Journal of Electromyography and Kinesiology 48 (2019) 205–211

Contents lists available at ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

Functional and postural recovery after bilateral or unilateral total hip arthroplasty

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ARTICLE INFO

Keywords:
Total hip arthroplasty
Functional recovery
Postural analysis

ABSTRACT

One-stage bilateral total hip arthroplasty (THA) implies similar complication rate and hospitalization time to unilateral THA, but no studies have evaluated the functional and postural recovery in these patients. The aim of this study was to assess short-term functional and postural recovery in patients after one-stage bilateral or unilateral THA.

Forty patients undergoing bilateral (n = 20) or unilateral (n = 20) THA were assessed by Timed Up and Go (TUG), Numeric Rating Scale (NRS), Tampa Scale of Kinesiophobia (TSK) and Body Weight Distribution Symmetry Index (BWDSI) during stand-to-sit (STS). Centre of Pressure (CoP) parameters and BWDSI during standing with eyes open (EO) and closed (EC) were also assessed. Data were collected one day before surgery, at three and seven days.

No between-group differences were found for TUG, NRS and TSK at any time-point, showing similar mobility, pain and fear of movement in both groups. BWDSI during STS ($P = 0.001$) and standing (OE $P = 0.007$; CE $P = 0.012$) revealed differences over time in favor of patients with bilateral THA, who showed better symmetry in weight distribution. Shorter CoP path length was observed during standing in patients with unilateral THA (OE $P = 0.023$; CE $P = 0.018$), who mainly used their non-affected limb to maintain balance.

1. Introduction

Total hip arthroplasty (THA) is a successful surgical treatment able to relieve pain and quickly restore independence and quality of life (Learmonth et al., 2007). The rapid improvement in functional performance after this operation ensures a short hospitalization and an early return to daily activities (Umpierres et al., 2014). A considerable number of patients undergoing THA due to the involvement of both hip joints requiring bilateral surgery (Sayeed et al., 2012). The advancements in surgical techniques have made bilateral THA surgery viable through one-stage procedure. This approach seems to be as safe as unilateral THA and even safer than two-stage bilateral THA in terms of postoperative complications and mortality rates (Aghayev et al., 2010; Kim et al., 2009). Furthermore, one-stage bilateral THA demonstrates decreased operative time, shorter hospitalization and better cost-effectiveness compared to two-stage procedure (Romagnoli et al., 2013; Saito et al., 2010; Reuben et al., 1998). One-stage bilateral THA is also associated with satisfactory pain scores and hip functionality similar to unilateral THA (Yoshii et al., 2009). However, the few studies considering functional outcomes in these patients only focus on hip function, assessed through Harris Hip Score and hip Range of Motion (RoM), without exploring any functional or postural ability. (Yoshii et al., 2009; Kim et al., 2017). Moreover, these studies report long-term follow-up results but do not assess motor and functional recovery during the first postoperative days, which are important for planning a safe early postoperative discharge (Aghayev et al., 2010).

The ability to maintain standing posture, to get up and sit down on a chair and to walk for some meters are essential motor tasks of daily life and are used to assess functional recovery after THA (Talis et al., 2008). Considering these tasks in patients with unilateral THA, previous studies report weight bearing asymmetry persisting until one year after surgery (Miura et al., 2018; Chang et al., 2015). The asymmetric limb

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https://doi.org/10.1016/j.jelekin.2019.08.002
Received 28 January 2019; Received in revised form 30 July 2019; Accepted 9 August 2019
1050-6411/

