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# Systematic literature review on the use of transcutaneous electrical nerve stimulation in the early recovery stage after total hip arthroplasty

**Călin VUTAN[1], Alina TOTOREAN[2], Jenel-Marian PĂTRAŞCU[3], Ana-Maria VUTAN[4], Mihaela ORAVIŢAN[5]**

**Abstract**

*Purpose*: The recovery of periarticular muscles plays a very important in the functional recovery after total hip arthroplasty. This recovery can be optimized by using transcutaneous electrical nerve stimulation (TENS) in addition to recovery exercises. This survey aims to prove the beneficial effects of electrical stimulation in the early recovery of patients with hip prosthesis.
*Material and method*: Searches in 4 databases (PubMed, Google Scholar, Web of Science and ResearchGate) have led to the identification of 38 articles as follows: in PubMed - 5, in Google Scholar - 18, in Web of Science - 11, in ResearchGate – 4.
*Results*: The use of TENS in the early recovery stage after hip arthroplasty is relatively little covered in the literature. Of all the articles studied 4 articles meet the inclusion criteria. The beneficial effects of applying TENS on atrophied muscles are: increased muscle strength, decreased edema, and improved functionality.
*Conclusions*: Although it cannot be recommended as the only treatment method in the early recovery stage after hip arthroplasty, in combination with physical exercises, applying TENS immediately after surgery may help repair atrophied muscles.

***Key words**: transcutaneous electrical nerve stimulation (TENS), total hip arthroplasty, early recovery, functional recovery, hip osteoarthritis*

**Rezumat**

*Scop*: În recuperarea funcțională post artroplastia totală de șold un rol foarte important este cel al recuperării musculaturii periarticulare. Această recuperare poate fi optimizată prin folosirea stimulării electrice transcutanate (TENS) în completarea exercițiilor fizice de recuperare. Acest studiu își propune să demonstreze efectele benefice ale stimulării electrice în recuperarea precoce a pacienților cu proteză de șold.
*Material și metodă*: Căutările în 4 baze de date (PubMed, Google Scholar, Web of Science și ResearchGate) au identificat un număr de 38 de articole după cum urmează: în PubMed - 5, în Google Scholar - 18, în Web of Science - 11, în ResearchGate - 4)
*Rezultate*: Folosirea TENS în recuperarea precoce post artroplastia de șold este destul de puțin tratată în literatura de specialitate, dintre toate articolele studiate 4 articole corespund criteriilor de includere. Efectele benefice ale aplicării TENS pe o musculatură atrofiată sunt: creșterea forței musculare, scăderea edemului, îmbunătățirea funcționalității.
*Concluzii*: Deși nu se poate recomanda ca și unică metodă de tratament în recuperarea precoce post artroplastia de șold, în combinație cu exercițiile fizice aplicarea TENS imediat după intervenția chirurgicală poate ajuta refacerea musculaturii atrofiate.

***Cuvinte cheie**: stimulare electrică transcutanată (TENS), artroplastie totală de șold, recuperare precoce, recuperare funcțională, coxartroză*

[1] PhD student, PT, West University of Timişoara, Romania, *e-mail: calin.vutan@e-uvt.ro*
[2] Assistant Professor, MD, PhD, Victor Babeş University of Medicine and Pharmacy, Medical Rehabilitation Departament, Timisoara, Romania
[3] Professor, MD, PhD, Hab. Dr, Victor Babeş University of Medicine and Pharmacy, Research Centre Prof. Dr. Teodor Şora, Timisoara, Romania
[4] University Assistant, PhD Student, PT, Faculty of Physical Education and Sport, West University of Timişoara, Romania
[5] Professor PhD, Faculty of Physical Education and Sports, West University of Timişoara, Romania

