ISSN: 2834-5274

Research Article

Journal of Surgery Care

An effect of digital rehabilitation on patients with total hip arthroplasty during the first-month hospital stay in China

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Submitted: 11 Oct 2022; **Accepted:** 19 Oct 2022; **Published:** 29 Oct 2022

Citation: *Zhang, X., Zhang, C., Zhang, Z., Ferland, A., Li, H., Yang, Y. (2022). An effect of digital rehabilitation on patients with total hip arthroplasty during the first-month hospital stay in China. J Surg Care, 1(1), 45-50.*

Abstract

Background and Objectives: *The video-based physical therapy has shown the promising enhancements in rehabilitation from total hip arthroplasty in the past decade. However, the critical question was whether patients 50 years old and above in China could follow the instructions from mobile application well? This study attempted to answer this question.*

Methods: *One hundred twenty patients with total hip arthroplasty participated in this study. They are randomly assigned into two groups: digital physical therapy (DPT) and conventional physical therapy (CPT) group. These two groups received similar exercise/balance interventions based on but not limited to the suggestions from the American Academy of Orthopedic Surgery in the first-month hospital stay. Five measures were used as follows: Lower Extremities Functional Score, Harris Hip Score, Ten-meter walking test, Timed-Up & Go, and Berg Balance Scale.*

Results: *Compared to CPT group, DPT group demonstrated similar or even better performance in the abovementioned measure, specifically in Berg Balance Scale ($p = 0.005$).*

Conclusions: *The results clearly showed that DPT was a feasible rehabilitation for future home- based rehabilitation for patients with total hip arthroplasty. Furthermore, our results also demonstrated that the DPT might be more effective than CPT in China due to the unlimited training opportunities after THA. In addition, it would be worthwhile to investigate the cost- effectiveness of this DPT.*

Introduction

Since total hip arthroplasty (THA) was introduced in 1969, this THA has become a common surgical procedure in past decades for patients with osteoarthritis, rheumatoid arthritis, or osteonecrosis. In China, the number of cases of THA increased from 168,040 in 2011 to 577,153 in 2019 [1]. Additionally, this THA may lead to the impairments in proprioception and further cause the motor abnormalities. These abnormalities have decreased quality of life dramatically and increase the potential risk of falls [2,3]. Therefore, physical rehabilitation following THA is desperately needed because the rehabilitation can effectively reduce the pain, promote functional motor skills, and reduce time spending on recovery [4]. These physical rehabilitations generally are related to the strengthening exercises and functional tasks to improve muscular strength, walking speed and mobility [5-7].

However, the major limitation of these physical rehabilitations is the supervisions of professional physical therapists at a hospital or rehabilitation center is required. Importantly, a study indicated that the total annual cost of physical therapy fee increases approximately $650 million from 1998 to 2009 associated to hospital reimbursements [8]. Thus, this rationale increases the burdens for both society and patients [9]. To resolve this issue, the home-based rehabilitation has been developed in this past decade. Home-based rehabilitation can be categorized into different types as follows: 1) preoperative exercise program; 2) video-based exercise rehabilitation though mobile devices; and 3) tele-physiolotherapy through real-time internet meeting software. Preoperative exercise program is a home-based balance and muscle strength enhancement program before patients receive the THA.

The outcomes reveal that the preoperative exercise program effectively enhance the physical function (faster cadence, greater stride length, greater walking distance and gait velocity), range of motion, and muscle strength (greater muscle strength of flexors, extensors and abductors) after THA. Similarly, as the rapid

technological development, such as tables with mobile internet access, real-time video streaming shows the promise for providing home-based program [10-12]. A study has proven that such a real-time video streaming is feasible for patients following THA [13]. These studies show the effectiveness of home-based rehabilitation under supervision of the physical therapists. However, these programs still didn't resolve the programs, which require the supervision of the physical therapists. Besides, the age of patients included in these studies are 18-65 years, in this range of age, the understanding on how to operate the mobile application with internet access is much greater than those age is 65 and above. In our opinions, it is necessary to train patients with THA to use these video-based rehabilitation carefully during hospital stays. In this study, the goal was to understand two critical rehabilitation questions: 1) did the video-based rehabilitation through mobile application without supervisions of physical therapists also enhance the outcomes during hospital stays? 2) would the video-based exercise have a better outcome than the traditional face-to-face rehabilitation? Based on previous literatures, we hypothesized that video-based rehabilitation should have similar effectiveness on rehabilitation as the traditional face-to-face rehabilitation during hospital stays.

