GSC Advanced Research and Reviews
eISSN: 2582-4597 CODEN (USA): GARRC2
Cross Ref DOI: 10.30574/gscarr
Journal homepage: https://gsconlinepress.com/journals/gscarr/

(Research Article)

Quantitative Gait Analysis Before and After Total Hip Arthroplasty

Omaima GHILAL *, Meryem ELMAJIDI, Fatima azzahra ANJJAR, Ahlam NACIRI, Fatima zahra KHADIM, Asmaa ELHANAFI and Youness ABDELFETTAH

Department of Physical Medicine and Functional Rehabilitation, Faculty of Medicine and Pharmacy of Marrakech, Cadi Ayyad University, Mohammed VI University Hospital, Marrakech, Morocco.

GSC Advanced Research and Reviews, 2026, 26(02), 178-188

Publication history: Received on 19 January 2026; revised on 24 February 2026; accepted on 27 February 2026

Article DOI: https://doi.org/10.30574/gscarr.2026.26.2.0054

Abstract

INTRODUCTION: Quantified gait analysis is essential for assessing joint function, detecting deficits surrounding arthroplasty, and ensuring recovery of normal walking patterns.

OBJECTIVE: Assess hip functional deficits after total hip arthroplasty.

MATERIALS AND METHODS: we conducted a prospective longitudinal observational cohort study on a series of 10 patients who underwent THA, evaluated preoperatively and then at 1, 3, and 6 months postoperatively using AQM, in collaboration with Orthopedic Traumatology, Physical Medicine, and Gait Analysis Laboratory, Mohamed VI University Hospital, Marrakech

RESULTS: Patients averaged 37.8 years, 70% male; 60% had primary coxarthrosis. All followed a standardized rehabilitation starting 24 hours post-surgery with assisted weight-bearing. No immediate complications occurred. Data from the quantified gait analysis reveal a gradual evolution of spatiotemporal parameters towards normal reference values, A significant improvement in speed (0.708 to 0.875 m/s), cadence (93.1 to 101.7 steps/min), and stride length (0.93 to 1.036 m). In addition, joint amplitudes are approaching the normal range, indicating a significant improvement in joint function in patients after surgery.

CONCLUSION: This study demonstrates that, after adequate care and an appropriate rehabilitation protocol, patients who have undergone total hip replacement are able to regain an almost normal gait.

Keywords: Analysis; Kinematics; Kinetics; Walking; Hip; Arthroplasty

1 Introduction

Total hip arthroplasty is one of the most effective treatments for severe degenerative hip conditions [1,3]. Despite the clinical improvement reported by functional scores, residual kinematic deficits may persist after surgery [8,13]. Quantified gait analysis provides an objective three-dimensional assessment of functional recovery and allows detection of subtle biomechanical alterations that may not be captured by conventional clinical evaluation [4,6].

The aim of this study was to analyze gait kinematics, with particular focus on hip motion, in patients who underwent total hip arthroplasty for coxarthrosis. Specifically, we sought to determine whether functional deficits persist after surgical correction and to evaluate the effectiveness of postoperative rehabilitation in restoring a physiological gait pattern.

* Corresponding author: Omaima GHILAL

2 Methods

2.1 Type of study

Prospective longitudinal observational cohort study conducted in 2024.

2.2 Study sitting

Mohammed VI University Hospital, Marrakech – Physical Medicine and Rehabilitation Department, Gait Analysis Laboratory, Traumatology Department.

2.3 Population

10 adult patients who underwent surgery for severe hip joint disease and received total hip arthroplasty using different surgical techniques. (18 patients were initially included, eight of whom were excluded bringing the final number to 10 patients)

2.3.1 Inclusion criteria

- Patients of both sexes
- Age > 18 years
- Ability to walk for more than two minutes without technical aids.
- Patients diagnosed with severe hip joint damage requiring total hip replacement.
- Ability to understand and follow study instructions.
- Patients who have given their consent to participate in the study.

2.3.2 Exclusion criteria

- BMI > 40
- Other severe conditions or comorbidities that could influence the results of the study on the homolateral or contralateral side.
- A history of total hip arthroplasty (revision)
- Musculoskeletal or neurological impairment interfering with
- walking or balance. Assessments: Preoperative AQM, at 1 month, 3 months, and 6 months; SF-36 score and Harris Hip Score.

