

Physiotherapy interventions in treating patients following total hip arthroplasty: a narrative review

DOI: <https://doi.org/10.5114/pq/171611>

Faruq Ahmed¹ , Md Shofiqul Islam² , Md Nazmul Hassan¹ , Md Shahoriar Ahmed¹ , Zahid Bin Sultan Nahid² ,
Md Aminul Hoque Rasel² 

¹ Department of Physiotherapy, Centre for the Rehabilitation of the Paralysed (CRP), Savar, Dhaka, Bangladesh

² Department of Physiotherapy, Bangladesh Health Professions Institute (BHPI), Savar, Dhaka, Bangladesh

Abstract

Introduction. Total hip arthroplasty (THA) is the most common, successful modern surgical intervention in orthopedic practice. Physiotherapy interventions are a major part of patient rehabilitation following THA. This study aimed to evaluate the effectiveness of physiotherapy interventions for improving functional outcomes following THA.

Methods. This narrative review was conducted on electronic platforms and databases, including PubMed, PEDro, CINAHL, and EMBASE, using a combination of search terms related to “physical therapy”, “physiotherapy”, “physical exercise”, “physiotherapy intervention”, “hip arthroplasty”, “total hip arthroplasty”, and “hip joint replacement”. Inclusion criteria included randomized controlled trials or clinical trials published in English from 2014 to 2021. Where THA was recognized as the primary concern, and physiotherapy management was one of the treatment options.

Results. The initial search of the databases revealed a total of 77 studies. Of those studies, 19 were selected as potentially meeting the inclusion criteria. Eventually, 10 studies were analyzed for the narrative review’s final conclusions. The evaluations supported the hypothesis that physiotherapy interventions have favorable outcomes for patients with THA.

Conclusions. After reviewing, it has been revealed that physiotherapy can improve physical function, balance, range of motion, muscle strength, and gait pattern following THA.

Key words: physiotherapy, physical therapy, total hip arthroplasty, hip joint replacement

Introduction

Total hip arthroplasty (THA) is the most widely performed orthopedic procedure for elderly patients with hip osteoarthritis [1]. It is the best surgical technique for osteoarthritis; since this intervention improves the patient’s quality of life (QOL) and encourages the patient’s return to daily activities. Physical rehabilitation is one of the best treatment options following THA [2]. Physiotherapy is essential for improving the strength of muscles and gait speed in patients with THA [3]. Patients who get a THA without a restoration program will develop functional limitations within 1 year of the surgical procedure [4]. Physiotherapy improves the patient’s portability and functional capability during hospitalization and after discharge [2].

Jogi et al. [5] stated that a person’s mobility and actual capacity, which include regular activities like transfers and self-care, are subsequently restricted by balance difficulties, which are also linked to a higher risk of falling. Individuals with severe hip OA require a THA to reduce the risk of falling [5]. Post-operative therapeutic programs following THA may differ across different rehabilitation settings and regularly emphasize joint range of motion (ROM) and muscle strengthening exercises [6].

Patients who achieved greater muscle strength were identified as having valuable impacts on practical execution and personal satisfaction, for example, chair raising, step climbing, and gait execution [7]. Muscle-strengthening activities should proceed in any event 1 year after THA [8]. Physiotherapist-coordinated rehabilitation seems advantageous for patients with a THA [3]. Sensibly, there is an incredible potential

for development, as weight-bearing activities and dynamic strength training are associated with good results [9].

Monaghan et al. (2017) revealed that the rates of THR are expanding globally, particularly in the UK and Ireland [10]. In Australia, the United States, New Zealand, and Canada; the reported rates have increased from 70 to 150 for essential THA [11]. In Europe, aquatic treatment is usually utilized in the post-operative period in patients undergoing a THA [12]. In the Netherlands, 86.7% of THAs were performed due to hip OA in 2015 [13].