loading may impact on motor and functional recovery after THA and it may be related to pain, fear of movements or muscle weakness, which mainly affect gluteal muscles and depend on surgical approach (Talis et al., 2008; Olsson et al., 2016; Winther et al., 2016). Moreover, patients with unilateral THA show greater postural instability and risk of fall during upright posture, persisting up to 2–3 years after surgery with respect to age-matched asymptomatic individuals (Pop et al., 2018). The asymmetric limb loading could be linked to adaptive strategies with the non-affected limb that hinder the motor potential of the affected limb. These adaptive strategies have already been described not only in patients with unilateral hip or knee osteoarthritis, but also in other pathological conditions of the musculoskeletal system characterized by unilateral involvement of the human body, such as anterior cruciate ligament reconstruction or limb amputation (Labanca et al., 2016; Shakor et al., 2003; Mayer et al., 2011). Bilateral THA is a more invasive operation compared to unilateral THA, but it could have the advantage of preventing adaptive strategies. Thus, the hypothesis of this study was that functional and postural recovery of patients undergoing one-stage bilateral THA could be similar or faster than recovery of patients undergoing unilateral THA. To our knowledge, no studies have compared the recovery in these cohorts of patients in the first week after surgery. Thus, the aim of this study was to compare short-term functional and postural recovery in patients with one-stage bilateral or unilateral THA.

2. Methods

2.1. Participants

This was a prospective observational study following the STROBE reporting guidelines (von Elm et al., 2007). Patients hospitalized for THA surgery at the Hip and Knee Orthopedic Unit of Humanitas Clinical Institute were enrolled between September 2017 and July 2018. Inclusion criteria were: primary cementless THA for severe unilateral or bilateral osteoarthritis (Kellgren&Lawrence grade III), age between 45 and 65 years and ability to walk 50 m without aids. Exclusion criteria were: surgery due to severe dysplasia (Crowe III and IV) or hip ankyloses, previous traumatic events (i.e. femur or pelvic fractures), femoral or pelvic osteotomy, revision surgery, difference between the length of the left and right leg greater than 1 cm and presence of neurological and/or other musculoskeletal disorders that may influence functional recovery (i.e. rheumatoid arthritis, spondylitis, severe osteoporosis or upper limb disorders limiting the use of walking aids). Since our Institute performs bilateral THA in under 65-year-old individuals, older patients were excluded in order to compare age-matched groups. Inclusion and exclusion criteria were assessed by an orthopedic surgeon involved in the study according to criteria of the American College of Rheumatology (Altman et al., 1991). Sample size was estimated using the Timed Up and Go (TUG) as the primary outcome. Considering a Minimal Detectable Change (MDC_{95}) of 6.2 s, standard deviation of 7.2 s, 80% of power and alpha error of 5%, 20 patients were required for each group (Naylor et al., 2014). Therefore, 20 patients with bilateral osteoarthritis underwent bilateral THA, while 20 patients with osteoarthritis on one side and a contralateral asymptomatic limb underwent unilateral THA. Table 1 shows the study participants' characteristics. All study participants were operated under spinal-epidural anesthesia by three orthopedic surgeons of the same team with the same surgical technique, based on the posterolateral approach. On the evening of the operation and every 12 h for 4 days patients received oral ketoprofen (100 mg) and ranitidine (50 mg). On the morning after surgery all patients took oral oxycodone-naloxone (10/5 mg) every 12 h for 4 days. Rescue paracetamol (1 g) was delivered in case of NRS < 4 until discharge. After surgery, all patients underwent the same supervised rehabilitation program, consisting of two daily sessions aimed at increasing muscle strength, RoM, balance and functionality in daily activities such as mobility and walking with crutches. The study was approved by the Ethical Committee of Humanitas Clinical Institute (n. CLF17/2 of March 20, 2017) and registered at clinicaltrial.gov (n. NCT03378986). All study participants signed informed consent.

Table 1
Characteristics of patients with bilateral and unilateral THA (unpaired *t*-test or chi-square test). Data are shown as mean and standard deviation.

