

Physiotherapy treatment of hip osteoarthritis

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Abstract

Arthrosis is a degenerative condition that results from mechanical joint overload. Hip arthrosis affects joint cartilage, leading to eventual loss and peeling of the cartilage. Patients feel morning stiffness as well as groin and buttock pain. The pain later increases during activities and wears off during a rest. Arthrosis normally appears in the elderly. It also causes changes to subchondral bones, ligaments, and joint capsules. With an ageing and increasingly obese population, this syndrome is becoming even more prevalent than in the past. The treatment of osteoarthritis should be focused on its prevention, including self-management and education, exercise, and weight loss. Surgery should be reserved for those that have not responded to less invasive methods appropriately. Keywords: osteoarthritis, management of hip osteoarthritis, physiotherapeutic treatment of hip osteoarthritis, therapeutic exercise for hip osteoarthritis

Fizioterapevtska obravnava artroze kolčnega sklepa

Povzetek

Artroza je degenerativno stanje, ki nastane kot posledica mehanskih preobremenitev. Artroza kolčnega sklepa prizadene sklepni hrustanec, ki počasi izginja in se lušči. Pojavi se jutranja okorelost in bolečina v področju dimelj ter zadnjice. Kasneje se bolečina poveča med telesno dejavnostjo in zmanjša ob počitku. Običajno se pojavi pri starejših odraslih. Artroza povzroča tudi spremembe subhondralne kosti, ligamentov in sklepne ovojnice. S starostjo in z naraščanjem števila ljudi s prekomerno telesno težo je postal sindrom artroze bolj pogost kot v preteklosti. Management osteoartritisa bi se moral osredotočiti na preventivno/osnovno zdravljenje, ki vključuje samodisciplino ter izobraževanja na tem področju, vaje ter izgubo telesne mase. Operativni poseg bi pripadal samo tistim, ki se niso odzvali na ostale manj invazivne metode zdravljenja. Ključne besede: osteoarthritis, management artroze kolčnega sklepa, obravnava pacientov z osteoartritisom kolčnega sklepa, kinezioterapevtske vaje pri bolnikih z osteoartritisom kolčnega sklepa

1. INTRODUCTION

Arthrosis or osteoarthritis (OA) is one of the most common diseases affecting joints, which normally appears in the elderly (Herman et al., 2006). It is the cause for reduced ability to perform daily tasks, pain, and limitations in activities and participation (Bijlsma et al 2011). About 10-15 percent of adults over the age of 60 struggle with osteoarthritis (Lodato & Kaplan, 2013). It is often accompanied by age and obesity-associated diseases, such as diabetes and cardiovascular disease. Moreover, osteoarthritis is accompanied by anxiety and depression, both affecting rehabilitations. Osteoarthritis can be classified as a process rather than a disease. It occurs if there is a disproportion between the mechanical loads of the articular cartilage and the ability of the cartilage to withstand the loads (Herman et al 2006). The symptoms of osteoarthritis include pain, stiffness, swelling, deformity, and decreased joint function. It is characterized by a barely perceptible onset of problems with occasional exacerbations (Association, 2010). In the first stages, the pain develops gradually, usually after physical activity. In the advanced phase of the disease, the pain is present also when resting. As patients relieve the hip joint pain, this makes the condition worse. Stiffness is most pronounced in the morning and after rest (Golja in Praprotnik, 2008). History, clinical examination and radiological examination (radiograph of the affected joint) are required to diagnose osteoarthritis of the hip joint. Radiographic changes that are characteristic of osteoarthritis include unevenly narrowed joint fissures, subchondral sclerosis, and osteophyte formation (Poquet et al 2016). Due high prevalence of hip and knee osteoarthritis, many recommendations and clinical guidelines for its treatment have been developed in the last decade (Conaghan et al 2008; Zhang et al 2010; Hochberg et al 2012). International recommendations are often divided into three main categories: nonpharmacological, pharmacological and surgical (Zhang et al, 2010), recently mainly focusing on non-pharmacological treatment. According to international guidelines, therapeutic exercises and weight loss are the most important part of treatment of patients with osteoarthritis (Conaghan et al 2008; Zhang et al 2010; Fernandes et al 2013; Basedow et al 2015; Kolasinski et al 2020). Non-pharmacological treatments, including manual therapy and therapeutic exercises, are the optimal methods for the treatment of hip joint osteoarthritis (Conaghan et al 2008; Zhang et al., 2010).