## Introduction

Over the last period, total hip arthroplasty has been considered one of the most successful surgeries, but with quite high costs. This intervention is mainly used for patients with hip osteoarthritis (Juliano et al., 2010). The types of approaches used during the operation, as well as the types of prostheses used, have undergone changes over time, which have led to much better results in terms of hip joint functionality. Following surgery, joint mobility improves, the patient gets rid of pain, and the quality of life increases (Suetta et al., 2004). It is known that hip osteoarthritis indirectly affects the periarticular muscles. These muscles, which are already atrophied, will lose even more tone after surgery (Levine et al., 2013). Early recovery will shorten the patient's time in the hospital and reduce the costs of hospitalization. However, recovery is a complex and long-lasting process, being effective only when the patient regains his/her mobility and, therefore, independence. The recovery of mobility and muscle strength can take up to 6 months after surgery, but given that muscle strength decreases by about 4% per day in the first week of immobilization, it is very important that recovery begins as soon as possible (Suetta et al., 2004). Recovery protocols for total hip arthroplasty vary depending on goals, but, recently, all have focused on starting the recovery procedures as soon as possible. Applying transcutaneous electrical nerve stimulation (TENS) to the deficient muscles after total hip arthroplasty is one of the procedures, which could bring visible improvements in the functional recovery of the patient.

The TENS therapy involves the application of electrodes to the plane of the skin above the muscles to be stimulated, in order to determine involuntary controlled contractions. Until recently, there was a myth according to which TENS is contraindicated in the treatment of recovery after implants in the knee or hip. Due to the evolution in the field of science and the appearance of microchips in muscle stimulation devices, precise muscle contractions can now be performed by different forms of currents, all being very well tolerated by the patient with prosthesis, without side effects (Broderick et al., 2011).

## Hypothesis

Based on the assumption that the majority of patients receiving a hip prosthesis are those who suffer from hip osteoarthritis and that this hip osteoarthritis causes a significant loss of hip and thigh muscle strength over time, we can say that in the functional recovery after total hip arthroplasty in addition to the recovery of joint mobility, a very important role is played by the recovery of periarticular muscles. This recovery is most often done through physical exercises. However, it can be optimized by using TENS in addition to these exercises. The combination of these two procedures (physiotherapy and TENS) will lead to a faster recovery and shortening of the hospitalization period.

## Material and method

This survey was conducted through a systematic review of the literature. The discovered results were reported in compliance with the PRISMA recommendations (www.prisma.org). The systematic search was performed in the PubMed, Google Scholar, Web of Science and ResearchGate databases using the following keywords: transcutaneous electrical nerve stimulation (TENS), total hip arthroplasty, early recovery, functional recovery, hip osteoarthritis.

*The inclusion criteria* of the studied materials focused on the following characteristics:

- Types of studies: randomized and non-randomized controlled trials written in English over the past 20 years have been included
- The articles used were only those found in full version
- Trial participants benefited from a total hip prosthesis
- The age of the patients was between 60 and 80 years.

*Exclusion criteria*

- Only the abstract of the articles was available
- Case studies, meta-analysis and systematic review articles
- Articles that did not concretely analyze the effectiveness of TENS in the recovery after total hip arthroplasty.

## Results

From the databases accessed, a number of 38 articles were initially identified, after eliminating duplicates and scanning titles and abstracts, as follows: in

