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Relevance of orthostatic posturography for clinical evaluation of hip and knee joint arthroplasty patients

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ABSTRACT

In order to verify whether orthostatic posturography (OP) can support clinical assessment of total hip (THA) and knee arthroplasty (TKA), 81 subjects with THA and 100 with TKA were recruited and compared with 59 healthy volunteers. All patients were tested one or two days prior to surgery; 42 subjects (20 THA and 22 TKA) were tested again after six months, and 34 (14 THA and 20 TKA) yet again after 12 months. OP was performed using a Kistler 9286A piezoelectric force plate and the following postural parameters (PPs) were adopted on account of their functional meaning: mean velocity and the root mean square of the distance of the centre of pressure (CoP), sway area, and 95% of the CoP power frequency. Eye condition and fatigue related to the test duration were also examined. The three most meaningful PPs were identified and a logarithmic transformation was then applied to these, as well as standardization. Almost all the PP values were higher preoperatively in the patients as compared with the healthy subjects and it was possible to detect many statistically significant differences between patients and healthy subjects. However, when examining the 181 subjects at the preoperative stage, the PPs did not show congruence with the clinical scores as well as they did during follow-up. Therefore, the use of the OP is not recommended to monitor patients undergoing THA or TKA.

1. Introduction

Objective outcomes are needed to support an evidence-based approach, as well as for medico-legal purposes [1]. Total hip (THA) and knee arthroplasty (TKA) procedures are widely adopted. THA is the second most commonly performed surgical procedure, with an estimated number of more than one million operations each year worldwide [2]. It is estimated that in the Unites States alone, by 2030 the demand for THA and TKA will have grown by 174% and 673%, respectively [3]. Orthostatic posturography (OP) is used to evaluate the trajectory of the centre of pressure (CoP) with the patient in upright stance [4]. Accepting the hypothesis that the CoP planar migration is stationary, about 40 posturographic parameters (PPs) are commonly adopted to describe the statistical properties of the CoP, in the time and frequency domains [5–8]. The robustness of PPs has been clearly assessed [9–11], but there are contrasting conclusions in literature about the sensitivity and clinical significance of PPs in subjects affected by osteoarthritis (OA), THA or TKA [12–19].

For Arokoski and colleagues, OP assessment of healthy subjects and patients with hip OA provided comparable results [12], but in other cases the performance of the impaired subjects did not reach the standard of the healthy subjects [13,16–19]. No studies using OP have been carried out to assess balance control in TKA patients, and the available literature concerning subjects affected by knee OA shows an impaired balance control [14–15].

This study was aimed at verifying whether OP could support the clinical assessment of THA or TKA. Therefore, only PPs with a functional meaning were adopted and a particular effort was made to decrease their number and to make the test shorter and simpler.

Firstly, the influence of visual feedback and fatigue and the possibility of discriminating between healthy subjects and patients before and after surgery were analysed. Then, the clinical use of OP was investigated in terms of its ability to pinpoint relationships between PPs and patients' clinical conditions.

2. Subjects and methods

2.1. Study groups

A total of 240 subjects, 98 males and 142 females, took part in the study (Table 1). One hundred and eighty-one subjects (81 THA and 100 TKA) belonged to the two experimental groups (EGs) and 59 to the control group (CG); 42 patients (20 THA

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Table 1
Anthropometric and posturographic parameters in the total hip arthroplasty, total knee arthroplasty and control groups.

AP	Group	THA		TKA		CG	
	Session	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
Age (yr)	Pre-op.	64.1 ± 11.3	40–80	68.8 ± 6.8	48–80		
	6 m	62.9 ± 11.7	40–80	67.7 ± 8.0	48–80	67.4 ± 5.9	48–76
	1 y	66.6 ± 10.9	42–80	68.7 ± 7.3	48–79		
Height (cm)	Pre-op.	160.8 ± 9.3	143–185	154.6 ± 8.1	133–178		
	6 m	159.8 ± 7.5	146–180	155.2 ± 7.9	142–175	162.3 ± 10.5	142–184
	1 y	159.9 ± 9.1	146–185	152.9 ± 7.0	142–165		
Body mass (kg)	Pre-op.	75.7 ± 13.2	48–106	77.7 ± 12.3	37–103		
	6 m	79.0 ± 11.4	63–109	79.6 ± 12.5	55–105	75.8 ± 12.4	46–100
	1 y	79.2 ± 14.8	51–112	75.9 ± 10.4	62–104		