2. METHODS

A rapid literature review was conducted to present the physiotherapy techniques for hip osteoarthrosis.

3. RESULTS

PUBLICATION	AIM/METHODS	CONCLUSIONS/RESULTS
A pragmatic randomized controlled study of the effectiveness and cost consequences of exercise therapy in hip osteoarthritis, Juhakoski et al 2010	The objectives of this study were to evaluate the short-term and long-term effects of supervised exercise training on pain and functional ability in hip osteoarthritis.	No effects were found on disease-specific pain or self-reported physical functioning scale score of RAND-36. The program may confer slight benefits of improved self-reported physical function in individuals with hip osteoarthritis. However, its clinical importance is uncertain, and it may not translate into actual performance benefits or health care cost savings.
Development of a Therapeutic Exercise Program for Patients with Osteoarthritis of the Hip Fernandes et al., 2010	The purpose of this case report is to describe and demonstrate the use of a therapeutic exercise program (TEP) designed for patients with hip OA. More specific aims of the TEP are to reduce pain and improve strength (force-generating capacity), flexibility, and physical function.	The main challenge associated with a TEP for patients with hip OA is balancing the progression in such a manner that it does not provoke persistent pain while improving muscular strength and physical function. The physical therapist should provide thorough information about the benefits of exercise and how to adjust exercise intensity according to pain level.

PUBLICATION	AIM/METHODS	CONCLUSIONS/RESULTS
Exercise Training in Treatment and Rehabilitation of Hip Osteoarthritis: A 12-Week Pilot Trial, Uusi-Rasi et al., 2017	The present 12-week pilot trial aimed to test the safety and feasibility of a specifically designed exercise program in relieving hip pain and improving function in hip OA subjects.	An isometric leg extensor muscle strength improved statistically significantly by 20% and hip extension ROM by 30%. The training program was found to be feasible and safe. Study supports the use of exercise training in reducing hip OA pain.
Efficacy of patient education and supervised exercise vs patient education alone in patients with hip osteoarthritis: a single blind randomized clinical trial Fernandes et al., 2010	To compare the benefits of adding a supervised exercise (SE) program to a patient education (PE) program, on pain, physical function, health-related quality of life, and activity level in patients with isolated hip OA over a 16-month period.	The present study is the first to evaluate a SE program in addition to PE vs PE alone in patients with isolated hip OA. For the reduction of pain, the combination of PE + SE showed no differences compared to attending PE only. However, adding SE to PE may be useful in improving physical function.
Education, Home Exercise, and Supervised Exercise for People with Hip and Knee Osteoarthritis as Part of a Nationwide Implementation Program: Data from the Better Management of Patients with Osteoarthritis Registry Dell'Isola et al., 2019	To compare the effectiveness of education (ED) alone, home exercise (HE) therapy, and supervised exercise (SE) according to the information provided by the Better Management of Patients with Osteoarthritis (BOA) Registry, a nationally implemented rehabilitation program for people with hip and knee OA.	People with OA who underwent supervised or unsupervised exercise experienced greater pain reduction than people who received ED alone, with those who had knee OA experiencing a greater benefit. People who are not willing or cannot undergo an SE program may experience similar benefit from an HE programs. However, assuming optimal adherence, SE may lead to better outcomes that extend beyond pain reduction.
Effects of high-velocity resistance training on muscle function, muscle properties, and physical performance in individuals with hip osteoarthritis: a randomized controlled trial Fukumoto et al., 2013	Low-intensity home-based exercise at high-velocity or low-velocity using elastic bands was evaluated in patients with hip osteoarthritis to investigate the effect of high-velocity training on muscle function, muscle properties, and physical performance by comparison with low-velocity training.	Eight weeks of high-velocity training at low resistance for patients with hip osteoarthritis had partially a greater effect on muscle composition and physical performance compared with low-velocity training. High-velocity training is an efficient intervention program for patients with hip osteoarthritis because it required lesser absolute total time per exercise session than low-velocity training.
Exercise Therapy in Hip Osteoarthritis— a Randomized Controlled Trial Krauß et al., 2014	To evaluate the effectiveness of a standardized, hip-specific exercise in patients with hip osteoarthritis compared with an untreated control group and a placebo intervention.	Twelve weeks of exercise therapy in hip osteoarthritis patients of normal vitality reduced pain and improved physical function. No improvement was found regarding general health-related quality of life.
Exercise therapy in patients with hip osteoarthritis: Effect on hip muscle strength and safety aspects of exercise—results of a randomized controlled trial Steinhilber et al., 2016	Analysis of the effects of the Tübingen exercise therapy approach (THüKo) on hip muscle strength (HMS) in comparison to sham ultrasound and a nontreated control.	THüKo – a 12 – week exercise designed for patients with hip OA increase hip muscle strength with superior effects in comparison to a non-treated control and placebo ultrasound group. Its safety was demonstrated. A well-instructed exercise program is safe and feasible.
Research article Feasibility of neuromuscular training in patients with severe hip or knee OA: The individualized goal-based NEMEX-TJR training program Ageberg et al., 2010	The aim of this study was to apply the principles of neuromuscular training at older patients with severe hip or knee OA.	The individualized goal-based neuromuscular training program, the NEMEX-TJR, is feasible in patients with severe hip or knee OA, in terms of safe-self reported pain following training, decreased or unchanged pain during the training period, few joint specific adverse events, and achieved progression of training level during the training period.