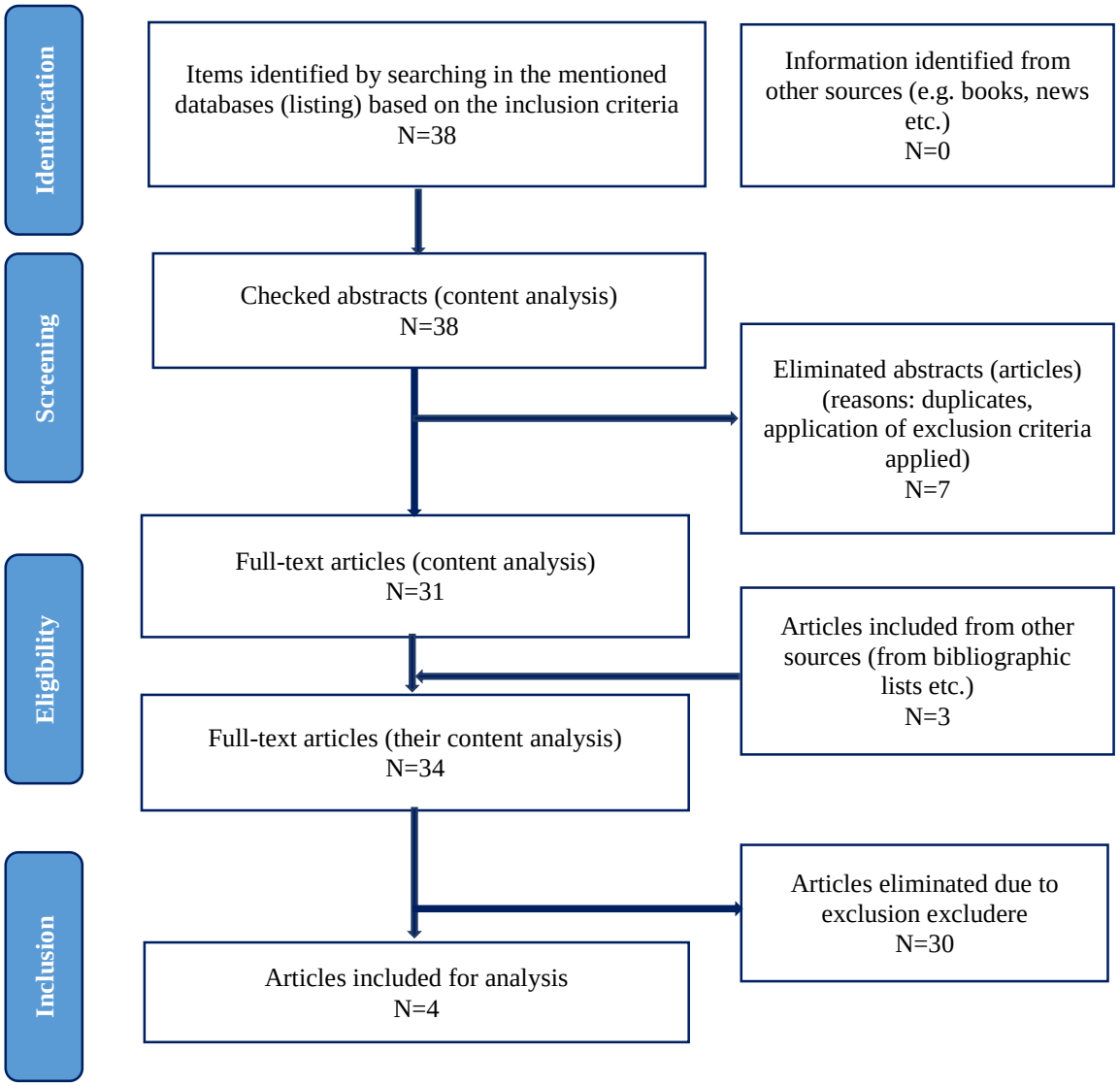



**Figure 1.** PRISMA diagram of the survey on the effects of transcutaneous electrical nerve stimulation in the early recovery stage after hip arthroplasty (www.prisma.org)

PubMed - 5, in Google Scholar - 18, in Web of Science - 11, in ResearchGate - 4. After the final screening process, 4 trials were included in this systematic review. The selection process was presented in a PRISMA diagram (Figure 1).

All articles that met the inclusion criteria were published between 2004 and 2019. The total number of subjects in the included trials was 38, and the sample size ranged between 10 and 36 subjects. Table 1 describes the interventions in the trials that investigated the use of TENS after hip arthroplasty.

**Discussions**

This study, a systematic review of the literature, has aimed to analyze the effects of using TENS in the early recovery of patients after total hip arthroplasty.