2.4 Measured parameters included

Spatio-temporal variables: cadence, stride length, walking speed, walking cycle duration, stance and swing phase durations

Joint kinematics (sagittal plane): movements of the pelvis, hip, knee, and ankle

2.4.1 Data collection

Questionnaire administered to patients who gave their consent, in the form of an interview conducted by the same person.

Observational data collected using gait analysis software (Motiv* and Visual3D*).

2.5 Statistical analysis

The data collected was analyzed using Microsoft Office Excel 2021 software. This analysis involved calculating the mean and standard deviation for quantitative variables, as well as calculating percentages for qualitative variables.

2.6 Gait analysis

Gait analysis was performed in the hospital's motion analysis laboratory using a complete set of equipment including:

6 optoelectronic cameras (Optitrack®)

- 2 force platforms (AMTI®)

- An 8-channel wireless EMG system (Delsys®)
- Motiv® and Visual3D® software for data processing

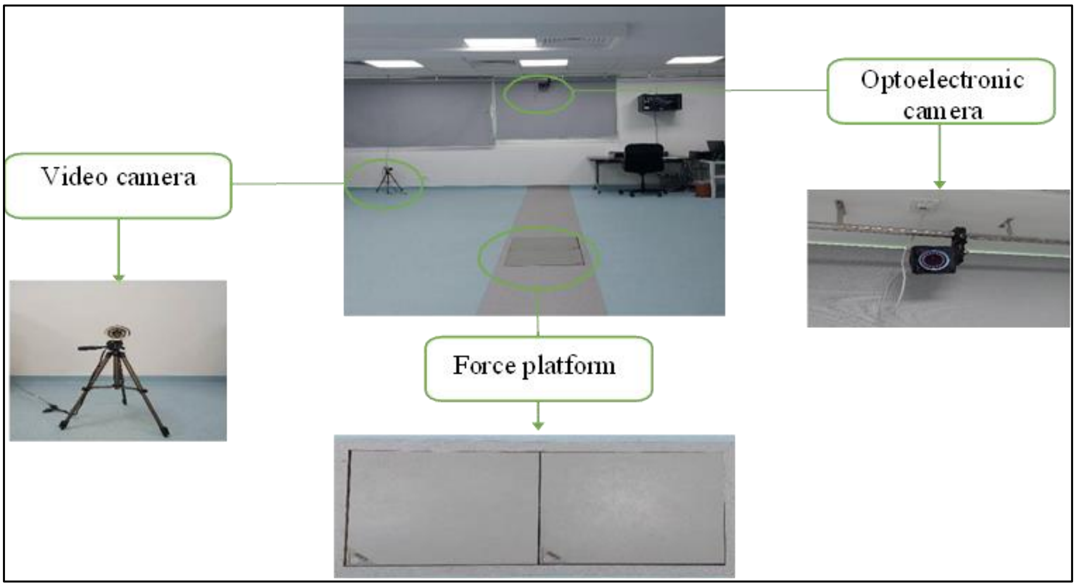

Figure 1 Gait and movement analysis laboratory at Marrakech University Hospital

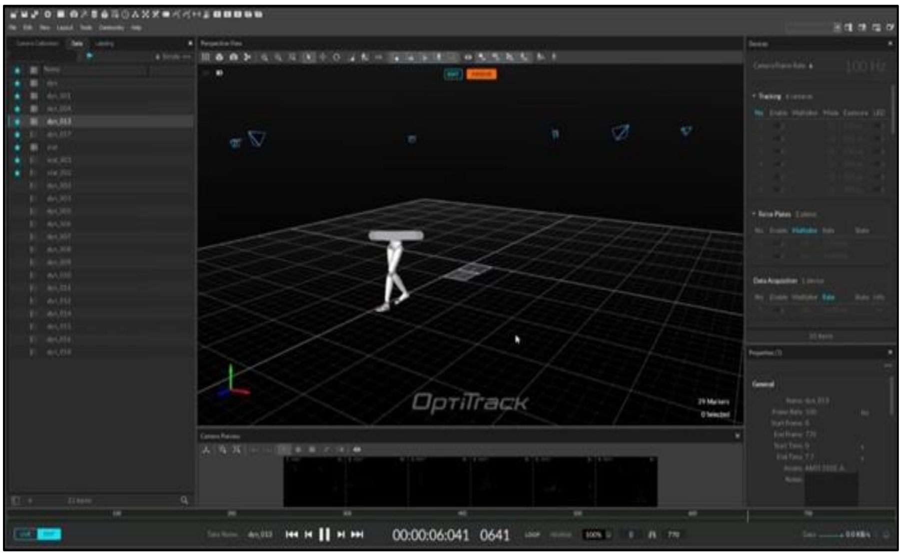

Figure 2 Interface of the Motiv software for quantified gait analysis

Figure 3 Markers for the Rizzoli lower body protocol

3 Results

3.1 Socio-demographic data:

