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Research article

Effects of early stimulation of the quadriceps femoris on pain-related quality of life in total hip arthroplasty patients: a pilot study

Călin Vutan [1], Alina Totorean [2], Jenel-Marian Pătrașcu [2], Alexandra Mihaela Stănilă [1,*], Ana Maria Vutan [1,*] and Mihaela Oravițan [1]

1 Faculty of Physical Education and Sport, West University of Timisoara, Romania;
2 Victor Babeș University of Medicine and Pharmacy, Timisoara, Romania

* Correspondence: ana.vutan@e-uvt.ro; alexandra.rusu@e-uvt.ro;

Abstract: To improve the quality of life for individuals with total hip prostheses, reducing pain to optimize rehabilitation treatments immediately after surgery is crucial.This study aims to illustrate the impact of pain on the quality of life during the early recovery phase of patients with total hip prostheses. 40 patients, randomly divided into the study group (physical therapy and NMES) and the control group (physical therapy), were evaluated functionally using WOMAC, HHS and HOOS. The study's results indicate that combining physical exercise with NMES of the quadriceps positively impacts the quality of life and hip functionality, especially in the first postoperative days, by reducing pain. The application of NMES resulted in pain reduction in patients with THA, but statistical analysis revealed that this had no significant impact on the final score of the questionnaires. Therefore, a more extensive study is needed.

Keywords: pain, Transcutaneous Electrical Stimulation (NMES), total hip arthroplasty, early recovery, quality of life

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1. Introduction

Coxarthrosis is a degenerative disease that affects the hip joint, resulting in a gradual and irreversible degradation of the articular cartilage [1]. This condition disrupts the mechanical functioning of the joint and can lead to complete destruction over time. Coxarthrosis is one of the most disabling conditions, deeply affecting the well-being of those who are impacted. Unlike normal aging, the degenerative process of coxarthrosis progresses slowly and is accompanied by pain and difficulty in movement.

Recent research from the World Health Organization shows that 10% of men and 18% of women over the age of 60 exhibit symptoms of coxarthrosis. The level of disability caused by this disease varies among patients, but it is estimated that approximately 80% of people diagnosed with coxarthrosis globally experience some degree of mobility difficulties. Furthermore, up to one-third of these individuals may be considered severely disabled [2].

Given projections that the population over 60 years of age will triple by 2050, along with the high prevalence of coxarthrosis in this demographic, it can be concluded that this condition is one of the most common in older adults and is a primary cause of functional limitations for those affected [3].

Endo prosthetic arthroplasty is a reconstructive surgical procedure that involves removing damaged bones and replacing joint components with prosthetic im-

plants [4]. Total hip arthroplasty is commonly recommended for patients experiencing severe pain, those who have not benefited from conservative treatments, and individuals with significant functional impairment. This procedure is among the most frequently performed surgeries worldwide and boasts a high success rate. This procedure implies excising the affected areas of the hip joint and replacing them with a prosthetic implant that mimics the natural function of the hip [5]. Normal hip biomechanics is the most important goal of hip arthroplasty and provides a better functional recovery [6].

Recovery after hip arthroplasty is a multidisciplinary process that can take a lot of time. Effective communication within the medical team is essential. Decisions about the recovery protocol and discharge timing depend on the patient's medical history, current condition, and the type of surgery. Functional recovery can vary among individuals and is influenced by personal expectations and physical status.

Various recovery protocols exist internationally for total hip arthroplasty, each differing according to the preferences of the orthopedic surgeon and the geographic location. However, most programs focus on exercises that strengthen the thigh and pelvic muscles, particularly the quadriceps femoris, gluteus medius, and gluteus maximus. They also include calf 'pump' movements and active hip flexion exercises. A crucial aspect of rehabilitation is the progressive recovery of the hip abductor muscles, which provide stability during standing and prevent lateral tilting of the pelvis during the swing phase of walking. Most rehabilitation protocols emphasize strengthening the abductors in the initial phase through concentric contractions with the hip in external rotation, followed by resistance-based isometric contractions.