The main articles found mentioned a visible decrease in the strength of the hip muscles, as well as of the quadriceps femoris muscle, immediately after surgery, and starting with the 2nd day after surgery (Holm et al., 2013; Maempel et al., 2016; Kehlet & Bandholm, 2012). The various protocols used in the recovery of patients with hip prosthesis focus, in addition to restoring the strength of the periarticular muscles, on the thigh muscles and the recovery of joint mobility. The mobilization started on the day of surgery is very important and can help early functional recovery and shorten the hospitalization period (Smith et al., 2012; Chiung et al., 2015). Recovering hip functionality is very important in daily activities.

**Table 1.** Interventions in the trials that investigated the use of TENS after hip arthroplasty

| TRIAL | PARTICIPANTS | INTERVENTION | EVALUATED PARAMETERS AND EVALUATION METHODS | CONCLUSIONS |
|---|---|---|---|---|
| Suetta et al., 2004 | N=36<br>3 study groups of 12 patients each (2 IG and 1 CG)<br>AA=69 years (IG1 and 2)<br>AA=68 years (CG) | IG1: TENS applied only on the lower prosthetic limb<br>CG: Standard home recovery program (plantar and dorsal ankle flexions, isometric exercises for gluteal and thigh muscles, knee flexions and extensions, hip abductions)<br>IG2: Resistance training for the prosthetic lower limb | - hospitalization period<br>- strength of the thigh muscles<br>- degree of functional rehabilitation (using the walk test, stair climb test, and up and down test)<br>- evaluation moments; at 5 and 12 weeks after surgery | The average hospitalization period for the group that received endurance training was of 10 days, as opposed to the group that undertook standard recovery where the average hospitalization period was of 16 days. ($p > 0.05$)<br>Functional rehabilitation improved after the application of TENS (15%, $p < 0.05$) and of endurance training (30%, $p < 0.001$); however, not after the standard recovery program. |
| Gremeaux et al., 2008 | N=29<br>2 study groups<br>AA=78 years (IG)<br>AA =76 years (CG) | IG: TENS applied bilaterally for quadriceps muscles and leg muscles + standard recovery program (including resistance exercises)<br>CG: Standard recovery program (exercises for restoring mobility, increasing muscle strength and functional rehabilitation) | - hospitalization period<br>- functional rehabilitation (the 6-minute walk test, 200 meter fast walk test)<br>- maximum isometric force of knee extensors. | The electrical stimulation was very well tolerated and led to an increase in the strength of the extensor muscles of the knee of the prosthetic lower limb.<br>Time improvements were also noticed in both walk tests. These improvements were similar in both groups (276 ± 89.4m vs. 283.2 ± 107m for the 6-minute walk test, and 226.7 ± 102.5s vs. 212.8 ± 123.6s for the 200m fast walk test) |

| | | | | |
|---|---|---|---|---|
| Broderick et al., 2013 | N=11<br>AA=70 years | TENS applied to the calf muscles | Differences in blood dynamics (peak venous velocity, mean velocity flow and volume flow). The following have been applied: Mann-Whitney test, Wilcoxon text and VAS scale<br>4 excitatory levels have also been evaluated: initial perception of the stimulus sensation (sensory threshold), when a muscle contraction is observed (motor threshold), the onset of discomfort (pain threshold) and the intensity at which the discomfort becomes unbearable (pain tolerance) | Electrical stimulation increases blood flow and thus reduces edema in the prosthetic lower limb. Peak venous velocity is 99% higher after the application of TENS (12 ± 5.9 vs. 22.5 ± 16.8 cm / s, p = 0.018)<br>Mean venous velocity is by approx. 178% higher after the application of TENS (2.3 ± 1.4 vs. 7 ± 5.7 cm / s, p = 0.003)<br>Volume flow is by 159% higher after the application of TENS (78.7 ± 61.1 vs. 230.4 ± 215.2 lm / min, p=0.003) |
| Krupa & Reji, 2019 | N=36<br>3 study groups of 12 patients each (2 IG and 1 CG)<br>AA=67 years | CG: Standard recovery program<br>CG1: TENS + standard recovery program<br>CG2: Biofeedback + standard recovery program | The isometric force of the quadriceps, the Harris score | Improvements in the quadriceps strength were noticed in all 3 groups, but in the group benefiting from the application of TENS the improvements were significantly higher compared to the group undertaking the standard recovery program (1.95 ± 0.81 vs. 8.16 ± 0.71 kg, p=0.00) |

***Legend: 1** – TENS: transcutaneous electrical nerve stimulation; N: number of participant; AA: average age; IG: intervention group; CG: control group*

A low tone of the flexor muscles of the thigh can make it difficult to walk, climb stairs and sit or get up from a chair (Frost et al., 2006). Also, the isometric force of the hip muscles plays an important role in walking and trunk stability.

