effectiveness of a group-based structured education and neuromuscular exercise program compared with usual care for the management of adults with knee osteoarthritis from the perspective of the Ontario Ministry of Health and Long-Term Care?

Methods

The information presented in this report follows the reporting standards set out by the Consolidated Health Economic Evaluation Reporting Standards Statement.[56]

Type of Analysis

We conducted a cost–utility analysis to assess the costs and health outcomes associated with adding a group-based structured education and neuromuscular exercise program to usual care for the nonsurgical management of knee osteoarthritis.

Target Population

The target population evaluated by our model consisted of adults with knee osteoarthritis. Our target population was based on a randomized controlled trial by Skou et al that compared a structured education and neuromuscular exercise program (the intervention) with usual care (the control) in people with knee osteoarthritis.[37] The mean ages of participants in the intervention and control groups were 64.8 and 67.1 years, respectively.[37] Of note, the mean age of participants in the study by Skou et al[37] is similar to previous studies of osteoarthritis conducted in Canada.[57,58] A retrospective cohort study indicated that people with osteoarthritis seeking primary care in Canada were 67 years of age on average.[59] Moreover, studies on structured education and neuromuscular exercise programs for the management of osteoarthritis from Canada and elsewhere have been conducted on participants whose ages ranged from 59 to 70 years.[4,21,29,37]

The severity of osteoarthritis across participants in the study by Skou et al varied and was assessed via the Kellgren–Lawrence system (with a grade of 0 signifying no radiographic features of osteoarthritis and a grade of 4 signifying large osteophytes, marked joint space narrowing, severe sclerosis, and definite bone deformity).[37]

The utility values in our model parameters were based on the clinical evidence from the trial by Skou et al (Table 8).[37]

Perspective

We conducted this analysis from the perspective of the Ontario Ministry of Health and Long-Term Care.

Intervention and Comparator

We evaluated the costs and health outcomes associated with a group-based structured education and neuromuscular exercise program versus usual care for the management of knee osteoarthritis in adults.[37] The educational component consisted of information about osteoarthritis, including its causes, modifiable and nonmodifiable risk factors, symptoms, diagnosis, treatment options, the potential impact of osteoarthritis on one's ability to perform activities of daily living, self-help options, and coping skills.[37,60] The education program was delivered by trained health care professionals (e.g., physiotherapists) over two weekly one-hour sessions.[37,60]

The goal of neuromuscular exercises is to restore strength, balance, and healthy movement patterns without causing additional joint damage.[13,43] Therefore, neuromuscular exercise is unique compared with other types of exercise, such as strengthening exercise (with the goal of improving muscle force) and aerobic exercise (with the goal of improving cardiorespiratory fitness).[43] The neuromuscular exercise component of the program consisted of 24 supervised sessions. The exercise program was delivered over 12 weeks, with two hour-long sessions per week.[37]

Usual care consisted of patient education leaflets about knee osteoarthritis, describing the etiology of osteoarthritis, risk factors, symptoms, diagnosis, management options, functional limitations, the importance of weight management, the potential impact of osteoarthritis on one's ability to perform activities of daily living, and advice on physical activity, healthy lifestyles, coping skills, and where to seek help.[37,60] Participants undergoing usual care may also have consulted with primary care physicians or specialists, and they may also have taken pain medications.[37]

Discounting and Time Horizon

We chose a 1-year time horizon for our reference case analysis. Therefore, we did not apply discounting to the reference case analysis.[61,62]

In the scenario analysis, we modelled a 2-year time horizon and discounted both costs and outcomes at a rate of 1.5% annually, as per the Canadian Agency for Drugs and Technologies in Health guidelines for economic evaluations.[63]

Main Assumptions

The major assumptions for the reference case were as follows:

- Each person participates in all sessions of the group-based structured education and neuromuscular exercise program in a clinic under the supervision of a trained health care professional

- The structured education and neuromuscular exercise program does not impact other health services use (e.g., physician visits, hospitalizations)
- All people following a structured education and neuromuscular exercise program also receive usual care, including pain medications

Model Structure

We developed a decision analytic model (Figure 3) to evaluate the cost-effectiveness of a group-based structured education and neuromuscular exercise program in people with knee osteoarthritis by synthesizing data from various sources.[64] The clinical evidence review did not find evidence suggesting a benefit of a structured education and neuromuscular exercise program in terms of survival or other clinical outcomes (e.g., progression of joint space narrowing). However, the review showed that a structured education and neuromuscular exercise program significantly improved health-related quality of life at 1 year post-intervention.[37] Therefore, we decided to use a 1-year time horizon in our reference case analysis. Based on the randomized controlled trial by Skou et al,[37] we assigned the same baseline utility to both the intervention and control groups and estimated utility at 12 months (equal to the baseline utility plus the utility change at 12 months). For both intervention and control, we calculated quality-adjusted life-years (QALYs) in the first year as the area under the utility curve.[65,66]

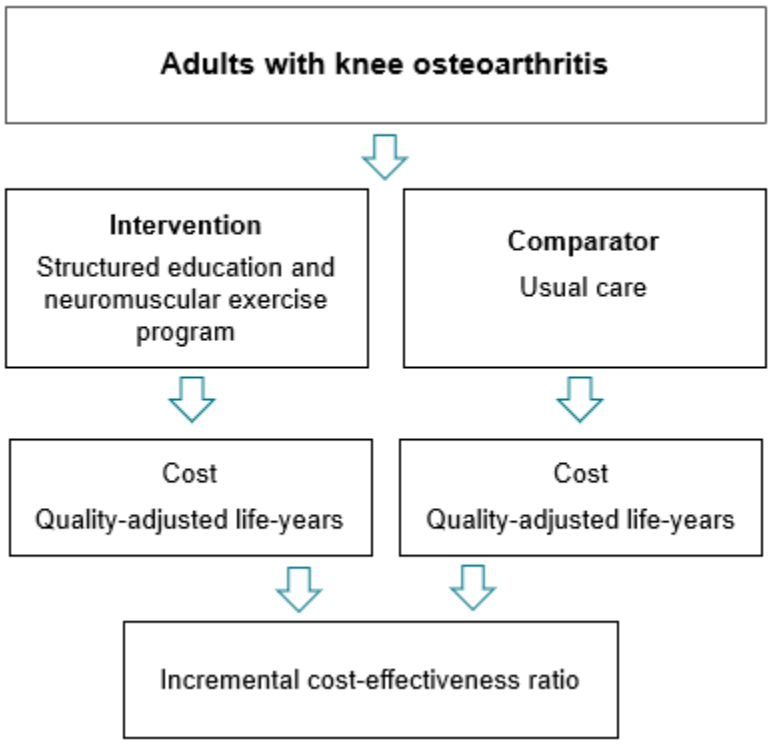

Figure 3: Conceptual Framework for the Cost-Effectiveness Analysis

Utility Parameters

We calculated utilities for our model using data from the randomized control trial by Skou et al that compared the efficacy of a group-based structured education and neuromuscular exercise program with usual care in people with knee osteoarthritis (Table 8).[37] EQ-5D utilities were self-reported by participants at baseline and at a 12-month follow-up.[37] We assumed the same baseline utility for both the intervention and control groups. Utility values at 12 months were estimated by adding the difference in utility at 12 months to the baseline value. Utilities reported by patients were converted to QALYs using the "area under the utility curve" method, which assumes a linear relationship between EQ-5D values at different time periods.[65,66]

Table 8: Utilities Used in the Economic Model

Variable	Structured Education and Neuromuscular Exercise Program Mean (SE)	Usual Care Mean (SE)	Reference
EQ-5D Utility			
Baseline	0.69 (0.02)[a,b]	0.69 (0.02)[a,b]	Skou et al, 2015,[37] assumption
Improvement at 12-month follow-up	0.135 (0.02)[c]	0.075 (0.03)[c]	Skou et al, 2015[37]

Abbreviations: EQ-5D, EuroQol Five Dimensions; SE, standard error.
[a]We assumed the same baseline utilities for both the intervention and control groups.
[b]Beta distribution used for probabilistic analysis.
[c]Normal distribution used for probabilistic analysis.

Cost Parameters

Based on Skou et al,[37] we assumed that primary care physicians referred patients to outpatient clinics, where they consulted with orthopaedic surgeons prior to participating in the structured education and neuromuscular exercise program. The group-based structured education and neuromuscular exercise program requires minimal equipment and can be delivered from an existing physiotherapy or other type of health clinic. Therefore, we excluded capital costs, equipment costs, and other facility costs.

The group-based structured education and neuromuscular exercise program consisted of two educational sessions and 24 exercise sessions conducted over 12 weeks, as described above.[37] We estimated costs per person for the program as follows:

- Administrative services related to patient consultations: $22
- Assessment of health condition to participate in the sessions: $48
- Educational component, 2 sessions × $25/session: $50
- Neuromuscular exercise component, 24 sessions × $25/session: $600

We estimated the total per-person cost of the program as $720 ($22 + $48 + $50 + $600). The estimated average per-person use of health services and the corresponding cost was categorized into baseline and follow-up. For baseline, we estimated the costs associated with the group-based structured education and neuromuscular exercise program and consultations with a primary care physician and orthopaedic surgeon (Table 9). We assumed the use of health care services across the structured education and neuromuscular exercise program and

usual care groups to be similar over the 12 months of follow-up. We obtained data on resource use and costs over the follow-up period from a study conducted in Ontario.[67]

Maetzel et al surveyed patients from randomly selected family practices in Ontario to measure their health care service use to manage osteoarthritis and comorbidities.[67] The authors categorized health care service use into consultations with health care professionals, diagnostic tests and examinations, and hospitalizations[67]:

- The cost of consultations with primary care physicians, orthopaedic surgeons, and rheumatologists was based on the Ontario Schedule of Benefits. The cost of consulting other health care professionals was obtained from specific professional bodies
- The cost of diagnostic tests and examinations included costs associated with the use of x-ray, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, electrocardiogram, bone density testing, and other lab tests
- The cost of hospitalizations included costs associated with both inpatient and outpatient visits

Maetzel et al reported costs in U.S. dollars.[67] We converted these to Canadian dollars using purchasing power parity,[67,68] and inflated costs to 2017 Canadian dollars using the Consumer Price Index.[69]

Table 9: Costs Used in the Economic Model

Intervention	Structured Education and Neuromuscular Exercises Program, $	Usual Care, $	Source
Structured education and neuromuscular exercise program	720	0	Estimate
Administration	22	–	Estimate
Initial assessment	48	–	Estimate
Education component (2 sessions)	50	–	Estimate
Neuromuscular exercise component (24 sessions)	600	–	Estimate
Usual care[a]	3,311	3,311	Maetzel et al, 2004[67]
Total cost	**4,031**	**3,311**	

[a]Based on the average costs in Ontario for diagnostic and other tests; primary care physician, specialist, and allied health professional visits; hospital inpatient and outpatient visits; and pain medications.

Analysis

We conducted a cost–utility analysis to estimate the incremental cost per QALY for the structured education and neuromuscular exercise program compared with usual care. We estimated QALYs based on EQ-5D utilities using the "area under the utility curve" method for both the intervention and control groups.[70]

For the reference case analysis, we estimated all outcomes using probabilistic analysis. We ran 10,000 Monte Carlo simulations to capture parameter uncertainty.[71] Model input parameters were assigned specific distributions and resampled from the assigned distributions. We assigned beta and gamma distributions to utilities and costs, respectively (Tables 9 and 10).[71]

We assessed uncertainty in the model using sensitivity analyses. We conducted deterministic one-way sensitivity analyses in which we varied specific model variables within plausible ranges and examined the impact on the results.[71] Mean costs were varied within a range of 25%. For the mean utility change over 12 months compared with baseline in the intervention group, we calculated lower and upper limits of 0.09 and 0.181, respectively, using the values reported by Skou et al.[37]

We considered a strategy to be cost-effective if the incremental cost-effectiveness ratio (ICER) was below a maximum amount (e.g., $50,000, $100,000) a decision-maker would be willing to pay for an additional QALY gained. In addition, we graphically represented uncertainty around the ICER using cost-effectiveness acceptability curves (Figure 4).[72] This graph represents the probability of the intervention being cost-effective compared with the comparator over a range of willingness-to-pay amounts ($0 to $100,000/QALY gained).

We then conducted additional analyses to evaluate the cost-effectiveness of a structured education and neuromuscular exercise program compared with usual care in two scenarios:

1. **24-month time horizon:** We assumed patients would continue to exercise on their own at home over the first 12 months of follow-up. Thus, the health benefit of the structured education and neuromuscular exercise program was assumed to last until the end of 24 months. We also assumed that there would be no difference in health-related quality of life between the intervention and control groups at the end of 24 months. We discounted costs and QALYs by 1.5% between the 12- and 24-month time points of this analysis.[61]

2. **Reduction in the use of pain medications among those who participate in a structured education and neuromuscular exercise program:** Skou et al[37] showed that participation in an education and neuromuscular exercise program was associated with a reduction in the use of pain medications at 12 months (relative risk [RR] = 0.61 [95%CI: 0.43–0.88]). Based on this study,[37] we assumed that 60% of patients in the usual care group would use pain medications. In the intervention group, we assumed that the proportion of patients using pain medications would be reduced from 60% at baseline to 37% (60% × 0.61) by the end of 12 months. Therefore, we assumed that, on average, the proportion of patients using pain medications in the intervention group would be approximately 49% ([60% + 37%] ÷ 2) over one year.

We estimated the cost of prescription pain medications used over one year based on a study from Ontario.[73] Marshall et al estimated the direct costs associated with the use of NSAIDs such as ibuprofen and diclofenac to manage osteoarthritis symptoms.[73] After inflating to 2017 Canadian dollars, the annual cost of NSAID use was $811.[69] The total annual cost of pain medications used in our analysis was $397 ($811 × 49%) for the intervention group and $487 ($811 × 60%) for the control group.

Generalizability

The findings of this economic analysis cannot be generalized to all people with osteoarthritis. They may, however, be used to guide decision-making about the specific patient populations addressed in the studies evaluated by Health Quality Ontario.

Expert Consultation

We solicited expert consultation from physicians, physiotherapist, and a health economist on the use of a structured education and neuromuscular exercise program for the management of osteoarthritis, the delivery of such a program, costs, and economic modelling. The role of the expert advisors was to contextualize the topic and existing evidence and to provide guidance on study design, analysis, and collecting cost data. However, the statements, conclusions, and views expressed in this report do not necessarily represent the views of the consulted experts.

Results

Reference Case Analysis

The results of the reference case analysis indicate that a group-based structured education and neuromuscular exercise program consisting of two educational sessions and 24 exercise sessions is more effective and more expensive than usual care (Table 10). Over a 12-month time horizon, compared with usual care, the program is associated with 0.03 incremental QALYs (95% CI: −0.006 to 0.06) and incremental costs of $719 (95% CI: $410–$1,118). The incremental cost per QALY gained is $23,967.

Table 10: Reference Case Analysis Results

Strategy	Average Total Cost, $ (95% CI)	Incremental Cost,[a] $ (95% CI)	Average Total Effect, QALYs (95% CI)	Incremental Effect,[b] QALYs (95% CI)	ICER, $/QALY
Usual care	3,310 (1,897–5,071)	–	0.73 (0.69–0.78)	–	–
Structured education and neuromuscular exercise program	4,030 (2,558–5,823)	719 (410–1,118)	0.76 (0.71–0.80)	0.03 (−0.006 to 0.06)	23,967

Abbreviations: CI, confidence interval; ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-year.
[a]Incremental cost = average cost (structured education and neuromuscular exercise program) − average cost (usual care).
[b]Incremental effect = average effect (structured education and neuromuscular exercise program) − average effect (usual care).
Note: Some numbers may appear inexact because of rounding. All costs are in 2017 Canadian dollars.

Cost-Effectiveness Acceptability Curve

The cost-effectiveness acceptability curve presented in Figure 4 shows the probability of a structured education and neuromuscular exercise program being cost-effective compared with usual care across a range of willingness-to-pay amounts. At willingness-to-pay amounts of $50,000 per QALY and $100,000 per QALY, the probabilities of a structured education and neuromuscular exercise program being cost-effective are 81% and 90%, respectively.