- Number of patients: Eighteen patients were initially included, eight of whom were excluded (inability to walk without assistance, non-cooperation, lower limb inequality, disabling pain), bringing the final number to 10 patients. A total of 444 walking cycles were analyzed.
- Age: The age of our patients ranged from 18 to 62 years, with an average of 37.8 years. The most common age group was between 18 and 39 years, representing 60% of cases. (Figure 4)

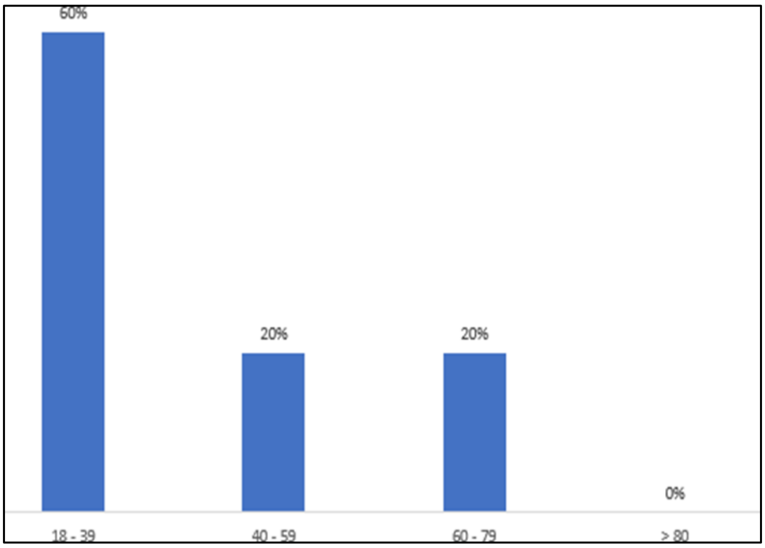

Figure 4 Distribution of patients by age in years

Gender: Our series included a majority of men (70%), with a sex ratio of 2.34. (Figure 5)

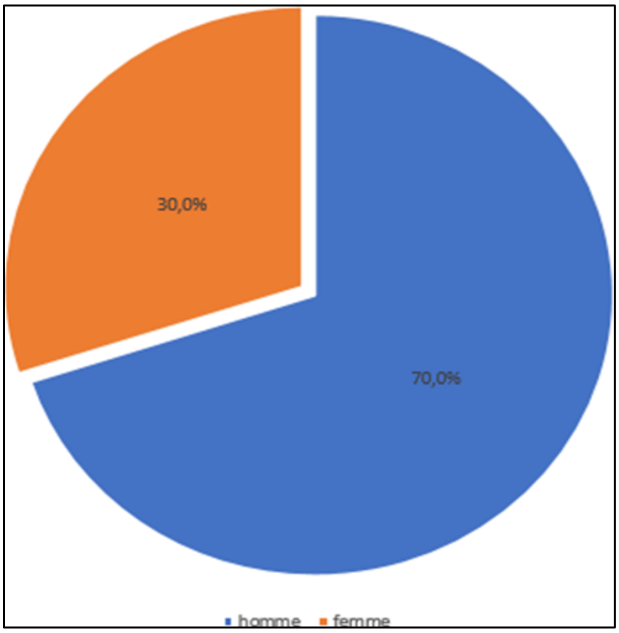

Figure 5 Distribution of patients by gender

- Medical history: included ankylosing spondylitis (20%), type 2 diabetes associated with high blood pressure (10%), rheumatoid arthritis (10%), and psoriatic arthritis (10%). A history of surgery was noted in 20% of patients (appendectomy 10%, cataract surgery 10%).
- Sports activity: Sixty percent of patients did not participate in any sports activities; 40% were classified as active according to the CLAS system.
- Etiologies: In our series, 60% of cases were due to primary or idiopathic coxarthrosis, while the remaining 40% were caused by secondary coxarthrosis. (Figure 6)

The causes of secondary coxarthrosis include ankylosing spondylitis in 50% of cases, and rheumatoid arthritis and psoriatic arthritis in 25% of cases each.