Method

Trial Design: This study was designed by randomized controlled trial in patients with total hip arthroplasty (THA). A total of one hundred twenty patients with THA participated in this study (Table 1). All patients were randomized assigned into two groups (Conventional Physical therapy – CPT, Digital Physical therapy -- DPT) using randomized trial (Figure 1). All patients were recruited at Shanghai First Rehabilitation Hospital. The primary outcomes were as follows:

1) Lower Extremities Functional Score (LEFS), 2) Harris Hip Score (HHS), 3) 10 meters walking test (10mWT), 4) timed up and go (TUG), and 5) Berg Balance Scale (BBS).

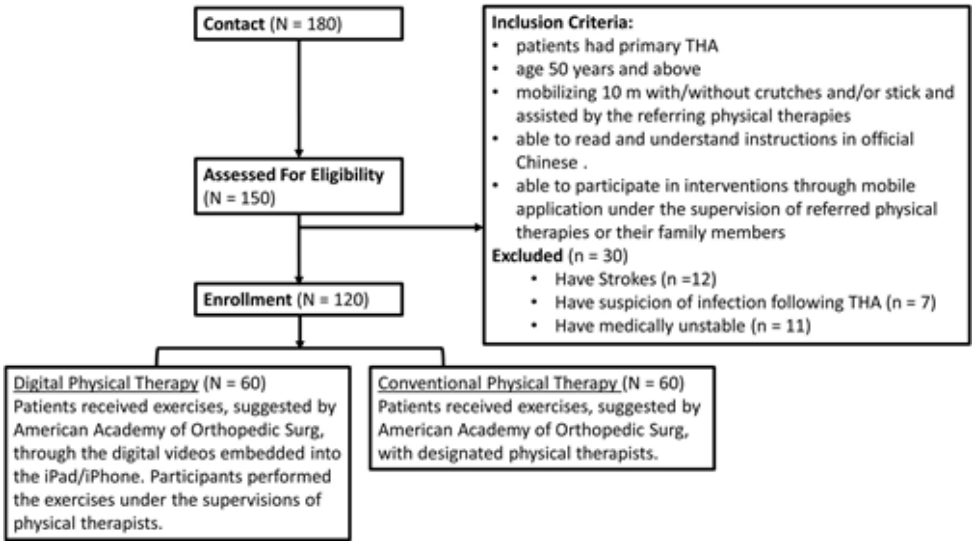

Figure 1: A consort diagram for the inclusion.

Patients: Patients had THA surgery, scheduled inpatient rehabilitation at Shanghai First Rehabilitation Hospital, were asked to participate in this study by a nurse at the admission office and assessed by. The inclusion criteria were 1) patients had primary THA, 2) age 50 years and above, 3) mobilizing 10 m with/without crutches and/or stick and assisted by the referring physical therapies, 4) able to read and understand instructions in official Chinese, and 5) able to participate in interventions through mobile application under the supervision of referred physical therapies or their family members. The exclusion criteria were 1) medically unstable, 2) had central/peripheral nervous disorders, 3) any cardiovascular diseases, 4) stroke, and 5) any suspicion of infection following THA.

Ethical considerations: This study obtained ethical approval from shanghai first rehabilitation hospital ethic committee in 2018.

Blinding: All outcome evaluators were blind to group assignments and were not involved in the interventions. The physical therapists supervising in the DPT, and CPT groups were not blinded. The statisticians were blinded to group allocation.

Randomization and allocation concealment

Before THA, a written document of this study and information was provided to participants during their first day of admission from shanghai first rehabilitation hospital, Shanghai, China. Following obtainment of written consent random allocation using sequentially numbered envelopes to both groups was carried out by administration officers who were not involved in the study. The number sequence was generated using a computer generated by Microsoft Excel software. Participants were randomly allocated either to a DPT group receiving digital Rehabilitation or to a CPT group receiving conventional physical therapy. Patients were asked not to discuss their group allocation and all blinded outcome assessment examinations.