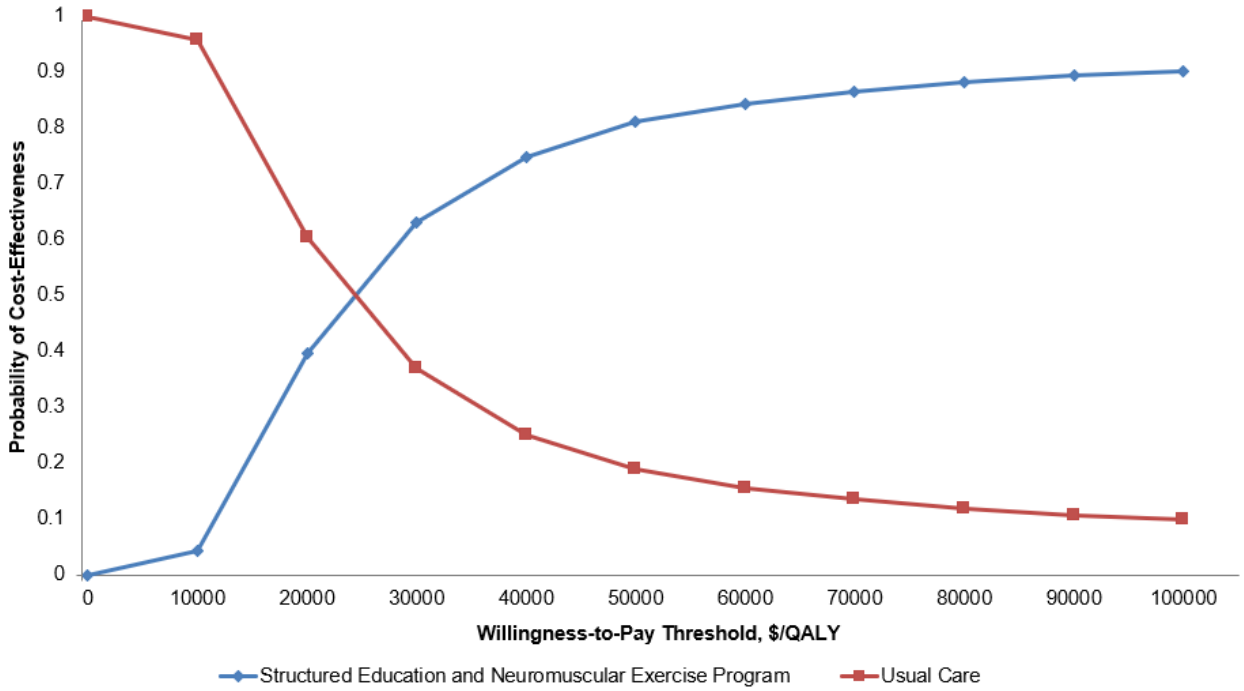

Figure 4: Cost-Effectiveness Acceptability Curve—Structured Education and Neuromuscular Exercise Program Versus Usual Care

Sensitivity Analysis

Table 11 presents the results of our one-way sensitivity analysis. Our model was most sensitive to the utility change associated with the structured education and neuromuscular exercise program at 12 months compared to baseline.

Table 11: One-Way Sensitivity Analysis Results—Structured Education and Neuromuscular Exercise Program Versus Usual Care

Parameter/Assumption	ICER ($/QALY), Structured Education and Neuromuscular Exercise Program vs. Usual Care
1. Utility change at 12 months compared to baseline: structured education and neuromuscular exercise program	
a. Scenario, lower range, mean: 0.09	a. 96,000
b. Scenario, upper range, mean: 0.181	b. 13,585
2. Cost of a structured education and neuromuscular exercise program	
a. Scenario, lower range, mean: $540	a. 18,000
b. Scenario, upper range, mean: $900	b. 30,000

Abbreviations: ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-year.
Note: Some numbers may appear inexact because of rounding.

Scenario Analyses

Our two scenario analyses (a 24-month time horizon and a reduction in the use of pain medications among those who participate in a structured education and neuromuscular exercise program) resulted in lower ICERs than the reference case analysis (Table 12).

Table 12: Scenario Analysis Results

Strategy	Average Total Cost, $ (95% CI)	Incremental Cost,[a] $ (95% CI)	Average Total Effect, QALYs (95% CI)	Incremental Effect,[b] QALYs (95% CI)	ICER ($/QALY)
Scenario 1: 24-month time horizon					
Usual care	6,564 (3,779–10,137)	–	1.54 (1.45–1.63)	–	–
Structured education and neuromuscular exercise program	7,281 (4,458–10,852)	716 (407–1,117)	1.48 (1.37–1.60)	0.06 (−0.01 to 0.13)	11,933
Scenario 2: Reduction in pain medication use among those who participate in a structured education and neuromuscular exercise program					
Usual care	2,998 (1,717–4,680)	–	0.73 (0.69–0.78)	–	–
Structured education and neuromuscular exercise program	3,623 (2,076–5,582)	539 (169–1,255)	0.76 (0.71–0.82)	0.03 (−0.005 to 0.06)	17,967

Abbreviations: CI, confidence interval; ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life-year.
[a]Incremental cost = average cost (structured education and neuromuscular exercise program) − average cost (usual care).
[b]Incremental effect = average effect (structured education and neuromuscular exercise program) − average effect (usual care).
Note: Some numbers may appear inexact because of rounding. All costs are in 2017 Canadian dollars.

Discussion

Our cost-effectiveness analysis demonstrated that a group-based structured education and neuromuscular exercise program for the management of knee osteoarthritis likely represents good value for money in the short term compared with usual care. However, this finding must be interpreted with caution as the efficacy data were based on a single randomized controlled trial of people with mostly moderate to severe osteoarthritis.[37] When combined with usual care, such a program may alleviate symptoms and decrease the use of pain medications.[37]

For our research question, we modeled the benefit of a group-based structured education and neuromuscular exercise program compared with usual care on general health status as influenced by the symptoms of knee osteoarthritis. Owing to a lack of data on the impact of such programs on survival and clinical outcomes, we were unable to develop a Markov model.[74] As in other studies on osteoarthritis,[65,66] we used the “area under the utility curve” method to estimate QALYs based on EQ-5D utilities associated with a structured education and neuromuscular exercise program.[70]

Our findings cannot be directly compared with the findings reported in the economic evaluation alongside the randomized controlled trial by Fernandes et al,[55] since our evaluation focused on people with varying degrees of osteoarthritis severity undergoing nonsurgical management for their symptoms, while Fernandes et al focused on people with severe osteoarthritis scheduled for joint replacement surgery.

Study Strengths and Limitations

One strength of our evaluation is that it is one of only a few modelling studies to estimate the cost-effectiveness of a structured education and neuromuscular exercise program for the nonsurgical management of knee osteoarthritis. The key clinical parameters of our economic model were based on high-quality evidence (i.e., a randomized controlled trial). We also examined the uncertainty associated with the data used in model development and assessed its impact on study findings.

Our findings should be interpreted in the light of the following limitations. The clinical evidence we used derived from a single randomized controlled trial that measured general health status at 12 months following baseline assessment.[37] Therefore, the long-term effectiveness of a structured education and neuromuscular exercise program is unclear. Further, the impacts of this type of program on survival, clinical outcomes, and health services use are unknown; therefore, we were unable to include these outcomes in our model. Including these outcomes would require numerous assumptions and would increase uncertainty. We were unable to model treatment compliance and its impact on the outcomes measured in our study owing to a lack of clinical evidence. Further, we were unable to evaluate the impact of a group-based structured education and neuromuscular exercise program for hip osteoarthritis owing to a lack of clinical evidence. Finally, the cost estimates used in this health technology assessment were based primarily on expert consultation and currently available (not publicly funded) group-based programs. The fee for the initial assessment and subsequent exercise sessions in some clinics may be higher than our current estimate. In our sensitivity analysis, we considered that the cost of a structured education and neuromuscular exercise program could range from $540 to $900. This range captured possible variations in program cost across clinics.

Conclusions

Our economic evaluation found that a group-based structured education and neuromuscular exercise program may be cost-effective for the nonsurgical management of knee osteoarthritis.

BUDGET IMPACT ANALYSIS

Research Question

What is the 5-year budget impact of a group-based structured education and neuromuscular exercise program for people with hip and/or knee osteoarthritis from the perspective of the Ontario Ministry of Health and Long-term Care?

Methods

Analytic Framework

We estimated the budget impact of a publicly funding a group-based structured education and neuromuscular exercise program using the cost difference between two scenarios: (1) the current uptake of structured education and neuromuscular exercise programs (current scenario); and (2) the anticipated increased uptake of structured education and neuromuscular exercise programs (new scenario).

Key Assumptions

Our key assumptions were as follows:

- The elements and duration of structured education and neuromuscular exercise programs are similar across settings (e.g., hospital, private setting)
- A structured education and neuromuscular exercise program is delivered in groups of 8 to 10 participants
- Each participant participates in all program sessions
- The program is conducted under the supervision of a trained health care professional
- The structured education and neuromuscular exercise program does not impact other health services use (e.g., physician visits, hospitalizations).
- The cost estimates of treatment for people with knee osteoarthritis are applicable to people with hip osteoarthritis

Target Population

We estimated our target population based on the Canadian estimate of a 14.8% prevalence for knee and/or hip osteoarthritis in adults.[4] According to population projections for Ontario adults aged 50 to 89 years, this prevalence translates into 5.3 million to 5.7 million affected individuals between 2018 and 2022.[75] We estimated that 7% of this population will undergo total joint replacement and thus excluded this percentage from our target population (Table 13). The number of people with hip and/or knee osteoarthritis eligible to participate in a structured education and neuromuscular exercise program ranges from 736,494 to 792,212 over the next 5 years.

Current Intervention Mix

A group-based structured education and neuromuscular exercise program has been available in Ontario since 2016.[27] Participants pay for this program out of pocket or through private health insurance.[27] Given the current limited access to this program, we assumed the current uptake rate to be 1% annually.

Uptake of the New Intervention and Future Intervention Mix

For the reference case analysis, we estimated a first-year uptake of 5%, followed by an increase in uptake of 3% per year over the next 5 years. These figures were based on such factors as an adequate number of trained health care professionals being needed to support access to programs and the complexities of health services delivery (e.g., an adequate number of clinics being needed to facilitate equitable access to programs). Based on the literature,[29,37] we assumed that participants would register for a program only once. Table 13 presents the number of eligible patients who would gradually access a structured education and neuromuscular exercise program over the next 5 years, from 2018 to 2022.

Table 13: Target Population and Expected Number of People with Hip and/or Knee Osteoarthritis Eligible for a Structured Education and Neuromuscular Exercise Program, 2018–2022

Variable	Year 1	Year 2	Year 3	Year 4	Year 5
Target Population					
Ontario population (50–89 years), N	5,350,869	5,457,328	5,561,157	5,662,981	5,755,684
Prevalence of hip and/or knee osteoarthritis (14.8%), n	791,929	807,685	823,051	838,121	851,841
Total number of people with hip and/or knee osteoarthritis eligible for a structured education and neuromuscular exercise program,[a] n	736,494	751,147	765,438	779,453	792,212
Current Scenario: Current Uptake of a Structured Education and Neuromuscular Exercise Program					
Uptake rate, %	1	1	1	1	1
Total number of people with hip and/or knee osteoarthritis who will participate in a program, n	7,365	7,511	7,654	7,795	7,922
New Scenario: Future Uptake of a Structured Education and Neuromuscular Exercise Program					
Uptake rate, %	5	8	11	14	17
Total number of people with hip and/or knee osteoarthritis who will participate in a program, n	36,825	60,092	84,198	109,123	134,676

[a]Excluding 7% who will undergo total joint replacement surgery.

Resources and Costs

For both the group-based structured education and neuromuscular exercise program (consisting of 24 exercise sessions) and usual care, we used the costs per patient estimated in our primary economic evaluation (see Table 10). For the estimation, we used costs associated with implementing a group-based structured education and neuromuscular exercise program, physician services, and inpatient and outpatient hospital visits. For details of our estimation of resources used and the corresponding costs, please refer to the Primary Economic Evaluation section of this report. For the reference case, the mean costs associated with a group-based structured education and neuromuscular exercise program and usual care were estimated at $4,030 and $3,310, respectively.

Analysis

Reference Case

We calculated the budget impact as the cost difference between the new scenario (a 5% uptake of a group-based structured education and neuromuscular exercise program in year 1, followed by 3% increases per year thereafter) and the current scenario (current uptake of 1% annually). We calculated the total cost of each scenario using the average cost per patient multiplied by the number of patients per year. We then calculated the net budget impact for each year over 5 years. In the reference case, the program consists of two educational sessions and 24 exercise sessions.

Sensitivity Analysis

To estimate the cost of delivering a group-based structured education and neuromuscular exercise program in Ontario, we performed sensitivity analyses of the following scenarios. All scenarios are adaptations of the current GLA:D Canada program, a pilot of which is currently being conducted in Ontario for people with hip and/or knee osteoarthritis.[29] This program is based on the GLA:D program created in Denmark.[21] In scenarios 1a to 1e and 2, the program consists of two educational sessions and a reduced number of exercise sessions (12 instead of 24, as in the established GLA:D Canada program).

Scenario 1a: GLA:D Canada Adaptation—12 Sessions Instead of 24

- Administrative services related to patient consultations: $22
- Assessment of health condition, required to participate in program: $48
- Two educational sessions, $25 per session: $50
- 12 neuromuscular exercise sessions, $25 per session: $300
- Total per-person program cost: $420

Scenario 1b: GLA:D Canada Adaptation—Health Assessment Cost Reduced From $48 to $40

- Administrative services related to patient consultations: $22
- Assessment of health condition, required to participate in program: $40
- Two educational sessions, $25 per session: $50
- 12 neuromuscular exercise sessions, $25 per session: $300
- Total per-person program cost: $412

Scenario 1c: GLA:D Canada Adaptation—Health Assessment Cost Increased From $48 to $57

- Administrative services related to patient consultations: $22
- Assessment of health condition, required to participate in program: $57
- Two educational sessions, $25 per session: $50
- 12 neuromuscular exercise sessions, $25 per session: $300
- Total per-person program cost: $429

Scenario 1d: GLA:D Canada Adaptation—Session Cost Reduced From $25 to $20

- Administrative services related to patient consultations: $22
- Assessment of health condition, required to participate in program: $48
- Two educational sessions, $20 per session: $40
- 12 neuromuscular exercise sessions, $20 per session: $240
- Total per-person program cost: $350

Scenario 1e: GLA:D Canada Adaptation—Program Session Cost Increased From $25 to $30

- Administrative services related to patient consultations: $22
- Assessment of health condition, required to participate in program: $48
- Two educational sessions, $30 per session: $60
- 12 neuromuscular exercise sessions, $30 per session: $360
- Total per-person program cost: $490

Scenario 2: Lower Rate of Program Uptake

We examined the net budget impact of a lower rate of program uptake of 3% in year 1, followed by a yearly increase in uptake of 2%, reaching 11% in year 5. As in scenarios 1a to 1e, the program in this scenario consists of two educational sessions and 12 exercise sessions.

Scenario 3: Patients Referred to Central Intake and Assessment Centres

Based on consultation with the Ministry of Health and Long-Term Care, we examined a scenario in which people with hip and/or knee osteoarthritis are referred by their primary care physician to a central intake and assessment centre to determine whether they are candidates for joint replacement surgery. Across the 14 local health integration networks (LHINs) in Ontario, the total number of people who would be assessed through such a referral program is estimated to be 73,944. Among those referred to a central intake and assessment centre, 40% would not require a surgical consultation (73,944 × 0.4 = 29,578), and 10% of those who would attend a surgical consultation would not undergo surgery (73,944 × 0.6 = 44,367; 44,367 × 0.1 = 4,437).

Therefore, we estimate that 34,014 (29,578 + 4,437) people would participate in a structured education and neuromuscular exercise program in year 1. We would expect this number to increase by 2% per year (Table 14). The per-person cost for the program was estimated to be $450.

Table 14: Expected Number of Patients with Hip and/or Knee Osteoarthritis Referred from Central Intake and Assessment Centers Eligible for a Structured Education and Neuromuscular Exercise Program, 2018–2022

Strategy	Year 1	Year 2	Year 3	Year 4	Year 5
Eligible patients with hip and/or knee osteoarthritis	34,014	34,695	35,389	36,096	36,818

Cost of Training Health Care Professionals

Presently, there are not enough health care professionals to deliver structured education and neuromuscular exercise programs to the target population in Ontario. Therefore, we performed an additional analysis to address the cost of additional training.

The estimated cost of training one health care professional to deliver a group-based structured education and neuromuscular exercise program is $450.[76] We assumed that in addition to their regular job requirements, each health care professional would deliver a program to a total of 200 people with osteoarthritis over the next 5 years. As shown in Table 13, an estimated 424,914 people with hip and/or knee osteoarthritis would participate in a program over the next 5 years in the new scenario. This would require about 2,125 full-time employees to undergo training to implement the program (424,914 ÷ 200 = 2,125).

Results

Reference Case

Table 15 presents the results of the reference case budget impact analysis. Adopting a group-based structured education and neuromuscular exercise program would increase costs by about $21.3 million in year 1 to about $91.5 million in year 5.

Table 15: Budget Impact Analysis Results—Reference Case

	Budget Impact, $				
Scenario	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Current scenario	2,442,212,808	2,490,802,212	2,538,191,246	2,584,665,169	2,626,976,139
New scenario	2,463,609,471	2,528,871,755	2,593,541,100	2,657,884,351	2,718,530,904
Net budget impact	**21,396,663**	**38,069,543**	**55,349,854**	**73,219,182**	**91,554,765**

Note: Some numbers may appear inexact because of rounding. All values are in 2017 Canadian dollars.

