International Journal of Physical Medicine & Rehabilitation

Bistolfi, et al., Int J Phys Med Rehabil 2016, 4:5
DOI: 10.4172/2329-9096.1000356

Review Article Open Access

Rehabilitation and Physical Therapy before and after Total Knee Arthroplasty: A Literature Review and Unanswered Questions

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Received date: June 07, 2016; **Accepted date:** July 22, 2016; **Published date:** July 25, 2016

Abstract

This review focuses on the validity and the effectiveness of rehabilitation techniques and physical therapies before and after total knee arthroplasty (TKA). The intent is to drive surgeons and rehabilitation specialists in the choice of the strategies for the treatment after TKA. The Data sources were MEDLINE, PubMed, CINAHL, EMBASE, and PsychINFO databases using the selected key words. Three authors independently selected studies for review using as criteria English, adults, any clinical population, and intervention for. Among several published studies of rehabilitation after TKA, only a few were based on scientific evidence. Moreover, many studies were heterogeneous and included different outcomes and evaluations. There is consensus that a complete and specific rehabilitation post-operative programme is effective in reducing the length of hospitalisation and the incidence of early complications. However, it is not clear what "complete and specific rehabilitation" may mean: the real efficacy of every specific treatment (continuous passive motion, cryotherapy, magneto therapy, neuro muscular electrical stimulation, whole body vibration, hydrotherapy, pre-operative physiotherapy) is still questionable, and often related to the experience of the authors. In conclusion, patients undergoing physiotherapy obtain a better and faster outcome achievement than non-treated patients; however, evidence-based treatments, protocols and clinical trials are recommended.

Keywords: Total knee arthroplasty; Rehabilitation; Physical therapy; Knee arthritis

Introduction

Arthritis of the knee is very common and has high social impact [1] because it reduces the mobility of the joint, causes pain, and limits the ability of the patient to walk, work and carry out daily and sport activities [2]. When pain and functional disability are no longer sustainable, the definitive treatment is total knee arthroplasty (TKA), which allows excellent recovery and complete return to normal activities [3-9].

The number of TKAs performed is increasing annually and the length of hospital stay is decreasing [10]. Patients have increased expectations for a fast and complete recovery. Nevertheless, TKA may result in severe post-operative pain, muscular weakness, articular reduction and disability in general, which may last for a considerable time. Since range of movement (ROM) and pain perception in the early post-operative phase seem to be important prognostic factors for the patient's future satisfaction and mental status, effective analgesia and appropriate rehabilitation are required [11,12].

For these reasons, there is strong support for a specific programme of pre- and post-operative rehabilitation. Nevertheless, most studies of the role of rehabilitation and physiotherapy around TKA do not have specific standardised protocols; therefore, controversies remain regarding the choice and the effectiveness of the different techniques. Consequently, the purpose of this literature review is to focus on physical therapy and rehabilitation techniques before and after total knee replacement, and to evaluate their efficacy.

Physiotherapy and Rehabilitation

Physiotherapeutic intervention: Relevant clinical studies

A randomised blinded study compared for two years 120 patients divided into groups, one of which received outpatient physiotherapy and the other did not [13]. Both groups began physiotherapy and home exercise regimes immediately after discharge: the outpatient physiotherapy group performed slightly better, although the difference was not clinically significant.

Another study investigated whether a standard protocol of outpatient physiotherapy could improve the knee ROM after primary TKA [14]. One hundred and fifty patients were recruited and randomised into two groups: one group received the outpatient physiotherapy and the other did not. All patients resumed full weight bearing and mobilisation as soon as possible after surgery. At three months, the outpatient physiotherapy group showed a better ROM compared to the other group while, at one year, there were no differences in the two groups in terms of ROM, walking distance and ability. According to these results, the physiotherapy was associated with a faster return to a functional range of motion but did not provide clinical benefits at one year.