Physiotherapy is a significant piece of patient rehabilitation following THA, including adaptability exercises, strengthening activities, cardio-respiratory wellness training, aerobic activities, and weight-bearing exercises [14]. THA is normally followed by an extensive rehabilitation program focused on muscle strengthening, stretching, ROM exercises, gait recovery, neuromuscular capacity, and proprioception [15]. This narrative review aimed to explore the effects of exercise therapy techniques specific to enhancing functional status after THA, as people do not comply with the rehabilitation protocols as a whole after THA.

Subjects and methods

Search strategy

We performed this narrative review using electronic platforms and databases, including PubMed, PEDro, CINAHL, and EMBASE, searching a combination of search terms related to “physical therapy”, “physiotherapy”, “physical exercise”, “physiotherapy intervention”, “hip arthroplasty”, “total

Correspondence address: Faruq Ahmed, Department of Physiotherapy, Centre for the Rehabilitation of the Paralysed (CRP), Savar, Dhaka-1313, Bangladesh, e-mail: physiofaruq2020@gmail.com; <https://orcid.org/0000-0003-0239-0113>

Received: 22.03.2023

Accepted: 28.08.2023

Citation: Ahmed F, Islam MS, Hassan MN, Ahmed MS, Nahid ZBS, Rasel MAH. Physiotherapy interventions in treating patients following total hip arthroplasty: a narrative review. *Physiother Quart.* 2024;32(3):1–6; doi: <https://doi.org/10.5114/pq/171611>.

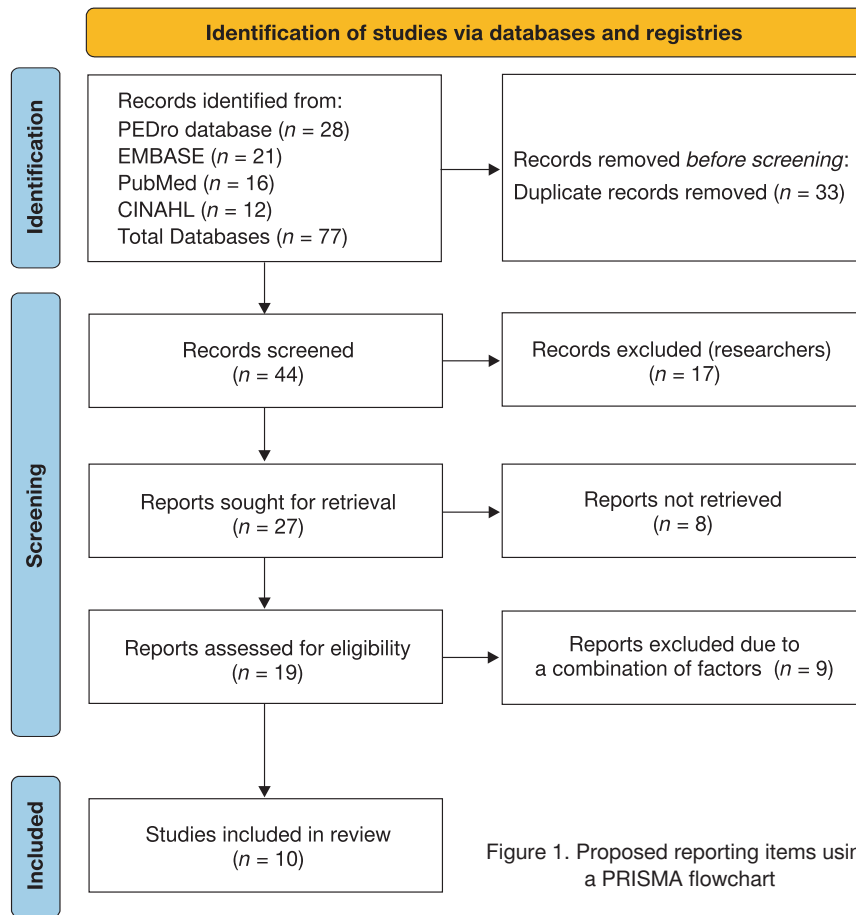


Figure 1. Proposed reporting items using a PRISMA flowchart

hip arthroplasty”, and “hip joint replacement”. The inclusion criteria consisted of studies that were randomized controlled trials or published clinical trials, which identified THA as the primary concern and physiotherapy management as one of the treatment options (Figure 1).

