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THE EFFECT OF TOTAL HIP ARTHROPLASTY ON SIT-TO-STAND SYMMETRY

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SUMMARY

This study looks at symmetry in kinetics of a group of 40 total hip arthroplasty patients and a matched control group of 19 healthy participants during a sit-to-stand motion. An infrared motion analysis system and two force plates measured kinetics through inverse dynamics. A symmetry formula was used; an index under ten indicating symmetry. Independent t-tests showed significant differences in hip and knee extension moment, hip and knee power, and peak sum of moments. While some patients exhibited symmetrical moments and power generation patterns, most of them still favoured their non-operated side in order to extend the hip and knee. This study emphasizes the need for rehabilitation programs that would focus on increasing the level of symmetry for this patient population.

INTRODUCTION

Total hip arthroplasty (THA) is known to relieve pain for patients with hip osteoarthritis, as well as increasing their functional abilities. While gait analysis is important, other functional tasks must also be assessed, such as sitting and standing, as these are also important for patient autonomy and are repeated numerous times each day [1]. These tasks can be difficult to achieve, as a greater range of movement is used at the lower limb articulations. It has been shown that THA patients favoured their non-operated leg while standing in terms of the vertical component of the ground reaction forces [2]. However, the study of ground reaction forces only can overlook specific asymmetries at each joint. For instance, Gilleard and colleagues [3] found no difference in symmetry for vertical ground reaction forces in a group of young healthy women, but they found asymmetry for frontal plane knee and ankle peak moments and transverse plane hip, knee and ankle moments. Similarly, the study by Miki and colleagues [4] revealed gait asymmetries for hip sagittal plane range of motion and pelvic tilt, while gait parameters (cadence, stride length, step length) did not show side to side differences, even prior to surgery. The comparison of kinetics of each side will enable us to identify which articulations present the most asymmetry, and address these differences during rehabilitation.

The purpose of this study was to compare symmetry in lower limb kinetics of THA patients to those of control group during a sit-to-stand task. It was hypothesized that THA patients would exhibit higher asymmetries then the control group and favour their non-operated limb.

METHODS

Sixty participants were recruited for two groups: THA (n=40, 16 men; age: 63.3 ± 6.9 yr; BMI: 27.8 ± 4.9 kg/m^2) and an age- and weight-matched controls (CON) (n=19, 10 men; age: 63.5 ± 4.4 yr; BMI: 24.9 ± 3.5 kg/m^2). THA patients either had a direct lateral or anterior surgical approach. They were excluded if they had prior lower limb surgery, presence of joint degeneration at other articulations, or any condition affecting their balance. We could not use, because of a technical error, the data from one of the control participants. Patients were assessed at 307 ± 98 days post-surgery.

Twenty lower limbs markers were strategically positioned on the participant's body following a modified Helen Hayes markerset [4]. The participant wore skintight clothing in order to reduce soft tissue artefact. The markers were tracked in 3D at 200 Hz with a nine-camera opto-electric infrared motion analysis system (Vicon MX, Vicon Motion Systems, Oxford, UK). Ground reaction forces were obtained at 1000 Hz with two force plates (AMTI OR-6-6-2000, Watertown, MA, USA) positioned side by side. The hip joint center was calculated with a common regression technique [5]. The knee and ankle joint centers were located midline between their respective medial and lateral markers. Kinematics were computed accordingly to the Euler angle convention [6].

Participants were asked to perform three trials of sit-to-stand on a bench adjusted to their tibial plateau height. Peak values for each variable were extracted for each trial and then averaged for each participant. A symmetry index (S) was calculated using the following formula:

$$S = |V_{no} - V_o| / (|V_{no}| + |V_o|) * 100\% \quad (1)$$

where V_{no} is the kinetic variables of the non-operated limb and V_o of the operated limb. This formula, adapted from Talis and colleagues [2], measures the symmetry regardless of direction. S was calculated for peak hip extension moment, peak hip abduction moment, peak knee extension moment, peak sum of moments [7], peak hip power generation, peak knee power generation and peak ankle power generation. It was decided that a symmetry index lower than 10 would indicate that the patient showed symmetry for the variable of interest.

Independent t-tests were performed on the symmetry indices and alpha was set at 0.05. For the variables that were found to be significantly different, the participants with an index higher than 10 were divided, from their mean differences, in two groups: favouring the operated (OP) or the non-operated (NO) limb. Control participants were divided similarly: favouring the matched dominant (OP) or non-dominant limb (NO).