A sequential cohort study compared the effectiveness and the time efficiency of physiotherapy rehabilitation provided through home

protocols with those provided in exercise groups (class-based exercise) [15]. The outcome measures were assessed by WOMAC, SF-36, the timed up and go test, knee ROM, a six minutes' walk test, and a patient evaluation questionnaire: no differences were detected between the two groups in any of the outcomes. However, it was noted that class-based rehabilitation allowed more frequent access to physiotherapy and reduced the physiotherapist's work.

A pilot randomised clinical trial [16] showed the importance of balance training after TKA. The exercises proposed were based on the protocol published by Fitzgerald [17] (involving agility and perturbation techniques). The authors demonstrated the potential benefits related to walking speed, single leg stance, stiffness and pain intensity.

None of these studies discusses the protocols of rehabilitation, but their common goal was to suggest whether physiotherapy is useful or not. The following paragraphs will discuss evidence-based studies of the specific rehabilitative techniques.

Neuro muscular electrical stimulation

Neuro muscular electrical stimulation (NMES) is defined as the application of an electrical current to the neuro muscular junction and to the surrounding muscle fibres to cause a muscle contraction [18]. It causes the muscle contraction by applying a transcutaneous current to terminal branches of the motor neuron [19], and it can increase the muscle strength by increasing the load on the muscle, using an electrically induced contraction with a training effect. According to the literature, all evaluations of the effects of NMES to improve strength in the quadriceps muscle after TKA must analyse all the parameters of electrical stimulation [20]. Neuro muscular electrical stimulation may be applied both before and after surgery.

To our knowledge, the first study that used NMES as a pre-rehabilitation modality was published in 2010: patients treated with NMES increased pre-operative quadriceps femoris muscle strength by 28% and had a faster functional recovery following TKA [21].

A Cochrane review published in 2010 was unable to assess the effectiveness of NMES in increasing quadriceps strength pre- and post-TKA. A meta-analysis could not be carried out because the imprecision of the results of studies analysed, published before 2008, led to a high risk of bias [22].

A randomised controlled trial (RCT), assessed the efficacy of a strengthening rehabilitation programme associated with NMES [23]. It compared two groups of 100 patients in whom the treatment began four to six weeks after surgery and lasted six weeks. There were no differences in outcomes between the two groups. A prospective, longitudinal RCT also evaluated the efficacy of NMES, which was applied to the quadriceps muscle twice a day at the maximum tolerable intensity for 15 contractions, while the treatment started 48 hours after TKA surgery complemented by standard rehabilitation [24]. At 3.5 weeks after surgery, significant improvements were found in quadriceps and hamstring muscle strengths, functional tests, and knee extension ROM. Fifty-two weeks after surgery, the differences between the two groups were reduced but still present.

Whole body vibration

Whole body vibration (WBV) can be used to improve muscular strength: it is a type of exercise used to rehabilitate patients with low extremity weakness to increase muscular strength at the same level as standard strength training [25]. A RCT showed an increase in knee extensor strength, and improvements in countermovement jumping in older women, and in the sit to stand test, and in postural control in the elderly [26].

Only one clinical trial concerning the role of WBV after TKA has been identified [27]. In this study, all subjects received physical therapy care including a warm up, pain relief, oedema management, ROM treatment and a strength training programme. While the WBV group carried out strengthening exercises on a WBV platform, the other did progressive resisted exercises. No increased pain was reported in the WBV group during or after vibrations. There was a significant increase in knee extensor strength and an improvement in mobility in both groups. However, no significant differences between groups regarding strength, muscle activation or mobility were seen, and the influence of WBV after TKA still remains unclear.

Continuous passive motion

Continuous passive motion (CPM), first introduced in the 1960s [28], is a way of providing regular movement to the knee using an external motorised device that passively moves the joint through an established arc of motion [29].

A study considered 178 papers that compared the physiotherapeutic treatment alone versus the physiotherapy plus CPM [30]. Continuous passive motion associated with rehabilitation was found to reach the goal of 90° knee flexion more quickly, and a statistically significant higher active knee flexion at two weeks after surgery. However, the results were not confirmed one year after surgery and CPM did not have a statistically significant effect on knee extension.