	Bilateral THA n = 20	Unilateral THA n = 20	p-value
Age (years)	51.6 ± 6.4	53.1 ± 6.2	0.472
Gender	18 M/2W	14 M/6W	0.114
Weight (kg)	81.7 ± 14.8	78.3 ± 12.7	0.441
Height (cm)	175.5 ± 8	171 ± 8.7	0.094
Dominant limb	16R/4L	16R/4L	0.376
K&L grade III (n.)	20	20	1
NRS (0–10)	1.6 ± 2	2.4 ± 2.2	0.241

R: Right, **L**: Left, **M**: Men, **W**: Women, **K&L**: Kellgren&Lawrence, **NRS**: Numeric Rating Scale.

2.2. Functional, subjective and postural assessment

All study participants underwent a functional assessment the day before (T0) and seven days after surgery (T2), whereas subjective and postural assessments were performed also at three days after surgery (T1). Data were collected by the same physiotherapist at the Motion Analysis Lab of the Humanitas Clinical Institute and analyzed by an engineer.

Functional assessment: patients were evaluated with Timed Up and Go (TUG) test performed without aids, which represents a valid tool to assess functional recovery in the first days after THA (Poitras et al., 2016). Patients were asked to rise from an armchair, walk at a comfortable pace for three meters, turn and walk back to the chair and sit down again. The performance was repeated three times interspersed with two minutes of rest and only the best test was used for data analysis. The test was not administered at T1 to avoid exposing patients to risk of fall.

Subjective assessment: before postural assessment, Tampa Scale of Kinesiophobia (TSK) was used to quantify fear of movement during daily activities performed by patients (Monticone et al., 2010; Heuts et al., 2004; Olsson et al., 2016). TSK consists of a 17-item self-administered questionnaire with a score ranging from 17 to 64 (maximum kinesiophobia). Finally, at the end of the postural assessment, patients were asked to indicate perceived pain using the Numeric Rating Scale (NRS). This scale is an 11-point numeric scale with a score ranging from 0 to 10 (maximum pain), representing a valid tool for pain intensity assessment after THA (De Luca et al., 2018).

Postural assessment: postural tasks were recorded with an eight-camera optoelectronic system (SMART DX, BTS, Italy) synchronized with two force platforms (P-6000, BTS, Italy). Three retro-reflective markers were placed on the two acromial angles and on the seventh cervical vertebra to detect their motion with the optoelectronic system (Sibella et al., 2003). The following tasks were recorded:

Standing - patients were asked to stand barefoot in standing position with their arms crossed over their chest. The same operator ensured that the feet of the study participants were positioned parallel on two adjacent force platforms with heels at 10 cm apart and equidistant from the medial edges (Paillard and Noé, 2015). Study participants were asked to maintain the standing position for 60 s with eyes open (EO) while looking at a fixed point placed in front of them at two meters distance. After resting for 5 min, the same test was executed with eyes closed (EC).

Stand-to-Sit - patients were seated on an adjustable-height chair with back support, with knees flexed at 100°. Feet were placed parallel on two adjacent force platforms with heels at 20 cm and equidistant from the medial edges. Patients were asked to stand up and, after 10 s, they were asked to sit down with their arm across their chest returning to the

Table 2

Functional and subjective outcome measures before surgery (T0), at three (T1) and seven days (T2) in both groups (Mixed model ANOVA and post-hoc within-group comparison). Data are shown as mean and standard deviation. Significant results are shown in bold text.

	T0		T1		T2		p-value (F-score) Time Factor	p-value (F-score) Between Group	p-value (F-score) Time × Group
	Bilateral THA	Unilateral THA	Bilateral THA	Unilateral THA	Bilateral THA	Unilateral THA			
Functional assessment									
TUG (sec)	9.9 ± 2	9.9 ± 1.7	–	–	15.9 ± 5.7	13.3 ± 2.4	**< 0.001** †† §§ **(49.027)**	0.240 (1.434)	0.157 (2.132)
Subjective assessment									
NRS (0–10)	1.6 ± 2	2.4 ± 2.2	0.7 ± 1.4	1.1 ± 1.6	1.3 ± 2.1	0.7 ± 1.8	**0.004** † **(6.042)**	0.632 (0.233)	0.115 (2.226)
TSK (17–64)	36.2 ± 8.6	33.9 ± 7.3	29.7 ± 8.9	29.2 ± 8.7	26.6 ± 8.6	28 ± 9.6	**< 0.001** † § ¶ § **(20.895)**	0.851 (0.036)	0.355 (1.098)

