e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15(7); 1455-1461

Original Research Article

Analyzing the Relationship of Biomechanical Parameters with Performance Based Tests and Self-Reported Functions in Subjects after Total Hip Arthroplasty - One Year Follow Up

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Received: 04-06-2023 / Revised: 02-07-2023 / Accepted: 25-07-2023

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Conflict of interest: Nil

Abstract:

Background: Different methods have been used in the literature to assess the results in subjects who underwent the THA (total hip arthroplasty). However, data are scarce in the literature concerning the correlation at various intervals following the surgery.

Aim: The present study aimed to assess the relationship between biomechanical parameters, PBTs (performance-based tests), and self-reported functions in subjects following total hip arthroplasty after one year.

Methods: The study assessed 22 subjects following total hip arthroplasty where biomechanical parameters, balance, gait, and hip strength were assessed, in performance-based tests, 30CST (30-second-chair-stand test) and TUG (Timed-up-and-Go test) was used, and for self-reported function, HOOS (Hip disability and Osteoarthritis Outcome score) was used. Data gathered were statistically analyzed with the Spearman correlation coefficient.

Results: A moderate to strong correlation was seen for PBT parameters and HOOS scores with $r<0.7$ and <0.4. Assessing the correlation between biomechanical parameters and HOOS scores showed a moderate to strong correlation for hip strength and a weak correlation with balance and gait parameters with $r<0.3$. Also, a moderate to strong correlation was seen between 30CST and hip strength.

Conclusion: The present study concludes that after 1 year postoperative, PBT or self-reported measures can be used to assess the outcome after total hip arthroplasty. Also, hip strength assessment is seen in PBT and HOOS parameters and these parameters can be additionally used. Weak correlations are seen in balance and gait parameters suggesting the use of PBT and PROM additionally to attain additive information in THA subjects at risk of falls.

Keywords: Functional performance, Gait, muscle strength, PROM, Total hip arthroplasty.

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Introduction

THA or total hip arthroplasty is an effective and successful procedure done in subjects with end-stage cox arthritis. After THA, subjects are usually satisfied with the surgical outcomes and present with reduced pain and improved function. However, previous literature data reported reduced strength and asymmetries, restricted motion range, and balance deficit even after several months or years following the surgery. Hence, it is vital to have valid and accurate measuring instruments to assess the post-surgical success after THA that ranges from self-reported results to biomechanical assessments and PBTs (performance-based tests).[1]

PROMs or patient-reported outcome measures describe the quality of life and functional ability from the perspective of the subjects. PROMs have been emerging as the main methods of assessing the outcomes of joint replacement in clinical research and practice protocols. Various PROMs have been used to assess health-related quality of life and general health along with providing the information on function of the hip and the pain. PROMs usually include the HOOS (Hip and Osteoarthritis Outcome Scores), HHS (Harris Hip Score), SF-36 (Medical Outcomes Study Short Form-36), and WOMAC (Western Ontario and McMaster University Osteoarthritis Index). HOOS is an extension of WOMAC and is useful in assessing the more active and young subjects that underwent the THA.[2]

With the high acceptance of PROMs globally owing to their easy administration and cost-effectiveness, the use of PROMs alone to assess outcomes remains controversial in the literature. As PROMs are subjective measures, they may not be sensitive to detect the physical function alteration postoperatively as those are greatly affected by the pain and the psychological factors. Also, PROMs are usually used in clinics and the therapists used PBTs in place of PROMs to assess outcomes and check the progress with STS (sit-to-stand test) and TUG (timed-up-and-go-test) as the PBTs are easily performed and can assess risk of fall, mobility, dynamic and static balance, and functional strength in the lower extremities. Following the total joint arthroplasty, PBTs can provide vital information concerning rehabilitation progress and functional performance.[3]

Also, PBTs have high sensitivity in assessing the functional impairments following THA compared to PROMs. However, PBT doesn't provide any information about movement biomechanics which might cause possible deficits which can only be seen by examining the biomechanics with various tests including the assessment of strength of lower extremities, gait, and balance. With biomechanical assessments, asymmetries of individual muscle groups and persistent muscle weakness on the treated side after THA can be assessed.[4]