At this moment, there is no international consensus on how soon recovery should start after hip arthroplasty. The recovery protocols encountered in the literature vary from the multimodal approach to pain control, recovery protocols with local anesthesia, postoperative physiotherapy to the approach of recovery from an emotional point of view. Multimodal pain control with revised anesthesia protocols and accelerated rehabilitation speed up recovery from minimally invasive hip arthroplasty compared to the standard approach (Vivek Sharma et al., 2009). Over the past 10 years, researches have begun to investigate whether accelerated or improved recovery programs can reduce a patient's hospitalization period while also maintaining clinical outcomes. They reported mixed findings on the benefit of preoperative exercises and educational hours, but also improved outcomes for patients who began early mobilization and received more intense rehabilitation (Smith et al., 2012). As a result of postoperative pain and psychological problems, many patients are unable to get out of bed early or to engage in functional exercises, which not only prolong the hospitalization period and aggravate the economic burden, but also increase mental pressure and physical pain. Improving the patients' bad mood also plays an important role in physical recovery with a positive effect on treatment and recovery (Xin et al., 2022).

For the moment, the effectiveness of these early recovery methods after hip arthroplasty has not been sufficiently studied; however, compared to the application of TENS in recovery, they come with a number of disadvantages. These include the risks of prolonged use of analgesic medication and anesthetics, as well as their costs.

Muscle strength recovery can be achieved through standard protocols, which use physical exercises as the main method of recovery, either by using TENS, or by combining the two. Recent studies have shown the beneficial effects of using TENS in early recovery after hip arthroplasty with improved blood flow, decreased edema, fighting thrombosis, and last but not least, increased endurance of the stimulated muscles (Broderick et al., 2013, Krupa & Reji, 2019). The types of currents generated by the TENS equipment differ depending on the desired effect, ranging from 50-100Hz currents with short pulses of 30-200m/sec and intensity of 10-40 mA, to currents with isolated pulses or pulse trains with a duration of 200 -500m/sec and intensity of 50-100mA or even 100-150Hz high frequency currents and pulses of 250-500m/sec.

The most frequent evaluation methods used in the trials included this review were the Harris score (Krupa & Reji, 2019), VAS pain scale, WOMAC score, as well as the Mann-Whitney test and Wilcoxon test (Broderick et al. 2013).

## Conclusions

The analyzed trials show that the use of TENS in the early recovery of patients with hip prosthesis leads to an efficient functional recovery, with a faster social integration of the patients. At the same time, the reduction of hospitalization costs makes TENS a procedure that should be introduced in all recovery protocols. Although it may not be recommended as the only method of treatment in the early recovery stage after hip arthroplasty, but in combination with physical exercises, the application of TENS immediately after surgery can help restore atrophied muscles, with all the subsequent benefits related thereto.

The literature of the past 20 years includes an extremely limited number of studies published on this topic, conducted on a relatively small number of subjects compared to the large number of such interventions in relation to the population in the targeted age group; this could justify the initiation of a randomized controlled study on a large group of subjects, with the possibility of also tracking other parameters (e.g. those focusing on other muscle properties by surface electromyography, quality of life etc.).

## References

1. Bandholm, T., & Kehlet, H. (2012). Physiotherapy exercise after fast-track total hip and knee arthroplasty: time for reconsideration?. *Archives of physical medicine and rehabilitation*, *93*(7), 1292-1294.
2. Broderick, B. J., Breathnach, O., Condon, F., Masterson, E., & ÓLaighin, G. (2013). Haemodynamic performance of neuromuscular electrical stimulation (NMES) during recovery from total hip arthroplasty. *Journal of orthopaedic surgery and research*, *8*(1), 1-8.