TUG: Timed Up and Go test, **NRS**: Numeric Rating Scale, **TSK**: Tampa Scale of Kinesiophobia.
* T0vsT1 $p < 0.05$.
** T0vsT1 $p < 0.001$ in Unilateral THA.
¶¶ T0vsT1 $p < 0.001$ in Bilateral THA.
† T0vsT2 $p < 0.05$.
†† $p < 0.001$ in Unilateral THA.
¶ T0vsT1 $p < 0.05$.
§ T0vsT2 $p < 0.05$.
§§ $p < 0.001$ in Bilateral THA.

same initial position. Only the stand-to-sit component of the task (STS) was processed due to the inability of several participants to rise from the chair without using their arms. The retro-reflective markers on the seventh cervical vertebra and on the two acromial angles were used to detect the beginning (Start-Sit) and the end (End-sit) of the STS task. The Start-Sit event was defined when the velocity of the markers on the acromial angles and the seventh cervical vertebra exceed 0.1 m/s in anterior direction, while the End-Sit was defined when the Ground Reaction Force (GRF) reached the baseline value, representing the amount of GRF in sitting position before the beginning of the sit-to-stand component of the task. (Talis et al., 2008).

2.3. Data processing

Three-dimensional marker data were sampled at 100 Hz and filtered using a Butterworth fourth-order low-pass filter (cut-off 2 Hz). During standing, the three components of GRF were sampled at 200 Hz and down-sampled at 20 Hz. Load distribution, GRF value, center of pressure (CoP) parameters were computed for the standing task, whereas only the load distribution was assessed during STS.

Load distribution to evaluate any asymmetries in load distribution during standing and STS, postural Body Weight Distribution Symmetry Index (BWDSI) was calculated using the formula: (Chang et al., 2015):

$$\text{BWDSI} = \left(\frac{\text{Load}_R - \text{Load}_L}{\text{Load}_R + \text{Load}_L}\right) * 100$$

Load_R and Load_L are the vertical component of GRF over right and left lower limbs. They represented the average value during the 60 s of standing task and between Start-Sit and End-Sit events of the STS. A BWDSI of zero denotes perfect symmetry.

GRF values: the mean value of vertical GRF during standing task in OE and EC conditions was computed.

CoP parameters: in accordance with previous studies, the range in anterior-posterior (CoP-AP) and medial-lateral (CoP-ML) directions and its total Path Length (CoP-PL) were analyzed (Chang et al., 2015). CoP-AP and CoP-ML represent the difference between maximum and minimum displacement of CoP in AP and ML directions, whereas CoP-PL is the sum of CoP two-dimensional displacement at each time-frame. In particular, CoP-PL was adopted, based on its clinical relevance for association with risk of fall (Johansson et al., 2017). All parameters were normalized to participants' height according to literature (Rigoldi et al., 2013). The analysis of kinetic and kinematic data was developed using Smart Analyzer software (BTS, Milan, Italy).

2.4. Statistical analysis

Data were checked for normality using Shapiro-Wilk test and, being normally distributed, were described by mean and standard deviation. Mixed Model Analysis of Variance (ANOVA) with Time as within-subjects variable and Group as between-subjects variable was used to evaluate between-group differences over time in presence of repeated measures and to incorporate any missing data. In case of significance, Univariate ANOVA was used to compare between-group values at T0, T1 and T2, whereas One-way repeated measure ANOVA was used to perform within-group comparison between the three time-points. Post-hoc analysis with Bonferroni correction was performed in case of significance of One-way repeated measure ANOVA and adjusted p-value was reported. Data were analyzed using SPSS 25.0 for Windows and the statistical level of significance was set at $\alpha = 0.05$.