Based on the assessing environment being research arena, rehabilitation centers, and/or clinics, one of the methods employed from biomechanical examinations, PBTs, or PROMs after THA. Adequate functional assessment is vital in subjects after THA as it is seen that low function seen after THA is the most common cause of revision surgeries. Previous literature data have assessed the relationship between various objective and subjective methods of assessing outcomes following THA and showed inconsistent results. The majority of the literature data reported no or weak correlation in objective and subjective measurements depicting the need for evaluating both after THA as PROM may overestimate the results of THA. [5] The existing literature data is non-conclusive concerning these postoperative assessments and warrants further literature studies to reach a definitive conclusion. Also, previous literature data have mainly assessed either PROMs or PBTs with each other or with the biomechanical parameters. Hence, the present study aimed to assess the relationship between biomechanical parameters, PBTs (performance-based tests), and self-reported functions in subjects following total hip arthroplasty after one year of THA.

Materials and Methods

The present prospective cross-sectional clinical study was aimed to assess the relationship of biomechanical parameters, PBTs (performance-based tests), and self-reported functions in subjects following total hip arthroplasty after one year. The study was done at Department of Orthopaedics, Saraswati medical college and Hospital, Unnao, Uttar Pradesh. Written informed consent was taken from all the subjects before study participation.The study included subjects from both genders that underwent THA in the institute 1 year back. The inclusion criteria were subjects that underwent THA in the institute, surgery was done 12 months before the assessment and gave consent for study participation. The exclusion criteria for the study were subjects that were not willing to study participate, had neurological conditions hampering the daily functions, orthopedic conditions hampering the daily functions, or another joint replacement.

For the study, all the parameters were assessed in a single visit by a single examiner expert in the field including the biomechanical examination of hip muscle strength, balance, and gait, 30CRt and TUG in PBTs, and HOOS in order following HOOS, gait, balance, PBTs, and hip strength. The tests were performed after collecting the demographic data and anthropometric data from all the study subjects. In PROMs, HOOS (Hip Disability and Osteoarthritis Outcome Score) was assessed which is a questionnaire having 40 items and is divided into five subscales assessing the Hip related quality of life, Spo/Rec (sport and recreation function), ADL (Activities of daily life) function, symptoms, and pain. In each question, points were assigned ranging from 0 to 4 where 0 depicting the no difficulty/never to 4 depicting the extremely difficult/always. The scores were calculated from 0 to 100 for each subscale where 0 showed the worst well-being or worst level of function and 100 showed the best well-being or best level of function for each subscale.[6]

In PBTs, 30 CST and TUG were assessed. TUG is a reliable and valid test for the quantification of functional mobility in elder subjects. TUG has been widely used in subjects after total hip arthroplasty. TUG assess the time taken by the subjects to stand up from the chair without the help of their hands and walk 3 meters at a speed selected by them, take the turn of 180º, and goes back to the sitting position.[7]

30 CST assesses the lower extremity strength, repetition numbers in sitting down and standing up from a chair is continued for 30 seconds and is counted. The subjects were seated in a comfortable position with a straight back and arms crossed at the wrist and against the chest. The subjects were then asked to stand up and sit down as many times as possible within 30 seconds. The repetition was considered valid if the body of the subject was straight and upright during standing and returned correctly to the initial position of sitting. Stands done incorrectly were not counted.[8]

Biomechanical examinations included the hip muscle strength, balance and gait assessment. For gait, spatial–temporal gait parameters were measured by assessing the interruptions in signals of communication by steps of the subjects with a photocell system with receiving and transmitting bars having LED implemented.[9] To achieve this, an 8-meter corridor was made keeping parallel bars, and subjects were asked to walk at a self-selected speed. The subjects walked before and after the test corridor to maintain speed and velocity. 10 trials were completed by each subject and the average of these was considered. Asymmetry and gait were assessed with contact time asymmetry and step length asymmetry. Asymmetry was assessed with the difference between left and right feet and is expressed as a percentage.