3. Broderick, B. J., Kennedy, C., Breen, P. P., Kearns, S. R., & ÓLaighin, G. (2011). Patient tolerance of neuromuscular electrical stimulation (NMES) in the presence of orthopaedic implants. *Medical engineering & physics*, *33*(1), 56-61.
4. Chiung-Jui Su, D., Yuan, K. S., Weng, S. F., Hong, R. B., Wu, M. P., Wu, H. M., & Chou, W. (2015). Can early rehabilitation after total hip arthroplasty reduce its major complications and medical expenses? Report from a nationally representative cohort. *BioMed research international*, *2015*.
5. Frost, K. L., Bertocci, G. E., Wassinger, C. A., Munin, M. C., Burdett, R. G., & Fitzgerald, S. G. (2006). Isometric performance following total hip arthroplasty and rehabilitation. *Journal of rehabilitation research and development*, *43*(4), 435.
6. Gremeaux, V., Renault, J., Pardon, L., Deley, G., Lepers, R., & Casillas, J. M. (2008). Low-frequency electric muscle stimulation combined with physical therapy after total hip arthroplasty for hip osteoarthritis in elderly patients: a randomized controlled trial. *Archives of physical medicine and rehabilitation*, *89*(12), 2265-2273.
7. Holm, B., Thorborg, K., Husted, H., Kehlet, H., & Bandholm, T. (2013). 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*, *8*(4), e62109.
8. Juliano, K., Edwards, D., Spinello, D., Capizzano, Y., Epelman, E., Kalowitz, J., ... & Ghomrawi, H. (2011). Initiating physical therapy on the day of surgery decreases length of stay without compromising functional outcomes following total hip arthroplasty. *HSS Journal®*, *7*(1), 16-20.
9. Krupa, M.S. & Reji, K.S. (2019). To compare the effectiveness of neuromuscular electrical stimulation and electromyography biofeedback in individuals following total hip and arthroplasty. *Journal of Medical Science and Clinical Research*, 07, 27-34.
10. Levine, M., McElroy, K., Stakich, V., & Cicco, J. (2013). Comparing conventional physical therapy rehabilitation with neuromuscular electrical stimulation after TKA. *Orthopedics*, *36*(3), e319-e324.
11. Maempel, J. F., Clement, N. D., Ballantyne, J. A., & Dunstan, E. (2016). Enhanced recovery programmes after total hip arthroplasty can result in reduced length of hospital stay without compromising functional outcome. *The bone & joint journal*, *98*(4), 475-482.
12. Mikkelsen, L. R., Mikkelsen, S. S., & Christensen, F. B. (2012). Early, Intensified Home-based Exercise after Total Hip Replacement—A Pilot Study. *Physiotherapy research international*, *17*(4), 214-226.
13. Sharma, V., Morgan, P. M., & Cheng, E. Y. (2009). Factors influencing early rehabilitation after THA: a systematic review. *Clinical Orthopaedics and Related Research®*, *467*(6), 1400-1411.
14. Smith, T. O., McCabe, C., Lister, S., Christie, S. P., & Cross, J. (2012). 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*, *98*(5), 499-505.
15. Suetta, C., Magnusson, S. P., Rosted, A., Aagaard, P., Jakobsen, A. K., Larsen, L. H., ... & Kjaer, M. (2004). Resistance training in the early postoperative phase reduces hospitalization and leads to muscle hypertrophy in elderly hip surgery patients—a controlled, randomized study. *Journal of the American Geriatrics Society*, *52*(12), 2016-2022.
16. Yi, X., Lee, J. H., Yu, X., Yi, G., & Lee, H. S. (2022). Assessing the Efficacy of the Early Rehabilitation Pathway in Combination with Morita Therapy after Hip and Knee Arthroplasty. *Journal of Healthcare Engineering*, *2022*.