3. Results

All patients completed the evaluation correctly at each time-point and no missing data occurred. At baseline, both groups had a Kellgren& Lawrence grade of III and a NRS score of 1.6 ± 2 in patients with bilateral THA and 2.4 ± 2.2 in patients with unilateral THA (mean ± standard deviation). No statistically significant difference was found for age, gender, height, weight and dominant limb (Table 1).

3.1. Functional assessment

No Time by Group interaction was observed, whereas a change depending on Time was detected for TUG, which showed a worsening in both groups after surgery (Table 2). Within-group post-hoc analyses are indicated in Table 2.

3.2. Subjective assessment

No Time by Group interaction was observed, whereas a change depending on Time was detected for NRS and TSK. In particular, NRS decreased, resulting in reduced pain in patients with unilateral THA from T0 to T2, and TSK scores improved, indicating reduced fear of movement in both groups after surgery (Table 2). Within-group post-hoc analyses are indicated in Table 2.

Table 3
Postural outcome measures before surgery (T0), at three (T1) and seven days (T2) in both groups. (Mixed model ANOVA and post hoc within-group comparison). Data are shown as mean and standard deviation. Significant results are shown in bold text.

	T0		T1		T2		p-value (F-score) Time Factor	p-value (F-score) Between Group	p-value (F-score) Time × Group
	Bilateral THA	Unilateral THA	Bilateral THA	Unilateral THA	Bilateral THA	Unilateral THA			
Eyes Open									
BWDSI (%)	12.8 ± 7.6	12.1 ± 10.1	10.2 ± 7.1	20.4 ± 14	7.8 ± 6.7	16.4 ± 12.2	0.151 (1.956)	**0.017 (5.364)**	**0.007** * **(6.279)**
GRF (N)	798 ± 140	756 ± 115	807 ± 138	762 ± 114	802 ± 148	755 ± 115	**0.032 (3.618)**	0.277 (1.216)	0.616 (0.488)
CoP-AP (mm/m)	31 ± 11	33 ± 8	29 ± 9	31 ± 10	34 ± 12	31 ± 8	0.305 (1.206)	0.980 (0.001)	0.105 (2.318)
CoP-ML (mm/m)	3 ± 3	4 ± 3	3 ± 3	4 ± 3	3 ± 3	5 ± 2	0.885 (0.122)	0.053 (3.050)	0.482 (0.736)
CoP-PL (mm/m)	343 ± 122	324 ± 53	408 ± 141	349 ± 83	460 ± 200	349 ± 69	**0.001** ¶, § **(13.009)**	0.078 (3.274)	**0.026 (5.386)**
Eyes Closed									
BWDSI (%)	11.1 ± 6.9	12 ± 11.5	10.6 ± 5.3	20.6 ± 13.1	9.2 ± 7.3	15.1 ± 12.9	**0.017** * **(4.313)**	**0.042 (4.414)**	**0.012 (4.678)**
GRF (N)	797 ± 139	759 ± 114	806 ± 140	766 ± 115	799 ± 144	759 ± 118	0.051 (3.090)	0.336 (0.950)	0.957 (0.044)
CoP-AP (mm/m)	43 ± 31	35 ± 18	36 ± 13	34 ± 10	40 ± 11	35 ± 9	0.444 (0.718)	0.151 (2.145)	0.456 (0.687)
CoP-ML (mm/m)	5 ± 5	3 ± 3	3 ± 3	5 ± 3	3 ± 3	4 ± 3	0.749 (0.104)	0.802 (0.064)	**0.018** * **(6.276)**
CoP-PL (mm/m)	522 ± 294	365 ± 74	597 ± 280	458 ± 150	598 ± 255	456 ± 136	**0.014** * † **(6.569)**	**0.021 (5.826)**	0.802 (0.064)
Stand-To-Sit									
BWDSI (%)	10.3 ± 8.6	13.9 ± 10.1	10.9 ± 9.1	34.6 ± 18.3	12.7 ± 8.8	30.9 ± 14.3	< **0.001** ** †† **(9.714)**	< **0.001 (35.575)**	< **0.001 (7.406)**