To assess static balance, a bipedal stance with a force plate was used. In a bipedal stance, subjects stood with legs parted to hip distance with arms down and without shoes. Two trials were done at a difference of 30 seconds. Balance data was taken at 250 Hz. The total COP (center of pressure) length was assessed along with mean and maximum COP as COPx and COPy for anteroposterior (AP) and mediolateral (ML).[10]

Isometric hip strength was assessed with a custom-made diagnostic device with subjects in an upright position ensured by pelvis support. A thigh cuff was used as an attachment for hauling rope. Isometric strength was assessed with an integrated force transducer in the pulling direction of hip adduction, abduction, extension, and flexion in a neutral hip position. Hip strength was assessed for both legs. Force data from strength analysis was taken at 1000Hz. To assess torque, the distance between the applied force point and the great trochanter was measured. Maximum torque in hip adduction, abduction, extension, and flexion was used along with average maximum hip torque on the assessed side.

The data gathered was analyzed statistically using SPSS software version 28.0 (IBM, Armonk, NY) to assess measurement, anthropometric, and demographic parameters. The relationship between performance-based outcomes and patient-reported outcomes to biomechanical variables was assessed using Spearman's correlation coefficient signified by r. The relationship was taken as weak, moderate, or strong with r=0.0-0.3, 0.3-0.7, 0.7-1.0.[11] The level of significance was taken at $p<0.05$.

Results

Table 1: Demographic and disease characteristics of the study subjects

Characteristic	Number (n=22)	Percentage (%)
Mean age (years)	65.4±3.8	
Mean BMI (kg/m2)	26.2±3.5	
Mean Mass (kg)	75.0±16.2	
Mean Height (m)	1.66±0.13	
Follow-up time (months)	12.6±5.3	
Side operated		
Left	12	54.5
Right	10	45.4
Reason for surgery		
Trauma	4	18.1
Coxarthrosis	18	81.8

Table 2: Biomechanical tests, PBTs, and HOOS scores in the study subjects following THA

Tests	Value
Hip strength (Nm/kg)	
Adduction (Nm/kg)	1.34±0.39
Abduction (Nm/kg)	1.13±0.33
Extension (Nm/kg)	1.07±0.24
Flexion (Nm/kg)	1.57±0.56
Average strength (Nm/kg)	1.28±0.56
Balance Bipedal stance	
Maximum excursion AP (mm)	32.2±12.8
Mean excursion AP (mm)	5.6±2.3
Maximum excursion ML (mm)	15.7±6.7
Mean excursion ML (mm)	3.2±1.5
Length of COP (mm)	460.6±154.7
Gait	
Contact time asymmetry (%)	1.76±1.42
Step length asymmetry (%)	2.54±1.83
Walking speed (m/s)	1.35±0.18

PBTs	
30 CST (n)	13.8±2.5
TUG (s)	8.2±1.4
HOOS scores (0-100)	
HOOS QoL	64±13
HOOS Spo/rec	64±13
HOOS ADL	84±15
HOOS pain	81±13
HOOS symptoms	83±14

Table 3: Relationship of HOOS subscale scores to other study parameters

	HOOS symptom	HOOS pain	HOOS ADL	HOOS spo/rec	HOOS QoL
Hip strength (Nm/kg)					
Adduction (Nm/kg)	0.27	0.70	0.47	0.47	0.45
Abduction (Nm/kg)	0.17	0.47	0.43	0.15	0.56
Extension (Nm/kg)	-0.28	0.08	-0.05	-0.19	0.19
Flexion (Nm/kg)	0.32	0.74	0.57	0.54	0.58
Average strength (Nm/kg)	0.17	0.63	0.46	0.36	0.46
PBTs					
30 CST (n)	0.59	0.79	0.66	0.53	0.74
TUG (s)	-0.44	-0.63	-0.26	-0.54	-0.46
Balance Bipedal stance					
Maximum excursion AP (mm)	0.27	0.17	0.07	0.46	0.35
Mean excursion AP (mm)	0.24	0.37	0.14	0.57	0.07
Maximum excursion ML (mm)	-0.18	-0.42	-0.47	-0.13	-0.13
Mean excursion ML (mm)	-0.09	-0.25	-0.32	-0.06	-0.05
Length of COP (mm)	-0.01	-0.06	-0.22	0.23	-.035
Gait					
Contact time asymmetry (%)	-0.34	-0.48	-0.34	-0.45	-0.71
Step length asymmetry (%)	-0.12	0.05	0.03	-0.01	-0.12
Walking speed (m/s)	0.24	0.56	0.32	0.26	0.41