Physical Therapists

Five experienced physical therapists were trained to perform exercise/balance interventions with patients face-to-face in CPT group or to supervise the patients performing the exercise/balance interventions through digital videos recorded by experienced physical therapists. A set of exercises lasted approximately half hour.

Intervention: Patients were allowed to participate this study after one week from THA. These patients were randomly assigned into two groups (DPT and CPT). These two groups received similar exercise/balance interventions based on but not limited to the suggestions from the American Academy of Orthopedic Surg including 1) assisted knee flexion with a strap in lying, knee extension on a towel roll in lying, 3) isometric quadriceps in lying, 4) hip abduction in standing with holding a stable support, 5) hip extension in standing with holding a stable support, hip flexion in standing with holding a stable support, 7) knee flexion in standing with holding a stable support, 8) rotate trunk clockwise and then in anti-clockwise direction in standing without support, 9) lunge in walk standing position without support and repeat with the other leg forward, and 10) shift weight to one side in a stride standing position without support and then repeated on the other side. Participants were advised to perform 10 repetitions for each exercise. 5-10 mins gait and stair training are included in each session. A session lasted approximately half hour and two sessions were given to participants per day and five days per week during their stays.

Also, all patients completed the four-week exercise/balance intervention period. The differences between two groups were that for CPT group, participants received exercise/balance trainings by designated physical therapists; however, for DPT group, participants received exercise/balance training with the customized videos made by designated physical therapists from CAPSAR-health (GOREHA GmbH, German). The evaluations were made at the end of 1st week, and the end of 4th week. All evaluations were made by three experienced physical therapists. Also, patients' family members were pre-educated by physical therapists for using this platform. Although these patients' members carried out the major responsibility assisted patients to use this platform for exercise/balance interventions, designated physical therapists still accompanied and supervised with patients. The CASPAR-health provides a platform for virtually connecting patients to their designated physical therapist through a mobile application.

Importantly, this CASPAR-health platform has been widely used in 183 rehabilitation facilities nationwide (https://caspar-health.com/en-us/clinics). Physical therapist can pre-record the customized rehabilitation exercise into the mobile application and allow patients to follow these exercise/balance interventions. This platform also provided the message function, which allowed patients to ask the question for their designated physical therapists/clinicians. Importantly, physical therapists/clinicians could track the progress of the rehabilitation by this interactive function. Additionally, this CASPAR-health platform also had notification function to remind patients to perform daily based exercises. In the current study, all abovementioned functions were used for building the PDT exercise/balance protocol.

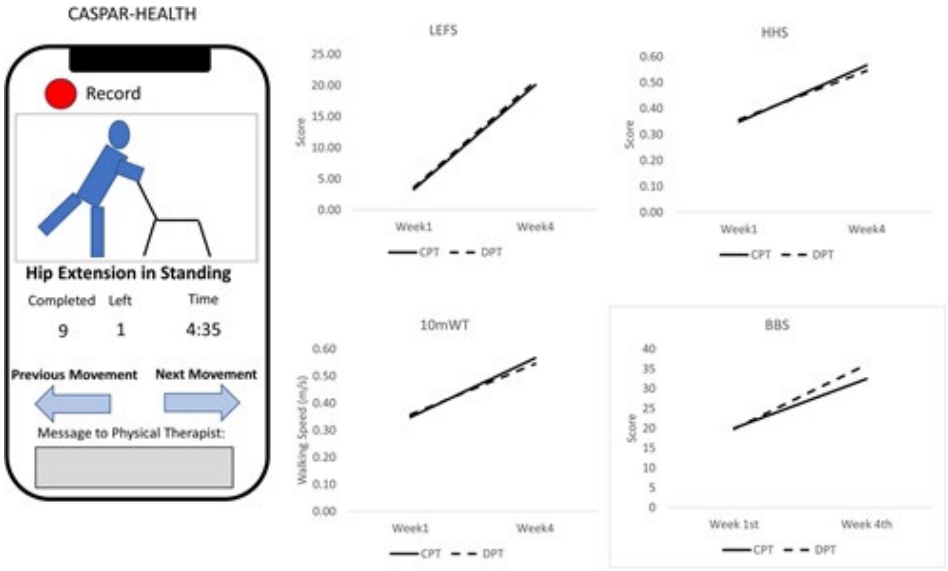

Figure 2: The illustration of CASPAR-Health and each outcome from week 1 and week 4 between two groups: digital physical therapy (DPT) and conventional physical therapy (CPT).