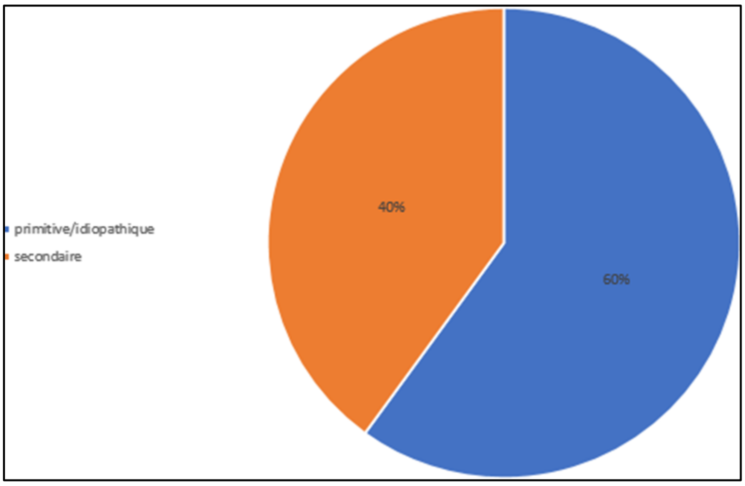

Figure 6 Distribution of patients according to the etiology of coxarthrosis

- Dominant side: In our series, 100% of patients were right-handed.
- Affected hip: In our series, the right hip was the most affected, with 60% of cases, while the left side accounted for 40% of cases.

3.2 Anthropometric data

- Weight (kg): 67.4 ± (54–83)

- Height (cm): 164.6 (145–179)
- BMI (kg/m^2): 26.01 (17.4–35.1)
- Shoe size: 40.5 (38–43)
- Inter-EIAS distance (cm): 26.1 (23–29)
- EIAS–MI distance (cm): 86 (78–93)

Table 1 Anthropometric data of study patients

	Minimum	Mean	Maximum
Weight in kg	54	67.4	83
Height in cm	145	164.6	179
BMI in kg/m^2	17.4	26.01	35.1
Shoe size	38	40.5	43
Distance between the two EIAS in cm	23	26.1	29
Distance between EIAS and MI in cm	78	86	93

3.3 Clinical data

- Lequesne index:
  - Score between 10 and 14: 50%
  - Score between 15 and 19: 40%
  - Score of 20: 10%
- Route of entry:
  - Hardinge: 90%
  - Moore: 10%
- Fixation: 100% cementless total prostheses
- Length of hospital stay: 6–7 days (100%)
- Rehabilitation: A standardized rehabilitation protocol was implemented 24 hours post-op with weight bearing allowed, continued during hospitalization and then on an outpatient basis. However, compliance varied due to socioeconomic constraints. The average number of outpatient sessions was 13.3, with extremes ranging from 0 to 20 sessions.
- Postoperative complications: 0% (infection: 0; DVT/PE: 0)
- Harris Hip Score: Marked functional improvement between preoperative, 3 months, and 6 months.
  - o Preoperative: 43.65 (23.4–65.4)
  - o 3 months: 79.70 (70.1–83.45)
  - o 6 months: 93.73 (82.5–99.8)