An essential aspect of recovery for patients undergoing total hip arthroplasty is the rapid restoration of the periarticular muscles. These muscles can be affected before surgery due to degenerative conditions and after surgical intervention. Furthermore, effective pain management is essential for recovery after hip surgery arthroplasty. Common causes of postoperative pain include:

1. immediate postoperative pain, which is normal and results from the tissue healing process and local inflammation.
2. muscle contracture, which occurs as the muscles surrounding the joint adapt to the new position.
3. inflammation because of surgical trauma.
4. pain related to the prosthesis, which can occur in rare cases if the prosthesis is improperly implanted or if there are mechanical complications.

2. Purpose of the Study

The aim of this research is to track and analyze the evolution of pain during the first few days post-surgery in patients aged 50 to 85 years who have undergone total hip arthroplasty. In addition, we seek to investigate whether and to what extent the presence of different degrees of pain influences the final scores of quality-of-life questionnaires. These patients will participate in a rehabilitation program that includes physical exercises combined with electrical stimulation of the quadriceps femoris muscle, focusing primarily on pain reduction and increasing muscle strength in the prosthetic lower limb.

2. Materials and Methods

Based on the hypothesis that combining electrostimulation with kinetic exercise during rehabilitation reduces pain and improves quality of life for patients with total hip prostheses, we conducted a study involving 40 participants. Subjects were randomly divided into two groups using ”Random.org program”. 20 individuals in the study group (GE1), while the remaining 20 formed the control group (GC1). The study

group received a recovery program that included physical exercises and electrical stimulation of the quadriceps muscle. In contrast, the control group only participated in the exercise-program. Each rehabilitation session lasted 40 minutes, with 20 minutes dedicated to recovery exercises and another 20 minutes for muscle electrostimulation. The program was conducted daily. Muscle electrical stimulation was carried out using the Chattanooga Wireless Pro device, with 2X2 cm electrodes applied bilaterally—on both the healthy lower limb and the prosthetic lower limb —on the anterior side of the thigh. Muscle stimulation was performed in 4 phases, each with the following parameters: warm-up phase lasting 2 min, at a frequency of 6Hz, with a ramp-up duration of 1.5 s, and a ramp-down duration of 2 s; contraction phase lasting 5 s, at a frequency of 40Hz, with a ramp-up duration of 1.5 s and a ramp-down duration of 0.75 s; active rest phase of 10 sec at a frequency of 4Hz with a ramp-up and a ramp-down duration phase of 0.5 s; the last phase, the recovery phase, lasting 3 min, at a frequency of 3Hz, with a ramp-up duration of 1.5 s and a ramp-down duration of 3 s.

The research for this study was conducted from August 2023 to May 2024. All subjects received a recommendation for physiotherapy from an orthopedic specialist and requested these services at Clinic 2 Orthopedics-Traumatology of the "Pius Brînzeu" Emergency County Clinical Hospital in Timisoara. The evaluation process and the implementation of the recovery program were carried out at this facility. All the participants gave us informed consent, according to the Declaration of Helsinki guidelines regarding studies involving human subjects.

A total of 40 patients with total hip prosthesis were selected based on specific inclusion criteria: subjects diagnosed with coxarthrosis, aged between 50 and 85 years, who had undergone unilateral hip arthroplasty using the anterolateral approach. Subjects with aphasia, neurological disorders, revision prostheses, psychiatric conditions, or postoperative complications (such as deep vein thrombosis, infections, or dislocations) were excluded from the study.

All subjects underwent functional evaluations. The functional assessment utilized the WOMAC scale, Harris Hip Score, and HOOS questionnaire before and after the intervention.

WOMAC Scale

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) is a widely used set of standardized questionnaires by healthcare professionals to assess the condition of patients with knee and hip osteoarthritis. It evaluates pain, stiffness, and joint functionality. The WOMAC score encompasses five items for pain (scoring 0 to 20 points), two items for stiffness (0 to 8 points), and 17 items for functional limitation (0 to 68 points). Completing the WOMAC scale takes approximately 12 minutes [7].

Harris Hip Score

The Harris Hip Score is designed to assess hip joints, developed in 1969 by William H. Harris. It evaluates outcomes following total hip arthroplasty and facilitates comparisons of results. The score includes ten items that cover four domains: pain, functionality, absence of joint deformity, and movement. A total score below 70 points is deemed deficient, between 70-79 points is acceptable, 80-89 points is considered good, and a score between 90-100 is excellent [8].