It has been suggested that CPM should be applied immediately after surgery in the recovery room, setting an initial value of 40° of flexion that could be increased in the following days, according to patient tolerance [31,32]. Other authors have proposed applying the CPM immediately at high flexion degrees for one or two days. They found a quick and significant gain in the degree of flexion; however, that gain was not confirmed in the long-term, patients reported severe pain and major bleeding was observed after surgery [33].

A RCT [34], studied 34 patients divided into two groups: the first group received CPM from the first day after surgery (1st day CPM-group), while the other started treatment with CPM immediately in the recovery room (immediate CPM-group). They concluded that the immediate CPM-group, at the first visit after TKA, had a higher active and passive knee flexion. At the outpatient visit three months after surgery, the knee flexion second was similar in the two groups.

Another RCT investigated the effectiveness of prolonged CPM use at home as an adjunct to standardised physiotherapy [35]. The CPM group achieved 5° more in ROM than the physiotherapy-only group. Another prospective RCT examined whether the incorporation of regular passive ROM exercise (PROM), in a post-operative rehabilitation protocol after TKA, was effective or not in 50 patients undergoing bilateral TKA. The authors concluded that there were no significant differences between the two groups in terms of pain level and maximum flexion [36].

However, a recent RCT observed that CPM, compared to active exercises alone, had no additional effect on knee ROM, pain or walking ability at one week or three months after TKA [37]. Similarly, another recent randomised study demonstrated that there was no statistical difference in flexion and oedema in the CPM group versus the no-

CPM group [38]. Another study aimed to compare mean knee flexion in patients on continuous passive motion and those without it after total knee arthroplasty (76 patients, 38 in each group: standardised physiotherapy from 1st postoperative day and physiotherapy and one hour of continuous passive motion twice a day from 1st postoperative day until discharge): again the conclusion was that continuous passive motion had no influence on knee range of motion after total knee arthroplasty at the time of discharge [39]. A systematic review, published by Cochrane, provided high quality evidence to indicate that CPM had small, short-term effects on active knee flexion ROM and passive knee flexion ROM [22]. However, there was no evidence to support the presence of CPM effects on active or passive knee extension. In addition, the medium and long-term effects of CPM on all ROM measures were unclear; although the data suggested a small long-term effect of CPM on active knee flexion ROM. Low-quality evidence was reported concerning the relationship between CPM and reductions in length of hospital stay, as well as between CPM and the need for manipulation under anaesthesia. Finally, there was inconclusive evidence of the short, medium and long-term effects of CPM on pain, function, swelling or quadriceps strength.

Hydrotherapy

Patients treated with hydrotherapy (HT) for six months after discharge from a rehabilitation unit after TKA showed better subjective functional outcome, compared to the non-HT land-kinesis group: the study showed reduced pain, stiffness and function impairment with HT [40].

A randomized single blind controlled trial, conducted in 2009, compared land-based versus pool-based exercise in people awaiting joint replacement surgery (land-based group, 40 patients: 23 total knee and 17 total hip arthroplasty; pool-based group 42 patients: 24 total knee and 18 total hip arthroplasty) [41]. One group underwent a six-week program comprising education, twice-weekly land-based exercise classes; the other group were given pool-based exercises and an occupational therapy home assessment. Both interventions were effective in reducing pain and improving function; there were no post-intervention differences between the groups. However, the pool-based exercise group appeared to experience less pain immediately after the exercises; whereas the facilities required for a land-based exercise program were more readily available, and cheaper.

A multi center RCT, to evaluate whether the timing of aquatic therapy affected clinical outcomes after TKA, showed that all the primary outcomes (as assessed by the WOMAC scale) were better in the early aquatic therapy group [42]. Hydrotherapy positively influenced mood and socialisation, and promoted social relationships such as friendship and feelings of well-being.