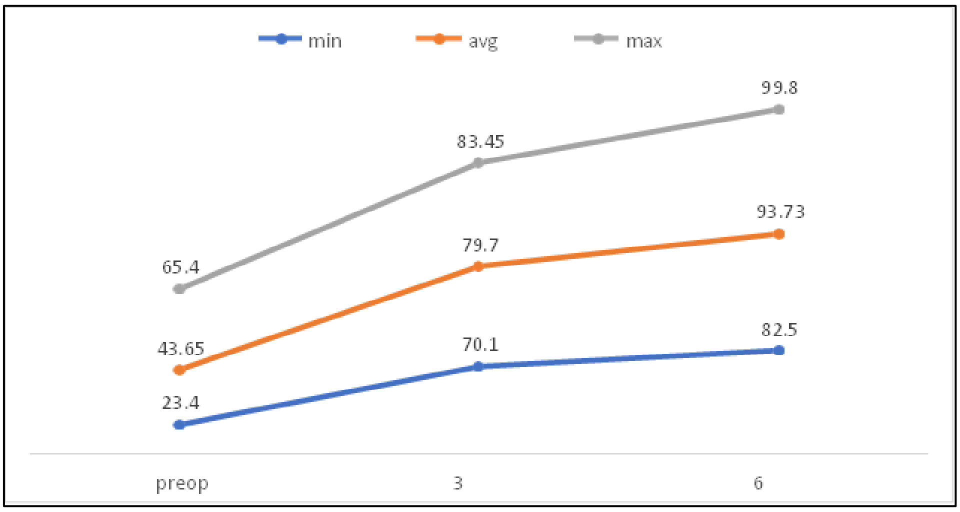

Figure 7 Change in Harris Hip Score

3.4 Spatio-temporal parameters

The average walking speed increased from 0.708 m/s preoperatively to 0.875 m/s at 6 months. Cadence increased from 93.1 to 101.7 steps/min. Stride length increased from 0.93 m to 1.036 m. Cycle time decreased from 1.32 s to 1.18 s.

Table 2 Changes in spatio-temporal parameters

	Preoperative		At 1 month		At 3 months		At 6 months	
	Value	SD	Value	SD	Value	DS	Value	DS
Number of cycles Analyses	56		80		154		154	
Speed (m/s)	0.708		0.820		0.819		0.875	
Cadence (steps/min)	93.1		102.5		97.6		101.7	
Striding length (m)	0.93	0.104	0.98	0.126	1.016	0.144	1.036	0.108
Cycle time (s)	1.32	0.136	1.18	0.087	1.24	0.115	1.18	0.065

3.5 Joint amplitudes

Pelvis (antepulsion/retropulsion): decrease in sagittal ranges (3.445° to 1.3°). (Figure 8)

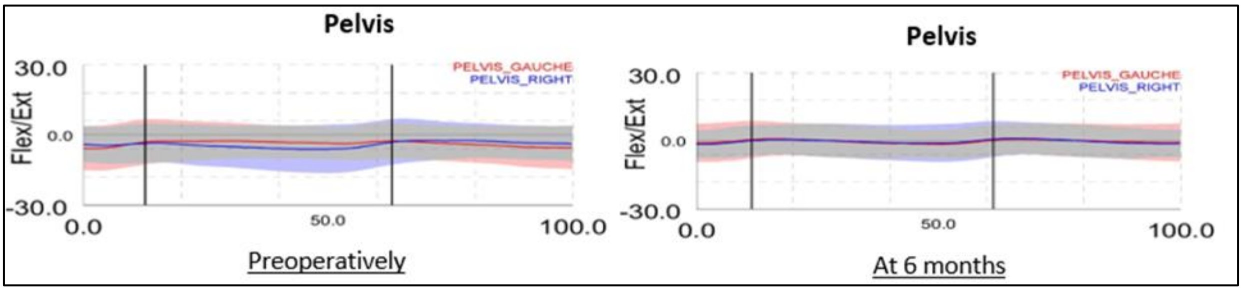

Figure 8 Graph showing degrees of pelvic antepulsion/retropulsion

Hip (flexion/extension): gradual improvement with right/left symmetrization (28.19° to 23.95°). (Figure9)

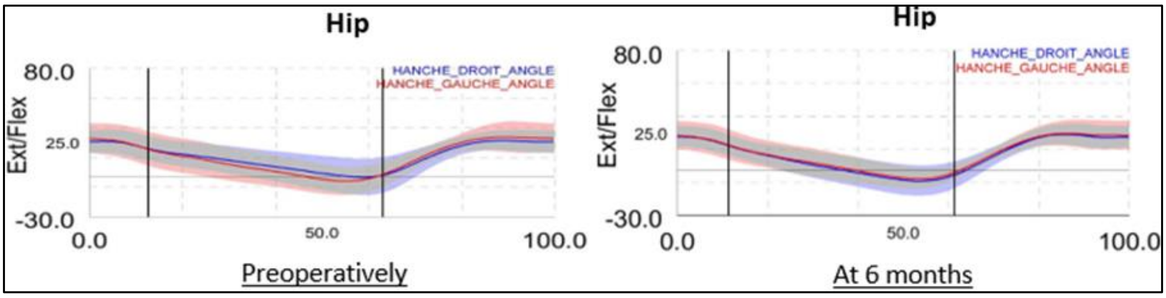

Figure 9 Graph showing hip flexion/extension degrees

Knee (flexion/extension): significant increase in range of motion (49.48° to 55.38°). (Figure 10)