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Immediate Efficacy of Neuromuscular Exercise in Patients with Severe Osteoarthritis of the Hip or Knee: A Secondary Analysis from a Randomized Controlled Trial Villadsen et al., 2014	The aim was to confirm the feasibility and evaluate the immediate effects (prior to surgery) of an 8-week neuromuscular exercise program in patients with clinically severe hip or knee OA.	Participation in an 8-week neuromuscular exercise according to the NEMEX-TJR program improves activities of daily living, objective functional performance, and quality of life as well as reduces pain in patients with severe OA. The study confirms previous findings from nonrandomized studies suggesting that neuromuscular exercise is feasible and safe for patients with severe hip OA.
Pain trajectory and exercise-induced pain flares during 8 weeks of neuromuscular exercise in individuals with knee and hip pain Fleng Sandal et al., 2015	To investigate the trajectory of joint pain during an 8-week NEMEX program together with the acute pain flare evoked from each exercise session in middle-aged individuals with knee or hip pain.	A clear decrease in size of acute exercise-induced pain flares with increasing number of exercise sessions. Similarly, the acute pain flare from an exercise session gradually decreased over time during the 8-week exercise period.
Exercise therapy for the management of osteoarthritis of the hip joint: a systematic review McNair et al., 2009	A systematic review to evaluate the exercise programs focused on hip joint OA and to decide whether they met the recommendations and to determine the efficacy.	Insufficient evidence was found to suggest that exercise therapy alone can present an effective short-term management approach for reducing pain level, function, and quality of life.
Exercise for osteoarthritis of the hip (Review) Fransen et al., 2014	To determine whether land-based therapeutic exercise is beneficial for people with hip OA in terms of reduced joint pain and improved physical function and quality of life.	Land-based exercise is beneficial in terms of reduced pain and improved physical function at the completion of a supervised exercise program. The benefits were present for at least a further three to six months.
Effects of aquatic exercise on flexibility, strength and aerobic fitness in adults with osteoarthritis of the hip or knee Wang et al., 2007	To test the effects of aquatic exercise on physical fitness (flexibility, strength, and aerobic fitness), self-reported physical functioning, and pain in adults with OA of the hip or knee.	A 12-week program of moderate intensity may improve joint flexibility, leg muscle strength and aerobic fitness. It may not offer pain relief/perceived functional improvement measured as by the self-reported questionnaire, exercise does not worsen the joint condition or results in injury.
Aquatic Physical Therapy for Hip and Knee Osteoarthritis: Results of a Single-Blind Randomized Controlled Trial Hinman et al., 2007	To test the efficacy of a 6-week aquatic physical therapy program in a group of people with symptomatic hip OA, knee, or both.	The program showed small improvements in pain, stiffness, hip strength, and quality of life in people with hip OA or knee OA compared with no intervention.
Physical Activity for Osteoarthritis Management: A Randomized Controlled Clinical Trial Evaluating Hydrotherapy or Tai Chi Classe Fransen et al., 2007	To determine whether 12 weeks of hydrotherapy or Tai Chi classes for individuals (59 years of age) with chronic symptomatic hip or knee OA are acceptable physical activities.	The access to hydrotherapy or Tai Chi classes for sedentary elderly with chronic symptomatic knee or hip OA resulted in clinical benefits that were visible a further 12 weeks. Both types of classes resulted in improvements in self-reported physical function, greater than in traditional land-based exercise.
Effect of Physical Therapy on Pain and Function in Patients with Hip Osteoarthritis a Randomized Clinical Trial Bennell et al., 2014	To evaluate whether a 12-week multimodal physical therapy program, with components typical of clinical practice, leads to greater improvements in pain and physical function than sham physical therapy.	A multimodal physical therapy program did not confer additional clinical benefits over a realistic sham treatment that controlled the therapeutic environment, therapist contact time and home task for people with hip osteoarthritis and was associated with relatively frequent but mild adverse effects.
Exercise and Manual Physiotherapy Arthritis Research Trial (EMPART) for Osteoarthritis of the Hip: A Multicenter Randomized Controlled Trial French et al., 2012	To determine if the addition of manual therapy (MT) to an 8-week program of exercise therapy (ET) for hip OA improved function and other clinical outcomes more than ET alone at 9 and 18 weeks.	An 8-week program of ET, with and without adjunctive MT, for people with hip OA, showed similar improvements in self-report function, ROM, and PGA at 9 weeks, which persisted 18 weeks. Patients that received MT as an adjunct to exercise reported higher satisfaction with the outcome.