Sensitivity Analysis

Scenarios 1a to 1e: GLA:D Canada Adaptation

We estimated the budget impact of delivering a group-based structured education and neuromuscular exercise program consisting of two education sessions and 12 exercise sessions, based on the GLA:D Canada model,[29] to be $12 million in year 1 and $53 million in year 5. Table 16 provides the budget impact of scenarios 1a to 1e.

Table 16: Sensitivity Budget Impact Analysis Results: Scenarios 1a–1e—GLA:D Canada Adaptation

	Budget Impact, $				
Scenario	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
1a: Program delivered over 12 sessions; other components and costs same as reference case					
Current scenario	2,439,414,132	2,487,947,854	2,535,282,583	2,581,703,249	2,623,965,732
New scenario	2,451,788,652	2,510,032,916	2,567,432,064	2,624,258,876	2,677,201,216
Net budget impact	**12,374,520**	**22,085,062**	**32,149,481**	**42,555,627**	**53,235,484**
1b: Health assessment cost reduced from $48 to $40					
Current scenario	2,440,099,071	2,488,646,421	2,535,994,440	2,582,428,140	2,624,702,489
New scenario	2,451,567,702	2,509,672,364	2,566,926,876	2,623,604,138	2,676,393,160
Net budget impact	**11,468,631**	**21,025,943**	**30,932,436**	**41,175,998**	**51,690,671**
1c: Health assessment cost increased from $48 to $57					
Current scenario	2,439,495,147	2,488,030,481	2,535,366,781	2,581,788,989	2,624,152,875
New scenario	2,452,193,727	2,510,693,928	2,568,358,242	2,625,259,229	2,678,682,652
Net budget impact	**12,698,580**	**22,663,447**	**32,991,461**	**43,470,240**	**54,529,777**
1d: Session cost reduced from $25 to $20					
Current scenario	2,438,913,317	2,487,437,075	2,534,762,085	2,581,173,221	2,623,427,027
New scenario	2,449,284,552	2,505,946,660	2,561,706,600	2,616,838,512	2,668,043,248
Net budget impact	**10,371,235**	**18,509,585**	**26,944,515**	**35,665,291**	**44,616,221**
1e: Session cost increased from $25 to $30					
Current scenario	2,439,944,408	2,488,488,680	2,535,833,698	2,582,264,455	2,624,536,125
New scenario	2,454,440,052	2,514,359,540	2,573,494,320	2,632,115,732	2,686,897,888
Net budget impact	**14,495,644**	**25,870,860**	**37,660,622**	**49,851,277**	**62,361,763**

Note: Some numbers may appear inexact because of rounding. All values are presented in 2017 Canadian dollars.

Scenario 2: Lower Rate of Program Uptake

Table 17 presents the results of the budget impact analysis for the scenario in which a program consisting of two educational sessions and 12 exercise sessions is adopted with a lower rate of program uptake: 3% in year 1, 5% in year 2, 7% in year 3, 9% in year 4, and 11% in year 5. In this scenario, we estimated a budget impact of about $6.1 million in year 1 and about $33.2 million in year 5.

Table 17: Sensitivity Analysis Results—Lower Rate of Program Uptake

	Budget Impact, $				
Scenario	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Current scenario	2,439,414,132	2,487,947,854	2,535,282,583	2,581,703,249	2,623,965,732
New scenario	2,445,602,052	2,500,564,908	2,554,572,924	2,607,893,944	2,657,237,356
Net budget impact	**6,187,920**	**12,617,054**	**19,290,341**	**26,190,695**	**33,271,624**

Note: Some numbers may appear inexact because of rounding. All values are presented in 2017 Canadian dollars.

Scenario 3: Patients Referred to Central Intake and Assessment Centres

Table 18 presents the results of the budget impact analysis for the scenario in which patients would access a group-based structured education and neuromuscular exercise program after referral to central intake and assessment centres across the province. In this scenario, we estimate a budget impact of about $15.3 million in year 1 and about $16.5 million in year 5.

Table 18: Sensitivity Analysis Results—Referral to Central Intake and Assessment Centres

	Budget Impact, $				
Strategy	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Structured education and neuromuscular exercise program	15,306,300	15,612,750	$15,925,050	16,243,200	16,568,100

Cost of Training Health Care Professionals

Assuming a one-time training cost of $450 per person for a total of 2,125 health care professionals, we estimated that the total cost of training would be about $956,250.

Discussion

Our budget impact analyses examined the range of funding that would be needed to increase access to a group-based structured education and neuromuscular exercise program for the nonsurgical management of hip and/or knee osteoarthritis. If such a program could be delivered through 12 exercise sessions, instead of 24, the net budget impact would be reduced substantially.

Our reference case analysis estimated that 424,914 people with hip and/or knee osteoarthritis could participate in a group-based structured education and neuromuscular exercise program over the next 5 years. Assuming that each health care professional involved in the program would deliver the program to a total of 200 people, 2,125 certified, regulated health care professionals would be required to implement the program. The total cost of funding the required training for these health care professionals is around $1 million.

The regulated health care professionals implementing the program should be certified to deliver a group-based structured education and neuromuscular exercise program to patients with hip and/or knee osteoarthritis in Ontario. The program on which we based our analyses (GLA:D Canada) requires minimal infrastructure and can be delivered from existing outpatient clinics and other settings. Therefore, implementation efforts would need to focus on training and certifying an adequate number of regulated health care professionals to deliver the program and ensuring equitable access to the program, rather than on infrastructure development.

Strengths and Limitations

Our study has both strengths and limitations. In terms of strengths, we used Ontario-specific data (i.e., population projections and costs) to estimate the budget impact of implementing a group-based structured education and neuromuscular exercise program in Ontario. We also consulted with clinical experts to verify our assumptions and main parameter inputs. However, given the lack of published data on the rate of program uptake, we had to use estimates in our analyses. Therefore, the net budget impact based on our model estimates may not represent

real-world data that take into account patient preferences and the complexities of health services delivery.

Conclusions

We estimate the budget impact of publicly funding a group-based structured education and neuromuscular exercise program consisting of two educational sessions and 24 exercise sessions for adults with hip and/or knee osteoarthritis in Ontario to be about $21.4 million in the first year and $91.6 million in the fifth year. The budget impact of publicly funding a program consisting of two educational sessions and 12 exercise sessions would be about $12.4 million in the first year and $53.2 million in the fifth year.

PATIENT PREFERENCES AND VALUES

Objective

The objective of this analysis was to explore the underlying values, needs, impacts, and preferences of those with hip and/or knee osteoarthritis. The treatment focus was a structured education and neuromuscular exercise program. We specifically explored experiences with the GLA:D Canada program

Background

Patient, caregiver, and public engagement provides a unique source of information about people's experiences of a health condition and the health technologies or interventions used to manage or treat that health condition. It includes the impact of the condition and its treatment on the patient, the patient's family and other caregivers, and the patient's personal environment. It also provides insights into how a health condition is managed by the province's health system.

Information shared from lived experience can also identify gaps or limitations in published research (e.g., typical outcome measures sometimes do not reflect what is important to those with lived experience).[77-79] Additionally, lived experience can provide information and perspectives on the ethical and social values implications of health technologies or interventions.

Because the needs, priorities, preferences, and values of those with lived experience in Ontario are not often adequately explored in published literature, we contact and speak directly with people who live with a given health condition, including those who may have experience with the intervention we are exploring.

For this project, we spoke with 24 people with lived experience of hip and/or knee osteoarthritis, its impact on their lives, and treatment options. A majority of people interviewed also had direct experience with the GLA:D Canada structured education and neuromuscular exercise program. Gaining an understanding of the day-to-day experience of living with osteoarthritis, including people's experiences with the GLA:D Canada program, helps us assess the potential value of this intervention from the perspective of patients and caregivers.

Osteoarthritis is a degenerative joint disease and a major source of disability, causing pain and decreased mobility.[3,80]. A study conducted in Ontario found that quality of life was 10% to 25% lower among people with osteoarthritis compared with those without.[8]

Methods

Engagement Plan

The engagement plan for this health technology assessment focused on consultation to examine the experiences of people with osteoarthritis, including their experience with the GLA:D Canada structured education and neuromuscular exercise program.

We used a qualitative interview, as this method of engagement allows us to explore the meaning of central themes in the experiences of people with osteoarthritis. Our main task in interviewing is to understand what people tell us and to gain an understanding of the meaning of their experiences.[81] The sensitive nature of exploring people's experiences of a health condition

and their quality of life are other factors that support our primary choice of an interview methodology.

Participant Recruitment

We used an approach called purposive sampling,[82-85] which involves actively reaching out to patients, families, and caregivers with direct experience of the health condition and health technology or intervention being reviewed. We approached a variety of partner organizations, health clinics, osteoarthritis support associations, and foundations to spread the word about this engagement activity and to make contact with patients, families, and caregivers with experience of osteoarthritis and the GLA:D Canada program.

Inclusion Criteria

We sought to speak with people with hip and/or knee osteoarthritis and their families. We also sought to speak with people with these health conditions who had experience with the GLA:D Canada program. We sought broad geographic, cultural, and socioeconomic representations to elicit possible equity issues with regard to accessing treatment options for osteoarthritis, including the GLA:D Canada program.

Exclusion Criteria

We did not set exclusion criteria.

Participants

We recruited participants from across the province and conducted interviews with 24 people with osteoarthritis ranging from mild to severe. Of these, 16 people had participated in the GLA:D Canada program.

All participants had direct experience with managing their osteoarthritis and were familiar with various treatment options. Because no participants had enrolled in the GLA:D Canada program immediately upon their diagnosis of osteoarthritis, those who had participated in the GLA:D Canada program were able to compare their experiences of the program, including its results, with other treatment options.

Approach

At the beginning of the interview, we explained the role of Health Quality Ontario, the purpose of this health technology assessment, the risks of participation, and how participants' personal health information would be protected. We gave this information to participants both verbally and in a letter of information (Appendix 7). We then obtained each participant's verbal consent before starting the interview. With participants' consent, we audio-recorded the interviews and then transcribed the recordings.

Interviews were conducted by phone and lasted 20 to 40 minutes. The interview was loosely structured and consisted of a series of open-ended questions. Questions were based on a list developed by the Health Technology Assessment International Interest Group on Patient and Citizen Involvement in Health Technology Assessment.[86] Questions focused on the progression of osteoarthritis, its impact on participants' quality of life, participants' experiences with treatment options, and participants' perceptions of the benefits and limitations of the GLA:D Canada program. See Appendix 8 for our interview guide.

Data Extraction and Analysis

We used a modified version of a grounded-theory methodology to analyze interview transcripts. The grounded-theory approach allows us to organize and compare information across participants. This method consists of a repetitive process of obtaining, documenting, and analyzing responses while simultaneously collecting, analyzing, and comparing information.[87,88] We used the qualitative data analysis software program NVivo (QSR International, Doncaster, Victoria, Australia) to identify and interpret patterns in interview data. The patterns we identified then allowed us to highlight the impact of hip and/or knee osteoarthritis and treatments on those we interviewed.

Results

Lived Experience of Osteoarthritis

People we interviewed reported a variety of experiences of the diagnosis and progression of osteoarthritis. Typically, people reported a slow progression of discomfort or pain in their hips or knees that was first attributed to the aging process. Several people mentioned that they did not take note of the pain at the time and only realized that the pain was caused by osteoarthritis after a formal diagnosis was made. Occasionally, this process could take several years:

> *And, so, as the years went by… the knee was kind of...they're a little more sore, a little tighter. And…when I went to the doctor, they said that I had arthritis in my knees.*

Pain, stiffness, and discomfort were the most common symptoms described by people with osteoarthritis. These symptoms were typically not constant, but increased and decreased in severity depending on circumstances and activities. In addition, symptoms could appear in one or more joint, depending on the person and the progression of their disease. More severe pain or stiffness could require the aid of a walker or cane, as reported by several of those interviewed:

> *My main symptom had been stiffness…not as advanced as some in the pain department.*

> *The left [knee] bothers me periodically, but really it is the right one that bothers me more, and I use the cane in my left hand for the right knee.*

> *Mine's a little bit different. I can walk. I'm not incapacitated in any way, but my problem is at rest. So, at the end of the day, I have a lot of discomfort when I stop because you can't keep going forever, because I would like to.*

The joint pain and discomfort caused by osteoarthritis results in activity restrictions for almost all those interviewed. These activities ranged from fairly intense physical exercises, such as running and biking, to even fairly simple tasks, such as climbing stairs or bending down to pick up a fallen object. Those interviewed expressed frustration and distress at their change in baseline level of activity. Many tried to carry on despite the pain and discomfort but often found they could no longer perform certain activities. For those who had been fairly active before their pain had progressed, the impact of this activity restriction could be quite pronounced:

> *I found myself being limited in what I could do insofar as any kind of impact or certain movements of hip rotation, that sort of thing. And, it's just become worse over time, to the point now where I can't tie my shoe.*
>
> *Well, walking long distances, if I was working out on the lawn and that, after a while I have to slow down, come in and take a break. Driving, I found driving, my knees and hips, probably a little more my hips; if I'd been driving for a long distance, then I'd get out and walk around.*
>
> *So as it gets worse, it does begin to affect your life. It makes it difficult…all of a sudden you can't go up and down stairs easily, and you find yourself going downstairs backwards instead of face first to not have as much pain. And so you begin to not be able to walk as far and that kind of thing. So it does definitely affect your life, and then as it gets even worse, it just constantly gets worse; it affects your life more and more. Right now it's affected my life, my entire lifestyle, and my husband's lifestyle and my family's lifestyle.*

Several of those interviewed spoke about the emotional impact that pain, activity restriction, and even the diagnosis of osteoarthritis had had on them. Viewed as a condition of the elderly, a few people expressed dismay at the perception that they were getting older and could be diagnosed with this condition. In addition, people with osteoarthritis reported on the psychological burden that osteoarthritis could have and the constant need to fight against pain and soreness in the joints:

> *All of a sudden you feel like you're old.*
>
> *Psychologically you're not as good, because long-term pain is very debilitating.*

The progressive nature of osteoarthritis also weighed on the minds of those we interviewed. Many reported that while their joint pain and discomfort was manageable, it was the future that worried them. They acknowledged the desire to manage their disease, slow its progression, and prevent the deterioration of their quality of life:

> *I mean the idea that it will get worse worries me, and I have thought about pushing my doctor into referring me to a doctor who I think is an osteoarthritis expert, but they're very few and far between, and I really don't have much hope that they would actually have any good ideas to prevent progression.*
>
> *I'm not a severe OA [osteoarthritis], but I'm also 73. I'm a very active 73. I have young grandchildren, and I just want to keep as active as I can.*

Osteoarthritis Treatment Options

The people we interviewed reported seeking out a variety of treatment options to manage their osteoarthritis symptoms, including chiropractic services, yoga, Tai Chi, acupuncture, and water aerobics such as aquafit. Participants reported varied results from these therapies, though in general, water aerobics was felt to provide the most relief from osteoarthritis symptoms:

> *I never knew when I would be able to walk or not. And then it would just [loosen up]. It was the weirdest thing. So then I went the route of chiropractic and acupuncture, and nothing was working.*

> *I did a yoga class, and I explained that I had arthritis in my knees. And I signed up for a class, and it cost a fair amount of money, and I had to quit because there was too much mat stuff and I had trouble kneeling. It hurts. It doesn't hurt so much anymore, but it did then.*
>
> *I started aquafit, and that was a great relief.*
>
> *[I] did have some feeling of mobility and relief from the pressure of osteoarthritis when I was in [the pool]. But then the second you get dressed and you're walking on the street and you're looking at those stairs again, it was right back where it was. So that really wasn't helping.*

Participants also spoke of using anti-inflammatory or other pain medications to help manage their symptoms. These were generally reported to be effective and could provide short-term relief:

> *I did have to rely on [ibuprofen] because I was a teacher standing on my legs all day and they had to move, but aquatics was always my go-to in the evening.*
>
> *I tried to deal with it unless there was something I needed—to go to a function or something—and it would bother me; then I would take some [ibuprofen] to help relieve it.*
>
> *So, I've been taking [diclofenac] once a day since, I don't remember exactly when this spring, and it makes a huge difference. I take [it] generally mid-morning, sort of ten-ish, because that way it covers me through to the evening, and in the morning, you know, I'm not so bad; it's effective.*

However, many people expressed hesitancy about the long-term use of medications, owing to potential side effects and personal preferences concerning long-term use:

> *I tried to deal with it unless there was something I needed—to go to a function or something—and it would bother me; then I would take some Advil to help relieve it. But no, I'm not on medication for that [i.e., pain].*
>
> *She says when it gnaws at her, then she'll take a Tylenol. But it's only one; she doesn't believe in medication.*
>
> *I don't like taking pain medication, and I don't know what other options I would have had other than exercise, I mean, I was already exercising, so what other options would there have been? Well, there's knee injections, but I'm not there yet.*
>
> *Pharmaceuticals are not a good route to go. You know, unless, you absolutely have to. And, even things like Advil, Tylenol, whatever, can be very hard on your system. But, weight management and exercise properly done can keep you going and participating in life. So you don't have depression. So you don't have other things creeping up on you as [you would when] you're not able to fully function.*

