Measurement properties of New Mobility Score to evaluate functional recovery in the elderly following total hip arthroplasty

Dragica Mitrović1,2, Predrag Erceg1,3, Ljiljana Milić1,4, Vladica Ćuk1,4, Jovan Juloski1,4, Radosav Radulović1,4, Ljubica Konstantinović5, Zoran Radojičić6, Vesna R. Jovanović2, Sanja Dugonjić8

1Zvezdara University Hospital, Belgrade, Serbia; 2Zvezdara University Hospital, Department of Physical Medicine and Rehabilitation, Belgrade, Serbia; 3Zvezdara University Hospital, Prof. Dr. Petar Korolija Clinical Department of Geriatrics, Belgrade, Serbia; 4Zvezdara University Hospital, Nikola Spasić Surgery Clinic, Belgrade, Serbia; 5Dr. Miroslav Zotović Clinic for Rehabilitation, Belgrade, Serbia; 6University of Belgrade, Faculty of Organizational Sciences, Institute for Statistics, Belgrade, Serbia; 7Academy of Applied Studies, Department of Applied Health Studies, Belgrade, Serbia; 8Military Medical Academy, Institute of Nuclear Medicine, Belgrade Serbia

Received: July 13, 2020
Accepted: January 10, 2022
Online First: January 15, 2022
DOI: https://doi.org/10.2298/SARH200713005M

*Accepted papers are articles in press that have gone through due peer review process and have been accepted for publication by the Editorial Board of the Serbian Archives of Medicine. They have not yet been copy-edited and/or formatted in the publication house style, and the text may be changed before the final publication.

Although accepted papers do not yet have all the accompanying bibliographic details available, they can already be cited using the year of online publication and the DOI, as follows: the author’s last name and initial of the first name, article title, journal title, online first publication month and year, and the DOI; e.g.: Petrović P, Jovanović J. The title of the article. Srp Arh Celok Lek. Online First, February 2017.

When the final article is assigned to volumes/issues of the journal, the Article in Press version will be removed and the final version will appear in the associated published volumes/issues of the journal. The date the article was made available online first will be carried over.

*Correspondence to:
Dragica MITROVIĆ
Department of Physical Medicine and Rehabilitation, Zvezdara University Hospital, Dimitrija Tucovića 161, Belgrade 11120, Serbia
E mail: mitdragica@gmail.com
Measurement properties of New Mobility Score to evaluate functional recovery in the elderly following total hip arthroplasty

Мерна својства Новог упитника за процену мобилности функционалном опоравку старијих особа после тоталне артродезе кука

**Summary**

Introduction/Objective The aim of this study is to identify and evaluate the use of New Mobility Score in estimating functional recovery 3 months after total hip arthroplasty (THA).

Methods Seventy patients, aged > 60, who underwent THA. Treatment group was subjected to the comprehensive rehabilitation program and control group to the standard one. Primary outcome was assessed with Harris Hip Score (HHS) and New Mobility Score (NMS), and secondary one by Medical Outcomes Health Survey (Short Form Health Survey – SF-36). Questionnaires were collected before and three months after hip surgery.

Results Treatment group showed significant improvement 3 months postoperatively. The correlation in both groups between HHS and NMS was very strong (r > 0.700). Treatment group following surgery showed strong correlation between Recovery through Personal Care Services (PCS) and HHS and NMS (r > 0.700), moderate to strong between pain categories and HHS (r = 0.380; r = 0.583) and NMS (r = 0.424). Control group showed strong correlation between PCS and HHS (r = 0.704), and NMS (r = 0.568) and moderate to pain categories and HHS (r = 0.546; r = 0.466). The area under the curve (AUC) described the inherent validity of all measurement used AUC_NMS = 0.724, p = 0.001, AUC_HHS = 0.788, p = 0.000 and AUC_PCS = 0.747, p = 0.001.

Conclusion The NMS could be successfully used in routine clinical assessment of elderly patients following THA.

The trial is registered in ISRCTN Register with https://doi.org/10.1186/ISRCTN73197506

**Keywords:** Harris Hip Score; New Mobility Score; SF-36; outcome assessment; hip arthroplasty; rehabilitation; ROC curve

**Conclusion**

The NMS could be successfully used in routine clinical assessment of elderly patients following THA. The area under the curve (AUC) described the inherent validity of all measurement used: AUC_NMS = 0.724, p = 0.001, AUC_HHS = 0.788, p = 0.000 and AUC_PCS = 0.747, p = 0.001. The NMS could be successfully used in routine clinical assessment of elderly patients following THA.
INTRODUCTION

Total hip arthroplasty (THA) is the most commonly performed surgical procedure undertaken to relieve pain and restore function in elderly people with end-stage hip osteoarthritis [1]. With the projected increase in the number of the elderly undergoing THA over the next two decades, it becomes even more critical to develop effective rehabilitation strategies, individually adapted, which can contribute most benefit. Surgery alone fails to fully restore physical function and address longstanding impairments associated with chronic joint disease [2, 3].