Study selection

The title and abstract provided the foundation for the initial examination. The title and abstract were accessible and identified related studies. Wherever it seemed uncertain, the pertinent full-text studies were carefully read, assessing the criteria for inclusion and exclusion.

Eligibility criteria

The following criteria included studies for the review, randomized controlled or clinical trials, THA, studies from 2014–2021, moderate Pedro scale scores, and studies in the English language. The exclusion criteria are as follows: abstract published papers, conference papers, qualitative and observational studies, and articles in non-English languages.

Quality appraisal

Critical appraisal of the included studies was conducted independently with the Pedro scale being used to score the individual quality of each selected study.

Results

We evaluated the results of a few randomized control trials to find out the efficacy of physiotherapy interventions

following THA procedures. Table 1 provides a summary of the scholarly studies, including outcome measurements, interventions, and results of the selected articles.

An examination of the quality evaluation using the PEDro score is shown in Table 2. The trials’ overall quality was rated as moderate, with a grading based on the PEDro scale. This narrative review consisted of 10 randomized control trials to evaluate the effectiveness of physiotherapy interventions following THA. After reviewing the results, a favorable outcome was found in applying physiotherapy exercises for improving functional activities following THA.

Discussion

We examined the effectiveness of physical exercise interventions in patients with THA through this narrative study. Winther et al. [16] conducted a study to evaluate muscle power after maximal strength training and conventional physiotherapy during THA rehabilitation. The MST Group performed leg press and abduction exercises on the operated leg for 4 × 5 repetitions, 3 times a week for up to 3 months, and the CP group used low or no external loads for 10–20 repetitions in each series. The study revealed that MST increased muscle strength more than CP in THA patients after rehabilitation in clinical practice. After primary THA, muscle strength is regarded as a key outcome. As a result, there was little proof found in research supporting the beneficial effects of progressive resistance exercise before or after THA on functional performance and muscular strength [9].

Umpierres et al. [17] conducted a study to determine whether physical therapy is effective in reducing functional difficulties after THA. The THAPCP group was provided physiotherapeutic interventions and gait practice by a physiotherapist, and in the THAP group assistance was provided through