By far, participants reported that the most effective therapy for managing their osteoarthritis symptoms was exercise. This included both structured physiotherapy classes as well as independent exercise activities. Often, exercise was recommended by a health care provider as a way to manage the pain and stiffness of osteoarthritis:

> *I've done acupuncture; gluten-free, dairy-free diet; exercise; aquafit; Pilates; just walking; cycling; any kind of activities, I've tried and done. As well as acupuncture, massage therapy, [and]…cupping. I've tried all kinds of things. Exercise is what keeps me going, definitely. If I didn't exercise, I would just become worse.*

> *So in a six-week period, she made remarkable progress actually, which shows you that, you know, just because you're 84 doesn't mean that you can't bring the muscles back. And, you know, with more strength in the muscles, then it puts less pressure on the joints.*

> *When I had a one-on-one with a home physiotherapist, that made a huge difference because they were committed, and they were very professional, and they gave you the time that you needed. Yeah, I was lucky to be in that situation; I know a lot of people are not.*

Despite the benefits of exercise and physiotherapy, many people reported experiencing barriers in accessing regular physiotherapy. For those on a fixed income, this barrier was often the cost associated with paying for private physiotherapy services. Cost thus prevented them from accessing resources they believed would be beneficial in managing their symptoms. In addition, for those living in rural areas, geographic access to physiotherapy services could be a challenge:

> *There were really no resources. And, you know, I did do physiotherapy, extremely expensive, though, for me. And, you know, it's not something I can continue with. It did help. Because again, you had somebody seeing how you were doing the exercise and correcting you to get it right. So that was critically important because you don't realize how out-of-kilter you are.*

> *You know, there [are] very few OHIP physios around…and the waiting lists are so long that, you know, it's prohibitive.*

> *So that's where I am right now. I'm a woman of limited means, and I must get support from OHIP in order for me to get physio, so I'm waiting for my number to come up quite frankly.*

> *Yeah, like, there would be no physiotherapy around here; you'd have to travel for that.*

Surgical Treatment for Osteoarthritis

Many participants reported that their motivation for managing their osteoarthritis and attempting to slow its progression was a fear of surgical intervention. Those we interviewed reported being familiar with surgery as an option from conversations with their health care providers. While many reported that their osteoarthritis was not yet severe enough for surgical intervention, the progressive nature of the disease meant that it could become a necessity in the future. This was

an option that many reported wanting to delay for as long as possible. Many of those interviewed felt their desire to delay surgery acted as extra motivation to exercise and attend physiotherapy sessions:

> *Now they're realizing that maybe exercise can prolong things and make things better, instead of getting knee replacements. Like, maybe not have to if you do exercise.*
>
> *Every single day I do some kind of fitness…and exercises that I know are good for my hip. And…anybody that I come across that has arthritis, I tell them the same thing: "Do this." Because you can delay it if you keep your joints healthy and exercise.*
>
> *No, I haven't got to the stage of discussing surgery, but I'm hoping to put that discussion off for 20 years.*
>
> *If you can put it off, you know, if you can have a comfortable or reasonable quality of life, well, you still have osteoarthritis in your knee, I think that's the plan because nobody really wants to go and have surgery. And I mean, I've heard of course that having a knee replacement surgery is quite effective, but still, you know, having surgery if you didn't have to, you wouldn't want to.*

Despite efforts to delay the need for surgery, many of those interviewed were aware that they may need surgical intervention in the future. Several also felt that surgery was a good option for them. These people had previously undergone joint replacement surgery or knew of others who had had it done successfully. This led to a more open and accepting attitude toward joint replacement as an ultimate treatment for osteoarthritis:

> *I've had surgery, I mean, I have [had] a few surgeries. They've all been successful; I do recover quickly. So the option of surgery is really not a scary one…it is something I can do. But, I mean, it'd be better to have me fixed rather than all these bionic parts in me and trying to go through airports. But anyway, at this point, it's the only option.*
>
> *I'm actually on a wait list now. Because it's [gotten to] a point where I've done as much as I can do exercise-wise. I mean, I still do exercise classes each week. I try and curl. I'm a downhill skier. I waterski…I love my life to be full and busy. And I have tried very hard to keep it going that way. But there comes a point where you start damaging other joints because your damage in the one primary joint is so bad.*
>
> *I could not move. So when she [my doctor] told me that the knee had to be replaced, there was not even a second thought in my mind that I had to have it. I was almost…I was dreading it because, you know, I had done enough reading about how painful it is and the recovery. But there was a certain amount of relief, too. Thinking, "Okay, this nightmare is going to come to an end."*

GLA:D Canada Structured Education and Neuromuscular Exercise Program

People interviewed reported that they viewed the GLA:D Canada program to be consistent with their efforts to manage symptoms through exercise. Several reported that they were made

aware of the GLA:D Canada program through their health care providers during discussions concerning the management of osteoarthritis. Others heard of the program through word of mouth from friends and family or through reading about the program online:

> *I'm still a member of the Physio Association, so I still get newsletters and emails. And I read about it; I read about this program with one of the Physio Association emails that came around, and I thought, "This looks interesting."*

> *I never heard about the GLA:D program until, well, the township where I live, they put the program through; it came in my tax bill.*

Expectations for the program were reported to be generally positive. All people with osteoarthritis interviewed had been dealing with the condition for a number of years and were familiar with different methods of managing the symptoms of stiffness and pain. Knowing the effectiveness that exercise could have in relieving these symptoms, most reported that they expected the GLA:D Canada program to be equally effective:

> *When I heard about the GLA:D program, I was very interested in that because I'm interested in prevention.*

> *I was really looking forward to it because I knew that it had been studied, and it had been…it was a science- [and] evidence-based program. So, they'd used the evidence to support the science. And I knew that there was a specific set of exercises. Like, there [are] 10 or 11 exercises that you do that target this neuromuscular area. So, I felt quite confident that that's what I really needed. That my previous experience with strengthening my core was doing a variety of things, but it wasn't a whole bunch of exercises just for my leg.*

Several people also mentioned the expectation that the GLA:D Canada program would encourage them to become more motivated to exercise owing to the group format of the program and the supervision by a trained physiotherapist. These were considered benefits that made the program preferable to exercising alone at home:

> *The other thing that I was really looking forward to was that physio was going to be nagging me twice a week. I was going to have to…yeah, that I was going to have to work hard for an hour. Because it's an hour. And you sweat.*

> *[It was] developed by physios…you can't run the program unless you've been trained by them to do their program, which ensures consistency and so forth, and so it looked promising.*

Access

Access to the GLA:D Canada program was not generally perceived to be a barrier for those interviewed. People reported that wait times were not unreasonable and that, with multiple GLA:D Canada centres across the province, they were able to find one that was conveniently located. Additionally, interviewees mentioned that the GLA:D Canada program was flexibly scheduled; several people had taken breaks or vacations during their programs and were able to adjust the schedule of their sessions:

> *There was no wait at all…I had phoned just, like, a couple of days after I'd seen the doctor, and they phoned me right back and said, "Look, this program is starting, and if you'd like to be on board with it, then you can go ahead and do that." So, that's what I did.*

> *I'm retired…so, I was able to get there with no problem. You know, my time…I could plan my time of leisure.*

The cost of the GLA:D Canada program appears to vary, according to those we interviewed. Only a minority of participants reported paying the full program price; those who did reported paying anywhere from $200 to $600. Participants also mentioned that private health insurance often helped offset this cost. Other participants indicated that the cost was covered as part of a research study or a promotional effort to increase awareness of the program. Reflecting on their ability to pay for and access the program, a number of those interviewed reported that they would not have been able to participate in the program if forced to pay the full price. They also acknowledged that many people living on fixed incomes would not be able to take advantage of the program:

> *I was very fortunate because the doctor that I went to said that this was a free introductory program. Now, if this was a program that I needed to do on my own, I wouldn't have been able to afford to do it because I'm living off my pension.*

> *I do remember them saying that there may be a cost attached to it in other areas, where they were going to develop it. And I thought that's unfortunate, because if it's keeping people out of surgery for a longer period of time, that's better. Because I'm at an age where [if] I have a replacement now, I'm going to need another one. You know, realistically.*

> *Personally I would highly recommend it. And the only time I was hesitant to recommend it was with people that I thought probably couldn't afford it.*

> *I thought the program was excellent, and I was very satisfied. And I only felt kind of badly that when I talked to people about it, that everybody didn't have, honestly, the same access as I did. You know, it's easy, like my sisters, one of my sisters doesn't have any insurance. And I told her how good I thought it was, and she said, "Yeah, but you know…"*

Almost all people interviewed were familiar with the cost of private physiotherapy sessions, so the cost of the GLA:D Canada program was not unexpected. However, a few participants expressed frustration at the cost and the lack of information about the varying costs at different GLA:D Canada locations:

> *It's too expensive, and [there was] no info that price may vary by location.*

> *Cost [is] prohibitive. And, it's not like it's a bad knee that is just from [an] accident, and then it's going to be better and then you move on. [Osteoarthritis] is progressive.*

Impact

Overall, the people we interviewed who had participated in a GLA:D Canada program reported positive outcomes with and opinions of the program. One particular element that received praise was the professionalism and knowledge of the staff. Having a regulated physiotherapist trained in the GLA:D Canada program available to correct positions in exercises and to motivate participant was reported as being of great benefit:

> *And the therapists, they are very good at what they do. I mean, you can ask any question you want. There were other people in the class who asked all kinds of questions, and I'm thinking, you know, "Was that necessary?" Or, "Why are you asking that?" But they explained. They didn't take it as a stupid question or say, "You don't need to know." They explained everything. They took the time. So they're very good at what they do.*
>
> *What I really liked about these exercises compared to going to regular classes and things is that somebody watches you. Like, the physiotherapist was there as you were doing everything, and I sort of felt confident that I wasn't going to hurt myself more, you know.*
>
> *It's also having someone run around and follow you and say, "Yes, do it this way, do it that way," or progress you over time. Seeing the difference; at the beginning I couldn't do the one little step, and then she'd make it higher, and yeah, you can do it, you know. So, you have the encouragement to give a little push and do a little more, which was nice.*

Other people highlighted the positive effect of participating as part of a group and the benefits of working and communicating with others who may be experiencing similar challenges in dealing with the symptoms of osteoarthritis:

> *When I look at these other people, we would chat, just, people are a lot worse off than me, so that's kind of helpful for me, mentally, to think, "Okay, I'm not great, but I'm not that bad." That was kind of nice.*
>
> *I really think this is a good program. I think one of the things, like I said, that I liked was being with other people, though.*
>
> *I liked the fact that it wasn't, I wasn't the only one there doing it. And I really found that, you know, like, there was a series of exercises. And I never realized how weak maybe my legs were, and through doing these exercises, my legs have become quite stronger.*

Additionally, many participants remarked on the program's effectiveness in helping them manage their osteoarthritis symptoms and strengthen their muscles. Upon completion of the program, many of those interviewed reported that they felt that their muscles were stronger and that they had achieved a positive result:

> *The exercises, they did help me, and they do help me.*
>
> *I found that with the specific exercises each week and being monitored on how I did them and the different levels that you had to achieve, I did become stronger,*

> *and I wasn't using the right muscles in some exercises at all. And that was corrected through GLA:D.*
>
> *I have an exercise program, but life is busy, and I wasn't as disciplined. But when you see the results, and that's what I think is so good about this program: you see the results. So that encourages you to be faithful in doing the exercise after.*

Participants felt that the strength they had gained through the program helped relieve pain and stiffness and allowed them to be more confident in their daily activities. Participants reported that activities such as bending over, climbing up and down stairs, playing golf, and walking were all improved as a result of participating in the GLA:D Canada program:

> *I do have some pain and some swelling, but I feel much more stable. And I definitely have a lot less swelling and pain than I ever had, like, a year ago. Significantly less. It doesn't hold me back from doing a lot of things, let's put it that way.*
>
> *I mean, I'm still not a 20-year-old, but I'm…my knee doesn't bother me now unless I twist it the wrong way, [whereas] before, I'd basically take a pill every day.*
>
> *I don't have the discomfort in the evening at rest. That was my big problem. Honestly, I had it for, I bet it's five or six years. I think with the increased strength in the muscle that's supporting my hip, I haven't had that pain at rest that I had before.*

One further aspect of the GLA:D Canada program that participants spoke of positively was the educational component. Those interviewed reported that each 12-week program included two educational sessions in which participants were taught the value of certain exercises and how to perform them. These educational sessions and the written materials provided to participants were reported to be useful in motivating participants to continue to exercise properly once the program was complete:

> *It also helped a lot of times when they say, "Do exercise," [and] you're not quite sure what exercise you should be doing. And this helps teach you what exercises are the ones to do. Because there are some exercises they don't recommend you do.*
>
> *They have an education section at the beginning, and that's really helpful in the education of what you should do and how to prevent things. And how to improve things and why. So, that was kind of helpful in that area, too.*
>
> *It's not as clear, but I have my file, and I go through it periodically, right. And I think, "Oh, yeah. I remember that. Right." And so it's beneficial definitely. And you can remember the key words, you know, that were said, when you start looking at the exercises.*
>
> *There's a lot of education, too, which was a good refresher for me, but it was a lot of new material for the average person who doesn't have a medical background. It's not just exercises; you have two sessions…and they talk about*

> *why it's so important to do the exercises, and they talk about osteoarthritis and the causes and all that kind of thing, too.*

A few of those interviewed expressed some disappointment in the follow-up provided by the GLA:D Canada program. These reported challenges revolved around the logistics and organization of GLA:D Canada program; for example, telephone numbers that weren't picked up, emails that were not replied to, and scheduling confusion. However, those who reported these negative experiences still felt that the education and exercise program they received were beneficial:

> *This GLA:D program, they send you information, the phone number's—nobody's there; the email address just doesn't exist.*

> *I think they still have to work out some of the kinks in terms of scheduling. I think it's tougher for people when it moves around and you don't know until the week before, you know, when it's going to be.*

> *Well, there was no follow-up on the part of GLA:D, not as far as I can see.*

Discussion

We conducted extensive patient engagement of those with lived experience of hip and/or knee osteoarthritis and the GLA:D Canada structured education and neuromuscular exercise program. We interviewed people from many parts of Ontario, including those living in rural areas, to gain perspectives on equity issues related to accessing treatment options. All participants had direct experience with osteoarthritis and with different treatment options to manage their symptoms. Therefore, those who had participated in the GLA:D Canada program were able to directly compare their experiences of the program with other treatment options and comment on the perceived impact of the program on their ability to perform activities of daily living.

Those interviewed spoke positively of the GLA:D Canada program and the impact it had on helping them manage their osteoarthritis symptoms. Participants reported on the negative impact of osteoarthritis on their quality of life and how this impact increased as the disease progressed. Those who had participated in a GLA:D Canada program reported on its positive effects and how it had allowed them to manage or reduce some of their symptoms. This resulted in an increased ability to perform activities of daily activities, such as walking, climbing stairs, and bending over.

Those who had participated in a GLA:D Canada program reported that the cost of the program was often supplemented by private insurance but could thus be a barrier to access for those without private coverage or the means to pay out of pocket. Geographical access was not reported to be a concern for participants; the number of GLA:D Canada sites across the province appears to allow many to access the program at a reasonable distance.

None of the participants interviewed had attended more than one GLA:D program, though several mentioned wanting to return. Because of this, participants were unable to speak to the consistency of the program across the province.

Conclusions

People with hip and/or knee osteoarthritis with whom we spoke reported on the negative impact osteoarthritis has on their quality of life. Of the various treatment options experienced, most participants felt that exercise was the most beneficial. Participants who had participated in a GLA:D Canada structured education and neuromuscular exercise program reported on the positive impact of the program, stating they felt the program had strengthened their muscles and reduced the severity of their symptoms, particularly stiffness and pain. Although most GLA:D participants were able to take part in the program at reduced cost, they acknowledged that having to pay full price would have been a barrier to participating.

CONCLUSIONS OF THE HEALTH TECHNOLOGY ASSESSMENT

There is moderate-quality evidence that, compared with usual care, a structured education and neuromuscular exercise program improves physical function, quality of life, and the ability to perform activities of daily living. There is low-quality evidence that, compared with usual care, this type of program improves pain. Low-quality evidence suggests that, compared with patient education, a structured education and neuromuscular exercise program improves pain and physical function.

Our economic evaluation found that a structured education and neuromuscular exercise program consisting of two educational sessions and 24 exercise sessions may be cost-effective for the nonsurgical management of knee osteoarthritis (ICER: $23,967/QALY gained). These results should be interpreted with caution given the limited amount of data.