HOOS Questionnaire

The Hip Disability and Osteoarthritis Outcome Score (HOOS) is designed to evaluate patients' perspectives on their hip condition and assess functional limitations during therapy. The questionnaire contains 40 items designed to assess five subscales: pain, symptoms, limitations in daily activities, sports, and recreational function, and quality of life-related to the hip joint. The pain subscale includes ten items with a total score of 40 points, symptoms include five items with a total score of 20, limitations in

daily activities cover 17 items with a total score of 68 points, and functionality in sports along with quality of life is assessed through 4 items with a total score of 16 points [9].

Statistical analysis

The research data was analyzed using DATAtab software.

The data distribution was analyzed using Shapiro-Wilk and Kolmogorov-Smirnov tests and checked with a QQ plot.

The accepted significance threshold is $p<0.05$. Analyzing the results obtained by subjects from both groups in the functional tests, we observed that the values of these tests improved, especially due to alleviating the pain factor. We thus decided to conduct a statistical analysis of this factor in each of the three functional and quality of life tests to observe its impact on the final test score. Therefore, the data analyzed and presented in the results chapter represents the pain scores (ordinal data) related to the three questionnaires used in the study. Based on the type and distribution of the data (which is non-Gaussian), we chose to use the Mann-Whitney test to compare the evolution of pain between groups.

3. Results

At baseline assessment, there were no significant differences between groups regarding pain scores (on any of the three scales).

Pain in the WOMAC Score

As seen in the table of descriptive statistics (Table 1), the *GE1* group had lower values for pain (*Mdn* = 9) than the *GC1* group (*Mdn* = 11).

The statistical analysis of the final test results regarding the pain factor in the WOMAC scale shows a significant difference between groups ($U = 99$, $p = 0.006$) with a medium-size effect ($r = 0.44$).

Table 1. Comparison between the study and control groups regarding Pain in the Womac score at the final assessment.

	n	Median	Standard deviation	Standard error of the mean
WOMAC_D_GE1_Tf	20	9.05	1.7	0.38
WOMAC_D_GC1_Tf	20	11.15	2.54	0.57

Legend: Womac_D_GE1_Tf=study group final test; Womac_D_GC1_Tf=control group final test; n=number of subjects

Pain in the Harris Hip Score

The results of the descriptive statistics showed that the GE1 group had higher values for pain (Mdn = 25) than the GC1 group (Mdn = 20) (Table 2).

The results of the Mann-Whitney test (U=190, p=0.799) demonstrate no significant differences between the final tests of the two groups regarding the pain factor, with a very small effect (r=0.05).

Table 2. Comparison of the study and control groups concerning Pain in the Harris score at the final assessment

	n	Mean	Median	Standard deviation
Harris_D_GE1_Tf	20	25	25	5.13
Harris_D_GC1_Tf	20	24,5	20	5.1

Legend: Harris D GE1 Tf = study group final test; Harris_D_GC1_Tf = control group final test; n = number of subjects

Pain in the HOOS Score

The results of the descriptive statistics showed that *the GE1 group had lower values for pain (Mdn = 19) than the GC1* group (*Mdn* = 21) (Table 3).

Data analysis showed a statistically significant difference in terms of pain between *the two groups* ($U = 124.5$, $p = 0.04$), at the final evaluation, with a medium effect size ($r = 0.32$).

Table 3. The evolution of pain in the HOOS score between the study group and the control group at the final test

	n	Mean	Median	Standard deviation
HOOS_D_GE1_Tf	20	19.3	19	4.19
HOOS_D_GC1_Tf	20	22.7	21	4.81

Legend: HOOS_D_GE1_Tf=study group final test; HOOS_D_GC1_Tf=control group final test; n=number of subjects

4. Discussion

Over the last two decades, a limited number of studies have focused on muscle electrostimulation following hip arthroplasty. These studies often involved small sample sizes, especially considering the large number of surgeries performed and the older demographic typically affected.

Research has indicated a significant decrease in muscle strength, particularly in the hip and quadriceps, starting from the second postoperative day after surgery [10-12].