Despite the increased interest in evaluating outcomes following hip arthroplasty, challenges remain in ensuring that such assessments of outcome are accurate, reliable, and relevant [4]. Generic patient-reported outcome measures describe a patient's global health status, and numerous comprehensive specific Patient-Reported Outcome Measures (PROMs) instruments are available for patients with hip problems [5]. Health-related quality-of-life data are valuable as they can provide relevant health-status information to health professionals and should be used as rationale for implementing the most adequate standard of health care [6].

There are many different tools available to measure an outcome, each with its advantages and drawbacks. Pain assessment is a crucial component of joint specific and generic self assessment instruments because it influences physical functioning [7]. After surgery, outcome measures are generally conveyed as the quality-of-life score, and joint-specific tools focus on disability relating to a particular joint irrespective of the underlying pathology [7, 8]. Therefore, there is a need for guidance in defining criteria for the most useful outcome measures, using the International Classification of Functioning, Disability, and Health (ICF) model to conceptualize joint replacement outcomes [9, 10].

The meta-analysis from 2019. distinguishes results on patient-reported function, hip-related pain, and health-related quality of life after total hip replacement and suggests focusing on early rehabilitation [11, 12].

The aim of this study is to identify and evaluate the use of New Mobility Score (NMS) together with already confirmed Harris Hip Score (HHS) and the medical outcomes study Short-Form Health Survey (SF-36) in estimating functional recovery three months after primary hip arthroplasty.
METHODS

Study design, participants, and ethics

This study was designed as a prospective randomized controlled study. The data were collected preoperatively and three months after THA to evaluate the effectiveness of a comprehensive rehabilitation program compared to the standard one after hip arthroplasty. Recruited patients were enrolled between 2013 and 2015, prior to surgery at the orthopedic surgery department. The inclusion criteria were older than 60, end-stage primary hip osteoarthritis, and primary unilateral total hip replacement. The exclusion criteria were postoperative complications, cognitive impairment (assessed clinically), history of congenital hip dislocation, bilateral hip disease or inflammatory arthritis, significant neuromuscular disease (e.g., Parkinson's disease), lower extremity fractures, or paralysis.

A randomization sequence was created using a computer-generated list of numbers in block sizes of four. Those who qualified for the trial underwent a hip replacement, by posterior-lateral approach, performed by the same surgery team. Both groups received a standard exercise program guided by a physiotherapist, starting on the first post-surgery day. Participants in the treatment group were given a comprehensive program with additional physical exercises for the arm and upper body. Both program sessions were performed twice a day, five days a week, during a two-week stay in the hospital. The patients were supervised in an inpatient rehabilitation center (for four weeks) and finally at home, unsupervised (for six weeks).

All participants gave their voluntary written consent according to approval by the Regional Committee for Medical Research Ethics (n.29/V-17). The trial is registered in ISRCTN Register with ISRCTN73197506.
Patient characteristics

Before surgery, a questionnaire including anthropometric characteristics (age, sex, body height and weight, comorbidities) was completed for all patients.

Patient assessment

The primary outcome was changed in the lower limbs' hip function and physical performances, assessed by Harris Hip Score (HHS) and New Mobility Score (NMS), from baseline and after 3 months. The Harris Hip Score is a multidimensional assessment of the results of hip surgery [2, 13]. The domains covered by the HHS are pain and daily living activities, and hip function assessment (limping), absence of deformity, and range of motion. The final score ranges from 100 points (no disability) to 0 (maximum disability).

The New Mobility Score is a composite score of the patient's ability to perform: indoor walking, outdoor walking, and shopping, providing a score between zero and three (0: not at all, 1: with help from another person, 2: with an aid, 3: no difficulty) for each function, resulting in a total score from 0 (no walking ability at all) to 9 (fully independent) [14, 15, 16].

Secondary outcomes were estimating and measuring functional physical recovery after primary hip arthroplasty and quality of life by SF-36. The SF-36 is a common general health scale evaluating physical and mental health, which includes one multi-item scale that assesses eight health concepts: 1) limitations in physical activities because of health problems; 2) limitations in social activities because of physical or emotional problems; 3) limitations in usual role activities because of physical health problems; 4) bodily pain; 5) general mental health (psychological distress and well-being); 6) limitations in usual role activities because of emotional problems; 7) vitality (energy and fatigue), and 8) general health state. It has been tested for its psychometric properties. Each subscale score is converted from 0 to 100; the higher the score, the better the quality of life [4, 17].
Statistical analysis

Baseline data on patients' characteristics were examined for differences between the two groups by chi-square test for categorical variables or Student t-test and Mann-Whitney U test for continuous variables.

In this paper, we used Norm Based Scoring (NBS) for all domains of SF-36. NBS generates Physical Component Summary (PCS) and Mental Component Summary (MCS) scores, using Scoring Software 4.5™ [18]. The response to 36 questions is transferred to 0-100 worst/best scale, according to which 50 points score corresponds to a generally healthy population.

Correlations between specific and generic tests in two measurement periods were assessed with the Pearson linear correlation coefficient. The degree of correlation was defined as low if the coefficient was less than 0.3, moderate if it was between 0.3 and 0.5, and reliable if it was more significant than 0.5 [19].