The budget impact of publicly funding a structured education and neuromuscular exercise program consisting of two educational sessions and 24 exercise sessions for adults with hip and/or knee osteoarthritis in Ontario would be about $21.4 million in the first year and $91.6 million in the fifth year. The budget impact of publicly funding a program consisting of two educational sessions and 12 exercise sessions would be about $12.4 million in the first year and $53.2 million in the fifth year.

People with hip and/or knee osteoarthritis with whom we spoke reported on the negative impact osteoarthritis has on their quality of life. Those who had participated in a structured education and neuromuscular exercise program reported on the positive impact of the program, stating they felt that participation in the program had strengthened their muscles and reduced the severity of their symptoms, particularly stiffness and pain. Program cost was reported as a potential barrier to access.

ABBREVIATIONS

CI	Confidence interval
EQ-5D	EuroQol Five Dimensions
GLA:D	Good Life with osteoArthritis in Denmark
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
HOOS	Hip Disability and Osteoarthritis Outcome Score
ICER	Incremental cost-effectiveness ratio
KOOS	Knee Injury and Osteoarthritis Outcome Score
NICE	National Institute for Health and Care Excellence
NPRS	Numeric Pain Rating Scale
NSAID	Nonsteroidal anti-inflammatory drug
PASE	Physical Activity Scale for the Elderly
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
QALY	Quality-adjusted life-year
RoBANS	Risk of Bias Assessment Tool for Nonrandomized Studies
RR	Relative risk
SD	Standard deviation
SE	Standard error
VAS	Visual Analog Scale
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index

GLOSSARY

Confidence interval	Where a value (e.g., the number of people in Ontario who have a particular condition) is estimated based on a sample of the population (e.g., the number of people in a particular area who have the condition), the true value for the entire population may fall above or below the estimated value. The confidence interval shows the range of values likely to include the true value and is usually given at 95%, meaning that there is a 95% chance that the true value falls within the given range around the estimated value.
Cost-effective	Good value for money; the overall benefit of the technique or intervention justifies the cost.
Cost–utility analysis	A type of analysis that estimates the value for money of an intervention by weighing the cost of the intervention against the improvements in length of life and quality of life. The result is expressed as a dollar amount per quality-adjusted life-year (QALY).
Discounting	A method that considers that costs and health benefits are worth more today than in the future.
Health state utility	The strength of patient preferences for a given state of health using a scale on which 1 represents full health and 0 represents dead. (Negative scores, meaning worse than dead, are possible.) Health state utility is an important data input in cost–utility models, but is also among the most uncertain inputs.
Incremental cost	The extra cost associated with using one test or treatment instead of another.
Incremental cost-effectiveness ratio (ICER)	Determines a unit of benefit for an intervention by dividing the incremental cost by the incremental effectiveness. The incremental cost is the difference between the cost of the treatment under study and an alternative treatment.
Monte Carlo simulation	Determines the uncertainty in an economic model by running many trials of the model. In each trial, random numbers are assigned wherever values are uncertain to see how the model result changes.
Quality-adjusted life-year (QALY)	A measurement that takes into account both the number of years gained by a patient from a procedure and the quality of those extra years (e.g., ability to function, freedom from pain). The QALY is commonly used as an outcome measure in cost–utility analyses.
Randomized controlled trial	A type of study in which subjects are assigned randomly into different groups, with one group receiving the treatment under study and the other group(s) receiving a different treatment or a placebo (no treatment) in order to determine the effectiveness of one approach compared with the other(s).
Reference case	A population or value used as a basis of comparison for the population under study. Where the population under study is said to deviate from a standard, this is the standard it deviates from.

Sensitivity	The ability of a test to accurately identify persons with the condition tested for (how well it returns positive results in persons who have the condition).
Sensitivity analysis	Every evaluation contains some degree of uncertainty. Study results can vary depending on the values taken by key parameters. Sensitivity analysis is a method that allows estimates for each parameter to be varied to show the impact on study results. There are various types of sensitivity analyses. Examples include deterministic, probabilistic, and scenario.
Statistical significance	The outcome of an analysis is statistically significant if the assumption that there is no effect (the null hypothesis) is sufficiently unlikely to be true. Typically, the outcome is considered statistically significant if there is less than a 5% chance that the outcome would have occurred if the null hypothesis were true.
Systematic review	A process to answer a research question by methodically identifying and assessing all available studies that evaluate the specified research question. The systematic review process is designed to be transparent and objective and is aimed at reducing bias in determining the answers to research questions.
Time horizon	Costs and outcomes are examined within a chosen time frame. In an economic evaluation, this time frame is referred to as the time horizon.

APPENDICES

Appendix 1: Literature Search Strategies

Clinical Evidence Search

Search date: October 2, 2017
Databases searched: Ovid MEDLINE, Embase, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, CRD Health Technology Assessment Database, NHS Economic Evaluation Database, and CINAHL

Database: EBM Reviews - Cochrane Central Register of Controlled Trials <August 2017>, EBM Reviews - Cochrane Database of Systematic Reviews <2005 to September 26, 2017>, EBM Reviews - Health Technology Assessment <4th Quarter 2016>, EBM Reviews - NHS Economic Evaluation Database <1st Quarter 2016>, Embase <1980 to 2017 Week 40>, All Ovid MEDLINE(R) <1946 to Present>

Search Strategy:
---
1 exp Osteoarthritis/ (166447)
2 (osteoarthriti* or osteoarthros#s or osteo arthrit* or osteo arthros#s or (degenerative adj (arthritis or joint disorder* or joint disease*)) or knee oa or hip oa).ti,ab,kf. (149801)
3 or/1-2 (210836)
4 exp Exercise Therapy/ (116689)
5 (((neuromuscular or neuro-muscular) adj2 (train* or exercis* or program* or control)) or NEMEX or NEXA).ti,ab,kf. (4584)
6 (educat* adj4 exercis*).ti,ab,kf. (7068)
7 ((structured adj2 (physiother* or exercis* or therap* or program*)) or ((targeted or semi structured or supervised or self management) adj program*)).ti,ab,kf. (14605)
8 ((strength* adj (train* or exercis*)) or (muscle adj (train* or strengthening)) or functional exercise* or flexibility train* or perturbation train* or proprioceptiv* or motor control or sensorimotor control or ((functional or dynamic) adj stability) or quality of movement or agility).ti,ab,kf. (74448)
9 or/4-8 (201107)
10 3 and 9 (6116)
11 (("gla?d" adj2 (Canada or Denmark or Australia)) or (good life adj2 (osteoarthr* or arthriti*))).ti,ab,kf. (13)
12 or/10-11 (6121)
13 Case Reports/ or Comment.pt. or Editorial.pt. or Letter.pt. or Congresses.pt. (4967189)
14 12 not 13 (5932)
15 limit 14 to english language [Limit not valid in CDSR; records were retained] (5288)
16 limit 15 to yr="2008 -Current" (3883)
17 16 use ppez,cctr,coch,clhta,cleed (1560)
18 exp osteoarthritis/ (166447)
19 (osteoarthriti* or osteoarthros#s or osteo arthrit* or osteo arthros#s or (degenerative adj (arthritis or joint disorder* or joint disease*)) or knee oa or hip oa).tw,kw. (152963)
20 or/18-19 (212795)
21 exp kinesiotherapy/ (64072)
22 (((neuromuscular or neuro-muscular) adj2 (train* or exercis* or program* or control)) or NEMEX or NEXA).tw,kw,dv. (4780)
23 (educat* adj4 exercis*).tw,kw,dv. (7572)

24 ((structured adj2 (physiother* or exercis* or therap* or program*)) or ((targeted or semi structured or supervised or self management) adj program*)).tw,kw,dv. (14897)
25 ((strength* adj (train* or exercis*)) or (muscle adj (train* or strengthening)) or functional exercise* or flexibility train* or perturbation train* or proprioceptiv* or motor control or sensorimotor control or ((functional or dynamic) adj stability) or quality of movement or agility).tw,kw,dv. (79180)
26 or/21-25 (160799)
27 20 and 26 (4810)
28 (("gla?d" adj2 (Canada or Denmark or Australia)) or (good life adj2 (osteoarthr* or arthriti*))).tw,kw,dv. (15)
29 or/27-28 (4817)
30 Case Report/ or Comment/ or Editorial/ or Letter/ or conference abstract.pt. (9488348)
31 29 not 30 (3866)
32 limit 31 to english language [Limit not valid in CDSR; records were retained] (3449)
33 limit 32 to yr="2008 -Current" (2494)
34 33 use emez (1576)
35 17 or 34 (3136)
36 35 use ppez (1189)
37 35 use cctr (358)
38 35 use coch (1)
39 35 use cleed (8)
40 35 use clhta (4)
41 35 use emez (1576)
42 remove duplicates from 35 (2039)

CINAHL

#	Query	Results
S1	(MH "Osteoarthritis+")	20,527
S2	(osteoarthriti* or osteoarthros?s or osteo arthrit* or osteo arthros?s or (degenerative N1 (arthritis or joint disorder* or joint disease*)) or knee oa or hip oa)	27,615
S3	S1 OR S2	27,788
S4	(MH "Therapeutic Exercise+")	39,005
S5	(((neuromuscular or neuro-muscular) N2 (train* or exercis* or program* or control)) or NEMEX or NEXA)	2,366
S6	(educat* N4 exercis*)	2,277
S7	((structured N2 (physiother* or exercis* or therap* or program*)) or ((targeted or semi structured or supervised or self management) N1 program*))	4,787
S8	((strength* N1 (train* or exercis*)) or (muscle N1 (train* or strengthening)) or functional exercise* or flexibility train* or perturbation train* or proprioceptiv* or motor control or	23,810

	sensorimotor control or ((functional or dynamic) N1 stability) or quality of movement or agility)	
S9	S4 OR S5 OR S6 OR S7 OR S8	56,440
S10	S3 AND S9	1,581
S11	(("gla?d" N2 (Canada or Denmark or Australia)) or (good life N2 (osteoarthr* or arthriti*)))	5
S12	S10 OR S11	1,584
S13	PT Case Study or Commentary or Editorial or Letter or Proceedings	404,471
S14	S12 NOT S13	1,495
S15	S12 NOT S13 Limiters - English Language	1,458
S16	S12 NOT S13 Limiters - Published Date: 20080101-20171231; English Language	1,027

Economic Evidence Search

Search date: October 4, 2017
Databases searched: Ovid MEDLINE, Embase, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Centre for Reviews and Dissemination (CRD) Health Technology Assessment Database, National Health Service (NHS) Economic Evaluation Database and Cumulative Index to Nursing and Allied Health Literature (CINAHL)

Database: EBM Reviews - Cochrane Central Register of Controlled Trials <August 2017>, EBM Reviews - Cochrane Database of Systematic Reviews <2005 to September 26, 2017>, EBM Reviews - Health Technology Assessment <4th Quarter 2016>, EBM Reviews - NHS Economic Evaluation Database <1st Quarter 2016>, Embase <1980 to 2017 Week 40>, All Ovid MEDLINE(R) <1946 to Present>
Search Strategy:
---
1 exp Osteoarthritis/ (166467)
2 (osteoarthriti* or osteoarthros#s or osteo arthrit* or osteo arthros#s or (degenerative adj (arthritis or joint disorder* or joint disease*)) or knee oa or hip oa).ti,ab,kf. (149890)
3 or/1-2 (210928)
4 exp Exercise Therapy/ (116733)
5 (((neuromuscular or neuro-muscular) adj2 (train* or exercis* or program* or control)) or NEMEX or NEXA).ti,ab,kf. (4586)
6 (educat* adj4 exercis*).ti,ab,kf. (7071)
7 ((structured adj2 (physiother* or exercis* or therap* or program*)) or ((targeted or semi structured or supervised or self management) adj program*)).ti,ab,kf. (14618)
8 ((strength* adj (train* or exercis*)) or (muscle adj (train* or strengthening)) or functional exercise* or flexibility train* or perturbation train* or proprioceptiv* or motor control or sensorimotor control or ((functional or dynamic) adj stability) or quality of movement or agility).ti,ab,kf. (74496)
9 or/4-8 (201209)
10 3 and 9 (6117)

11 (("gla?d" adj2 (Canada or Denmark or Australia)) or (good life adj2 (osteoarthr* or arthriti*))).ti,ab,kf. (13)
12 or/10-11 (6122)
13 economics/ (254301)
14 economics, medical/ or economics, pharmaceutical/ or exp economics, hospital/ or economics, nursing/ or economics, dental/ (787981)
15 economics.fs. (409433)
16 (econom* or price or prices or pricing or priced or discount* or expenditure* or budget* or pharmacoeconomic* or pharmaco-economic*).ti,ab,kf. (779078)
17 exp "costs and cost analysis"/ (551101)
18 (cost or costs or costing or costly).ti. (239119)
19 cost effective*.ti,ab,kf. (279072)
20 (cost* adj2 (util* or efficacy* or benefit* or minimi* or analy* or saving* or estimate* or allocation or control or sharing or instrument* or technolog*)).ab. (181158)
21 models, economic/ (11072)
22 markov chains/ or monte carlo method/ (73477)
23 (decision adj1 (tree* or analy* or model*)).ti,ab,kf. (36034)
24 (markov or markow or monte carlo).ti,ab,kf. (115714)
25 quality-adjusted life years/ (34137)
26 (QOLY or QOLYs or HRQOL or HRQOLs or QALY or QALYs or QALE or QALEs).ti,ab,kf. (58792)
27 ((adjusted adj (quality or life)) or (willing* adj2 pay) or sensitivity analys*s).ti,ab,kf. (95369)
28 or/13-27 (2330585)
29 12 and 28 (525)
30 29 use ppez,cctr,coch,clhta (214)
31 12 use cleed (18)
32 or/30-31 (232)
33 Case Reports/ or Comment.pt. or Editorial.pt. or Letter.pt. or Congresses.pt. (4968367)
34 32 not 33 (230)
35 limit 34 to english language [Limit not valid in CDSR; records were retained] (208)
36 limit 35 to yr="2008 -Current" (146)
37 exp osteoarthritis/ (166467)
38 (osteoarthriti* or osteoarthros#s or osteo arthrit* or osteo arthros#s or (degenerative adj (arthritis or joint disorder* or joint disease*)) or knee oa or hip oa).tw,kw. (153052)
39 or/37-38 (212887)
40 exp kinesiotherapy/ (64072)
41 (((neuromuscular or neuro-muscular) adj2 (train* or exercis* or program* or control)) or NEMEX or NEXA).tw,kw,dv. (4782)
42 (educat* adj4 exercis*).tw,kw,dv. (7575)
43 ((structured adj2 (physiother* or exercis* or therap* or program*)) or ((targeted or semi structured or supervised or self management) adj program*)).tw,kw,dv. (14910)
44 ((strength* adj (train* or exercis*)) or (muscle adj (train* or strengthening)) or functional exercise* or flexibility train* or perturbation train* or proprioceptiv* or motor control or sensorimotor control or ((functional or dynamic) adj stability) or quality of movement or agility).tw,kw,dv. (79227)
45 or/40-44 (160862)
46 39 and 45 (4811)
47 (("gla?d" adj2 (Canada or Denmark or Australia)) or (good life adj2 (osteoarthr* or arthriti*))).tw,kw,dv. (15)
48 or/46-47 (4818)
49 Economics/ (254301)

50 Health Economics/ or Pharmacoeconomics/ or Drug Cost/ or Drug Formulary/ (128682)
51 Economic Aspect/ or exp Economic Evaluation/ (423347)
52 (econom* or price or prices or pricing or priced or discount* or expenditure* or budget* or pharmacoeconomic* or pharmaco-economic*).tw,kw. (803422)
53 exp "Cost"/ (551101)
54 (cost or costs or costing or costly).ti. (239119)
55 cost effective*.tw,kw. (289922)
56 (cost* adj2 (util* or efficac* or benefit* or minimi* or analy* or saving* or estimate* or allocation or control or sharing or instrument* or technolog*)).ab. (182277)
57 Monte Carlo Method/ (59569)
58 (decision adj1 (tree* or analy* or model*)).tw,kw. (39736)
59 (markov or markow or monte carlo).tw,kw. (120675)
60 Quality-Adjusted Life Years/ (34137)
61 (QOLY or QOLYs or HRQOL or HRQOLs or QALY or QALYs or QALE or QALEs).tw,kw. (62548)
62 ((adjusted adj (quality or life)) or (willing* adj2 pay) or sensitivity analys*s).tw,kw. (114596)
63 or/49-62 (1973447)
64 48 and 63 (498)
65 Case Report/ or Comment/ or Editorial/ or Letter/ or conference abstract.pt. (9489514)
66 64 not 65 (412)
67 limit 66 to english language [Limit not valid in CDSR; records were retained] (394)
68 limit 67 to yr="2008 -Current" (280)
69 68 use emez (135)
70 36 or 69 (281)
71 70 use ppez (96)
72 70 use cctr (40)
73 70 use coch (0)
74 70 use cleed (8)
75 70 use clhta (2)
76 70 use emez (135)
77 remove duplicates from 70 (186)