Measurements: Baseline descriptive data was obtained by questionnaire and included age, sex, and BMI (Table 1).

Table 1: Demographic Characteristics of the individuals (N = 120)

	DPT	CPT
Sample size (n)	60	60
Age (years)	71.65(4.99)	71.05 (9.43)
Height (cm)	165 (10)	166 (12)
BMI	21.41 (2.61)	22.46 (1.92)
Gender	28F, 32M	25F, 35M
Side of Hip surgery	24L, 36R	22L, 38R

Outcome measures: Five primary outcomes were used to evaluate the effects of two different interventions. **Lower Extremities Functional Score (LEFS)** was a questionnaire including 20 questions about a person's ability to perform everyday tasks, such as getting into or out the bath, walking between rooms, putting on your shoes or socks and so on [14]. The maximum score was 80, and the scale was from 0 to 4. Lower score indicated greater the disability. **Harris Hip Score (HHS)** was first introduced by Harris (1969) to assess the results after hip surgery [15]. This HHS contained 10 items from three sections: the first section was the questions about pain and its impact, which were answered by patients, the second and third section needed the physical therapists to evaluate the patients' hip joint function (range of motion) during daily activities and gait. The maximum score was 100 and the interpretation was as follows: < 70 = poor, 70-80 = fair, 80-90 = good, 90-100 = excellent. **Ten-meter walking test (10mWT)** was used to measure the walk speed when completing the 10 m walk. **Timed-Up & Go (TUG)** test was a test of functional mobility from sitting on a single chair to walking a 3 m distance, then turning around and sitting down again.

The time of completion was the major measure [16]. The faster the time of completion, the better is the subject's function of mobility. **Berg Balance Scale (BBS)** contained 14 items, which were designed to assess balance control [17]. These 14 balance tasks are scored on a 5-point ordinal scale (0 to 4), with a maximum total score of 56. Higher scores indicated better balance.

Statistical analyses: An independent t test was used to compare two groups' age and BMI. A mixed two-way ANOVA tests with a repeated measure were used to examine each of five outcomes measures by time after THA surgery with rehabilitation (at the 1st, and 4th week) and by two groups (DPT and CPT) If the interaction was found, a Tukey post hoc pairwise comparison was used. All statistical tests were completed using SPSS 21 and used the 0.05 level to denote statistical significance. A priori power analysis using data from previous study with patients with THA (Jogi et al., 2015) indicating that a sample of 30 participants per group could reach the power of 0.80 to identify the statistical significance between groups at a level of 0.05. Thus, a total of 60 participants in this study should provide an appropriate sample size in this study. To understand the effect size, we used the partial eta squared method as this method has been widely used for measuring the effect size, based on Cohen's guideline 0.138 for a large effect size, 0.059 for a moderate effect size, and 0.01 for a small effect size [18].

Results

Age and BMI: No significant differences were found in age and BMI between CPT and DPT groups.

The effect of intervention: a significant effect of intervention was found in LEFS, HHS, 10mWT, TUG, and BBS. Marginal means indicated that longer the rehabilitation time duration better the outcomes were in all measures. All details were written in Table 2.

Table 2: the effect of different groups (DPT & CPT) during different time frame (Week 1 & Week 4) on Lower Extremities Functional Score, Harris Hip Score, Ten-meter walking test, Timed-Up & Go, and Berg Balance Scale. The duration was the two different time frames.

Outcome measure	Effect	F values	p values
LEFS	Duration	F = 5721.2	p < 0.0001
	Groups	F = 4.08	p = 0.046
	Duration X Groups	F = 0.402	p = 0.527
HHS	Duration	F = 1356.47	p < 0.0001
	Groups	F = 0.036	p = 0.850
	Duration X Groups	F = 0.633	p = 0.428
10mWT	Duration	F = 362.64	p < 0.0001
	Groups Duration X Groups	F = 1.992 F = 0.273	p = 0.161 p = 0.802
TUG	Duration Groups	F = 594.01 F = 2.123	p < 0.0001 p = 0.148
	Duration X Groups	F = 0.308	p = 0.580
BBS	Duration	F = 467.52	p < 0.0001
	Groups	F = 8.226	p = 0.005

The differences between the CPT and DPT groups: a significant difference between groups was found in LEFS, and in BBS. A better performance was found in DPT group than CPT group in above mentioned outcome measures.