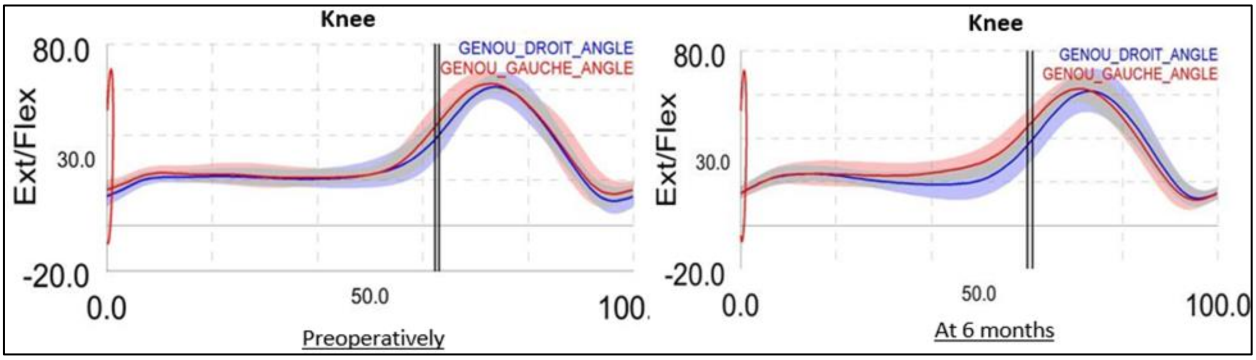

Figure 10 Graph showing degrees of knee flexion/extension

3.6 Quality of life (SF-36)

Significant improvement in physical function (18.06 to 54.5), pain (22.5 to 80.4), and social score (53.83 to 87.8).

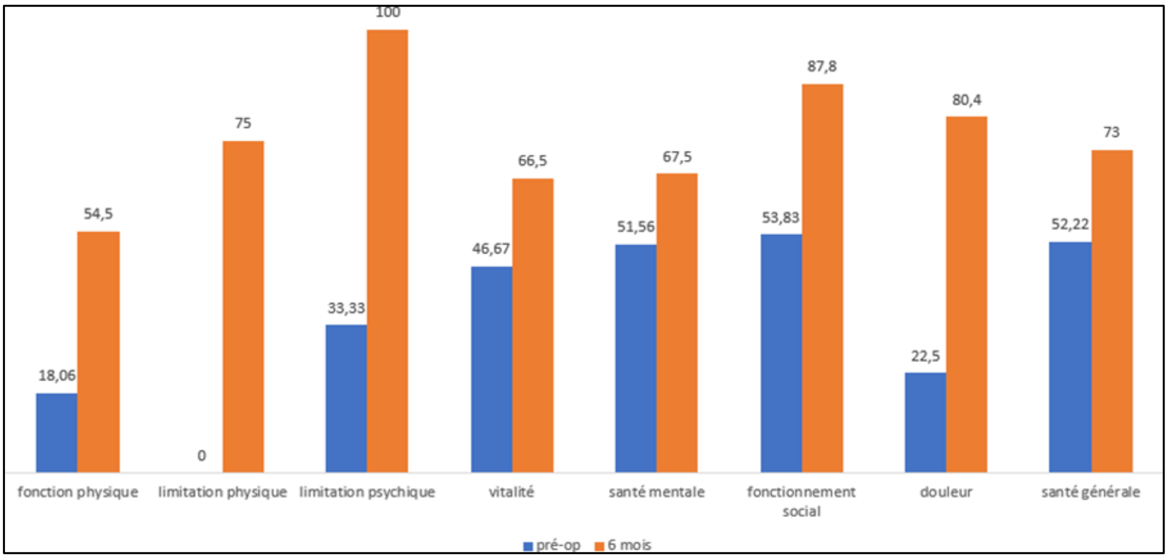

Figure 11 Comparison of patients' quality of life according to the SF-36

4 Discussion

Walking, although natural, is a complex activity requiring coordination of the lower limbs and pelvis, neuromuscular control, and joint integrity to ensure propulsion, balance, and energy efficiency [4,5]. Coxarthrosis limits this mobility and causes pain, stiffness, and functional impairment, often assessed by X-ray and clinical scores [1,7,8]. Total hip arthroplasty (THA) is a reliable procedure for relieving pain and restoring function [3,20], combined with an appropriate choice of prosthesis and surgical approach [9,10,15], as well as personalized rehabilitation aimed at optimizing functional recovery and preventing complications [2,6].