CINAHL

#	Query	Results
S1	(MH "Osteoarthritis+")	20,544
S2	(osteoarthriti* or osteoarthros?s or osteo arthrit* or osteo arthros?s or (degenerative N1 (arthritis or joint disorder* or joint disease*)) or knee oa or hip oa)	27,627
S3	S1 OR S2	27,800
S4	(MH "Therapeutic Exercise+")	39,018
S5	(((neuromuscular or neuro-muscular) N2 (train* or exercis* or program* or control)) or NEMEX or NEXA)	2,367
S6	(educat* N4 exercis*)	2,279
S7	((structured N2 (physiother* or exercis* or therap* or program*)) or ((targeted or semi structured or supervised or self management) N1 program*))	4,787

S8	((strength* N1 (train* or exercis*)) or (muscle N1 (train* or strengthening)) or functional exercise* or flexibility train* or perturbation train* or proprioceptiv* or motor control or sensorimotor control or ((functional or dynamic) N1 stability) or quality of movement or agility)	23,818
S9	S4 OR S5 OR S6 OR S7 OR S8	56,462
S10	S3 AND S9	1,582
S11	(("gla?d" N2 (Canada or Denmark or Australia)) or (good life N2 (osteoarthr* or arthriti*)))	5
S12	S10 OR S11	1,585
S13	(MH "Economics")	11,459
S14	(MH "Economic Aspects of Illness")	7,020
S15	(MH "Economic Value of Life")	525
S16	MH "Economics, Dental"	111
S17	MH "Economics, Pharmaceutical"	1,810
S18	MW "ec"	146,046
S19	(econom* or price or prices or pricing or priced or discount* or expenditure* or budget* or pharmacoeconomic* or pharmaco-economic*)	225,307
S20	(MH "Costs and Cost Analysis+")	88,053
S21	TI cost*	41,505
S22	(cost effective*)	30,406
S23	AB (cost* N2 (util* or efficacy* or benefit* or minimi* or analy* or saving* or estimate* or allocation or control or sharing or instrument* or technolog*))	21,118
S24	(decision N1 (tree* or analy* or model*))	5,507
S25	(markov or markow or monte carlo)	3,668
S26	(MH "Quality-Adjusted Life Years")	2,928
S27	(QOLY or QOLYs or HRQOL or HRQOLs or QALY or QALYs or QALE or QALEs)	6,964
S28	((adjusted N1 (quality or life)) or (willing* N2 pay) or sensitivity analys?s)	12,956
S29	S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28	301,633
S30	S12 AND S29	95
S31	PT Case Study or Commentary or Editorial or Letter or Proceedings	404,531
S32	S30 NOT S31	92

S33	S30 NOT S31 Limiters - English Language	92
S34	S30 NOT S31 Limiters - Published Date: 20080101-20171231; English Language	67

Grey Literature Search

Performed on: October 4–5, 2017

Websites searched: HTA Database Canadian Repository, Alberta Health Technologies Decision Process reviews, Canadian Agency for Drugs and Technologies in Health (CADTH), Institut national d'excellence en santé et en services sociaux (INESSS), Institute of Health Economics (IHE), McGill University Health Centre Health Technology Assessment Unit, National Institute for Health and Care Excellence (NICE), Agency for Healthcare Research and Quality (AHRQ) Evidence-based Practice Centers, Australian Government Medical Services Advisory Committee, Centers for Medicare & Medicaid Services Technology Assessments, Institute for Clinical and Economic Review, Ireland Health Information and Quality Authority Health Technology Assessments, Washington State Health Care Authority Health Technology Reviews, ClinicalTrials.gov, Tufts CEA Registry

Keywords used: GLA:D, good life osteoarthritis, good life arthritis, neuromuscular, nemex, structured therapy, structured physiotherapy, structured exercise, exercise and education

Results (included in PRISMA): 2
Ongoing clinical trials: 5 (ClinicalTrials.gov)

Appendix 2: Critical Appraisal of Clinical Evidence

Table A1: Risk of Bias[a]—Randomized Controlled Trials (Cochrane Risk of Bias Tool)

Author, Year	Random Sequence Generation	Allocation Concealment	Blinding of Participants and Personnel	Incomplete Outcome Data	Selective Reporting	Other Bias
da Silva et al, 2015[39]	Low	Low	Low	Low	Low	High[b]
Hurley et al, 2012[36]	Low	Low	Low	Low	Low	High[b]
Skou et al, 2015,[37] 2016[38]	Low	Low	Low	Low	Low	Low
Svege et al, 2015[40]	Low	Low	Low	Low	Low	High[b]

[a]Possible risk-of-bias levels: low, high, unclear.
[b]More than 20% of participants in the intervention group were lost to follow-up.

Table A2: Risk of Bias[a]—Observational Studies (RoBANS)

Author, Year	Selection of Participants	Confounding Variables	Measurement of Exposure	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Outcome Reporting
Al-Khlaifat et al, 2015[41]	High[b]	High[c]	Low	High	Low	Low
Davis et al, 2017[29]	High[d]	High[c]	High[e]	High[f]	Low	Low
Patel et al, 2010[42]	Low	High[c]	Low	High	Low	Low
Skou et al, 2012[43]	Low	High[c]	Low	High[f]	Low	Low
Skou et al, 2014[44]	Low	High[c]	Low	High	Low	Low
Skou and Roos, 2017[21]	Low	High[g]	High[e]	High[f]	Low	Low

Abbreviation: RoBANS, Risk of Bias Assessment Tool for Nonrandomized Studies.
[a]Possible risk-of-bias levels: low, high, unclear.
[b]Convenience sample of participants.
[c]No consideration of potential confounders in analyses.
[d]Targeted recruitment of participants from single assessment centre.
[e]Participants completed self-administered questionnaires for outcome assessment (e.g., pain).
[f]Outcome assessors were not blinded for performance tests that assessed physical function.
[g]Residual confounders.

Table A3: GRADE Evidence Profile for Pain

Number of Studies (Design)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Upgrade Considerations	Quality
Structured Education and Neuromuscular Exercise Program Versus Usual Care							
2 (RCT)	Serious limitations (–1)[a]	No serious limitations	No serious limitations	Serious limitations (–1)[b]	Undetected	None	⊕⊕ Low
Structured Education and Neuromuscular Exercise Program Versus Patient Education							
2 (RCT)	Serious limitations (–1)[c]	No serious limitations	No serious limitations	Serious limitations (–1)[b]	Undetected	None	⊕⊕ Low
Structured Education and Neuromuscular Exercise Program Only							
6 (observational)	Serious limitations (–1)[d]	No serious limitations	Serious limitations (–1)[e]	No serious limitations	Undetected	None	⊕Very Low

Abbreviations: GRADE, Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial.
[a]In one study,[36] more than 20% of participants in the intervention group were lost to follow-up at 30 months.
[b]Small sample sizes increased the standard error and the width of the 95% confidence interval.
[c]In one study,[40] participants lost to follow-up prior to 29 months proceeded to undergo total hip replacement, which may bias pain outcomes.
[d]GRADE rating starts at low for nonrandomized studies. In one study,[21] participants lost to follow-up reported more pain and higher body mass index than participants who continued. One study[42] provided no patient demographics table with baseline characteristics.
[e]In one study,[29] generalizability was a concern, as more than 80% of the population had completed college or university. One study[42] provided no patient demographics table with baseline characteristics. In one study,[41] the mean body mass index of all participants was classified as obese class I.

Table A4: GRADE Evidence Profile for Physical Function

Number of Studies (Design)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Upgrade Considerations	Quality
Structured Education and Neuromuscular Exercise Program Versus Usual Care							
2 (RCT)	Serious limitations (–1)[a]	No serious limitations	No serious limitations	No serious limitations	Undetected	None	⊕⊕⊕ Moderate
Structured Education and Neuromuscular Exercise Program Versus Patient Education							
2 (RCT)	Serious limitations (–1)[b]	No serious limitations	No serious limitations	Serious limitations (–1)[c]	Undetected	None	⊕⊕ Low
Structured Education and Neuromuscular Exercise Program Only							
5 (observational)	Serious limitations (–1)[d]	No serious limitations	Serious limitations (–1)[e]	Serious limitations (–1)[c]	Undetected	None	⊕ Very low

Abbreviations: GRADE, Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial.
[a]In one study,[36] more than 20% of participants in the intervention group were lost to follow-up at 30 months.
[b]In one study,[40] participants lost to follow-up prior to 29 months proceeded to undergo total hip replacement, which may bias physical function outcomes.
[c]Small sample sizes increased the standard error and the width of the 95% confidence interval.
[d]GRADE rating starts at low for nonrandomized studies. In one study,[21] participants lost to follow-up reported more pain and a higher body mass index than participants who continued. One study[42] provided no patient demographics table with baseline characteristics.
[e]In one study,[21] generalizability was a concern, as participants were already physically active at baseline (i.e., taking part in 30 minutes of physical activity per day for 5 days).

Table A5: GRADE Evidence Profile for Quality of Life

Number of Studies (Design)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Upgrade Considerations	Quality
Structured Education and Neuromuscular Exercise Program Versus Usual Care							
1 (RCT)	No serious limitations	No serious limitations	No serious limitations	Serious limitations (–1)[a]	Undetected	None	⊕⊕⊕ Moderate
Structured Education and Neuromuscular Exercise Program Versus Patient Education							
1 (RCT)	Serious limitations(–1)[b]	No serious limitations	No serious limitations	Serious limitations (–1)[a]	Undetected	None	⊕⊕ Low
Structured Education and Neuromuscular Exercise Program Only							
2 (observational)	Serious limitations (–1)[c]	No serious limitations	Serious limitations (–1)[d]	Serious limitations (–1)[a]	Undetected	None	⊕ Very low

Abbreviations: GRADE, Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial.
[a]Small sample sizes increased the standard error and the width of the 95% confidence interval.
[b]In one study,[39] more than 20% of participants in the intervention group were lost to follow-up at 8 weeks.
[c]GRADE rating starts at low for nonrandomized studies. In one study,[21] participants lost to follow-up reported more pain and a higher body mass index than participants who continued.
[d]In one study,[29] more than 50% of participants were retired.

Table A6: GRADE Evidence Profile for Function in Activities of Daily Living

Number of Studies (Design)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Upgrade Considerations	Quality
Structured Education and Neuromuscular Exercise Program Versus Usual Care							
1 (RCT)	No serious limitations	No serious limitations	No serious limitations	Serious limitations (–1)[a]	Undetected	None	⊕⊕⊕ Moderate
Structured Education and Neuromuscular Exercise Program Versus Patient Education							
1 (RCT)	Serious limitations (–1)[b]	No serious limitations	No serious limitations	No serious limitations	Undetected	None	⊕⊕⊕ Moderate
Structured Education and Neuromuscular Exercise Program Only							
2 (observational)	Serious limitations (–1)[c]	No serious limitations	Serious limitations (–1)[d]	Serious limitations (–1)[a]	Undetected	None	⊕ Very Low

Abbreviations: GRADE, Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial.
[a]Small sample sizes increased the standard error and the width of the 95% confidence interval.
[b]In one study,[39] more than 20% of participants in the intervention group were lost to follow-up at 8 weeks.
[c]GRADE rating starts at low for nonrandomized studies. One study[29] used targeted recruitment at a single assessment centre. In one study,[41] more than 20% of participants were lost to follow-up.

[d]In one study,[41] generalizability was a concern, as the mean body mass index of all participants was classified as obese class I, which may have affected the ability of these participants to execute activities of daily living.

Table A7: GRADE Evidence Profile for Physical Activity

Number of Studies (Design)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Upgrade Considerations	Quality
Structured Education and Neuromuscular Exercise Program Versus Patient Education							
1 (RCT)	Serious limitations (–1)[a]	No serious limitations	No serious limitations	Serious limitations (–1)[b]	Undetected	None	⊕⊕ Low
Structured Education and Neuromuscular Exercise Program Only							
2 (observational)	Serious limitations (–1)[c]	No serious limitations	Serious limitations (–1)[d]	Serious limitations (–1)[b]	Undetected	None	⊕Very low

Abbreviations: GRADE, Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial.
[a]In one study,[40] participants lost to follow-up prior to 29 months proceeded to undergo total hip replacement, which may have biased physical activity outcomes.
[b]Small sample sizes increased the standard error and the width of the 95% confidence interval.
[c]GRADE rating starts at low for nonrandomized studies. In one study,[21] participants lost to follow-up reported a lower level of educational completion, more pain, and a higher body mass index than those who continued; these factors may have influenced the likelihood of these participants to participate in physical activity.
[d]In one study,[21] generalizability was a concern, as participants were already physically active at baseline (i.e., taking part in 30 minutes of physical activity per day for 5 days). In one study,[29] generalizability was a concern as more than 80% of the population had completed college or university.

Table A8: GRADE Evidence Profile for Adverse Events

Number of Studies (Design)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Upgrade Considerations	Quality
Structured Education and Neuromuscular Exercise Program Versus Usual Care							
1 (RCT)	No serious limitations	No serious limitations	No serious limitations	No serious limitations[a]	Undetected	None	⊕⊕⊕⊕ High

Abbreviations: GRADE, Grading of Recommendations Assessment, Development, and Evaluation; RCT, randomized controlled trial.
[a]No 95% confidence interval reported.

Appendix 3: Selected Excluded Studies

Citation	Primary Reason for Exclusion
Bearne LM, Walsh NE, Jessep S, Hurley MV. Feasibility of an exercise-based rehabilitation programme for chronic hip pain. Musculoskeletal care. 2011;9(3):160-8.	Intervention < 6 weeks
Gill SD, McBurney H, Schulz DL. Land-based versus pool-based exercise for people awaiting joint replacement surgery of the hip or knee: results of a randomized controlled trial. Arch Phys Med Rehabil. 2009;90(3):388-94.	Intervention
Jessep SA, Walsh NE, Ratcliffe J, Hurley MV. Long-term clinical benefits and costs of an integrated rehabilitation programme compared with outpatient physiotherapy for chronic knee pain. Physiotherapy. 2009;95(2):94-102	Intervention < 6 weeks
Marconcin P, Espanha M, Teles J, Bento P, Campos P, Andre R, et al. A randomized controlled trial of a combined self-management and exercise intervention for elderly people with osteoarthritis of the knee: the PLE(2)NO program. Clin Rehabil. 2017:269215517718892.	Intervention

Appendix 4: Reliable and Validated Measurement Scales

Measurement Scale	Objective	Components	Interpretation of Score
Hip Disability and Osteoarthritis Outcome Score (HOOS)[89]	Participants report opinions about hip and associated problems	Five valid and reliable subscales: Pain, Other Symptoms, Function in Activities of Daily Living, Function in Sport and Recreation, Hip-Related Quality of Life	A normalized score (with 100 indicating no symptoms and 0 indicating extreme symptoms) is calculated for each subscale
Knee Injury and Osteoarthritis Outcome Score (KOOS)[90]	Participants report opinions about knee and associated problems	Five valid and reliable subscales: Pain, Other Symptoms, Function in Activities of Daily Living, Function in Sport and Recreation, Knee-Related Quality of Life	A normalized score (with 100 indicating no symptoms and 0 indicating extreme symptoms) is calculated for each subscale
Numeric Pain Rating Scale (NPRS)[48]	Participants select a number that best reflects pain intensity	Valid and reliable numeric version of the Visual Analog Scale (VAS)	Scores range from 0 to 10, with 0 indicating no pain and 10 indicating “worst possible pain”
Physical Activity Guidelines for Adults[91]	Participants self-report how many days per week they were physically activity for at least 30 minutes	N/A	Adults who are physically active are healthier and less likely to develop many chronic diseases than adults who aren’t active, regardless of their gender or ethnicity
Physical Activity Scale for the Elderly (PASE)[92]	Participants aged 65 years and older report on their physical activity over the past 7 days	Twenty-four questions on leisure time, household, and work-related activities	The total score expresses a person’s overall physical activity level. Scores range from 0 to 315, with 0 indicating complete inactivity and 315 indicating an extremely high level of activity
Visual Analog Scale (VAS)[93]	Participants report “current” pain intensity or pain intensity “in the last 24 hours”	The scale consists of a 10 cm line; 0–4 mm indicates no pain; 5–44 mm indicates mild pain (5–44); 45–74 mm indicates moderate pain; and 75–100 mm indicates severe pain. Participants mark the spot on the line they feel best represents their pain intensity. VAS scores are highly correlated with a 5-point verbal descriptive scale (“nil,” “mild,” “moderate,” “severe,” and “very severe”)	The score is determined by measuring the distance (in mm) between the “no pain” anchor and the person’s mark; higher scores indicate greater pain intensity

Measurement Scale	Objective	Components	Interpretation of Score
Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[94]	Participants report pain, stiffness, and physical function associated with knee and/or hip osteoarthritis	Twenty-four validated and reliable items divided into 3 subscales: • Pain (5 items): during walking, using stairs, in bed, sitting or lying, standing • Stiffness (2 items): after first waking, later in the day • Physical Function (17 items): stair use, rising from sitting, standing, bending, walking, getting in/out of a car, shopping, putting on/taking off socks, rising from bed, lying in bed, getting in/out of bath, sitting, getting on/off toilet, heavy household duties, light household duties	On the Likert scale version, the scores are summed for items in each subscale, with possible ranges as follows: pain, 0–20; stiffness, 0–8; physical function: 0–68. On the visual analog version, a ruler is used to measure the distance (in mm) from the left end marker to the patient's mark. For each item, the possible score ranges from 0 to 10. Higher scores signify poorer functioning.