Receiver operating characteristic (ROC) curve plots were generated for all used outcome measurements. The point closest to the upper left corner of the curve represents the optimal trade-off between sensitivity and specificity for detecting clinical improvement. The area under the curve can be interpreted as the probability of the test to identify an improvement in patients correctly. An AUC of 1 demonstrates an ideal test with a 100% sensitivity and specificity, while an AUC of less than 0.5 indicates that the test is less useful. Cut-off points are defined by positive-to-negative (P/N) ratios [20].

Statistical Package for Social Science for Windows (SPSS) version 21.0 was used for statistical analyses.

RESULTS

Ninety-eight patients were eligible for participation in the study from January 1, 2013, to June 30, 2015. After exclusion criteria had been implemented, 70 participants underwent randomization and did not change groups until the end of the research.
The treatment group consisted predominantly of females, 63% (n = 22) as well as in the control group, 77% (n = 27). There were no significant pre-treatment differences between the groups, suggesting that the randomization procedure produced well-balanced and comparable groups at baseline. The average age of participants was 69 (SD = 6.3 years) in both groups.

A flow diagram of the trial progression (recruitment, randomization, intervention allocation, follow-up, and data analysis) is shown in figure 1. The average baseline characteristics of both groups are listed in table 1.

The only significant difference between treatment and control study groups before the intervention was detected in the Vitality (VT) domain of the SF-36 questionnaire. A higher score of vitality was detected among treatment patients (45.7 vs. 39.7).

After the intervention, there were significant differences in favor of treatment group as regards HHS (88.3 vs. 82.4), pain category of HHS (42.63 vs. 41.14), NMS (8.2 vs. 7.1), and SF-36 domains (Physical Functioning (PF) (49.3 vs. 44.2), Role-Physical (RP) (51.9 vs. 47.0), Bodily Pain (BP) (60.3 vs. 55.4), Vitality (VT) (61.8 vs. 56.6), Social Functioning (SF) (55.8 vs. 52.2), Mental Health (MH) (56.3 vs. 52.4), as well as PCS (54.0 vs. 49.1), but for MCS (p = 0.067) there were no statistically significant differences between groups. (Table 2)

Correlations prior to THA were given in Table 3.

In the treatment group, a strong statistically significant correlation was found between HHS and NMS. Moderate to strong positive statistically significant correlation was found between SF-36 domains: PF, RP, BP, SF, RE, PCS, HHS, and NMS. A moderate statistically significant correlation was found between the pain category of HHS and total HHS.

In the control group, a strong statistically significant correlation was found between HHS and NMS. Moderate to strong positive statistically significant correlation was found between SF-36 domains: PF, BP, VT, PCS, pain category of HHS, and total HHS and NMS. A moderate level of statistically significant correlation was found between SF-36 domains: BP, SF, and NMS, as well as VT and HHS.

Correlations 3 months after THA were given in Table 3.
In the treatment group, a strong significant correlation was found between HHS and NMS. Moderate to strong positive statistically significant correlation was found between SF-36 domains: PF, RP, GH, VT, PCS, pain category of HHS, and total HHS and NMS. A moderate significant correlation was present between BP and HHS.

In the control group, a strong significant correlation was found between HHS and NMS. Moderate to strong positive statistically significant correlation was found between SF-36 domains: PF, RP, GH, VT, and PCS and both HHS, as well as SF-36 domains: BP, SF, RE, MH, MCS, pain category HHS and total HHS. (Figure 2, Table 4)

AUC for NMS was 0.724 (CI 95% 0.598-0.849) p = 0.001, cut-off 7.5, with sensitivity of 80% and specificity of 71%.

AUC for HHS was 0.788 (95% CI 0.683-0.894) p = 0.000, cut-off 85.5, with sensitivity of 71% and specificity of 74%.

AUC for PCS SF-36v2 was 0.747 (95% CI 0.628-0.867) p = 0.001, cut-off 51.8, with sensitivity of 77% and specificity of 77%.

DISCUSSION

Previous studies have found that NMS was only used for functional assessment of patients with hip fractures [14-16]. In our study, NMS was used for the first time to evaluate physical functional recovery after primary hip arthroplasty in the elderly and recorded the same significant improvement as estimated by HHS and SF-36. Many papers assessed the physical functioning of patients undergoing hip replacement surgery using different patient-reported outcome measures. They provided a shortlist of the most promising generic and joint-specific instruments [4, 5, 11, 12]. In Garnier et al. [4], seventy-three studies were investigated, and 26 instruments were included, one of the most frequently assessed instruments being HHS. This study opted for physician-administered HHS, a widely used important instrument for evaluating outcomes and predicting early revision surgery after THA [6, 13, 21]. HHS and SF-36 are highly valid and reliable outcome measurement instruments, which we also used in this
study. Mariconda et al. [22] presented that HHS was the essential determinant of SF-36 PCS and PF scale scores, showing that hip functionality is critical in determining the patients' general functioning. The most important findings of the systematic review and meta-analysis are that mid-term health-related quality of life following THA is superior to preoperative levels in a broad range of SF-36 domains and results in patient satisfaction and specific functional gains [23]. Our study has proven statistically significant functional improvement, predominantly in the treatment group, three months postoperatively, assessed with all used measurements: NMS, HHS and in virtually all domains SF-36: physical function, role physical, bodily pain, social functioning, vitality, mental health, and physical summary component. We found that correlation in treatment and control groups between HHS and NMS was very strong. The correlation in both groups between preoperative physical performances and pain was strong. Three months after arthroplasty, the correlation between the treatment and control group was strong to very strong between assessed physical performances. Following surgery and both physical exercise programmes (comprehensive and standard), we found a moderate correlation in treatment group and moderate to strong in control one between pain domain SF-36, pain category HHS and functional ability HHS.