PUBLICATION	AIM/METHODS	CONCLUSIONS/RESULTS
The effect of adding grade B hip mobilization to a muscle strengthening home exercise programme on pain, function, and range of movement in adults with symptomatic early-stage hip osteoarthritis: A pilot study for a randomized controlled trial Blackman, Atkins, 2014	To explore whether the addition of grade B hip mobilization to a muscle strengthening home exercise program improves pain, function or range of movement in adults with symptomatic early-stage hip OA.	Both groups demonstrated an improvement in all outcome measure scores at the end of the 6-week treatment period, with the grade B mobilization group showing greater improvement than the home exercise group in all outcome measures except function. Results suggests that there was a significant difference for the outcome measures of pain and passive hip flexion in favor of the grade B mobilization treatment, but no significant difference for function or passive medial rotation.
Manual therapy, exercise therapy, or both, in addition to usual care, for osteoarthritis of the hip or knee: a randomized controlled trial. 1: clinical effectiveness, Abbott et al., 2013	To evaluate the clinical effectiveness of manual physiotherapy and/or exercise physiotherapy in addition to usual care for patients with osteoarthritis (OA) of the hip or knee.	A manual physiotherapy provided significant, clinically important, and sustained improvements in symptoms for patients with OA of hips or knees. Exercise physiotherapy also provided physical performance benefits over usual care. There was no added benefit from a combination of the two therapies.
Short- and long-term clinical outcomes following a standardized protocol of orthopedic manual physical therapy and exercise in individuals with osteoarthritis of the hip: a case series Hando et al., 2012	To (1) describe the management of patients with unilateral hip OA using manual therapy and exercise interventions and (2) observe the magnitude of short- and long-term changes in clinical outcomes using a generalizable, standardized protocol that would represent the best available research on a manual therapy and exercise approach for the individuals with hip OA.	Subjects in this prospective case-series demonstrated clinically meaningful short and long-term improvements in outcomes following a standardized protocol of manual therapy and therapeutic exercise interventions.
Effects of exercise and manual therapy on pain associated with hip osteoarthritis: a systematic review and meta-analysis Beumer et al., 2015	To examine the short-term, medium-term, and long-term efficacy of land-based, water-based exercise therapies and manual therapies in the reduction of pain in patients with hip OA.	The review identified a number of RCTs that evaluated the efficacy of exercise and manual therapies on pain associated with hip OA. Meta-analyses indicate that both land-based and water-based exercise programs were superior to a control intervention in the short term. No benefits of land-based exercise therapy were seen at a medium-term or long-term follow-up. There were no benefits of manual therapy when either combined with exercise or introduced in isolation.
Patient education with or without manual therapy compared to a control group in patients with osteoarthritis of the hip. A proof-of principle three-arm parallel group randomized clinical trial Poulsen et al., 2013	The current trial was designed as a proof-of-principle trial to inform the design of future RCTs involving PE (patient education) and MT (manual therapy) by investigating the effectiveness, in terms of pain reduction, of a PE program with or without the added effect of MT compared to a minimal control intervention (MCI) involving home stretching.	The combined PE and MT intervention demonstrated a clinically relevant pain reduction and improvements in self-reported (activities of daily living) when compared to the control group receiving a minimal intervention of home stretching. No difference was found when comparing PE alone to the minimal intervention.
The impact of mobilization on hip osteoarthritis Maria et al., 2020	To compare the efficacy of hip mobilization with non-weight bearing exercises in females aged 55–65 who experience impairments related to hip osteoarthritis.	The mobilization of the hip joint resulted in increased ranges of motion and pain reduction. It improves hip joint function and relieved pain more than non-weight bearing exercises.
Immediate effects of hip mobilization with movement in patients with hip osteoarthritis: a randomised controlled trial, Beselga et al., 2015	To determine the immediate effects of a single session of MWM (mobilization with movement) on hip pain in people with hip OA.	The pain immediately decreased. Hip flexion, internal rotation, ROM and physical function improved after a single session of hip MWM in elderly subjects suffering hip OA.

