Physical and Mental Demand During Direct Anterior Total Hip Arthroplasty: Comparison of Robotic-assisted vs Manual Technique

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INTRODUCTION: As the US continues to face a growing demand for total hip arthroplasties (THAs), the average caseload per orthopaedic surgeon is expected to double over the next few decades to meet demand [1]. Manual total hip arthroplasty (MTHA) is a physically and mentally demanding procedure, and increasing caseloads could result in higher rates of surgeon injury, fatigue, and burnout [2]. CT-based robotic-assisted total hip arthroplasty (RATHA) has been shown to provide surgeons with accurate acetabular component placement, even when utilizing a direct anterior approach (DAA) [3]. However, few have studied the potential physical benefits of RATHA on operating surgeons. The aim of this study was to compare the physical and mental energy expenditure of surgeons during direct anterior approach (DAA) MTHA and RATHA.

METHODS: Two orthopaedic surgeons with previous experience in MTHA and RATHA completed bilateral DAA THA's on six cadaveric specimens. MTHA with fluoroscopy was performed on the first hip and RATHA without fluoroscopy was performed on the matched contralateral hip. Surgeons wore protective lead vests under their surgical gowns during MTHA cases. Biometric data was recorded for both surgeons throughout the procedures using smart watches, including heart rate (HR), respiration, HR variability (stress), calories burned, and sweat loss. Following each procedure, surgeons completed a modified SURG-TLX questionnaire to assess mental and physical demand on a scale of 1 to 10. Data from both surgeons were pooled together for analysis. The percentage change in the mean and maximum HR, respiration, and stress was calculated for the overall procedure and individual procedural step based on the values measured at the start. Two sample t-test was performed for statistical analysis.

RESULTS: The percentage changes in all mean and max biometric parameters for the overall procedure were lower for RATHA when compared to the MTHA, as seen in Figure 1. RATHA also resulted in lower average calorie expenditure (89.2±29.74 vs 90.3±35.89) and sweat loss (157.3±27.24 vs 171.6±45.93) compared to MTHA. Further, the percentage changes in all biometric parameters were lower for all individual procedural steps with RATHA. No statistically significant differences were found between RATHA and MTHA for any of the biometrics parameters measured.

Both surgeons reported through the questionnaire that their over overall mental and physical demand was significantly less for RATHA then when compared to MTHA ($p=0.001$). Additionally, RATHA was shown to be less mentally and physically demanding for individual procedural steps compared to MTHA, as seen in Figure 2.

DISCUSSION: This study demonstrated a correlation in results from biometric and questionnaire data indicating that RATHA resulted in less physical and mental demand for orthopaedic surgeons for the overall procedure and individual procedural steps. RATHA led to a reduction in HR, respiration, and stress relative to the start of the procedures, with surgeons often operating closer to baseline levels, as opposed to MTHA which increased these biometric parameters. When considering physical demand, surgeons may omit the use of protective lead vests during DAA RATHA procedures since the robotic technology allows for intraoperative visualization of the joint. Additionally, the intraoperative information that the technology provides to the surgeon during the case may reduce their mental demand during the procedure. Further studies are needed to confirm if these encouraging findings translate in a clinical setting.

SIGNIFICANCE/CLINICAL RELEVANCE: The mentally and physically demanding nature of a direct anterior total hip arthroplasty procedures can have a significant impact on the overall health of orthopedic surgeons. Therefore, the implementation of a less demanding alternative such as robotic-assistance, can result in a positive impact to surgeons experience.

References: [1] Rullán et al. The Arthroplasty Surgeon Growth Indicator: A Tool for Monitoring Supply and Demand Trends in the Orthopaedic Surgeon Workforce from 2020 to 2050. J Bone Joint Surg Am. 2023 Jul 5;105(13):1038-1045. doi: 10.2106/JBJS.22.00874 [2] Abbruzzese et al. Physical and Mental Demand During Total Hip Arthroplasty. Orthop Clin North Am. 2022 Oct;53(4):413-419. doi: 10.1016/j.ocl.2022.06.005. [3] Kunze et al. Accuracy and Precision of Acetabular Component Position Does Not Differ Between the Anterior and Posterior Approaches to Total Hip Arthroplasty With Robotic Assistance: A Matched-Pair Analysis. Arthroplast Today. 2022 Oct 18;18:68-75. doi: 10.1016/j.artd.2022.08.004.

Surgical Steps	Average Percentage Change in Mean and Maximum Biometric Paramenters From the Start of Each Procedure											
	Physcial Demand								Mental Demand			
	Mean HR		Max HR		Mean Resp		Max Resp		Mean Stress		Max Stress	
	MTHA	RATHA	MTHA	RATHA	MTHA	RATHA	MTHA	RATHA	MTHA	RATHA	MTHA	RATHA
Overall Procedure	5.91%	-0.99%	28.06%	9.74%	2.21%	-4.98%	22.32%	13.29%	19.45%	-9.45%	99.77%	59.00%
Acetabular Prep	2.80%	-2.46%	9.14%	0.94%	2.22%	-0.02%	12.22%	6.93%	14.52%	-18.82%	46.14%	-3.56%
Acetabular Reaming	4.45%	-0.98%	10.36%	-1.09%	4.26%	-22.75%	7.59%	-10.92%	21.28%	-9.94%	36.66%	-0.83%
Acetabular Impaction	3.88%	-1.18%	8.54%	0.39%	6.90%	-17.09%	9.12%	-8.29%	21.63%	-16.29%	53.96%	-7.48%
Femoral Prep	8.22%	-1.37%	13.89%	1.62%	6.98%	-20.68%	14.58%	-5.37%	19.93%	-5.78%	41.41%	33.62%
Femoral Broaching	7.34%	-0.06%	13.30%	1.98%	6.78%	-23.08%	11.31%	-8.28%	16.16%	-16.85%	36.14%	-2.68%
Trialling	7.44%	1.06%	11.57%	3.61%	0.92%	-12.88%	8.74%	-2.67%	25.79%	-12.38%	56.51%	-5.08%

Figure 1: Average percentage change in mean and maximum biometric parameters from the start of each procedure

Surgical Steps	Average Questionnaire Values			
	Physical Demand		Mental Demand	
	MTHA	RATHA	MTHA	RATHA
Overall Procedure	5.0	2.5	4.7	1.7
Acetabular Prep	2.5	1.5	3.0	1.5
Acetabular Reaming	4.2	1.8	4.2	1.5
Acetabular Impaction	3.8	2.0	4.0	1.5
Femoral Prep	2.7	2.5	2.8	2.8
Femoral Broaching	4.0	2.8	3.6	2.5
Trialling	2.5	1.8	2.5	1.6

Figure 2: Average physical and mental demand questionnaire values for various procedural steps. Questions were assessed on a scale of 1 to 10, with 1 indicating low and 10 indicating high demand.