A RCT showed that aquatic resistance training after knee replacement, from day four after surgery, gave increased mobility, increased knee extensor and flexor power and tightened muscle strength in the affected leg [43].

Finally, a study evaluated the effect of inpatient aquatic physiotherapy (comprising an aquatic physiotherapy session or non-specific water exercise) in addition to the usual land physiotherapy from day four after TKA. The recovery of strength, function and gait speed, measured on day 14, was all better in the specific aquatic exercise group. The same outcomes measured at days 90 and 180 did not present statistically significant differences. However, the non-specific water exercise group remained weaker than the aquatic physiotherapy group. The conclusion was that hydrotherapy gave beneficial effects on the recovery of hip muscle strength early after surgery without adverse effects [44].

Cryotherapy

Two literature reviews concerning the effects of cryotherapy have been published. The first found small, but statistically significant benefits concerning blood loss and early knee flexion. In addition, a marginal gain in pain reduction on day two post-operatively was identified, although no statistically significant benefit was found regarding post-operative narcotic consumption. A simultaneous application of cold and compression resulted in more reduction of the swelling compared to cryotherapy alone [45]. Six of the studies examined by the second review showed significantly lower pain scores when a cold compression was applied. Also, three studies showed an increase in the ROM in the cold compression group; and most of the studies noted a decrease in swelling and in blood loss with the cold compression [46].

Low frequency, low intensity magnetic fields

Very few studies have addressed the application of magnetic fields after TKA. A two-part clinical trial indicated, in the first part, that magnetic fields did not influence the parameters evaluated and did not give danger for the stability of the prosthesis [47]. The second part comprised a clinical trial that could not demonstrate improved rehabilitation using magnetic fields after total knee replacement [48].

A RCT studying patients undergoing TKA and stimulated with pulsed electromagnetic fields (PEMFs), showed a statistically significant level of pain reduction in the treated group at one and six months follow-up [49]. In addition, the SF-36 pain evaluation instrument showed a significant improvement in the treated group only; and also a significantly better result in the treated group regarding knee swelling. Finally, one month after surgery, the treated group showed a statistically significant improvement in function and knee score, but at two and six months no significant difference between the groups was observed. The entire group of patients in the treated group reported walking without limitation or walking aids. The advantages deriving from early control of joint inflammation can certainly justify the use of PEMF therapy in the first two months post-operatively and should be considered as an effective completion of the surgical procedure. Another controlled trial demonstrated a good effect of PEMF therapy in the first months after surgery [50], demonstrating that PEMF has an agonist effect on A22 adenosine receptors; this explains the anti-inflammatory effects. These two RCTs were conducted in a similar way and reached similar results.

The role of prehabilitation before total knee arthroplasty: education and treatment Post-operative functional ability following TKA surgery has been strongly associated with pre-operative functional ability [51]. Moreover, pre-operative quadriceps strength has been found to be a predictor of post-operative functional ability up to a year following surgery [52]. The concept of preparing the body for a stressful event, such as surgery, has been named “prehabilitation” [53]. Its efficacy is still under debate: the effects of pre-operative physical therapy and general cardiovascular conditioning exercises on the post-operative functional recovery have been compared with those of no pre-operative therapy [54]. Three patient groups were created, each one characterised by different pre- and post-operative protocols; the results

showed that, if all groups showed tolerance on their exercise protocols, none showed significant benefits compared with the others.

A Cochrane systematic review assessed the effect of pre-operative education on outcomes in hip and knee replacement [55]. Only one study demonstrated a positive effect of pre-operative rehabilitation on the length of hospital stay; however, there was no effect on disability [56]. Another review assessed some RCTs, and concluded that there were no effects of pre-operative physical therapy on post-operative impairment and disability after TKA [57]. A systematic review was published concerning pre-operative rehabilitation for patients' undergoing TKA or Total Hip Arthroplasty, with the aim of constructing French clinical guidelines: the main finding was that analysis of the studies was difficult because of the heterogeneous interventions. Four types of outcomes had been suggested to assess the evidence of pre-operative rehabilitation: impairment, disability, medical-economic implications, and post-operative complications [58].