Table 1. Outcome measures, interventions, and results of the articles

S/N	Author	Subjects	Study design	Intervention	Tools	Impression	PEDro scale	Journal name, country, and year
1	Winther et al. (2018) [16]	60 subjects muscle strength training (MST): 31 conventional physiotherapy: 29	RCT	mentioned below in the discussion section	6-minute walk test HHS scale HOOS questionnaire SF-12 score	MST enhances muscle strength more than CP in THA subjects after completion of rehabilitation	7/10	Acta Orthopaedica Norway 2018
2	Umpierres et al. (2014) [17]	106 patients total hip arthroplasty physiotherapy care protocol (THAPCP = 54) total hip arthroplasty protocol (THAP = 52)	RCT double-blind	mentioned below in the discussion section	muscle strength force goniometry SF-36 scale Merle d'Aubigné and postel score	physiotherapy intervention improved functional capacity over a short period of time and improved the QOL of patients after THA	7/10	JRDA Brazil 2014
3	Rampazo-Lacativa and D'Elboux (2015) [18]	60 years old and older subjects with OA hip primary unilateral THA	RCT prospective, single-center pilot RCT	mentioned below in the discussion section	HHS scale SPPB test SF-36 scale and WOMAC test	exercise on a cycle ergometer mixed with standard exercise improved function, physical ability, and QOL	5/10	Trials Brazil 2015
4	Jogi et al. (2015) [5]	63 patients typical exercise = 33 typical exercise plus balance = 30)	RCT	mentioned below in the discussion section	BBS TUG test WOMAC test ABC Scale	balance and functional mobility significantly revealed greater improvements compared to typical exercises alone	5/10	SAGE Open Medicine Canada 2015
5	Nakanowatari et al. (2016) [19]	33 patients SEA = 11 MHL = 11 CG = 11	RCT	mentioned below in the discussion section	block test VAS TUG and WOMAC test	applying SEA and MHL during early post-surgical intervention can create important changes in useful LLD after THA	8/10	Physical Therapy Research Japan 2016
6	Monaghan et al. (2017) [10]	63 subjects usual care group (UCG = 31) functional exercise + usual care group (FE + UCG = 32)	RCT	mentioned below in the discussion section	WOMAC test walking speed hip abduction dynamometry, SF-12 scale, and VAS score	physiotherapy conducted practical intervention program after THR may pick up huge useful improvement contrasted with UCG	8/10	Physiotherapy Ireland 2017
7	Matheis and Stöggl (2018) [20]	39 patients intervention group = 20 control group = 19	RCT	mentioned below in the discussion section	goniometer stopwatch MMT 6-minute walk test	mobilization and strength training of the hip muscles with THA improves hip ROM and gait performance compared to standard PT	5/10	Journal of Bodywork and Movement Therapies Germany 2018
8	Nankaku et al. (2016) [21]	28 patients exercise group = 14 control group = 14	RCT	mentioned below in the discussion section	goniometer MMT TUG test	therapeutic exercise programs concentrating on hip external rotator muscle may prompt huge improvement in hip abductor muscle strength and gait capability	4/10	Disability and Rehabilitation Japan 2016
9	Nakanowatar et al. (2015) [11]	33 patients SEA = 11 MHL = 11 CG = 11	RCT single blind	mentioned below in the discussion section	block test VAS score WOMAC test	SEA and MHL suggest that their use may be useful for improving functional LLD recovery in the early phase after THA	5/10	Physiotherapy Japan 2015
10	Krastanova et al. (2017) [22]	152 subjects female = 107 male = 45	RCT	mentioned below in the discussion section	MMT goniometry VAS score	kinesiotherapy and ergotherapy can result in a considerably faster recovery and ensure that patients reach optimal functional results	5/10	Folia Medica Bulgaria 2017

ABC – activities-specific balance confidence scale, BBS – Berg balance scale, HHS – Harris hip score, HOOS – hip disability and osteoarthritis outcome score, LLD – leg length discrepancy, MHL – modifiable heel lift, MMT – manual muscle test, MST – maximal strength training, RCT – randomized clinical trial, SEA – specific exercise approach, TUG – time up and go test, UCG – usual care group, VAS – visual analog scale, WOMAC – Western Ontario and McMaster universities osteoarthritis index

Table 2. Quality assessment through the PEDro scale

Trial no.	Author, year of publication	PEDro scale criteria											Total score
		1	2	3	4	5	6	7	8	9	10	11	
1	Winther et al. (2018) [16]	+	+	+	+	-	-	-	+	+	+	+	7
2	Umpierres et al. (2014) [17]	+	+	+	+	+	-	-	+	-	+	+	7
3	Rampazo-Lacativa and D'Elboux (2015) [18]	+	+	-	+	-	-	-	+	-	+	+	5
4	Jogi et al. (2015) [5]	+	+	-	+	-	-	-	+	-	+	+	5
5	Nakanowatari et al. (2016) [19]	+	+	+	+	-	-	+	+	+	+	+	8
6	Monaghan et al. (2017) [10]	-	+	+	+	-	-	+	+	+	+	+	8
7	Matheis and Stöggl (2018) [20]	+	+	-	+	-	-	-	+	-	+	+	5
8	Nankaku et al. (2016) [21]	+	+	-	+	-	-	-	+	-	-	+	4
9	Nakanowatari et al. (2015) [11]	+	+	-	+	-	-	-	+	-	+	+	5
10	Krastanova et al. (2017) [22]	+	+	-	+	-	-	-	+	-	+	+	5