Pain and physical function represent different but related health concepts and interventions [7, 23]. Therefore, separate assessments of these attributes were recommended at the Outcome Measures in Arthritis Clinical Trials conference (OMERACT) [9, 10]. Results of the Terwee et al. [24] study confirmed that self-report measures of physical functioning are more influenced by the amount of pain experienced than performance-based measures of physical functioning. We have established a connection between pain and physical functioning following hip replacement measured by specific HHS, NMS, and generic SF-36.

Elibol et al. [25] found moderate to strong correlations between HHS and performance-based tests in evaluating patients with THA. In contrast, our study presented a strong correlation between outcomes assessment HHS and NMS in evaluating patients with THA.

ROC curves synthesized information on the sensitivity and specificity to discriminate significant functional improvement in the treatment group, on the one hand, and functional improvement in the control group. The AUC is an effective and combined measure that describes all measurements' inherent validity used HHS, NMS, and SF-36 [20]. The ROC curves of NMS with HHS and PCS of SF-36 were located closer to each other in "ROC space,"
which confirmed validity for NMS. Hoeksma et al. [26] also used ROC curve to determine the ability of HHS and SF-36, walking speed, and pain to measure clinically relevant improvement after exercise therapy. In summary, they showed that HHS could detect a small improvement in hip function and recommended that it be used in rehabilitation interventions that focus on the improvement of functional ability in patients with OA of the hip.

Kristensen et al. [27] suggest that the New Mobility Score is a valid and easily applicable score that provides a predictive value of the short-term potential of the patient’s independence in functional mobility during admission and discharge status. Pietro-Moreno et al. [28] confirmed that NMS is a reliable and valid outcome measure to assess the pre-fracture functional status and cognitive impairment in older patients with hip fracture in Spain. We agreed that the NMS is an easy-to-use and quick-to-complete score that can be used for all patients with hip surgery, based on the information provided by the caregivers for the patients with functional status [28]. We also found that a strong correlation between used outcome measurements confirms that NMS is useful and important instrument for fast and relevant clinical assessment and evaluation of functional recovery after primary hip arthroplasty in the elderly in Serbia.

Consensus on which combination of measures will best assess physical function in people with hip OA still does not exist [9]. We related physical functional performances to "the ability to move around "and "the ability to perform daily activities "in THA patients unified in NMS, HHS, and SF-36. These functional activities were classified using the ICF model WHO [29].

There are potential limitations of this study, the first being using only self-reported generic and specific instruments. The second limitation is that the patients undergoing hip replacement were evaluated for a short follow-up time.

The strong points of this study are that we have created a randomized control study for assessing outcomes three months following primary hip arthroplasty in the elderly and that we have used valid outcome assessment.

Our further research will focus on the correlation between self-reported generic, specific, and performance-based outcome measurements to evaluate the effectiveness of a comprehensive rehabilitation programme over a more extended follow-up period.
CONCLUSION

In conclusion, we strongly support the use of joint self-reported specific and generic measurements in the assessment of impact of pain experience on physical functioning after total hip arthroplasty. We believe the findings of a strong correlation with all used outcome measurements confirm that the New Mobility Score is useful and important for fast and adequate clinical evaluation of functional abilities after primary hip arthroplasty over a short follow-up time. The NMS can be successfully used in routine clinical practice to assess functionality outcomes after hip replacement in elderly patients.

Conflict of interest: None declared.
REFERENCES

1. Colibazzi V, Coladonato A, Zanazzo M, Romanini E. Evidence-based rehabilitation after hip arthroplasty. Hip Int. 2020 Dec;30(2):suppl):20-29. DOI: 10.1177/1120700020971314.

2. Saueressig T, Owen PJ, Zebisch J, Herbst M, Belavy DL. Evaluation of Exercise Interventions and Outcomes After Hip Arthroplasty: A Systematic Review and Meta-analysis. JAMA Netw Open. 2021 Feb 1;4(2):e210254. DOI: 10.1001/jamanetworkopen.2021.0254. PMID: 33635529; PMCID: PMC7910817.

3. Wu JQ, Mao LB, Wu J. Efficacy of exercise for improving functional outcomes for patients undergoing total hip arthroplasty: A meta-analysis. Medicine (Baltimore). 2019 Mar;98(10):e14591. DOI: 10.1097/MD.0000000000014591. PMID: 30855443; PMCID: PMC6417520.