Rehabilitation programs for patients with hip prostheses aim to restore muscle strength around the hip and thigh and recover joint mobility. Mobilization begins on the day of surgery, contributing to early functional recovery and reducing the length of hospital stays [13, 14]

Restoring hip function is crucial for daily activities, as reduced muscle tone in the hip flexors negatively impacts walking, climbing stairs, and transitioning between sitting and standing [15]. The isometric strength of the hip muscles is vital for maintaining walking ability and trunk stability.

There is no international consensus on the optimal timing for initiating recovery after hip arthroplasty. Protocols differ widely, encompassing multimodal pain management, local anesthesia, and postoperative physiotherapy and addressing recovery from an emotional perspective. Multimodal pain control and accelerated rehabilitation have been shown to facilitate quick recovery following minimally invasive arthroplasty compared to traditional methods [16]. Over the past decade, research has explored whether accelerated recovery programs can shorten hospital stays while ensuring consistent clinical outcomes. The findings have been mixed, revealing some advantages of preoperative exercises and education, particularly for patients who engage in early mobilization and intensive rehabilitation [14].

Worldwide, post-hip arthroplasty pain management is a heavily debated topic, as effective pain control is crucial to patient recovery. Various organizations and experts advocate for multimodal pain management strategies that combine basic analgesics, such as paracetamol and NSAIDs, with local or regional anesthesia alongside non-pharmacological measures like physical therapy and preoperative education [17].

Postoperative complications, including pain and psychological challenges, can hinder early patient mobilization, leading to prolonged hospital stays and increasing

both the economic and mental strain on patients. Enhancing patients' emotional well-being is essential for physical recovery and positively influences treatment outcomes [16].

While the effectiveness of early recovery methods following hip arthroplasty is still inadequately studied, they present certain disadvantages compared to muscle stimulation, including the risks associated with prolonged use of analgesics and anesthetics and their costs.

However, there are several recent studies with promising results that demonstrate the beneficial effects of quadriceps femoris stimulation after knee and hip arthroplasty. Significant pain reduction using NMES was demonstrated by Zhao et al. 2022 [18]. Similar results were also obtained by Delanois et al. (2019), who emphasized the importance of using NMES after knee arthroplasty in reducing pain and improving function [19].

One of the main limitations of this research is the relatively small group of subjects. Applying the questionnaire method, in our case, the WOMAC scale, the HOOS questionnaire, and the Harris score, involves a degree of subjectivity in the collection of participation data. We tried to reduce the appearance of distorted results as much as possible by anonymizing and respecting the confidentiality of the data, the validity of the selected questionnaires, the clarity of the questions, and the answer variants in the developed questionnaire.

Regarding the analysis of the pain factor in the quality of life tests, the subjects' responses regarding what it means could be attributed to analgesic medical administration.

5. Conclusions

This study highlights the beneficial impact of early (right after surgery) quadriceps femoris muscle stimulation in patients with total hip prostheses, especially regarding quality of life. The intervention for the experimental group (GE1) led to a significant reduction regarding pain factor compared to the control group (GC1), yielding notable enhancements in symptoms and quality of life for these patients.

Statistical analysis revealed significant differences in the pain factor in the HOOS and WOMAC questionnaires, but this does not seem to affect the final score of these tests. Following the evolution of pain and in the HHS it was observed that the differences between the two groups are insignificant and this can be attributed to the subjective nature of the patients' responses to the questionnaires as well as to the analgesic and anti-inflammatory medication administered to them after the surgical intervention. We consider that a study on a larger number of subjects is necessary.