PUBLICATION	AIM/METHODS	CONCLUSIONS/RESULTS
American College of Rheumatology/Arthritis Foundation Guideline for the Management of Osteoarthritis of the Hand, Hip, and Knee, Kolasinski et al., 2020	To develop an evidence-based guideline for the comprehensive management of osteoarthritis (OA).	Optimal management requires a comprehensive, multimodal approach to treating patients with hand, hip, and/or knee OA offered in the context of shared decision-making with patients, to choose the safest and most effective treatment possible.

4. DISCUSSION

There are different recommendations and guidelines for the treatment of the hip OA, which should include education and programs for improving physical function. Fernandes et al (2010) conducted a study with a purpose of describing and demonstrating the use of a therapeutic exercise program for a patient with the hip OA. They recommend that the physical therapist provide thorough information about the benefits of exercise and how to adjust exercise intensity according to pain level. In summary, patients reduced pain and improved physical function over the period of six months. Uusi-Rasi et al (2017) conducted a study to develop a specific training program for the hip OA rehabilitation. The aim of the specifically designed exercise program was to improve the joint function, relieving hip pain. The goal was achieved with the exercise program, which was found to be feasible and safe. However, Juhakoski et al (2011) evaluated the short- and long-term effects of therapeutic exercises on individual pain and functional ability. Therapeutic exercises did not reduce pain and improve general wellbeing in patients with hip OA. In their study, Fernandes et al (2010) tried to determine the efficiency of supervised exercise but they could not claim that supervised exercise contributed to the improvement of the joint function and general well-being. The aim of the study made by Dell'Isola et al (2019) was to compare effectiveness of education (ED) with two types of exercises: home exercises and supervised exercise. They ascertain that home and supervised exercises have similar effect on reducing pain, yet exercises are still more effective than education alone. Fukumoto et al (2013) compared the effects of a high and low intensity resistance training. They discovered that a high-velocity training exerts a slightly stronger effect on physical performance and muscle composition than a low-velocity training. A high-velocity training is an efficient program for patients with hip OA as the total duration of exercise session is shorter compared to low velocity training. The effectiveness of the Tübingen exercise therapy approach (THüKo) for the patient with OA was evaluated by Krauß et al (2014). THüKo approach includes sharing of knowledge, social interactions and, in particular, exercise to strengthen muscles, improve proprioception, provide balance training and improve flexibility. Pain and physical function improved due to the THüKo therapeutic exercise. Future research should evaluate the long-term effectiveness of the therapeutic regimen and investigate whether the THüKo concept is appropriate and effective for patients with more pronounced impairments. Steinhilber et al (2016) wanted to evaluate the impact of exercise therapy approach (THüKo) as well. They wanted to examine any adverse events related to the intervention. The results showed a statistically significant improvement in muscle strength in the group that performed the exercise according to Tübingen exercise therapy approach. Ageberg et al (2010) tested feasibility of neuromuscular training in patients with hip and knee OA. A neuromuscular training program has been found to be feasible in patients with severe hip or knee OA. The pain remained unchanged or decreased during the training period and there were a few joint specific adverse events. Patients progressed on training level during the neuromuscular training period. Villadsen et al (2014) followed Ageberg et al (2010) footsteps. They discovered that in the past research, neuromuscular exercise offered clinically relevant improvements in physical function and is feasible and safe treatment option for patients with severe OA eligible for total joint replacement. Contrary to research conducted by Ageberg and Villadsen et al., Fleng Sandal et al (2015) determined a decrease in size of acute exercise-induced pain with expanding number of exercise session. Overall, pain decreased over the 8 weeks exercise period. McNair et al (2009) and Fransen et al (2014) conducted a literature review. McNair et al (2009) observed that there was insufficient evidence to suggest that exercise therapy alone can be an effective short-term management approach for patients with OA. On the other hand, Fransen et al (2014) discovered that a land-based exercise is beneficial for patients with OA, as it reduces pain and