RESULTS AND DISCUSSION

The THA group had a mean *S* significantly different from the control group for peak hip extension moment, peak knee extension moment, peak extension sum of moments, as well as peak hip and knee power (Table 1).

Table 1: Results of the series of ANOVAs on symmetry (*S*).

Variable	p-value	Group	Mean *S* (SD)
Peak hip extension moment*	**.003**	CON	9 (9)
		THA	21 (16)
Peak hip adduction moment	.386	CON	37 (36)
		THA	45 (34)
Peak knee extension moment*	**.003**	CON	9 (6)
		THA	17 (12)
Peak sum of moments*	**.003**	CON	7 (5)
		THA	15 (11)
Peak hip power*	**.001**	CON	9 (8)
		THA	23 (13)
Peak knee power*	**.015**	CON	9 (6)
		THA	17 (13)
Peak ankle power	.205	CON	13 (17)
		THA	19 (14)

*Indicates a significant difference ($p<0.05$) between the symmetry index of THA and CON participants.

We hypothesized that THA patients would exhibit more asymmetry compared to the control group. Our hypothesis was confirmed, as several variables had significantly higher symmetry indices for the THA participants, compared to the control group. Our results coincide with those of Talis et al. [2], who observed a non-operated side preference in THA patients for vertical ground reaction force.

Most THA patients clearly preferred using the NO leg to produce the hip extension moment and power needed to rise from a seated position (Fig. 1). Interestingly, the knee joint was also affected, as shown by the asymmetry in its peak extension moment and peak power generation (Fig 1). Mizner and Snyder-Mackler [8] had similar findings for patient with total knee replacement: they showed reductions in both hip and knee extension moment at three months after surgery.

While we should try restoring symmetry for patients undergoing joint replacement, we must keep in mind that a certain level of asymmetry is present in the general healthy population [9], and this should be viewed as acceptable [3]. However, too much asymmetry might cause muscle disuse and consequently muscle atrophy in the long term.

It is difficult to identify the mechanisms explaining why THA patients have this asymmetry in hip and knee kinetics. It could be a pre-operative adaptation to alleviate pain that patients are used to do and, regardless of the postoperative absence of pain, perpetuate after surgery. Another explanation could be that they do not trust their prosthetic hip as much as their contralateral one, and thus they would mainly use the latter for bilateral tasks such as sit-to-stand.

CONCLUSIONS

This study demonstrated that total hip arthoplasty affects symmetry during a sit-to-stand movement, even 10 months after surgery. While some patients exhibited symmetrical moments and power generation patterns, most of them still favoured their non-operated side in order to extend the hip and knee. This study emphasizes the need for rehabilitation programs that would focus on increasing the level of symmetry for this patient population.

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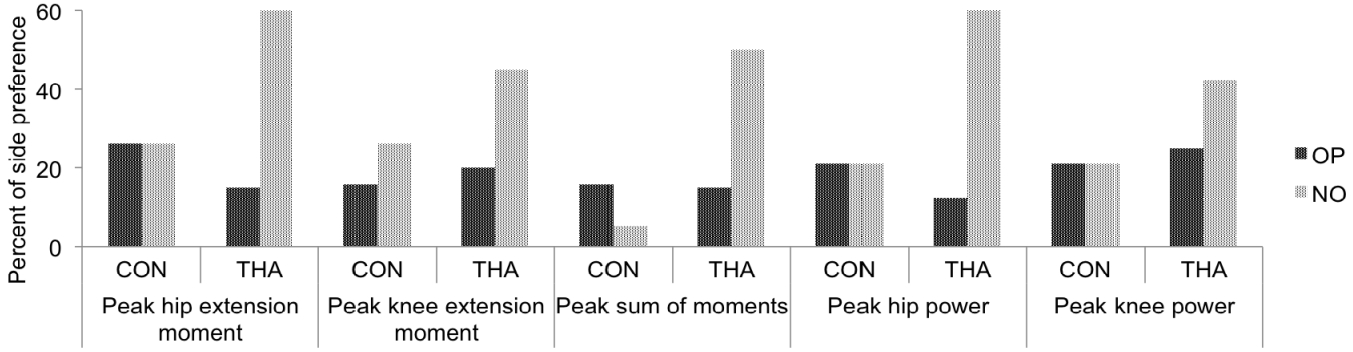

Figure 1. Side preference in percentage of frequency for THA and CON participants for hip and knee extension moment and power, as well as peak sum of moments.