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References

1. Bennell, K.L., R. Buchbinder, and R.S. Hinman, Physical therapies in the management of osteoarthritis: current state of the evidence. Current opinion in rheumatology, 2015. 27(3): p. 304-311.
2. Kurtz, S., K. Ong, E. Lau, F. Mowat, and M. Halpern, Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. Jbjs, 2007. 89(4): p. 780-785.
3. McAlindon, T. and R. Bannuru, OARSI recommendations for the management of hip and knee osteoarthritis: the semantics of differences and changes. Osteoarthritis and cartilage, 2010. 18(4): p. 473-475.
4. Tooms, R. and J. Harkess, Arthroplasty introduction and overview. Campbell's Operative Orthopedics. Mosby-Year Book, St Louis, 1992: p. 371-387.
5. Charnley, J., Arthroplasty of the hip: a new operation. The Lancet, 1961. 277(7187): p. 1129-1132.
6. Obada, B., M.G. Iliescu, D.-M. Iliescu, B.M. Caraban, and R. Baz, 638 Early rehabilitation after total arthroplasty with custom hip prosthesis–case report. Balneo and PRM Research Journal, 2023. 14(4).
7. Nilsdotter, A.K., L.S. Lohmander, M. Klässbo, and E.M. Roos, Hip disability and osteoarthritis outcome score (HOOS)–validity and responsiveness in total hip replacement. BMC musculoskeletal disorders, 2003. 4: p. 1-8.
8. Nguyen, C., M.-M. Lefèvre-Colau, S. Poiraudeau, and F. Rannou, Rehabilitation (exercise and strength training) and osteoarthritis: A critical narrative review. Annals of physical and rehabilitation medicine, 2016. 59(3): p. 190-195.
9. Wellmon, R., M. Cameron, and L. Monroe, Gait assessment and training. Physical Rehabilitation. St. Louis: Elsevier, 2007: p. 844-76.
10. Holm, B., K. Thorborg, H. Husted, H. Kehlet, and T. Bandholm, Surgery-induced changes and early recovery of hip-muscle strength, leg-press power, and functional performance after fast-track total hip arthroplasty: a prospective cohort study. PloS one, 2013. 8(4): p. e62109.
11. Bandholm, T. and H. Kehlet, Physiotherapy exercise after fast-track total hip and knee arthroplasty: time for reconsideration? Archives of physical medicine and rehabilitation, 2012. 93(7): p. 1292-1294.
12. Maempel, J., N. Clement, J. Ballantyne, and E. Dunstan, Enhanced recovery programmes after total hip arthroplasty can result in reduced length of hospital stay without compromising functional outcome. The bone & joint journal, 2016. 98(4): p. 475-482.
13. Chiung-Jui Su, D., K.-S. Yuan, S.-F. Weng, R.-B. Hong, M.-P. Wu, H.-M. Wu, and W. Chou, Can early rehabilitation after total hip arthroplasty reduce its major complications and medical expenses? Report from a nationally representative cohort. BioMed research international, 2015. 2015(1): p. 641958.
14. Smith, T., C. McCabe, S. Lister, S. Christie, and J. Cross, Rehabilitation implications during the development of the Norwich Enhanced Recovery Programme (NERP) for patients following total knee and total hip arthroplasty. Orthopaedics & Traumatology: Surgery & Research, 2012. 98(5): p. 499-505.
15. Frost, K.L., G.E. Bertocci, C.A. Wassinger, M.C. Munin, R.G. Burdett, and S.G. Fitzgerald, Isometric performance following total hip arthroplasty and rehabilitation. Journal of rehabilitation research and development, 2006. 43(4): p. 435.
16. Sharma, V., P.M. Morgan, and E.Y. Cheng, Factors influencing early rehabilitation after THA: a systematic review. Clinical Orthopaedics and Related Research®, 2009. 467(6): p. 1400-1411.
17. Yi, X., J.H. Lee, X. Yu, G. Yi, and H.S. Lee, Assessing the efficacy of the early rehabilitation pathway in combination with morita therapy after hip and knee arthroplasty. Journal of Healthcare Engineering, 2022. 2022(1): p. 4285197.
18. Zhao, Y., B. Zhang, Y. Wang, and J. Liu, Effectiveness of neuromuscular electrical stimulation for enhanced recovery after total hip replacement surgery: a randomized controlled trial. Geriatric Orthopaedic Surgery & Rehabilitation, 2022. 13: p. 21514593221129528.
19. Delanois, R., N. Sodhi, A. Acuna, K. Doll, M.A. Mont, and A. Bhave, Use of home neuromuscular electrical stimulation in the first 6 weeks improves function and reduces pain after primary total knee arthroplasty: a matched comparison. Annals of translational medicine, 2019. 7(Suppl 7): p. S254.