4. Gagnier JJ, Huang H, Mullins M, Marinac-Dabić D, Ghammeray A, Eloff B, et al. Measurement Properties of Patient-Reported Outcome Measures Used in Patients Undergoing Total Hip Arthroplasty: A Systematic Review. JBJS. Rev. 2018 Jan;6(1):e2. DOI: 10.2106/JBJS.RVW.17.00038. PMID: 29315123.

5. Bohn ER, Kirby S, Trepmann E, Hallstrom BR, Rolfsen O, Wilkinson JM, et al. Collection and Reporting of Patient-Reported Outcome Measures in Arthroplasty Registries: Multinational Survey and Recommendations. Clin Orthop Relat Res. 2021 October 1;479(10):2151-2166. DOI: 10.1097/CORR.0000000000001852. PMID: 34288999; PMCID: PMC8445553.

6. Miettinen HJA, Mäkirinne-Kallio N, Kröger H, Miettinen SSA. Health-Related Quality of Life after Hip and Knee Arthroplasty Operations. Scand J Surg. 2021 Sep;110(3):427-433. DOI: 10.11171/1457496920952232. Epub 2020 August 31. PMID: 32862793; PMCID: PMC8551429.

7. Stephan A, Stadelmann VA, Leunig M, Impellizzeri FM. Measurement properties of PROMIS short forms for pain and function in total hip arthroplasty patients. J Patient Rep Outcomes. 2021 May 30;5(1):41. DOI: 10.1186/s41687-021-00313-1. PMID: 34056667; PMCID: PMC8165047.

8. Konopka JF, Lee YY, Su EP, McLawhorn AS. Quality-Adjusted Life Years After Hip and Knee Arthroplasty: Health-Related Quality of Life After 12,782 Joint Replacements. JBJS Open Access. 2018 Aug 15;3(3):e0007. DOI: 10.2106/JBJS.OA.18.00007. PMID: 30533590; PMCID: PMC6242318.

9. Singh JA, Dowsey MM, Dohm M, Goodman SM, Leong AL, Schulte Voshaar MMJH, et al. Achieving Consensus on Total Joint Replacement Trial Outcome Reporting Using the OMERACT Filter: Endorsement of the Final Core Domain Set for Total Hip and Total Knee Replacement Trials for Endstage Arthritis. J Rheumatol. 2017 Nov;44(11):1723-1726. DOI: 10.3899/jrheum.161113. Epub 2017 January 15. PMID: 28089984.

10. Cibulka MT, Bloom NJ, Enseki KR, Macdonald CW, Woehrle J, McDonough CM. Hip Pain and Mobility Deficits-Hip Osteoarthritis/Revision 2017. J Orthop Sports Phys Ther. 2017 Jun;47(6): A1-A37. DOI: 10.2519/jospt.2017.0301. PMID: 28566053.

11. Hansen S, Aaboe J, Meehlenburg I, Overgaard S, Mikkelsen LR. Effects of supervised exercise compared to non-supervised exercise early after hip and knee replacements. Acta Orthop. 2020 Sep;91(5):587-91. DOI: 10.1177/1403389619870895. Epub 2019 Mar 27. PMID: 30975385.

12. Takamura D, Iwata K, Sueyoshi T, Yasuda T, Moriyama H. Relationship between physical activity after total knee arthroplasty and postoperative physical function: are these related? Knee Surg Relat Res. 2021 September 28;33(1):35. doi:10.1186/s43019-021-00118-y. PMID: 34583777; PMCID: PMC8488087.

13. Nilsdotter A, Bremander A. Measures of hip function and symptoms: Harris Hip Score (HHS), Hip Disability and Osteoarthritis Outcome Score (HOOS), Oxford Hip Score (OHS), Lequesne Index of Severity for Osteoarthritis of the Hip (LISOH), and American Academy of Orthopedic Surgeons (AAOS) Hip and Knee Questionnaire. Arthritis Care Res (Hoboken). 2011;63(11): S200-7.

14. Parker MJ, Palmer CR. A new mobility score for predicting mortality after hip arthroplasty. J Bone Joint Surg Br. 1993 Sep;75(5):797-8. DOI: 10.1302/0301-620X.75B5.8376443. PMID: 8376443.

15. McDonough CM, Harris-Hayes M, Kristensen MT, Overgaard JA, Herring TB, Kenny AM, et al. Physical Therapy Management of Older Adults With Hip Fracture. J Orthop Sports Phys Ther. 2021 Feb;51(2): CPG1-CPG81. DOI: 10.2519/jospt.2021.0301. PMID: 33522384.

16. Kristensen MT, Foss NB, Ekdahl C, Kehlet H. Prefracture functional level evaluated by the New Mobility Score predicts in-hospital outcome after hip fracture surgery. Acta Orthop. 2020 Jun;81(3):296-302. DOI: 10.3109/17453674.2010.487240. PMID: 20450426; PMCID: PMC2876830.

17. Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care. 1992 Jun;30(6):473-83. PMID: 1593914.