Table 4: Relationship of biomechanical parameters to PBTs in study subjects ATLAS

Parameter	30CST	TUG
Hip strength (Nm/kg)		
Adduction (Nm/kg)	-0.49	0.79
Abduction (Nm/kg)	-0.45	0.73
Extension (Nm/kg)	-0.07	0.38
Flexion (Nm/kg)	-0.39	0.62
Average strength (Nm/kg)	-0.29	0.66
Balance Bipedal stance		
Maximum excursion AP (mm)	0.08	0.05
Mean excursion AP (mm)	-0.14	0.15
Maximum excursion ML (mm)	0.26	-0.43
Mean excursion ML (mm)	0.26	-0.17
Length of COP (mm)	0.06	-0.35
Gait		
Contact time asymmetry (%)	0.14	-0.47
Step length asymmetry (%)	0.34	0.34
Walking speed (m/s)	-0.74	0.26

The present prospective cross-sectional clinical study was aimed to assess the relationship of biomechanical parameters, PBTs (performance-based tests), and self-reported functions in subjects following total hip arthroplasty after one year. The study assessed 22 subjects from both genders. The mean age of the study subjects was 65.4±3.8 years. The mean height of the study subjects was 1.66±0.13 meters and the mean weight was 75.0±16.2 kgs. The mean BMI of 22 study subjects was 26.2±3.5 kg/m2. The mean follow-up duration among 22 assessed study subjects was 12.6±5.3 months. Among 22 subjects, 54.5% (n=12) subjects were operated on the left side of the leg and 45.4% (n=10) subjects were operated on the right side of the leg. The reason for total hip arthroplasty was trauma in 18.1% (n=4) study subjects and coxarthrosis in 81.8% (n=18) study subjects respectively as shown in Table 1.

On assessing the various parameters in the study subjects, it was seen that the average hip strength was 1.28±0.56 Nm/kg in study subjects. The adduction, abduction, extension, and flexion had mean values of 1.34±0.39, 1.13±0.33, 1.07±0.24, and 1.57±0.56 Nm/kg respectively. Concerning the balance bipedal stance, the maximum excursion (AP), mean excursion AP (mm), maximum excursion (ML), mean excursion ML, and length of COP were 32.2±12.8, 5.6±2.3, 15.7±6.7, 3.2±1.5, and 460.6±154.7 mm respectively in the study subjects. For Gait, contact time asymmetry and step length asymmetry was 1.76±1.42% and 2.54±1.83% respectively. The walking speed was 1.35±0.18 m/s. Concerning PBTs, 30CST was 13.8±2.5 and TUG was 8.2±1.4. The HOOS score ranged from 0-100 with HOOS QoL, HOOS spo/rec, HOOS ADL, HOOS pain, and HOOS symptoms were 64±13, 64±13, 84±15, 81±13, and 83±14 respectively as depicted in Table 2.

Concerning the correlation of HOOS subscale scores to other study parameters, it was seen that for hip strength, a significant association was seen in flexion and HOOS pain with r=0.74 and average hip strength to HOOS pain with r=0.63. However, a non-significant correlation was seen in other hip strength parameters and HOOS parameters. In PBTs, a significant association was seen between 30 CST to HOOS pain, ADL, and QoL with r-0.79, 0.66, and 0.74. Also, a significant negative correlation was seen in TUG and HOOS pain with r=-0.63 and p<0.05. No significant correlation was seen between the balance bipedal stance and any of the HOOS parameters. For gait, a significant negative correlation was seen in contact time asymmetry and HOOS quality of life with r=-0.71 and p<0.05 (Table 3). On assessing the correlation of biomechanical parameters to PBTs and other parameters in study subjects, it was seen that in hip strength, a significant correlation was seen in adduction, abduction, flexion, and average hip strength to TUG with r=0.79, 0.73, 0.62, and 0.66 respectively and p<0.05. Balance bipedal stance showed a mild correlation to CST and TUG both. Also, a strong negative correlation was seen in gait and walking speed with r=-0.74 and p=0.01 as shown in Table 4.