a multidisciplinary team for the hip group without physiotherapy. Both groups received intervention for 3 repetitions of 12 complete movements for each exercise. The developed physiotherapy rehabilitation protocol implemented in routine care by the hip multidisciplinary care group yielded functional improvements in patients receiving THA. An exercise program with regular mobilization, physical therapy, and gait practices should also be considered for the success of rehabilitation and the reduction in the length of hospital stays [23].

According to Rampazo-Lacativa and D'Elboux [18], the purpose of their RCT study was to determine the effect of conventional exercises performed alongside ergometer cycling for physical function and QOL in elderly THA patients. Exercises on a cycle ergometer and standard exercises were performed by Group I, while just standard exercises were performed by Group II. Both groups got treatment twice a week for eight weeks. The findings of this study displayed that cycle ergometers combined with conventional exercises showed better results in function, physical performance, and QOL. The cycle ergometer requires motor skills to complete tasks, engages the hip, knee, and ankle muscle groups, and encourages the enhancement and maintenance of the range of motion of the joints of the lower limbs [24].

Jogi et al. [5] designed a study to evaluate the efficacy of balance exercises in the early post-operative period after THA and TKA. The randomized groups received treatment with ten repetitions of exercise thrice daily, 1–2 times a week for five weeks. The TE group performed seven particular joint ROM and muscular strength exercises and the TEB groups performed the standard exercises along with three balancing exercises. Balance and functional mobility significantly improved compared to typical exercises alone. Another RCT reported that two physical therapists who regularly performed physiotherapy with THA or TKA patients after surgery used normal joint ROM, muscular strength, and balance activities, which demonstrated significant effects [6].

Nakanowatari et al. [19] conducted an RCT study to explore the efficacy of specific exercise approaches or a modifiable heel lift to enhance functional LLD after THA. The MHL group used an insole-style heel lift to treat functional LLD, while the CG group received standard physical treatment following THA. The SEA group engaged in exercises to improve hip contractures and lumbar scoliosis. These three different groups received interventions once daily until discharge. The findings of this study displayed that SEA and MHL during

early post-surgical intervention can create important changes in useful LLD after THA. A parallel study displayed proprioceptive neuromuscular facilitation (PNF) techniques are well recognized for expanding the limited range of motion of the hip joints through post-isometric relaxation [25].

According to Monaghan et al. [10], the research investigated the effectiveness of a functional workout program after THA under the supervision of a physiotherapist. The control group adhered to the standard treatment regimen without any exercise program, while the experimental group received functional exercises under the supervision of a licensed physiotherapist. Both groups received intervention twice weekly for a total of 6 weeks, with each session lasting 35 min. Physical therapy techniques may exhibit noticeably superior improvement around 12 and 18 weeks after THA than UCG. Five to twelve months after THA, the training group walked much more than the control group. According to the findings of another RCT study, there was a beneficial outcome for the training group who walked much more than the control group five to twelve months after THA [26].

Matheis and Stöggl [20] conducted a study to improve hip capacity by mobilization and strength training of the hip muscles in the early post-operative week, adhering to THA rather than standard physiotherapy. The IG completed hip mobilization, strength training, and passive ROM, and The CG completed standard physiotherapy only. Both groups received interventions in three daily sessions lasting a total of 40 min each. In comparison to traditional PT, THA-assisted hip mobility and strengthening exercises were well tolerated and enhanced gait performance, and hip ranges within 1 week. Although early, rigorous physical treatment with strengthening programs had significant results, the advantages during surgical rehabilitation were also shown [27].