BWDSI: Body Weight Distribution Symmetry Index, **GRF**: Ground Reaction Force, **CoP**: Centre of Pressure, **PL**: Path Length, **AP**: Anterior-Posterior, **ML**: Medial-Lateral.
¶¶ T0vsT1 $p < 0.001$ in Bilateral THA.
§§ $p < 0.001$ in Bilateral THA.
* T0vsT1 $p < 0.05$.
** T0vsT1 $p < 0.001$ in Unilateral THA.
† T0vsT2 $p < 0.05$.
†† $p < 0.001$ in Unilateral THA.
¶ T0vsT1 $p < 0.05$.
§ T0vsT2 $p < 0.05$.

3.3. Postural assessment

The analysis is summarized with respect to the different tasks (Table 3).

Standing Eyes Open: A Time by Group interaction was found for BWDSI (P = 0.007, F = 6.279) and CoP-PL (P = 0.026, F = 5.386) (Figs. 1a, 2a). Post-hoc analysis showed a BWDSI closer to zero in patients with bilateral THA at T1 (P = 0.007) and T2 (P = 0.009), whereas shorter CoP-PL (P = 0.024) was found in patients with unilateral THA at T2. Moreover, a change depending on Group was found for BWDSI (P = 0.017, F = 5.364), whereas changes depending on Time was detected for CoP-PL (P = 0.001, F = 13.009) and GRF (P = 0.032, F = 3.618). Within-group post-hoc analyses are shown in Table 3.

Standing Eyes Closed: A Time by Group interaction was found for BWDSI (P = 0.012, F = 4.678) and CoP-ML (P = 0.019, F = 6.007), whereas changes depending on Group was found for BWDSI (P = 0.042, F = 4.414) and CoP-PL (P = 0.021, F = 5.826) (Figs. 1b, 2b). Post-hoc analysis showed a BWDSI closer to zero (P = 0.003) and lower CoP-ML (P = 0.042) in patients with bilateral THA at T1, whereas shorter CoP-PL was found at T0 (P = 0.026), and T2 (P = 0.033) in patients with unilateral THA. Moreover, changes depending on Time were detected for BWDSI (P = 0.017, F = 4.313) and for CoP-PL (P = 0.014, F = 6.569). Within-group post-hoc analyses are shown in Table 3.

Stand-to-sit: A Time by Group interaction (P < 0.001, F = 7.406) and changes depending on Group (P < 0.001, F = 35.575) and Time (P < 0.001, F = 7.406) were found for BWDSI-STS. Post-hoc analysis revealed a BWDSI-STS closer to zero at T1 (P < 0.001) and T2 (P < 0.001) in patients with bilateral THA. Within-group post-hoc analyses are shown in Table 3.

Fig. 1. a and b. Greater symmetry in Body Weight Distribution Symmetry Index during standing with eyes open and closed in patients with bilateral total hip arthroplasty. Lower values indicate better symmetry in weight distribution.

4. Discussion

The aim of the study was to evaluate the functional and postural recovery in patients after bilateral or unilateral THA during the first postoperative days. The main finding was that patients with bilateral