The interaction between the effect of intervention and effect of Digital Physical Therapy: a significant interaction was found in BBS. Post hoc pairwise comparisons found better performance when receiving DPT than when receiving CPT at 4th week ($p < 0.001$).

The effect sizes

The values of partial eta squared showed 0.98 for LEFS, 0.92 for HHS, 0.754 for 10mWT, 0.834 for TUG, 0.789 for BBS, indicating the large effect size.

Discussion

The aim of this study was to determine the effectiveness of a video-based rehabilitation without supervision of physical therapists compared to the traditional face-to-face rehabilitation under supervisions with physical therapists during hospital stays. The results confirmed that a video- based rehabilitation could be an effective alternative to usual care. First and the most important observations were that the LEFS, HHS, 10mWT, TUG, and BBS had significant improvements after 4 weeks rehabilitation during hospital stays in both DPT and CPT groups. Specifically, the outcomes enhanced 508% in CPT and 469% in DPT for LEFS, 150% in CPT and 140% in DPT for HHS, 62.71% in CPT and 52.63% in DPT for 10mWT, 38.35% in CPT and 40.67% in DPT for TUG, 62.31% in CPT and 81.78% in DPT for BBS.

In particular, the evaluations (LEFS & HHS) related to functions of lower extremities had tremendous improvements from week 1 to week 4, confirming the effective exercise suggested by American Academy of Orthopedic Surg. These results therefore could be concluded that compared to face- to-face conventional rehabilitation, the video-based interactive rehabilitation had a large effect on outcome measures. Secondly, it has been shown that a rehabilitation didn't need to be a conventional setting to be effective [19]. This study further confirmed that using latest technology (digital video interactive- based rehabilitation) can provide further home-based rehabilitation protocol. The rationale was that our patients (average 71.65 years old) could still learn how to use the functions from tablets and further follow the instructions from these mobile applications during stays in hospital. Also, this study confirmed the findings with previous studies that the rehabilitation outcomes from unsupervised at home and supervised in an outpatient's center were similar [20].

Although the DPT rehabilitation group was performed unsupervised during stays in the hospital, our digital video-based rehabilitation mobile application provided an interactive function for patients to leave message to their designated physical therapists. A review by Geraedts et al., (2013) suggested that remote coaching system (interactive message system in this study) might be an excellent alternative for non-real-time supervision [12]. Although the numbers of messages were not quantified in this study, this function was not limited in this study. And our designated physical therapists answered all questions raised from patients in daily-based fashion. Hoogland et al., (2019) who investigated the feasibility of home-based rehabilitation, suggested that patients appreciated the remote support and even believed that this remote support built a positive connection between patients and their physical therapists [13]. This also might be rationale that the improvements in rehabilitation were found in DPT and CPT groups.

Surprisingly, in this study, our results showed that BBS score was significantly better when receiving DPT than when receiving CPT, indicating that a DPT could be more effective than CPT. This rationale might be the Chinese culture. For most of Chinese, it might be embarrassed to ask the similar questions again to the authorities, such as physicians/physical therapists even if they didn't fully understand the instructions. Therefore, the digital video provided the opportunities to review the instructions repeatedly without any limitations and this speculation was suggested by the latest study [21].

A limitation of this study was that we didn't follow the outcome between CPT and DPT after 1 month (after discharging) because patients needed to pay themselves without insurance cover for the home-based rehabilitation; thus, we didn't know whether the DPT could be used at home-based rehabilitation. In future study, the following investigation should be performed to understand the benefit for the DPT. In conclusion, our results clearly showed that DPT was a feasible rehabilitation for future home- based rehabilitation for patients with THA. Furthermore, our results also demonstrated that the DPT might be more effective than CPT in China due to the unlimited training opportunities after THA. In addition, it would be worthwhile to investigate the cost-effectiveness of this DPT.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest

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