improves physical function. The positive effect of supervised exercise program is visible for at least 3-6 months after the completion of the program. Wang et al (2007) report about the effects of aquatic exercises on physical function (flexibility, strength, and aerobic fitness). They ascertain that aquatic exercises have a short-term positive effect. Hinman et al (2007) also discovered that aquatic physical therapy slightly improved physical function, strength, pain and quality of life. Based on patients' assessments, Fransen et al (2007) observed that an access to 12-week hydrotherapy or Tai Chi classes for people older than 59 years of age with chronic hip or knee OA resulted in clinical benefits that persisted a further 12 weeks. They discovered that aquatic exercised are more effective than land-based exercises. There is some evidence that different techniques of manual therapy have different effects on patients with hip OA. Bennell et al (2014) conducted a study to determine whether physiotherapy treatment consisting of manual therapy and therapeutic exercises improves pain and physical function in patients with hip OA. Authors concluded that among adults with hip OA, physical therapy did not result in greater improvement in pain or function compared to sham treatment. Their findings are consistent with French et al (2012), who compared two groups and discovered that the group in which patients performed exercise without adjunctive manual therapy provided no further benefit, except for higher patient satisfaction with outcome. According to the findings, authors emphasized that physiotherapy-based exercise is beneficial for patients with hip OA. However, authors believe that manual therapy does not have an additional benefit. Blackman & Atkins (2014) researched whether a group of patients with OA following a program that included grade B mobilization in addition to a muscle strengthening home exercise programme has better results. They concluded that manual therapy helps to reduce pain and increases range of motion in certain movements. Abbott et al (2013) discovered that manual physiotherapy provided benefits persisting for one year after the usual care of patients with hip or knee OA. Hando et al (2012) discovered that manual therapy and therapeutic exercises represent an effective approach available to physiotherapists to help guide individuals with hip OA. Maria et al (2020) believe that mobilization in patients with hip OA increases hip range of motion, decreases pain and improves hip function more than non-weight bearing exercise. Nevertheless, authors note that the number of studies is limited, and future research is needed to observe the long-term effects of mobilization. Research conducted by Beselga et al (2015) suggests that mobilization with movement is an effective physiotherapy method in elderly patients suffering from hip OA. Based on a literature review, Beumer et al (2015) discovered that an exercise therapy (whether land-based or water-based) is more effective short-term in patients who perform exercises regularly compared to those who exercise rarely. There were no significant benefits of manual therapy. In their study, Poulsen et al (2013) established that a treatment that included various manual therapy techniques and therapeutic exercise was more effective than a minimal control intervention. Kolasinski et al (2020) demonstrated that an optimal management of patients with OA requires a comprehensive, multimodal approach. Together with their therapist, patients should be able to decide which program is potentially more effective and safer for them.

To conclude, we tried to determine which physiotherapy techniques are the most effective in hip osteoarthritis treatment. The currently recommended guidelines for hip arthrosis treatment are therapeutic exercises, patient education and weight loss. However, we also discovered that manual therapy in combination with therapeutic exercises is also efficient. Joint mobilization with movement is recommended, as it helps achieve a more proper arthrokinetic movement in the hip joint. Furthermore, some studies reviewed concluded that water exercise also has positive short-term effects. Once the physiotherapy hip arthrosis treatment program is prepared, it must be presented to the patient. In doing so, the therapists must consider patient's opinion as well as change or adjust the program during rehabilitation if the desired results are not achieved.

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