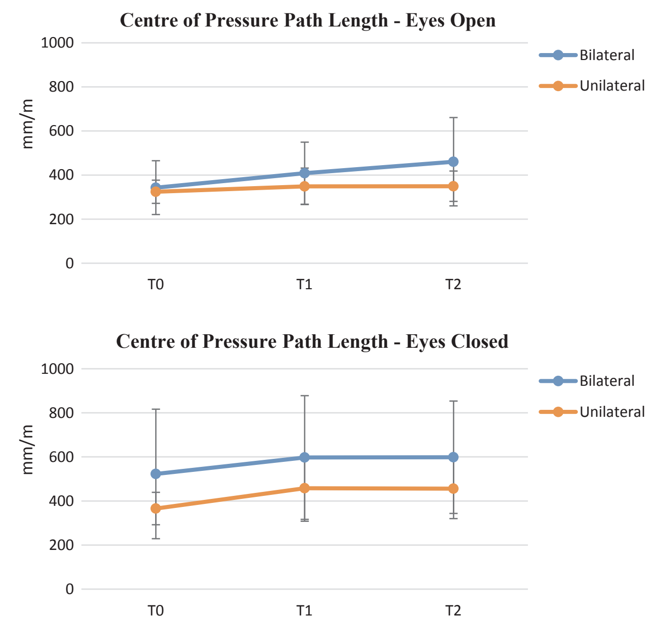

Fig. 2. a and b. Shorter Centre of Pressure Path Length during standing with eyes open and closed in patients with unilateral total hip arthroplasty. Lower values indicate better postural stability.

THA revealed better symmetry in body weight distribution than patients with unilateral THA as well as similar functional mobility, pain and fear of movement. At seven days, greater postural stability was observed in patients with unilateral THA who mainly used their non-affected limb to maintain balance.

At baseline, no between-group differences were found for demographic variables or outcome measures, except for CoP-PL in EC condition, which was greater in patients with bilateral THA, denoting a lower postural stability when the degenerative process involved both hip joints (Sanchez-Heran et al., 2016).

Physiological functional mobility is a goal after THA in order to promote early discharge and complete return to activities of daily living. The TUG test represents a tool to assess functional recovery and risk of falls in these patients immediately after surgery (Poitras et al., 2016) (Nankaku et al., 2013). Poitras et al. evaluated this variable shortly after THA, reporting a TUG score lower than 30 s on the second postoperative day as a predictor of functional independence and safe discharge (Poitras et al., 2015). In fact, previous studies reported that mobility decreases in the first days after unilateral THA and usually reaches preoperative values at 6 weeks (Poitras et al., 2016). At seven days, even though mobility of both groups remained lower than baseline, their TUG score was similar to that found by other authors at 1 month in age-matched patients with unilateral THA (Judd et al., 2014). However, considering the normative reference value of 9.9 ± 2.3 s for individuals between 50 and 59 years, a residual risk of fall in our patients could not be excluded (Kear et al., 2017).

Pain can affect functional recovery after THA (Husted et al., 2011). It negatively influences patients' functional abilities, sleep and cognition, and its control is essential to ensure expected recovery (Olsson et al., 2016). In our study, pain reported by both groups during the first postoperative week decreased when compared to pain before surgery but perhaps was too low to influence functional recovery. In addition, it is reasonable to speculate that postoperative pharmacological treatment ensured good pain management.

Studies have described fear of movement as a common condition after orthopedic surgery consisting of cognitive and behavioral elements that lead to mobility reduction and postural instability, slowing the functional recovery (Sanchez-Heran et al., 2016; Meier et al., 2016). In our study, TSK decreased similarly in the two groups on third day after surgery. Studies have found a relationship between TSK score and pain at five days after orthopedic surgery, such as total knee arthroplasty (Filardo et al., 2016). Therefore, decreased fear of movement in our patients could be related to low level of pain. Moreover, in patients with anterior cruciate ligament reconstruction, fear of movement has been reported as decreasing during rehabilitation process, revealing a correlation with residual disability and quality of life (Tichonova et al., 2016). Consequently, since decrease in fear of movement has been related to functional and subjective outcomes, the good level of functional mobility achieved by study participants could explain the observed reduction. Finally, postoperative awareness of improved health status compared to preoperative status might also play a role in reduced fear of movement (Larsson et al., 2016).