Appendix 5: Results for Computed Mean Differences and 95% Confidence Intervals

Table A9: Computed Mean Differences and 95% Confidence Intervals—Structured Education and Neuromuscular Exercise Program

		Baseline	Follow-Up	
Author, Year	Measurement Scale	Mean (SD)	Mean (SD)	Mean Difference (95% CI)
da Silva et al, 2015[39]	Lequesne Index pain subscale	Intervention: 4.93 (1.33) Control: 4.47 (1.46) *P* = .37	8 weeks Intervention: 2.60 (1.55) Control:4.00 (1.56) *P* = .009	8 weeks −1.9 (−3.0 to −0.8) −1.6 (−2.6 to −0.5)[a]
	Lequesne Index activities of daily living subscale	Intervention: 3.57 (1.08) Control: 3.23 (1.53) *P* = .49	8 weeks Intervention: 2.30 (1.36) Control: 3.13 (1.45) *P* = .02	8 weeks −0.9 (−1.9 to 0.1) −1.1 (−1.9 to −0.2)[a]
	30-second chair-stand test	Intervention: 10.07 (2.49) Control: 11.27 (2.89) *P* = .23	8 weeks Intervention: 14.07 (2.52) Control: 11.33 (3.24) *P* < .001	8 weeks 2.8 (0.7–4.9) 3.5 (1.8–5.2)[a]
	Timed up-and-go test	Intervention: 9.25 (2.76) Control: 8.70 (1.48) *P* = 0.50	8 weeks Intervention: 7.17 (0.94) Control: 9.22 (1.89) *P* < .001	8 weeks −2.1 (−3.1to−1.0) −1.8 (−2.7 to−0.9)[a]
	6-minute walk test	Intervention: 409.77 (48.11) Control: 417.20 (48.11) *P* = .73	8 weeks Intervention: 485.47 (57.99) Control: 435.07 (64.40) *P* = .001	8 weeks 68.3 (24.4–112.1) 56.4 (28.2–84.6)[a]

Author, Year	Measurement Scale	Baseline	Follow-Up	
		Mean (SD)	Mean (SD)	Mean Difference (95% CI)
Hurley et al, 2012[36]	WOMAC pain subscale	Intervention: 7.5 (1.7) Control: 7.7 (1.7)	6 weeks Intervention: 5.2 (1.7) Control: 7.1 (1.8) *P* < .001 6 months Intervention: 5.7 (1.9) Control: 6.5 (2.1) *P* = .178 18 months Intervention: 5.7 (2.0) Control: 6.4 (2.1) *P* = .263 30 months Intervention: 5.9 (2.6) Control: 6.4 (2.0) *P* = .459	6 weeks −1.7 (−2.1 to −1.3) 6 months −0.6 (−1.1 to −0.1) 18 months −0.5 (−1.0 to −0.0) 30 months −0.3 (−0.8 to 0.2)
	WOMAC physical function subscale	Intervention: 27.1 (6.7) Control: 27.2 (7.0)	6 weeks Intervention: 20.0 (5.9) Control: 25.9 (6.3) *P* = .002 6 months Intervention: 21.7 (6.7) Control: 23.4 (7.5) *P* = .423 18 months Intervention: 21.9 (2.0) Control: 24.3 (6.6) *P* = .257 30 months Intervention: 22.3 (8.7) Control: 23.8 (6.3) *P* = .525	6 weeks −5.8 (−7.1 to −4.5) 6 months −1.6 (−3.2 to 0.0) 18 months −2.3 (−3.9 to −0.7) 30 months −1.4 (−3.2 to 0.4)

Author, Year	Measurement Scale	Baseline	Follow-Up	
		Mean (SD)	Mean (SD)	Mean Difference (95% CI)
Svege et al, 2015[40]	PASE	Intervention: 114 (43.5) Control: 123 (50.6)	4 months Intervention: 115 (52.9) Control: 121 (45.4) 10 months Intervention: 118 (48.6) Control: 126 (57.3) 16 months Intervention: 123 (50.7) Control: 133 (57.3) 29 months Intervention: 120 (46.8) Control: 139 (59.2)	4 months 3 (−15.5 –21.5) 10 months 1 (−21.2 to 23.2) 16 months −1 (−25.0 to 23.0) 29 months −10 (−35.6 to 15.6)

Abbreviations: CI, confidence interval; PASE, Physical Activity Scale for the Elderly; SD, standard deviation; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[a]Adjusted for baseline value mean differences and 95% confidence intervals.

Appendix 6: Results of Applicability Checklist for Studies Included in Economic Evidence Review

Table A10: Assessment of the Cost-Effectiveness of a Structured Education and Neuromuscular Exercise Program for Hip and/or Knee Osteoarthritis

Objective: To assess the cost-effectiveness of a structured education and neuromuscular exercise program					
Author, Year	**Is the study population similar to the question?**	**Are the interventions similar to the question?**	**Is the health care system in which the study was conducted sufficiently similar to the current Ontario context?**	**Were the perspectives clearly stated? If yes, what were they?**	**Are estimates of relative treatment effect from the best available source?**
Fernandes et al, 2017[55]	No	Yes	No	Yes, health care system	Yes

Author, Year	Are all future costs and outcomes discounted? If yes, at what rate?	Is the value of health effects expressed in terms of quality-adjusted life-years?	Are costs and outcomes from other sectors fully and appropriately measured and valued?	Overall judgment (directly applicable/partially applicable/ not applicable)
Fernandes et al, 2017[55]	Not applicable	Yes	Partially	Not applicable

Note: Response options for all items were “yes,” “partially,” “no,” “unclear,” and “not applicable.”

Appendix 7: Letter of Information

ATTENTION: PATIENTS

CALL FOR PARTICIPATION FROM HEALTH QUALITY ONTARIO

REVIEW OF EDUCATION AND EXERCISE PROGRAM FOR KNEE AND/OR HIP OSTEOARTHRITIS

WHO IS HEALTH QUALITY ONTARIO?

Health Quality Ontario is a provincial agency ensuring our health care system delivers high quality care, a positive patient experience and responsible use of health care dollars. This includes evaluating the effectiveness of health care technologies and services through a review called **health technology assessments (HTAs)**.

WHAT IS THE OPPORTUNITY?

Health Quality Ontario is currently reviewing a **evidence-based education and exercise program called GLA:D Canada** for patients with **knee and/or hip Osteoarthritis**. The purpose is to understand whether this program should be more broadly funded in Ontario. A key part of this review is to make sure the lived-experience of patients with knee and/or hip Osteoarthritis and their families is taken into account.

WHO ARE WE LOOKING FOR?

We are looking to speak to **patients** with knee and/or hip Osteoarthritis and their families and may have had experience with the GLA:D Canada exercise program. Patients do not need to have been enrolled in the GLA:D Canada program to participate.

WHY GET INVOLVED?

This review will result in a recommendation to the Ministry of Health and Long Term Care about the public funding of the GLA:D education and exercise program. The views, values, and experiences of patient and caregivers are of vital importance to this review.

WHAT WE NEED FROM YOU

- **20-40 minutes of your time for a phone or in-person interview to share your story**
- **Permission to audio (not video) record the interview, if possible**

We are hoping to conduct interviews through the end of **December, 2017**. If you are interested in participating, please don't hesitate to reach out to us at HQO:

Appendix 8: Interview Guide

Interview for Structured Education and Exercise Program (GLA:D Canada)

Intro
Explain HQO purpose, HTA process, and purpose of interview
History of osteoarthritis: diagnosis and background (general only)

Lived- Experience
Day-to-day routine
How active is patient? What is the impact of OA and its progression on quality of life? (Loss of independence?)
Most intrusive aspect of condition, most distressing?
Impact on loved ones/caregivers, work, etc.?

Therapies
What current therapies/treatments are used and their impact?
Is accessibility to therapies/treatments an issue (are you able to take advantage of all potential therapies?)
Expectations of current therapies?
Specific question about use of exercise programs (if not mentioned already)
Would cost be an impediment to an exercise program?

GLA:D Canada
Information surrounding this program?
Expectations
Description of the program
Result, impact, change in quality of life (if applicable)

REFERENCES

(1) Osteoarthritis Research Society International. What is osteoarthritis? [Internet]. Mount Laurel (NJ): The Society; 2013 [cited 2017 Sep 28]. Available from: https://www.oarsi.org/what-osteoarthritis

(2) Silverwood V, Blagojevic-Bucknall M, Jinks C, Jordan JL, Protheroe J, Jordan KP. Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis. Osteoarthritis Cartilage. 2015;23(4):507-15.

(3) Cross M, Smith E, Hoy D, Nolte S, Ackerman I, Fransen M, et al. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. Ann Rheum Dis. 2014;73(7):1323-30.

(4) Plotnikoff R, Karunamuni N, Lytvyak E, Penfold C, Schopflocher D, Imayama I, et al. Osteoarthritis prevalence and modifiable factors: a population study. BMC Public Health. 2015;15:1195.

(5) Posnett J, Dixit S, Oppenheimer B, Kili S, Mehin N. Patient preference and willingness to pay for knee osteoarthritis treatments. Patient Prefer Adherence. 2015;9:733-44.

(6) Johnson VL, Hunter DJ. The epidemiology of osteoarthritis. Best Pract Res Clin Rheumatol. 2014;28(1):5-15.

(7) Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. Osteoarthritis Cartilage. 2010;18(1):24-33.

(8) Tarride JE, Haq M, O'Reilly DJ, Bowen JM, Xie F, Dolovich L, et al. The excess burden of osteoarthritis in the province of Ontario, Canada. Arthritis Rheum. 2012;64(4):1153-61.

(9) Brosseau L, Wells GA, Pugh AG, Smith CA, Rahman P, Alvarez Gallardo IC, et al. Ottawa Panel evidence-based clinical practice guidelines for therapeutic exercise in the management of hip osteoarthritis. Clin Rehabil. 2016;30(10):935-46.

(10) World Health Organization. Chronic rheumatic conditions [Internet]. Geneva (Switzerland): The Organization; 2017 [cited 2017 Aug 2]. Available from: http://www.who.int/chp/topics/rheumatic/en/

(11) MacDonald K, Sanmartin C, Langlois K, Marshal D. Symptom onset, diagnosis and management of osteoarthritis [Internet]. Ottawa (ON): Statistics Canada; 2014 [cited 2017 Sep 28]. Available from: https://www.statcan.gc.ca/pub/82-003-x/2014009/article/14087-eng.pdf

(12) Statistics Canada. Table 1: Prevalence of osteoarthritis, by age group and site of joint pain, household population aged 20 or older diagnosed with arthritis, Canada excluding territories, 2009 [Internet]. Ottawa (ON): Statistics Canada; 2009 [cited 2017 Jul 27]. Available from: http://www.statcan.gc.ca/pub/82-003-x/2014009/article/14087/tbl/tbl1-eng.htm

(13) Allen KD, Choong PF, Davis AM, Dowsey MM, Dziedzic KS, Emery C, et al. Osteoarthritis: models for appropriate care across the disease continuum. Best Pract Res Clin Rheumatol. 2016;30(3):503-35.

(14) Arthritis Alliance of Canada. The impact of arthritis in Canada: today and over the next 30 years [Internet]. Toronto (ON): The Alliance; 2011 [cited 2017 Oct 6]. Available from: http://www.arthritisalliance.ca/images/PDF/eng/Initiatives/20111022_2200_impact_of_arthritis.pdf

(15) Lohmander LS, Roos EM. Clinical update: treating osteoarthritis. Lancet. 2007;370(9605):2082-4.

(16) Hawker GA. The challenge of pain for patients with OA. HSS J. 2012;8(1):42-4.

(17) Brosseau L, Taki J, Desjardins B, Thevenot O, Fransen M, Wells GA, et al. The Ottawa Panel clinical practice guidelines for the management of knee osteoarthritis. Part two: strengthening exercise programs. Clin Rehabil. 2017;31(5):596-611.
(18) National Institute for Health and Care Excellence. Osteoarthritis: care and management [Internet]. London (UK): The Institute; 2014 [cited 2017 Jul 27]. Available from: https://www.nice.org.uk/guidance/cg177/chapter/1-recommendations#education-and-self-management-2
(19) Health Quality Ontario. Osteoarthritis: Care for Adults With Osteoarthritis of the Knee, Hip, or Hand. Toronto (ON): Queen's Printer for Ontario; In Press.
(20) da Costa BR, Reichenbach S, Keller N, Nartey L, Wandel S, Juni P, et al. Effectiveness of non-steroidal anti-inflammatory drugs for the treatment of pain in knee and hip osteoarthritis: a network meta-analysis. Lancet. 2017;390(10090):e21-e33.
(21) Skou ST, Roos EM. Good Life with osteoArthritis in Denmark (GLA:D): evidence-based education and supervised neuromuscular exercise delivered by certified physiotherapists nationwide. BMC Musculoskelet Disord. 2017;18(1):72.
(22) Ageberg E, Roos EM. Neuromuscular exercise as treatment of degenerative knee disease. Exerc Sport Sci Rev. 2015;43(1):14-22.
(23) Ageberg E, Link A, Roos EM. Feasibility of neuromuscular training in patients with severe hip or knee OA: the individualized goal-based NEMEX-TJR training program. BMC Musculoskelet Disord. 2010;11:126.
(24) Ageberg E, Nilsdotter A, Kosek E, Roos EM. Effects of neuromuscular training (NEMEX-TJR) on patient-reported outcomes and physical function in severe primary hip or knee osteoarthritis: a controlled before-and-after study. BMC Musculoskelet Disord. 2013;14:232.
(25) Bone and Joint Canada. GLA:D Canada [Internet]. [cited Jul 27 2017]. Available from: http://boneandjointcanada.com/osteoarthritis/health-care-professionals/glad-canada/
(26) GLA:D Canada. What is GLA:D Canada? [Internet]. 2017 [cited 2017 Jul 27]. Available from: http://gladcanada.ca/index.php/what-is-glad-canada/
(27) GLA:D Canada [Internet]. Toronto (ON): GLA:D Canada; c2016 [cited 2017 Oct 20]. Available from: http://gladcanada.ca/
(28) Government-funded (OHIP) physiotherapy [Internet]. Toronto (ON): College of Physiotherapists of Ontario; c2017 [cited 2017 July 27]. Available from: https://www.collegept.org/patients/Accessing-Government-Funded-Physiotherapy
(29) Davis AM, Kennedy D, Wong R, Robarts S, Skou ST, McGlasson R, et al. Cross-cultural adaptation and implementation of Good Life with osteoArthritis in Denmark (GLA:D): group education and exercise for hip and knee osteoarthritis is feasible in Canada. Osteoarthritis Cartilage. 2018;26(2):211-19.
(30) McGowan J, Sampson M, Salzwedel DM, Cogo E, Foerster V, Lefebvre C. PRESS peer review of electronic search strategies: 2015 guideline statement. J Clin Epidemiol. 2016;75:40-6.
(31) Stauffer ME, Taylor SD, Watson DJ, Peloso PM, Morrison A. Definition of nonresponse to analgesic treatment of arthritic pain: an analytical literature review of the smallest detectable difference, the minimal detectable change, and the minimal clinically important difference on the pain visual analog scale. Int J Inflam. 2011;2011:231926.
(32) Tubach F, Ravaud P, Baron G, Falissard B, Logeart I, Bellamy N, et al. Evaluation of clinically relevant changes in patient reported outcomes in knee and hip osteoarthritis: the minimal clinically important improvement. Ann Rheum Dis. 2005;64(1):29-33.
(33) Kennedy DM, Stratford PW, Wessel J, Gollish JD, Penney D. Assessing stability and change of four performance measures: a longitudinal study evaluating outcome following total hip and knee arthroplasty. BMC Musculoskelet Disord. 2005;6:3.