18. White MK, Maher SM, Rizio AA, Bjorner JB. A meta-analytic review of measurement equivalence study findings of the SF-36 and SF-12® Health Surveys across electronic modes compared to paper administration. Qual Life Res. 2018 Jul;27(7):1757-1767. DOI: 10.1007/s11136-018-1851-2. Epub 2018 April 16. PMID: 29663258; PMCID: PMC5997721.

DOI: https://doi.org/10.2298/SARH200713005M

Copyright © Serbian Medical Society
19. Rokicki S, Cohen J, Fink G, Salomon JA, Landrum MB. Inference With Difference-in-Differences With a Small Number of Groups: A Review, Simulation Study, and Empirical Application Using SHARE Data. Med Care. 2018 Jan;56(1):97-105. DOI: 10.1097/MCR.0000000000000830. PMID: 29112050.

20. Hajian-Tilaki K. Receiver Operating Characteristic (ROC) Curve Analysis for Medical Diagnostic Test Evaluation. Caspian J Intern Med. 2013 Spring;4(2):627-35. PMID: 24009950; PMCID: PMC3755824.

21. Singh JA, Schleck C, Harmsen S, Lewallen D. Clinically important improvement thresholds for Harris Hip Score and its ability to predict revision risk after primary total hip arthroplasty. BMC Musculoskelet Disord. 2016 June 10;17:256. DOI: 10.1186/s12891-016-1106-8. PMID: 27286675; PMCID: PMC4901425.

22. Mariconda M, Galasso O, Costa GG, Recano P, Cerbasi S. Quality of life and functionality after total hip arthroplasty: a long-term follow-up study. BMC Musculoskelet Disord. 2011 October 6;12:222. DOI: 10.1186/1471-2474-12-222. PMID: 21978244; PMCID: PMC3204273.

23. Shan L, Shan B, Graham D, Saxena A. Total hip replacement: a systematic review and meta-analysis on midterm quality of life. Osteoarthritis Cartilage. 2014 Mar;22(3):389-406. DOI: 10.1016/j.joca.2013.12.006. Epub 2014 January 1. PMID: 24389057.

24. Terwee CB, van der SLikke RM, van Lummel RC, Benink RJ, Meijers WG, de Vet HC. Self-reported physical functioning was more influenced by pain than performance-based physical functioning in knee-osteoarthritis patients. J Clin Epidemiol. 2006 Jul;59(7):724-31. DOI: 10.1016/j.jclinepi.2005.11.019. PMID: 16765276.

25. Elibol N, Unver B, Karatosun V, Gunal I. Relationship between self-reported and performance-based tests in assessment of patients with total hip arthroplasty. Hip Int. 2018 Sep;28(5):566-570. DOI: 10.1177/1120794117752557. Epub 2018 May 9. PMID: 29739250.

26. Hoeksma HL, Van Den Ende CH, Ronday HK, Heering A, Breedveld FC. Comparison of the responsiveness of the Harris Hip Score with generic measures for hip function in osteoarthritis of the hip. Ann Rheum Dis. 2003 Oct;62(10):935-8. DOI: 10.1136/ard.62.10.935. PMID: 12972470; PMCID: PMC1754316.

27. Kristensen MT, Foss NB, Kehlet H. The New Mobility Score as a predictor of early independency after hip fracture surgery. Orthopaedic ProceedingsVol. 92-B, No. SUPP_II. Published Online:21 Feb 2018

28. Prieto-Moreno R, Ariza-Vega P, Ortiz-Piña M, Ashe MC, Romero-Ayuso D, Kristensen MT. Translation, Reliability, and Validity of the Spanish Version of the Modified New Mobility Score (NMS-ES). Int J Environ Res Public Health. 2021 January 15;18(2):725. DOI: 10.3390/ijerph18020723. PMID: 33467712; PMCID: PMC7830379.

29. World Health Organization International classification of functioning, disability, and health: ICF. Geneva, Switzerland: http://www.who.int/iris/handle/10665/42407
### Table 1. Socio-demographic and clinical characteristics of the participants

| Characteristics                     | Study group n = 35 | Control group n = 35 | P   |
|-------------------------------------|--------------------|----------------------|-----|
| Age in years, mean (SD)             | 69.2 (6.29)        | 68.1 (6.35)          | 0.725 |
| Sex                                 |                    |                      | 0.192 |
| Male, n (%)                         | 13 (37.1)          | 8 (22.9)             |     |
| Female, n (%)                       | 22 (62.9)          | 27 (77.1)            |     |
| BMI in categories, n (%)            |                    |                      | 0.408 |
| Normal, n (%)                       | 7 (20)             | 11 (31.4)            |     |
| Overweight, n (%)                   | 17 (48.6)          | 12 (34.3)            |     |
| Obese, n (%)                        | 11 (31.4)          | 12 (34.3)            |     |
| Comorbidities, mean (SD)            | 2.77 (1.8)         | 3.34 (2.38)          | 0.138 |
| ICED score                           |                    |                      | 0.405 |
| Mild, n (%)                         | 1 (2.9)            | 0 (0)                |     |
| Moderate, n (%)                     | 2 (5.7)            | 2 (5.7)              |     |
| Severe, n (%)                       | 30 (85.7)          | 33 (94.3)            |     |