Discussion

The present prospective cross-sectional clinical study assessed 22 subjects from both genders. The mean age of the study subjects was 65.4±3.8 years. The mean height of the study subjects was 1.66±0.13 meters and the mean weight was 75.0±16.2 kgs. The mean BMI of 22 study subjects was 26.2±3.5 kg/m2. The mean follow-up duration among 22 assessed study subjects was 12.6±5.3 months. Among 22 subjects, 54.5% (n=12) subjects were operated on the left side of the leg and 45.4% (n=10) subjects were operated on the right side of the leg. The reason for total hip arthroplasty was trauma in 18.1% (n=4) study subjects and coxarthrosis in 81.8% (n=18) study subjects respectively. These findings were similar to the studies of Ahmad MA et al [12] in 2011 and Imada A et al [13] in 2018 where authors assessed subjects with demographic and disease data similar to the present study in subjects following total hip arthroplasty.

It was seen that for the various parameters in the study subjects, it was seen that average hip strength was 1.28±0.56 Nm/kg in study subjects. The adduction, abduction, extension, and flexion had mean values of 1.34±0.39, 1.13±0.33, 1.07±0.24, and 1.57±0.56 Nm/kg respectively. Concerning the balance bipedal stance, the maximum excursion (AP), mean excursion AP (mm), maximum excursion (ML), mean excursion ML, and length of COP were 32.2±12.8, 5.6±2.3, 15.7±6.7, 3.2±1.5, and 460.6±154.7 mm respectively in the study subjects. For Gait, contact time asymmetry and step length asymmetry was 1.76±1.42% and 2.54±1.83% respectively. The walking speed was 1.35±0.18 m/s. Concerning PBTs, 30CST was 13.8±2.5 and TUG was 8.2±1.4. The HOOS score ranged from 0-100 with HOOS QoL, HOOS spo/rec, HOOS ADL, HOOS pain, and HOOS symptoms 64±13, 64±13, 84±15, 81±13, and 83±14 respectively. These results were consistent with the studies of Bolink SAAN et al [14] in 2016 and Boekesteijn R et al [15] in 2022 where similar parameters were recorded in their study subjects by the authors as seen in the results of the present study.

The study results also showed that for the correlation of HOOS subscale scores to other study parameters, it was seen that for hip strength, a significant association was seen in flexion and HOOS pain with r=0.74 and average hip strength to HOOS pain with r=0.63. However, a non-significant correlation was seen in other hip strength parameters and HOOS parameters. In PBTs, a significant association was seen between 30 CST to HOOS pain, ADL, and QoL with r-0.79, 0.66, and 0.74. Also, a significant negative correlation was seen in TUG and HOOS pain with r=-0.63 and p<0.05. No significant correlation was seen between the balance bipedal stance and any of the HOOS parameters. For gait, a significant negative correlation was seen in contact time asymmetry and HOOS quality of life with r=-0.71 and p<0.05. These findings were in agreement with the studies of Furu M et al [16] in 2016 and Elibol N et al [17] in 2018 where authors reported a correlation comparable to the present study in HOOS subscale scores to hip strength and performance-based tests in subjects after total hip arthroplasty.

It was also seen that concerning the correlation of biomechanical parameters to PBTs and other parameters in study subjects, it was seen that in hip strength, a significant correlation was seen in adduction, abduction, flexion, and average hip strength to TUG with r=0.79, 0.73, 0.62, and 0.66 respectively and $p<0.05$. Balance bipedal stance showed a mild correlation to CST and TUG both. Also, a strong negative correlation was seen in gait and walking speed with r=-0.74 and p=0.01. These results were in line with the previous studies of Mark Christensen T et al [18] in 2019 and Dayton MR et al [19] in 2016 where authors reported a negative correlation in walking speed and gait following total hip arthroplasty as seen in the present study.

Conclusion

Considering its limitations, the present clinical study concludes that after 1 year postoperative, PBT or self-reported measures can be used to assess the outcome after total hip arthroplasty. Also, hip strength assessment is seen in PBT and HOOS parameters and these parameters can be additionally used. Weak correlations are seen in balance and gait parameters suggesting the use of PBT and PROM additionally to attain additive information in THA subjects at risk of falls.

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