Nankaku et al. [21] conducted a study to explore the impacts of an activity program targeting the lateral rotator muscle of the hip on actual salvation in the early THA surgery. In the experimental group, the hip lateral rotator exercise program was carried out five times a week for a total of 4 weeks, while the CG received no intervention. Hip abductor muscular endurance and gait efficiency significantly increased with strength training that concentrates on the external rotator muscles of the hip in the acute post-THA period. Additional research found that functional ability started to decline one month after surgery, suggesting that rehabilitation might be most beneficial during the first month [28].

Nakanowatari et al. [11] carried out RCT research to assess the efficacy of each unique exercise strategy and adjustable heel lift to improve functional LLD after THA. The MHL group used an insole-style heel lift to treat functional LLD, while the CG group received standard physical treatment following THA. The SEA group engaged in exercises to improve hip contracture of hip and lumbar scoliosis. These three different groups received interventions for two weeks. The findings of this study suggest that SEA and MHL may be useful for improving functional LLD recovery in the early phase after THA. Based on one study, an inflexible lumbar spine and hip abduction contracture can result in functional LLD after THA, which suggests a post-surgical SEA regimen [29].

Krastanova et al. [22] used rehabilitation services during the late post-surgery stage of hospital restoration to monitor patients' progress and assess the outcomes. The kinesiotherapy group provided massage, isometric exercises, isotonic exercises, breathing techniques, gymnastics activity, balance exercise, and gait reeducation initially 4–5 times, and then gradually increased to 10–15 times. The control exercise group was not provided any interventions. The findings of this study displayed a complex rehabilitation program can result in a considerably faster recovery and ensure that patients reach optimal functional results. For individuals who have undergone a THA, there is currently no structured rehabilitation strategy available in the literature that not only includes a variety of Kinesiotherapeutic approaches and physical agent approaches but also plans out the patient's care in terms of time frames and stages [30].

The results of the narrative review have given proof that physiotherapy exercises show better results in physical performance and QOL and gain significant functional improvement after THA compared to usual care. The most robust evidence correlates ergometer cycling, hip mobilization, isometric exercise, isotonic exercise, resistant strength training, posture, and balance training in the early post-operative phase, and weight-bearing exercise, leg press, and gait practice in the late stage. There are some limitations in this review. In the included studies, the exercise regimen, timing, and frequency varied; therefore, further research on the ideal exercise protocol is required. More studies with extended follow-up periods are required. After taking into account the advantages of post-operative exercise, we adopt a favorable outlook toward using exercise for THA patients.

Conclusions

Physiotherapy is a safe and useful way to hasten recovery following THA. The study illustrates the importance of physiotherapist's role for effective rehabilitation following THA. The finding of this review demonstrates that physiotherapy applications are fruitful for enhancing balance, functional ability, and hip muscle strength in THA patients.

Acknowledgments

The authors would like to appreciate the Department of Physiotherapy, Bangladesh Health Professions Institute (BHPI), CRP, Savar, Dhaka, Bangladesh.

Ethical approval

The conducted research is not related to either human or animal use.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflicts of interest

The authors state no conflicts of interest.

Funding

This research received no external funding.