(34) Schünemann H, Brożek J, Guyatt G, Oxman A, eds. GRADE handbook [Internet]. Hamilton (ON): GRADE Working Group; 2013 [cited 2017 Dec]. Available from: http://gdt.guidelinedevelopment.org/app/handbook/handbook.html#h.hnedbo8gqjqk.
(35) Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(6):e1000097.
(36) Hurley MV, Walsh NE, Mitchell H, Nicholas J, Patel A. Long-term outcomes and costs of an integrated rehabilitation program for chronic knee pain: a pragmatic, cluster randomized, controlled trial. Arthritis Care Res (Hoboken). 2012;64(2):238-47.
(37) Skou ST, Rasmussen S, Laursen MB, Rathleff MS, Arendt-Nielsen L, Simonsen O, et al. The efficacy of 12 weeks non-surgical treatment for patients not eligible for total knee replacement: a randomized controlled trial with 1-year follow-up. Osteoarthritis Cartilage. 2015;23(9):1465-75.
(38) Skou ST, Roos EM, Simonsen O, Laursen MB, Rathleff MS, Arendt-Nielsen L, et al. The efficacy of non-surgical treatment on pain and sensitization in patients with knee osteoarthritis: a pre-defined ancillary analysis from a randomized controlled trial. Osteoarthritis Cartilage. 2016;24(1):108-16.
(39) Da Silva FS, de Melo FE, do Amaral MM, Caldas VV, Pinheiro IL, Abreu BJ, et al. Efficacy of simple integrated group rehabilitation program for patients with knee osteoarthritis: single-blind randomized controlled trial. J Rehabil Res Dev. 2015;52(3):309-22.
(40) Svege I, Nordsletten L, Fernandes L, Risberg MA. Exercise therapy may postpone total hip replacement surgery in patients with hip osteoarthritis: a long-term follow-up of a randomised trial. Ann Rheum Dis. 2015;74(1):164-9.
(41) Al-Khlaifat L, Herrington LC, Tyson SF, Hammond A, Jones RK. The effectiveness of an exercise programme on dynamic balance in patients with medial knee osteoarthritis: a pilot study. Knee. 2016;23(5):849-56.
(42) Patel S, Hossain FS, Paton B, Haddad FS. The effects of a non-operative multimodal programme on osteoarthritis of the knee. Ann R Coll Surg Engl. 2010;92(6):467-71.
(43) Skou ST, Odgaard A, Rasmussen JO, Roos EM. Group education and exercise is feasible in knee and hip osteoarthritis. Dan Med J. 2012;59(12):A4554.
(44) Skou ST, Simonsen ME, Odgaard A, Roos EM. Predictors of long-term effect from education and exercise in patients with knee and hip pain. Dan Med J. 2014;61(7):A4867.
(45) Klassbo M, Larsson G, Harms-Ringdahl K. Promising outcome of a hip school for patients with hip dysfunction. Arthritis Rheum. 2003;49(3):321-7.
(46) Skou ST, Rasmussen S, Laursen MB, Rathleff MS, Arendt-Nielsen L, Simonsen O, et al. The two-year efficacy of 12-weeks non-surgical treatment for patients not eligible for total knee replacement-a pre-defined analysis from a randomized controlled trial. Osteoarthritis Cartilage. 2016;24(31).
(47) Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). Arthritis Care Res (Hoboken). 2011;63 Suppl 11:S208-28.
(48) Farrar JT, Young JP Jr, LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. Pain. 2001;94(2):149-58.

(49) Pua YH, Cowan SM, Wrigley TV, Bennell KL. The Lower Extremity Functional Scale could be an alternative to the Western Ontario and McMaster Universities Osteoarthritis Index physical function scale. J Clin Epidemiol. 2009;62(10):1103-11.
(50) Tubach F, Ravaud P, Martin-Mola E, Awada H, Bellamy N, Bombardier C, et al. Minimum clinically important improvement and patient acceptable symptom state in pain and function in rheumatoid arthritis, ankylosing spondylitis, chronic back pain, hand osteoarthritis, and hip and knee osteoarthritis: Results from a prospective multinational study. Arthritis Care Res (Hoboken). 2012;64(11):1699-707.
(51) Wright AA, Cook CE, Baxter GD, Dockerty JD, Abbott JH. A comparison of 3 methodological approaches to defining major clinically important improvement of 4 performance measures in patients with hip osteoarthritis. J Orthop Sports Phys Ther. 2011;41(5):319-27.
(52) Svege I, Kolle E, Risberg MA. Reliability and validity of the Physical Activity Scale for the Elderly (PASE) in patients with hip osteoarthritis. BMC Musculoskelet Disord. 2012;13:26.
(53) Dawson J, Linsell L, Doll H, Zondervan K, Rose P, Carr A, et al. Assessment of the Lequesne index of severity for osteoarthritis of the hip in an elderly population. Osteoarthritis Cartilage. 2005;13(10):854-60.
(54) National Institute for Health and Care Excellence. Methods for the development of NICE public health guidance (third edition). Appendix I: Quality appraisal checklist–economic evaluations [Internet]. London (UK): The Institute; 2012 [cited 2017 Nov 30]. Available from: https://www.nice.org.uk/process/pmg4/chapter/appendix-i-quality-appraisal-checklist-economic-evaluations
(55) Fernandes L, Roos EM, Overgaard S, Villadsen A, Sogaard R. Supervised neuromuscular exercise prior to hip and knee replacement: 12-month clinical effect and cost-utility analysis alongside a randomised controlled trial. BMC Musculoskelet Disord. 2017;18(1):5.
(56) Husereau D, Drummond M, Petrou S, Carswell C, Moher D, Greenberg D, et al. Consolidated Health Economic Evaluation Reporting Standards (CHEERS)--explanation and elaboration: a report of the ISPOR Health Economic Evaluation Publication Guidelines Good Reporting Practices Task Force. Value Health. 2013;16(2):231-50.
(57) Kopec JA, Rahman MM, Berthelot JM, Le Petit C, Aghajanian J, Sayre EC, et al. Descriptive epidemiology of osteoarthritis in British Columbia, Canada. J Rheumatol. 2007;34(2):386-93.
(58) Rahman MM, Cibere J, Goldsmith CH, Anis AH, Kopec JA. Osteoarthritis incidence and trends in administrative health records from British Columbia, Canada. J Rheumatol. 2014;41(6):1147-54.
(59) Birtwhistle R, Morkem R, Peat G, Williamson T, Green ME, Khan S, et al. Prevalence and management of osteoarthritis in primary care: an epidemiologic cohort study from the Canadian Primary Care Sentinel Surveillance Network. CMAJ Open. 2015;3(3):E270-5.
(60) ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine. 2016 Mar 7 - 2017 Dec. Identifier NCT02693873, Stop OA: a pilot study (GLA:D Canada) - education and targeted, personalized exercise for hip and knee osteoarthritis; 2016 Feb 29 [cited 2017 Oct 10]. Available from: https://clinicaltrials.gov/ct2/show/NCT02693873.
(61) Canadian Agency for Drugs and Technologies in Health. CADTH methods and guidelines: guidelines for the economic evaluation of health technologies: Canada. 4th ed. [Internet]. Ottawa (ON): The Agency; 2017 [cited 2017 Oct 10]. Available from: https://www.cadth.ca/sites/default/files/pdf/guidelines_for_the_economic_evaluation_of_health_technologies_canada_4th_ed.pdf

(62) Takata SC, Wade ET, Roll SC. Hand therapy interventions, outcomes, and diagnoses evaluated over the last 10 years: a mapping review linking research to practice. J Hand Ther. 2017;21:21.
(63) Paulden M, Galvanni V, Chakraborty S, Kudinga B, McCabe C. Discounting and the evaluation of health care programs [Internet]. Ottawa (ON): Canadian Agengy for Drugs and Technologies in Health; 2016 [cited 2017 Mar 13]. Available from: https://www.cadth.ca/sites/default/files/pdf/CP0008_Economic_Evaluation_Guidelines_Discount_Rate_Report.pdf
(64) Drummond MF, Sculpher MJ, Torrance G, O'Brien B, Stoddart G. Methods for the economic evaluation of health care programmes. 3rd ed. Oxford: Oxford University Press; 2005.
(65) Dakin H, Gray A, Fitzpatrick R, Maclennan G, Murray D. Rationing of total knee replacement: a cost-effectiveness analysis on a large trial data set. BMJ Open. 2012;2(1):e000332.
(66) Woods B, Manca A, Weatherly H, Saramago P, Sideris E, Giannopoulou C, et al. Cost-effectiveness of adjunct non-pharmacological interventions for osteoarthritis of the knee. PLoS One. 2017;12(3):e0172749.
(67) Maetzel A, Li LC, Pencharz J, Tomlinson G, Bombardier C. The economic burden associated with osteoarthritis, rheumatoid arthritis, and hypertension: a comparative study. Ann Rheum Dis. 2004;63(4):395-401.
(68) Temple J. Purchasing power parities and real expenditures, United States and Canada, 1992 to 2005 [Internet]. Ottawa (ON): Statistics Canada; 2007 [cited 2018 Jan 23]. Available from: http://www.statcan.gc.ca/pub/13-604-m/13-604-m2007053-eng.pdf
(69) Bove AM, Baker N, Livengood H, King V, Mancino J, Popchak A, et al. Task-specific training for adults with chronic knee pain: a case series. J Orthop Sports Phys Ther. 2017;47(8):548-56.
(70) Manca A, Hawkins N, Sculpher MJ. Estimating mean QALYs in trial-based cost-effectiveness analysis: the importance of controlling for baseline utility. Health Econ. 2005;14(5):487-96.
(71) Briggs A, Claxton K, Sculpher M. Decision modelling for health economic evaluation. Oxford: Oxford University Press; 2006.
(72) Fenwick E, O'Brien BJ, Briggs A. Cost-effectiveness acceptability curves--facts, fallacies and frequently asked questions. Health Econ. 2004;13(5):405-15.
(73) Marshall JK, Pellissier JM, Attard CL, Kong SX, Marentette MA. Incremental cost-effectiveness analysis comparing rofecoxib with nonselective NSAIDs in osteoarthritis: Ontario Ministry of Health perspective. Pharmacoeconomics. 2001;19(10):1039-49.
(74) Institute of Medicine Committee on Pain, Disability, and Chronic Illness Behavior; Osterweis M, Kleinman A, Mechanic D, editors. Measuring pain and dysfunction. In: Pain and disability: clinical, behavioral, and public policy perspectives. Washington (DC): National Academies Press; 1987.
(75) Ministry of Finance. Ontario population projections update, 2016-2041. Table 6: Ontario population by age, 2016-2041 - reference scenario [Internet]. Toronto (ON): Queen's Printer for Ontario; 2010 [cited 2017 Nov 30]. Available from: https://www.fin.gov.on.ca/en/economy/demographics/projections/table6.html
(76) Sign up for a training course [Internet]. Toronto (ON): GLA:D Canada; c2016 [cited 2017 Dec 15]. Available from: http://gladcanada.ca/index.php/for-trainers/sign-up-for-a-training-course/
(77) Henriksen M, Klokker L, Bartholdy C, Schjoedt-Jorgensen T, Bandak E, Bliddal H. No effects of functional exercise therapy on walking biomechanics in patients with knee osteoarthritis: exploratory outcome analyses from a randomised trial. BMJ Open Sport Exerc Med. 2016;2(1):e000230.

(78) Yilmaz Yelvar GD, Cirak Y, Dalkilinc M, Demir YP, Baltaci G, Komurcu M, et al. Impairments of postural stability, core endurance, fall index and functional mobility skills in patients with patello femoral pain syndrome. J Back Musculoskelet Rehabil. 2016;30:30.
(79) OHTAC Public Engagement Subcommittee. Public engagement for health technology assessment at Health Quality Ontario—final report from the Ontario Health Technology Advisory Committee Public Engagement Subcommittee [Internet]. Toronto (ON): Queen's Printer for Ontario; 2015 [cited 2016 Jan]. Available from: http://www.hqontario.ca/Portals/0/documents/evidence/special-reports/report-subcommittee-20150407-en.pdf
(80) Fernandes L, Hagen KB, Bijlsma JW, Andreassen O, Christensen P, Conaghan PG, et al. EULAR recommendations for the non-pharmacological core management of hip and knee osteoarthritis. Ann Rheum Dis. 2013;72(7):1125-35.
(81) Kvale S. Interviews: an introduction to qualitative research interviewing. Thousand Oaks (CA): Sage; 1996.
(82) Kuzel AJ. Sampling in qualitative inquiry. In: Miller WL, Crabtree BF, editors. Doing qualitative research. Thousand Oaks (CA): Sage; 1999. p. 33–45.
(83) Morse J. Emerging from the data: cognitive processes of analysis in qualitative research. In: Morse J, editor. Critical issues in qualitative research methods Thousand Oaks (CA): Sage; 1994. p. 23-41.
(84) Patton MQ. Qualitative research and evaluation methods. 3rd ed. Thousand Oaks (CA): Sage; 2002.
(85) Strauss AL, Corbin JM. Basics of qualitative research: techniques and procedures of developing a grounded theory. 2nd ed. Thousand Oaks (CA): Sage; 1998.
(86) Health Technology Assessment International Interest Group on Patient and Citizen Involvement in HTA. Introduction to health technology assessment [Internet]. Edmonton (AB): Health Technology Assessment International; 2015 [cited 2016 Jan]. Available from: http://www.htai.org/fileadmin/HTAi_Files/ISG/PatientInvolvement/v2_files/Resource/PCISG-Resource-Intro_to_HTA__KFacey__Jun13.pdf
(87) Strauss AL, Corbin JM. Grounded theory research: procedures, canons, and evaluative criteria. Qual Sociol. 1990;13(1):3-21.
(88) Strauss AL, Corbin JM. Grounded theory methodology: an overview. In: Denzin NK, Lincoln YS, editors. Handbook of qualitative research. Thousand Oaks (CA): Sage; 1994. p. 273-85.
(89) Nilsdotter AK, Lohmander LS, Klässbo M, Roos EM. Hip disability and osteoarthritis outcome score (HOOS) – validity and responsiveness in total hip replacement. BMC Musculoskelet Disord. 2003;4(1):10.
(90) Roos EM, Lohmander LS. The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. Health Qual Life Outcomes. 2003;1:64.
(91) Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee report, 2008 [Internet]. Washington (DC): U.S. Department of Health and Human Services; 2008 [cited 2018 Jan]. Available from: https://health.gov/paguidelines/report/pdf/committeereport.pdf
(92) Canadian Society for Exercise Physiology. Canadian physical activity guidelines for adults (18-64 years) [Internet]. [cited 2017 Jul 27]. Available from: http://csepguidelines.ca/adults-18-64/
(93) Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of

Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care Res (Hoboken). 2011;63 Suppl 11:S240-52.

(94) American College of Rheumatology. Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [Internet]. Atlanta: The College; 2015 [cited 2018 Jan 9]. Available from: https://www.rheumatology.org/I-Am-A/Rheumatologist/Research/Clinician-Researchers/Western-Ontario-McMaster-Universities-Osteoarthritis-Index-WOMAC

About Health Quality Ontario

Health Quality Ontario is the provincial lead on the quality of health care. We help nurses, doctors and others working hard on the frontlines be more effective in what they do – by providing objective advice and by supporting them and government in improving health care for the people of Ontario.

Our focus is making health care more effective, efficient and affordable which we do through a legislative mandate of:

- Reporting to the public, organizations and health care providers on how the health system is performing,
- Finding the best evidence of what works, and
- Translating this evidence into concrete standards, recommendations and tools that health care providers can easily put into practice to make improvements.

Health Quality Ontario is governed by a 12-member Board of Directors appointed by the Minister of Health and Long-Term Care and with representation from the medical and nursing professions, patients and other segments of health care.

In everything it does, Health Quality Ontario brings together those with first-hand experience – doctors, nurses, other health care providers, patients and families – to hear their experiences and how to make them better. Health Quality Ontario also works collaboratively with organizations across the province to encourage the spread of innovative and proven programs to support high quality, while also saving money and eliminating redundancy. And, we partner with patients to be full participants in designing our programs – another part of our work we take very seriously.

Examples of what we do include providing ways for clinicians to use their collective wisdom and experience to bring about positive change. In 2017, 29 Ontario hospitals participated in a pilot program that reduced infections due to surgery by 18%. This program enabled surgeons to see their surgical data and how they perform in relation to each other and to 700 other hospitals worldwide. We then helped them identify and action improvement practices. Forty-six hospitals across Ontario are now part of this program.

We also develop quality standards that are based on the best evidence, to guide on caring for health conditions where there are gaps in care. Each quality standard provides recommendations to government, organizations and clinicians, and is accompanied by a guide for patients to help them ask informed questions about their care.

In addition, Health Quality Ontario's health technology assessments use evidence to assess the value for money and safety of new technologies and procedures and make recommendations to government on whether or not they should be funded.

And each year, we help organizations across the system create Quality Improvement Plans, for improving health care quality.

Health Quality Ontario is committed to supporting the development of a quality health care system based on six fundamental dimensions: efficient, timely, safe, effective, patient-centred and equitable.

Our goal is to challenge the status quo and to focus on long-lasting pragmatic solutions that improve the health of Ontarians, enhance their experience of care, reduce health care costs, and support the well-being of health care providers – because we believe a quality health system results in Ontarians leading healthier and more productive lives, and a vibrant society in which everyone benefits.

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