PP	Group	THA						TKA						CG					
	Test cond.	Eyes open			Eyes closed			Eyes open			Eyes closed			Eyes open			Eyes closed		
	Session	Q1	Med.	Q3	Q1	Med.	Q3	Q1	Med.	Q3	Q1	Med.	Q3	Q1	Med.	Q3	Q1	Med.	Q3
MV (mm/s)	Pre-op.	8.84	12.20	14.81	13.00	16.00	22.38	8.94	11.27	14.21	11.68	14.49	19.67	7.56	9.09	10.11	8.99	11.19	13.02
	6 m	9.23	12.40	17.60	12.88	15.43	18.92	9.12	10.88	14.54	12.82	14.98	16.79						
	1 y	8.06	12.47	17.67	11.65	16.22	20.63	9.59	10.79	15.32	10.91	14.65	20.02						
$RMSD_{RD}$ (mm)	Pre-op.	4.50	5.52	6.92	5.25	6.55	8.23	4.15	5.04	6.13	4.81	5.54	6.77	3.61	5.05	6.07	4.02	4.79	5.98
	6 m	4.81	5.62	6.89	5.10	5.94	7.29	4.43	6.01	7.19	4.60	6.39	7.12						
	1 y	3.81	5.90	6.82	4.41	5.12	7.34	4.47	5.64	6.61	4.67	5.94	7.11						
$RMSD_{AP}$ (mm)	Pre-op.	3.24	3.95	5.55	4.02	4.95	6.40	3.03	3.53	4.32	3.36	4.21	5.01	2.86	3.99	5.43	3.17	4.12	4.88
	6 m	3.11	3.97	4.84	3.88	4.37	5.88	3.42	3.82	5.51	3.65	4.79	5.52						
	1 y	2.70	3.32	5.47	3.03	4.20	6.03	3.17	4.16	5.27	3.14	4.87	5.61						
$RMSD_{ML}$ (mm)	Pre-op.	2.73	3.27	4.62	3.08	3.93	5.48	2.53	3.34	4.14	2.65	3.74	4.61	1.89	2.39	3.19	1.74	2.47	3.33
	6 m	3.12	3.99	4.89	3.27	3.96	4.46	2.70	4.07	5.10	2.77	3.55	4.57						
	1 y	2.31	3.76	4.87	2.73	3.23	3.97	2.71	3.54	4.20	2.74	3.45	3.91						
SA (mm^2/s)	Pre-op.	12.50	17.62	28.33	17.98	29.26	53.73	11.06	16.63	22.88	16.37	22.51	34.50	9.18	11.36	14.91	9.67	12.53	17.80
	6 m	12.25	19.48	34.17	19.50	25.57	35.32	12.31	21.25	27.00	17.38	24.30	32.58						
	1 y	9.52	14.83	32.81	14.41	22.24	34.32	12.42	19.45	24.31	17.58	21.07	31.66						
$PF95_{AP}$ (Hz)	Pre-op.	0.65	0.83	1.02	0.86	1.05	1.31	0.67	0.85	1.11	0.87	1.06	1.39	0.44	0.61	0.78	0.73	0.87	1.03
	6 m	0.68	0.99	1.18	0.75	1.24	1.43	0.59	0.80	0.99	0.75	0.90	1.21						
	1 y	0.74	0.92	1.03	0.87	1.16	1.26	0.67	0.86	0.95	0.87	1.05	1.28						
$PF95_{ML}$ (Hz)	Pre-op.	0.58	0.81	1.01	0.76	0.98	1.24	0.51	0.73	0.94	0.64	0.90	1.13	0.59	0.79	0.98	0.64	0.91	1.14
	6 m	0.56	0.72	0.79	0.75	0.88	1.07	0.44	0.72	0.90	0.62	0.78	0.96						
	1 y	0.65	0.83	1.04	0.81	0.96	1.13	0.49	0.58	0.85	0.58	0.70	1.00						

AP, anthropometric parameters; PP, posturographic parameters. THA, total hip arthroplasty; TKA, total knee arthroplasty, CG, control group. For the THA and TKA patients, the data are referred to the three trial sessions: preoperative (pre-op.), six months (6 m), one year (1 y), whereas for the CG they refer to a single session. Since the PP data were not normally distributed they are reported as first quartile (Q1), median and third quartile (Q3).