Quantified gait analysis (QGA) allows postoperative progress to be objectively assessed and persistent deficits to be identified, particularly in terms of speed and stride length [4,6,16], and is an essential complement to traditional clinical scores [13].

Our results show that total hip arthroplasty (THA) significantly improves joint function and gait parameters at 6 months post-op [11,14,22,23]. The mean Harris Hip Score (HHS) increased from 43.65 pre-op to 93.73, reflecting major functional recovery. Although the initial score was lower than that reported in other studies [21,23,12,24], our patients caught up functionally after surgery, confirming the effectiveness of THA even in patients who were initially more severely affected [3,18].

Table 3 Comparison of spatio-temporal parameters in patients who underwent surgery

		Our study	C. Yildiz et al. al. [49]	L. Dong jae et al. [48]	V. Agostini et al. [39]	B.O. Zomar et al. [46]
Speed (m/s)	Preop	0.708	0.68	0.68	-	0.993
	1 month	0.820	-	-	-	-
	3 months	0.819	-	-	0.78	1.158
	6 months	0.875	0.8	0.82	0.92	-
Cadence (steps/min)	Preop	93.1	80	93.24	-	-
	1 month	102.5	-	-	-	-
	3 months	97.6	-	-	-	-
	6 months	101.7	87	98.5	-	-
Straddle length (m)	Preop	0.93 +/- 0.104	0.86	0.85 +/- 0.3	-	1.164
	1 month	0.98 +/- 0.126	-	-	-	-
	3 months	1.016 +/- 0.144	-	-	-	1,299
	6 months	1,036 +/- 0.108	0.96	0.96 +/- 0.2	-	-

Table 4 Comparison of joint amplitudes in the sagittal plane

The joints	period	Joint ranges of motion in our study	B. Rey et al. [29]	V. Agostini et al. [39]	L. Martinez et al. [41]	K.C. Foucher et al. [37]
Bassin	Preop	3,445	-	-	-	-
	6 months	1.3	-	-	-	-
	After 1 year	-	3,875	-	-	-
Hip	Preop	28.19	-	-	-	18.45
	6 months	23.95	-	16.75	-	-
	After 1 year	-	35.61	17.65	33.97	26.25
Knee	Preop	49.485	-	-	-	-
	6 months	55.38	-	42.3	-	-
	After 1 year	-	-	42.3	-	-

Walking improves gradually and almost symmetrically: speed and cadence increase steadily, and stride length and step length approach the values reported in the literature [11,22,23], although they remain slightly lower than those of healthy subjects [23]. Recovery appears to be particularly marked in the knee, suggesting a dynamic compensatory role [17], while the decrease in pelvic amplitudes may reflect improved postural stability [4]. Compared to published cohorts, our results are average, with significant progress at 6 months but a slight persistent deficit compared to healthy subjects at one year [11,23,24].

Joint ranges of motion vary depending on the joint. For the pelvis, the range of motion drops from 3.445° to 1.3°, probably due to postural adaptations [4]. The hip goes from 28.19° to 23.95°, remaining higher than in some studies but lower than long-term values [22,24]. The knee progresses from 49.49° to 55.38°, exceeding comparative data [11,21]. These results confirm a gradual recovery, with distinct joint dynamics and potential for additional functional gain beyond 6 months [14,22].

Quantified gait analysis makes it possible to objectively assess these changes and identify persistent deficits, particularly in terms of speed and stride length [6,23]. It is an essential complementary tool to traditional clinical scores [8,13].

5 Limitations

Our study is limited by a small sample size, relatively short follow-up, the absence of comparisons between surgical techniques, and analysis limited to the sagittal plane, highlighting the need for longer and more comprehensive future studies, including the frontal and muscular planes, to better assess functional recovery and neuromuscular adaptations.

6 Outlook

Follow-up at 12 and 24 months would be necessary to assess the complete normalization of gait parameters. Quantified gait analysis should be integrated into post-arthroplasty clinical follow-up to provide objective measurements, detect persistent deficits, and adapt rehabilitation to optimize functional recovery.