Instrumental postural assessment provided information on characteristics of functional recovery. Standing task revealed quasi-symmetrical body weight distribution in patients with bilateral THA both in EO and EC conditions, whereas patients with unilateral THA mainly loaded their non-affected limb. This asymmetry increased sitting on a chair, when greater lower limbs muscular activity is required. This behavior was still present one week after surgery and is reported as persisting for several months (Chang et al. 2015). In addition, patients with unilateral THA showed greater postural stability than patients with bilateral THA, in which surgery compromised the musculoskeletal and somatosensory system of both hip joints (Dominguez-Navarro et al., 2018). It is reasonable to speculate that patients after unilateral THA mainly relied on the non-affected limb to stabilize the whole body. Studies have shown that weight bearing asymmetries in patients with unilateral musculoskeletal disorders induce patients to organize postural control around the non-affected side to minimize postural sway (Mayer et al., 2011). The development of adaptive strategies with the non-affected lower limb has been described during functional tasks in patients after unilateral THA or anterior cruciate ligament surgery, where reduced loading on the affected limb could result from muscle weakness (Martinez-Ramirez et al., 2014; Labanca et al., 2016). Moreover, although a single study has investigated arthrogenic muscular inhibition in hip joints, such inhibition may also contribute to asymmetric loading (Freeman et al., 2013). In addition, edema and pain, affecting only one body side, may play a role in determining these results. Therefore, while functional recovery in patients with unilateral THA could be explained through adaptive strategies with the non-affected limb, in case of bilateral THA it could derive from greater motor recovery of the affected limbs, due to patients' inability to compensate with the contralateral body structures.

Some limitations of this study need to be underlined. First, the mean age is different from populations usually undergoing THA. However, patients eligible for bilateral THA are younger than those with unilateral THA, consequently an under 65 population was considered to compare age-matched groups (Kim et al., 2017). Moreover, the age of patients undergoing THA is decreasing with increased incidence among young adults (Skytta et al., 2011). Second, the number of men was greater in both groups and, since a slower functional recovery has been reported in women, caution is needed to generalize our results (Vincent et al., 2006). Third, we studied the motor and functional recovery in *peri*-operative phase, without providing a medium or long-term follow-up. Therefore, since hospitalization time has decreased, current findings could assist clinicians to understand trajectory of recovery at discharge, but no long-term conclusions can be drawn (Husted et al., 2011).

Fourth, although no study participants reported symptoms or adverse events during the evaluation sessions, other factors able to affect symmetry in limb loading and postural stability in the early postoperative period (i.e. muscle weakness, blood pressure, hemoglobin values, etc.) were not considered in the present study. In particular, as the surgical approach may impact on surgical and functional outcomes after THA, our results could not be generalized to all patients (Petis et al., 2015). Moreover, although the non-affected side of patients who underwent unilateral THA was asymptomatic, the hip joint status was not assessed by imaging techniques. Finally, since pain was measured at the end of functional and postural assessments, we have no information about its effects on performance of each task.

In conclusion, in addition to clinical advantages of bilateral THA, similar trajectory of functional recovery, reduced pain and fear of movement were found compared to unilateral surgery. Furthermore, bilateral THA enhances symmetry in body weight distribution on operated limbs during functional tasks, differently from patients with unilateral THA who mainly use their non-affected limb to ensure postural stability.

The current findings might have implications in management of patients with bilateral or unilateral THA. The focus on short-term functional and postural recovery could help physiotherapists in selecting proper rehabilitation approaches immediately after surgery. It is worth noting that hospitalization time is decreasing, and treatments focused on patients' clinical features shortly after THA, have been described as also influencing post-discharge recovery. Moreover, since bilateral surgery seems to enhance lower limbs motor recovery without compromising functional recovery, our results might support orthopedic surgeons in deciding on this approach also when an early recovery is expected.

Declaration of Competing Interest

None

Acknowledgements

The authors thank Dr. Emanuela Morenghi for suggestions on data analysis and Patricia Taylor for language revision.

Funding sources

The authors received no funding

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