A two-group study evaluated the efficacy of pre-operative physical therapy for patients undergoing TKA: one group performed physical therapy before surgery and the control group did not. The therapy produced modest gains in isokinetic flexion strength but no difference in extension strength [59]. A Cochrane review suggested a benefit of pre-operative rehabilitation comprising at least physiotherapy with education and also suggested a multidisciplinary approach for the most fragile patients [22]. A singular case-report of a female patient who underwent two separate TKA surgeries (and had a four-week prehabilitation program for the left knee, but not for the right) compared pre- and post-operative functional ability: the comparison between the two knees showed that prehabilitation was effective in facilitating rehabilitation after TKA surgery and had positive effects on strength and some functional tasks. The authors strongly suggested the implementation of prehabilitation 6-12 weeks before TKA [60]. A RCT compared the leg strength and performance of functional tasks among subjects scheduled for TKA with osteoarthritis and pain that was non-responsive to medicine. These patients were randomized into two groups assigned either to the usual care or to exercises. Again, the results suggested the efficacy of prehabilitation in increasing surgical leg strength, decreasing leg strength asymmetry, and increasing the ability to perform functional tasks before TKA [61].

Nevertheless, concerns still exist: there is a systematic review on how TKA preoperative rehabilitation affects quality of life, pain, and physical outcomes after surgery. The conclusion was unfavourable for preoperative rehabilitation, which is conflicting with the conclusion drawn by the previous authors [62].

Discussion

There is a wide clinical consensus by physicians, as well as patients' expectations, about the role of rehabilitation after TKA. Many studies suggest or support specific rehabilitative treatments [63]. Most of these studies have important clinical relevance because they are based on large patients series, on case-control groups, on well-functioning practical experiences and on world-wide accepted treatments. Nevertheless, close analysis of the literature reveals a certain deficiency in terms of evidence-based protocols, well defined studies and the use of scientific approaches in general, as well as suggested by a recently published revision about TKA and rehabilitation [63].

Many different kinds of physical therapies and strategies have been proposed and studied. Differences in terms of rapidity of recovery and better knee function have been found between patients undergoing post-operative rehabilitation and non-treated patients in the short and medium term. Moreover, even when the two groups, comprising treated and non-treated patients, reached the same outcome after a certain period of time, the treated patients showed a great advantage in terms of cost and general health. Consequently, rehabilitation after TKA is recommended for a faster recovery.

Unfortunately, it is difficult to find evidence of the effectiveness of rehabilitation programmes before and after TKA because of the lack of randomisation and the low number of subjects included in the studies [63]. Moreover, in many cases, the types of exercises and interventions are not clear, or are too heterogeneous for effective comparison. All these factors cause the exclusion of many clinical trials in systematic reviews or meta-analyses. We, however, are taking this opportunity to comment on such studies in this present review. In addition, although many studies may not be able to detect differences in outcomes in patients who performed, or did not perform, the particular rehabilitation, it should be remembered that "no-difference studies make a big difference" [64].

Physiotherapy

Patients undergoing standard physiotherapy, including exercises for balance, gait training initially with devices, muscular strength training and ROM recovery, obtain a better and faster outcome than non-treated patients. It is recommended to begin knee mobilisation as soon as possible to avoid stiffness and the complications of prolonged bed-rest (for example: deep venous thrombosis, pulmonary oedema, and skin lesions). Another advantage of early post-operative rehabilitation is the possibility of avoiding the development of a stiff knee. Stiff TKA is a problem that must be avoided with intensive rehabilitation and possibly with prehabilitation, since the most important factor to be considered in stiff TKA is the pre-surgery ROM. Nevertheless, to our knowledge, there are no high quality studies investigating the optimal timing and procedure to treat stiffness after TKA [13-17].