7 Conclusion

Quantified gait analysis shows significant functional improvement after total hip arthroplasty (THA) and is an essential objective tool for patient assessment and follow-up. After THA and an appropriate rehabilitation protocol, patients quickly regain near-normal functional mobility, with a noticeable improvement in gait and joint range of motion, confirming the effectiveness of the procedure. However, further studies, particularly during demanding activities, are still needed to optimize recovery and personalize care.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

Statement of ethical approval

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the local Institutional Ethics Committee of Mohammed VI University Hospital, Marrakech.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Lespasio MJ, Sultan AA, Piuzzi NS, Khlopas A, Husni ME, Muschler GF, et al. Hip osteoarthritis: a primer. Perm J. 2018;22:17-084.

[2] Kolasinski SL, Neogi T, Hochberg MC, Oatis C, Guyatt G, Block J, et al. 2019 American College of Rheumatology/Arthritis Foundation Guideline for the Management of Osteoarthritis of the Hand, Hip, and Knee. Arthritis Rheumatol. 2020;72:220-233.

[3] Christofilopoulos P, Lübbeke A, Peter R, Hoffmeyer P. Update on total hip replacement. Rev Med Suisse. 2010;6:2454-2458.

[4] Armand S, Bonnefoy-Mazure A, Hoffmeyer P, de Coulon G. Quantified gait analysis: instructions for use. Rev Med Suisse. 2015;11:1916-1920.

[5] Perry J, Burnfield J. Gait Analysis: Normal and Pathological Function. CRC Press; 2024.

[6] Bahadori S, Middleton RG, Wainwright TW. Using gait analysis to evaluate hip replacement outcomes—current use and future importance: a narrative review. Healthcare. 2022;10:2018.

[7] Lequesne MG, Mery C, Samson M, Gerard P. Indexes of severity for osteoarthritis of the hip and knee. Scand J Rheumatol. 1987;16:85-92.

[8] Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC. J Rheumatol. 1988;15:1833-1840.

[9] Petis S, Howard J, Lanting B, Jones I, Birmingham T, Vasarhelyi E. Comparing the anterior, posterior and lateral approach: gait analysis in total hip arthroplasty. Can J Surg. 2018;61:50-57.

[10] Yoo JI, Cha YH, Kim KJ, Kim HY, Choy WS, Hwang SC. Gait analysis after total hip arthroplasty using direct anterior vs anterolateral approach. BMC Musculoskelet Disord. 2019;20:63.

[11] Agostini V, Ganio D, Facchin K, Cane L, Moreira Carneiro S, Knaflitz M. Gait parameters and muscle activation patterns at 3, 6 and 12 months after total hip arthroplasty. J Arthroplasty. 2014;29:1265-1272.

[12] Foucher KC. Preoperative gait mechanics predict clinical response to total hip arthroplasty. J Orthop Res. 2017;35:366-376.

[13] Behery OA, Foucher KC. Are Harris hip scores and gait mechanics related before and after THA? Clin Orthop Relat Res. 2014;472:3452-3461.

[14] Queen RM, Campbell JC, Schmitt D. Gait analysis reveals that total hip arthroplasty increases power production. Clin Orthop Relat Res. 2019;477:1839- 1847.

[15] Acker A, Fischer JF, Aminian K, Lécureux E, Jolles BM. Cementless dual- mobility cup and gait parameters at five years follow-up. Orthop Traumatol Surg Res. 2017;103:21-25.

[16] Rey B. Quantified analysis of gait after total hip arthroplasty. DRJSCS Île-de- France; 2017.

[17] Bouffard V. Biomechanical evaluation of locomotion after hip arthroplasty. University of Montreal; 2012.

[18] Vučković M, Ružić L, Tudor A, Šutić I. Quality of life after hip arthroplasty: minimally invasive vs classic approach. Acta Clin Croat. 2021;60:89-95.

[19] Colas S. Determinants of prosthetic survival of hip prostheses in France. Paris- Saclay University; 2017.

[20] Mziouid M. Total hip replacement: Indications and results at Med VI University Hospital. Faculty of Medicine, Marrakech; 2009.

[21] Yildiz C, et al. Gait analysis after total hip arthroplasty. Acta Orthop Traumatol Turc. 2000;34:123-130.

[22] Dong J, et al. Changes in spatiotemporal gait parameters after total hip arthroplasty. Gait Posture. 2016;44:1-6.

[23] Zomar BO, et al. Gait characteristics following total hip arthroplasty: a systematic review. J Arthroplasty. 2018;33:123-131.

[24] Martinez L, et al. Kinematic recovery after total hip arthroplasty: a 1-year follow- up study. Clin Biomech.