ICED – Index of Coexistent Disease; BMI – body mass index;

According to $\chi^2$, t-test, or Mann–Whitney U-test where appropriate
Table 2. Mean scores of NMS, SF36, and HHS questionnaires before and 3 months after the intervention in treatment and standard groups

| Time                        | Questionnaire, mean (SD) | Groups                  | p*          |
|-----------------------------|--------------------------|-------------------------|-------------|
|                             |                          | Treatment n = 35        | Control n = 35 |
|                             |                          |                         |             |
| Before intervention         | HHS                      | 34.6 (10.56)            | 35.5 (9.3)  | 0.693 |
|                             | HHS-pain                 | 11.71 (3.82)            | 12.86 (4.58) | 0.261 |
|                             | Physical Functioning     | 25.7 (4.93)             | 24.0 (3.73)  | 0.121 |
|                             | Role-Physical            | 30.4 (6.95)             | 28.4 (10.3)  | 0.362 |
|                             | Bodily Pain              | 29.9 (5.52)             | 27.3 (5.55)  | 0.106 |
|                             | General Health           | 53.9 (9.06)             | 52.5 (8.84)  | 0.511 |
|                             | Vitality                 | 45.7 (10.68)            | 39.7 (10.29) | 0.019 |
|                             | Social Functioning       | 29.8 (10.63)            | 27.4 (9.22)  | 0.309 |
|                             | Role-Emotional           | 35.1 (11.1)             | 36.3 (12.17) | 0.670 |
|                             | Mental Health            | 38.2 (13.45)            | 34.1 (12.09) | 0.183 |
|                             | Physical Component summary| 32.9 (5.44)            | 30.4 (4.93)  | 0.054 |
|                             | Mental Component summary | 41.3 (12.31)            | 38.8 (12.62) | 0.402 |
|                             | NMS                      | 3.9 (1.82)              | 3.9 (1.14)   | 1.000 |
| 3 months after intervention | HHS                      | 88.3 (4.62)             | 82.4 (5.51)  | < 0.001 |
|                             | HHS-pain                 | 42.6 (1.92)             | 41.1 (1.83)  | < 0.002 |
|                             | Physical Functioning     | 49.3 (6.9)              | 44.2 (7.8)   | 0.005 |
|                             | Role-Physical            | 51.9 (5.17)             | 47.0 (5.42)  | < 0.001 |
|                             | Bodily Pain              | 60.3 (4.54)             | 55.4 (5.43)  | < 0.001 |
|                             | General Health           | 58.9 (7.04)             | 56.0 (7.09)  | 0.096 |
|                             | Vitality                 | 61.8 (7.04)             | 56.6 (7.55)  | 0.004 |
|                             | Social Functioning       | 55.8 (4.83)             | 52.2 (5.37)  | 0.005 |
|                             | Role-Emotional           | 54.1 (5.88)             | 51.4 (6.92)  | 0.086 |
|                             | Mental Health            | 56.3 (7.96)             | 52.4 (7.13)  | 0.032 |
|                             | Physical Component summary| 54.0 (5.70)            | 49.1 (5.62)  | 0.001 |
|                             | Mental Component summary | 57.9 (7.08)             | 54.9 (6.37)  | 0.067 |
|                             | NMS                      | 8.2 (1.09)              | 7.1 (1)      | < 0.001 |

HHS – Harris Hip Score; NMS – New Mobility Score;

*a* according to the t-test
### Table 3. Correlation coefficients between HHS, NMS, and SF-36 domains before and three months after the intervention in treatment and control groups