Neuro muscular electric stimulation

Studies suggest that-in subjects with knee osteoarthritis and/or TKA - NMES increases quadriceps strength and improves functional performance and therefore may be effective as an exercise therapy. Furthermore, NMES may also reduce the extent of post-operative muscle atrophy [18-24].

Whole body vibration

The influence of WBV after TKA remains unclear: in many studies the improvements in knee strength and function was similar in treated and non-treated patients. In the very few studies that have been found on the use of magnetic fields after total knee replacement the authors could not demonstrate a significant improvement in outcome measures through their application [25-27].

Continuous passive motion

Despite being probably the most studied among the physical treatments, there is not a definitive judgement about CPM. The use of CPM in the classic way after TKA can have a beneficial effect on knee flexion, post-surgery pain, knee oedema and hospitalisation, but it has no effect on extension recovery, wound healing or reduction of thromboembolic risk. Continuous passive motion can be considered as

an adjuvant device to increase results in the short-term, but the effects of CPM on ROM are too small to justify its use, even if there is some evidence that CPM may reduce the need for subsequent manipulation under anaesthesia [28-39].

Hydrotherapy

The positive effects of hydrotherapy on mood can be a great help in the management of subclinical surgery-correlated depression. The problems connected with hydrotherapy are cost and organisation. Hydrotherapy seems to be a better treatment than land-kinesis, because pain, stiffness and function impairment emerged as significantly lower and it had a positive influence on social behaviour and mood [40-44].

Cryotherapy

Cryotherapy after TKA has uncertain clinical benefits; however, it was associated with better patient compliance. Clinical evidence seems to suggest that cold and compression together are more effective than ice alone. In conclusion, no particular clinical benefits have been demonstrated by using cryotherapy after TKA [45-46].

Pre-operative rehabilitation

Concerning pre-operative rehabilitation, the literature generally recognises some benefits of pre-operative treatment when based at least on physiotherapy with education; while a multidisciplinary approach is usually suggested for the most fragile patients. Occupational therapy and patient education could also improve patient compliance with further treatments. The efficacy of pre-operative rehabilitation programmes has been clearly related to increased strength of the affected leg, decreased leg strength asymmetry and increased ability in performing functional tasks before TKA. Similarly-and most interestingly-encouraging results have been shown after prehabilitation, in terms of achieving a better quality of life, a faster ROM recovery and shorter time of hospitalisation: also it can improve muscle tropism, which is a positive predictor for post-operative functional recovery [50-61]. Neuro muscular electrical stimulation was found to be useful in prehabilitation to expedite a return to normal activities in patients undergoing TKA for knee osteoarthritis.

Nevertheless, concerns still exist and studies had a conclusion unfavourable for preoperative rehabilitation [62].

Conclusion

Most of the analysed studies did not show statistically significant results regarding the effectiveness of rehabilitation and physical therapies before and after TKA. The lack of well-designed randomised trials, the heterogeneous interventions, and the imprecision of the results make analysis of the literature difficult. Future well-designed RCTs to assess the effectiveness of balance exercises are recommended: larger sample size groups, programmes with more specific task oriented exercises and the analysis of the influence of the non-affected leg on rehabilitation results. Future studies are needed to elaborate better rehabilitation and physical therapy programmes, with the ultimate aim of improving patients' recovery and quality of life in the first period after TKA.

Clinical Message

Most of the current studies did not show significant differences in groups who had, or did not have, physiotherapy after approximately one year after TKA, when most of the patients had recovered well, even without physiotherapy. However, there is no doubt about the benefits of rehabilitation in the short and medium term after surgery. The key point concerns patient satisfaction and patient perception in the first months after surgery. A rapid recovery has an immense effect on patients' activities and mood: they can resume their normal life and activities faster, and will be safer and happier. In this way, patients can avoid depression, anxiety, immobility and longer illness in general. They can return to their ADL and habits without caregiver assistance, resulting in higher patient satisfaction and reduced economic impact on the healthcare services.

Conflict of Interest Statement

The authors declare that there is no conflict of interest and that this research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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