References

- [1] Bagarić I, Šarac H, Borovac JA, Vlak T, Bekavac J, Hebrang A. Primary total hip arthroplasty: health-related quality of life outcomes. *Int Orthop*. 2014;38(3):495–501; doi: 10.1007/s00264-013-2142-8.
- [2] Freburger JK. An analysis of the relationship between the utilization of physical therapy services and outcomes of care for patients after total hip arthroplasty. *Phys Ther*. 2000;80(5):448–58.
- [3] Coulter CL, Scarvell JM, Neeman TM, Smith PN. Physiotherapist-directed rehabilitation exercises in the outpatient or home setting improve strength, gait speed, and cadence after elective total hip replacement: a systematic review. *J Physiother*. 2013;59(4):219–26; doi: 10.1016/S1836-9553(13)70198-X.
- [4] Okoro T, Lemmey AB, Maddison P, Andrew JG. An appraisal of rehabilitation regimes used for improving functional outcomes after total hip replacement surgery. *Sports Med Arthrosc Rehabil Ther Technol*. 2012;4(1): 5; doi: 10.1186/1758-2555-4-5.
- [5] Jogi P, Overend TJ, Spaulding SJ, Zecevic A, Kramer JF. Effectiveness of balance exercises in the acute post-operative phase following total hip and knee arthroplasty: a randomized clinical trial. *SAGE Open Med*. 2015;3:2050312115570769; doi: 10.1177/2050312115570769.
- [6] Trudelle-Jackson E, Smith SS. Effects of a late-phase exercise program after total hip arthroplasty: a randomized controlled trial. *Arch Phys Med Rehabil*. 2004; 85(7):1056–62; doi: 10.1016/j.apmr.2003.11.022.
- [7] Buirs LD, Van Beers LW, Scholtes VA, Pastoors T, Sprague S, Poolman RW. Predictors of physical functioning after total hip arthroplasty: a systematic review. *BMJ Open*. 2016;6(9):e010725; doi: 10.1136/bmjopen-2015-010725.
- [8] Shih CH, Du YK, Lin YH, Wu CC. Muscular recovery around the hip joint after total hip arthroplasty. *Clin Orthop Relat Res*. 1994;302:115–20.
- [9] Skoffer B, Dalgas U, Mechlenburg I. Progressive resistance training before and after total hip and knee arthroplasty: a systematic review. *Clin Rehabil*. 2015;29(1): 14–29; doi: 10.1177/0269215514537093.
- [10] Monaghan B, Cunningham P, Harrington P, Hing W, Blake C, O'Dohertya D, Cusack T. Randomised controlled trial to evaluate a physiotherapy-led functional exercise program after total hip replacement. *Physiotherapy*. 2017;103(3):283–8; doi: 10.1016/j.physio.2016.01.003.
- [11] Nakanowatari T, Suzukamo Y, Izumi S. Specific exercises and heel lift improve functional and patient-perceived leg length discrepancies after total hip arthroplasty: a randomized controlled trial. *Physiotherapy*. 2015;101 (suppl 1):e1074; doi: 10.1016/j.physio.2015.03.1961.
- [12] Long W, Dorr L, Healy B, Perry J. Functional recovery of noncemented total hip arthroplasty. *Clin Orthop Relat Res*. 1993;288:73–7.
- [13] Wijnen A, Bouma SE, Seeber GH, van der Woude LH, Bulstra SK, Lazovic D, Stevens M, van den Akker-Scheek I. The therapeutic validity and effectiveness of physiotherapeutic exercise following total hip arthroplasty for