| SF-36 | Before intervention | 3 months after intervention |
|-------|---------------------|----------------------------|
|       | HHS                 | NMS                        | HHS             | NMS             |
| Physical Functioning | \( r = 0.715 \ p < 0.001 \) | \( r = 0.626 \ p < 0.001 \) | \( r = 0.733 \ p < 0.001 \) | \( r = 0.757 \ p < 0.001 \) |
| Role-Physical | \( r = 0.659 \ p < 0.001 \) | \( r = 0.467 \ p = 0.005 \) | \( r = 0.543 \ p < 0.001 \) | \( r = 0.515 \ p = 0.002 \) |
| Bodily Pain | \( r = 0.708 \ p < 0.001 \) | \( r = 0.454 \ p = 0.006 \) | \( r = 0.380 \ p = 0.024 \) | \( r = 0.305 \ p = 0.079 \) |
| General Health | \( r = 0.201 \ p = 0.246 \) | \( r = 0.196 \ p = 0.259 \) | \( r = 0.616 \ p < 0.001 \) | \( r = 0.659 \ p < 0.001 \) |
| Vitality | \( r = 0.321 \ p = 0.060 \) | \( r = 0.186 \ p = 0.284 \) | \( r = 0.635 \ p < 0.001 \) | \( r = 0.513 \ p = 0.002 \) |
| Social Functioning | \( r = 0.674 \ p < 0.001 \) | \( r = 0.470 \ p = 0.004 \) | \( r = 0.323 \ p = 0.058 \) | \( r = 0.263 \ p = 0.133 \) |
| Role-Emotional | \( r = 0.378 \ p = 0.025 \) | \( r = 0.146 \ p = 0.404 \) | \( r = 0.258 \ p = 0.135 \) | \( r = 0.209 \ p = 0.236 \) |
| Mental Health | \( r = 0.322 \ p = 0.059 \) | \( r = 0.125 \ p = 0.473 \) | \( r = 0.292 \ p = 0.089 \) | \( r = 0.212 \ p = 0.229 \) |
| Physical Component summary | \( r = 0.567 \ p < 0.001 \) | \( r = 0.556 \ p < 0.001 \) | \( r = 0.714 \ p < 0.001 \) | \( r = 0.757 \ p < 0.001 \) |
| HHS-Pain | \( r = 0.527 \ p = 0.001 \) | \( r = 0.218 \ p = 0.208 \) | \( r = 0.583 \ p < 0.001 \) | \( r = 0.424 \ p = 0.011 \) |
| Mental Composite score | \( r = 0.396 \ p = 0.019 \) | \( r = 0.159 \ p = 0.363 \) | \( r = 0.214 \ p = 0.217 \) | \( r = 0.130 \ p = 0.463 \) |
| Control group | \( r = 0.695; \ p < 0.001 \) | \( r = 0.472; \ p = 0.004 \) | \( r = 0.733; \ p < 0.001 \) | \( r = 0.750; \ p < 0.001 \) |
| Physical Functioning | \( r = 0.676 \ p < 0.001 \) | \( r = 0.522 \ p < 0.001 \) | \( r = 0.603 \ p < 0.001 \) | \( r = 0.519 \ p = 0.001 \) |
| Role-Physical | \( r = 0.319 \ p = 0.062 \) | \( r = 0.337 \ p = 0.048 \) | \( r = 0.608 \ p < 0.001 \) | \( r = 0.504 \ p = 0.002 \) |
| Bodily Pain | \( r = 0.797 \ p < 0.001 \) | \( r = 0.603 \ p < 0.001 \) | \( r = 0.546 \ p < 0.001 \) | \( r = 0.264 \ p = 0.125 \) |
| General Health | \( r = 0.243 \ p = 0.160 \) | \( r = 0.224 \ p = 0.195 \) | \( r = 0.627 \ p < 0.001 \) | \( r = 0.436 \ p = 0.009 \) |
| Vitality | \( r = 0.398 \ p = 0.018 \) | \( r = 0.529 \ p = 0.053 \) | \( r = 0.625 \ p < 0.001 \) | \( r = 0.501 \ p = 0.002 \) |
| Social Functioning | \( r = 0.458 \ p = 0.006 \) | \( r = 0.380 \ p = 0.024 \) | \( r = 0.530 \ p < 0.001 \) | \( r = 0.223 \ p = 0.198 \) |
| Role-Emotional | \( r = 0.280 \ p = 0.103 \) | \( r = 0.195 \ p = 0.262 \) | \( r = 0.393 \ p = 0.020 \) | \( r = 0.263 \ p = 0.126 \) |
| Mental Health | \( r = 0.288 \ p = 0.103 \) | \( r = 0.117 \ p = 0.503 \) | \( r = 0.542 \ p < 0.001 \) | \( r = 0.302 \ p = 0.077 \) |
| Physical Composite score | \( r = 0.632 \ p < 0.001 \) | \( r = 0.575 \ p < 0.001 \) | \( r = 0.704 \ p < 0.001 \) | \( r = 0.568 \ p < 0.001 \) |
| HHS-Pain | \( r = 0.715 \ p < 0.001 \) | \( r = 0.474 \ p = 0.004 \) | \( r = 0.466 \ p = 0.005 \) | \( r = 0.228 \ p = 0.187 \) |
| Mental Component summary | \( r = 0.292 \ p = 0.089 \) | \( r = 0.175 \ p = 0.305 \) | \( r = 0.483 \ p = 0.003 \) | \( r = 0.249 \ p = 0.149 \)

HHS – Harris Hip Score; NMS – New Mobility Score
Table 4. Area Under the Curve (AUC) and P/N ratio cut-off points

| Test result variable(s) | AUC | p     | 95% CI lower limit | 95% CI upper limit | Cut-off | Sensitivity | Specificity |
|-------------------------|-----|-------|--------------------|--------------------|---------|-------------|-------------|
| PCS postoperative       | 0.747 | 0.000 | 0.628              | 0.867              | 51.8    | 77          | 77          |
|                         |     |       |                    |                    |         |             |             |
| HHS postoperative       | 0.788 | 0.000 | 0.683              | 0.894              | 85.5    | 71          | 74          |
|                         |     |       |                    |                    |         |             |             |
| NMS postoperative       | 0.724 | 0.001 | 0.598              | 0.849              | 7.5     | 80          | 71          |
|                         |     |       |                    |                    |         |             |             |

PCS – Recovery through Personal Care Services; HHS – Harris Hip Score; NMS – New Mobility Score
Figure 1. Flow diagram of the randomized clinical trial
**Figure 2.** ROC curves three months postoperatively