- osteoarthritis: a systematic review. *PLOS ONE*. 2018; 13(3):e0194517; doi: 10.1371/journal.pone.0194517.
- [14] Jan M-H, Hung J-Y, Lin J-C, Wang S-F, Liu T-K, Tang P-F. Effects of a home program on strength, walking speed, and function after total hip replacement. *Arch Phys Med Rehabil*. 2004;85(12):1943–51; doi: 10.1016/j.apmr.2004.02.011.
- [15] Papalia R, Campi S, Vorini F, Zampogna B, Vasta S, Papalia G, Fossati C, Torre G, Denaro V. The role of physical activity and rehabilitation following hip and knee arthroplasty in the elderly. *J Clin Med*. 2020;9(5):1401; doi: 10.3390/jcm9051401.
- [16] Winther SB, Foss OA, Husby OS, Wik TS, Klaksvik J, Husby VS. A randomized controlled trial on maximal strength training in 60 patients undergoing total hip arthroplasty: implementing maximal strength training into clinical practice. *Acta Orthop*. 2018;89(3):295–301; doi: 10.1080/17453674.2018.1441362.
- [17] Umperies CS, Ribeiro TA, Marchisio ÂE, Galvão L, Borges ÍN, de Souza Macedo CA, Galia CR. Rehabilitation following total hip arthroplasty evaluation over short follow-up time: a randomized clinical trial. *J Rehabil Res Dev*. 2014;51(10): 1567–78; doi: 10.1682/JRRD.2014.05.0132.
- [18] Rampazo-Lacativa MK, D'Elboux MJ. Effect of cycle ergometer and conventional exercises on rehabilitation of older patients with total hip arthroplasty: study protocol for a randomized controlled trial. *Trials*. 2015;16(1):1–9; doi: 10.1186/s13063-015-0647-8.
- [19] Nakanowatari T, Suzukamo Y, Izumi SI. The effectiveness of specific exercise approach or modifiable heel lift in the treatment of functional leg length discrepancy in early post-surgery in patients after total hip arthroplasty: a randomized controlled trial with a PROBE design. *Phys Ther Res*. 2016;19(1):39–49; doi: 10.1298/PTR.E9892.
- [20] Matheis C, Stöggel T. Strength and mobilization training within the first week following total hip arthroplasty. *J Bodyw Mov Ther*. 2018;22(2):519–27; doi: 10.1016/j.jbmt.2017.06.012.
- [21] Nankaku M, Ikeguchi R, Goto K, So K, Kuroda Y, Matsuda S. Hip external rotator exercise contributes to improving physical functions in the early stage after total hip arthroplasty using an anterolateral approach: a randomized controlled trial. *Disabil Rehabil*. 2016;38(22): 2178–83; doi: 10.3109/09638288.2015.1129453.
- [22] Krastanova MS, Ilieva EM, Valcheva DE. Rehabilitation of patients with hip joint arthroplasty. *Folia Med*. 2017; 59(2):217–21; doi: 10.1515/folmed-2017-0016.
- [23] Siggeirsdottir K, Olafsson Ö, Jonsson Jr H, Iwarsson S, Gudnason V, Jonsson BY. Short hospital stay augmented with education and home-based rehabilitation improves function and quality of life after hip replacement: a randomized study of 50 patients with 6 months of follow-up. *Acta Orthop*. 2005;76(4):555–62; doi: 10.1080/17453670510041565.
- [24] Roberts D, Ageberg E, Andersson G, Fridén T. Effects of short-term cycling on knee joint proprioception in ACL-deficient patients. *Knee Surg Sports Traumatol Arthrosc*. 2004;12(5):357–63; doi: 10.1007/s00167-003-0468-2.
- [25] Sady SP, Wortman MV, Blanke D. Flexibility training: ballistic, static or proprioceptive neuromuscular facilitation? *Arch Phys Med Rehabil*. 1982;63(6):261–3.
- [26] Heiberg KE, Bruun-Olsen V, Ekeland A, Mengshoel AM. Effect of a walking skill training program in patients who have undergone total hip arthroplasty: follow-up one year after surgery. *Arthritis Care Res*. 2012;64(3):415–23; doi: 10.1002/acr.20681.
- [27] Bade MJ, Stevens-Lapsley JE. Early high-intensity rehabilitation following total knee arthroplasty improves outcomes. *J Orthop Sports Phys Ther*. 2011;41(12): 932–41; doi: 10.2519/jospt.2011.3734.
- [28] Judd DL, Dennis DA, Thomas AC, Wolfe P, Dayton MR, Stevens-Lapsley JE. Muscle strength and functional recovery during the first year after THA. *Clin Orthop Relat Res*. 2014;472(2):654–64; doi: 10.1007/s11999-013-3136-y.
- [29] Koga D, Jinno T, Okawa A, Morita S, Shinomiya K. The effect of preoperative lateral flexibility of the lumbar spine on perceived leg length discrepancy after total hip arthroplasty. *J Med Dental Sci*. 2009;56(1):69–77.
- [30] Bodén H, Adolphson P. No adverse effects of early weight bearing after uncemented total hip arthroplasty. A randomized study of 20 patients. *Acta Orthop Scand*. 2004;75(1):21–9; doi: 10.1080/00016470410001708040.