Medicina Sportiva (2012), vol VIII, no 2, 1858 - 1865
Romanian Sports Medicine Society

Pre and postoperative gravity center and muscular activity evaluation in patients with total hip arthroplasty

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Abstract. Total hip arthroplasty (THA) represents one of the most important options for many orthopaedic pathologic contexts. Patient recovery following THA is complex and involves a detailed, clinical-functional, preoperative evaluation of the hip joint biomechanics in order to quantify the functional deficit and to select the most effective rehabilitation procedures. The present study included 17 patients that addressed the Clinic of Orthopaedics and Traumatology in the Recovery Hospital of Iasi and Arcadia Hospital Iasi, to be treated by total hip arthroplasty. This study was rolled out between September 2009 - April 2012 and included 11 male and 6 female patients, with a mean age of 64.7years. It evaluates the functional evolution in patients with total hip arthroplasty as well as the biomechanical changes of the walking during the two stages of the treatment, in order to determine the degree of functional rehabilitation in such patients. The study concludes that early start of recovery treatment lead to improvement in hip joint biomechanics and in walking activities, reducing the degree of wear on prosthesis, on contralateral healthy hip and other joints in the lower limbs
Key words: *hip joint, rehabilitation, functional evaluation.*

Introduction

At present time, total hip arthroplasty (THA) allows patients with various hip invalidating pathologies to improve their life quality parameters, by joint functionality recovery and pain alleviation.

THA represents one of the most common solutions for many pathologic contexts such as: arthrosis, rheumatoid arthritis, hip fracture, necrosis, with increased incidence in elderly (1-4). Thus, in USA, over 150000 surgical interventions are performed every year, the number growing continuously (5). In Australia, between September 2009 and January 2012, 217400 patients underwent such implants (6).

Romania also recorded a significant increase in hip arthroplasty incidence, with 599943 primary interventions performed between January 2003 and April 2011, according to the Romanian Arthroplasty Registry (7).

Regarding these facts, the role of physical therapy in biomechanical evaluation and functional rehabilitation of the operated hip becomes essential. An important role for this procedure success is played by the patient positive attitude towards rehabilitation (8, 9).

The present study evaluates the functional evolution in patients with total hip arthroplasty as well as the biomechanical changes of the walking during the two stages of the treatment, in order to determine the degree of functional rehabilitation in such patients.

Material and Methods

The present study included 17 patients that addressed the Clinic of Orthopaedics and Traumatology in the Recovery Hospital of Iasi and Arcadia Hospital Iasi, to be treated by total hip arthroplasty.

This study was rolled out between September 2009 - April 2012 and included 11 male and 6 female patients, with a mean age of 64.7 years. The study group included patients who agreed to continue the rehabilitation program throughout all 90 days and fulfilled the inclusion criteria.

These criteria are represented by a minimal age of 20 years old, a surgical indication for total hip arthroplasty, with no other medical issues in the lower limbs except for hips, with no neurological issues that may imbalance orthostatic posture. From the 17 considered patients, 9 patients showed right hip impairment, while 8 patients showed contralateral hip impairment.

We have evaluated the functional evolution in the study group that underwent total hip arthroplasty and the biomechanical changes in walking parameters, during the two treatment steps, in order to determine the degree of resulted functional rehabilitation.

The study was performed in two steps (pre- and postoperative). In preoperative step, we have evaluated the gravity center position through the sustaining polygon, for all 17 patients that underwent total hip arthroplasty. In this step, muscular assessment was performed, following the procedures specific to Myotest Pro System (Sion, Switzerland).

In postoperative step, we have evaluated the hip gravity center position and muscular strength at 30 and 90 days following surgery. During the postoperative period, the patients were included in a rehabilitation program specific for total hip arthroplasty, on which articular load bearing rehabilitation and barycentre position reeducation exercises were added using the GPS 400 platform (Chinesport Spa, Udine, Italy).

Support rehabilitation is performed on a stabilometric platform, starting day 4 postoperatively, with the patient in orthostatic position, supported on the walking frame. This platform allows the patient to track the gravity center position on a display and to switch load bearing from the healthy leg to the operated one, according to the indications of the physical therapist; the latter will take into account the prosthesis type and the number of postoperative care days. These exercises are performed during the first days following surgery, with support on the walking frame, in order to adjust load bearing for each treatment step, so that starting the second week the patient will be able to use the stabilometric platform without any other support.

This method of support rehabilitation and gravity center position (10) through the sustaining polygon offers the patient the possibility to acknowledge the degree of joint load and to equally distribute both hip strengths when going back to walking without support and with normal load (11).

Among all the patients, only 7 benefitted from this type of reeducation exclusively during hospitalization, at release being recommended to continue the functional recovery program at home, according to the doctor's indications, and to return for evaluation at 30 and 90 days after the surgery. The other 10 patients continued the recovery program for a period of 30 days, 5 days a week. The duration of a reeducation session on the stabilometric platform was 10 minutes from the entire recovery session.

The testing was accomplished by placing the patient in orthostatic posture on the GPS400 stabilometric platform, lower legs slightly spread, and maintaining this position for 30 seconds during the 3 testing stages, pre- and postoperative, at 30 and at 90 days. This 30 seconds duration was established as the testing reference interval in order to avoid the muscle fatigue induction or intense postural and balance reactions, which may produce significant gravity center deviations. First, the patient was subjected to a control test, so that he can accustom to and understand the method, then the second testing was considered the main evaluation test.

The frontal deviations (left-right) were analyzed by the system software and represented the topic of our study. Deviations from the normal values were depicted in graphs, with two axes that will indicate the degree of deviation from the sustaining polygon, and as numbers, in units corresponding to observed displacements. For frontal displacements, the "+" sign represent numerical values on right side deviation while the "-" sign will correspond to left side deviations. Ideally, the barycentre position must be as close to the central axis as possible, whereas the numerical values expressed in units must as close to zero as possible.

The muscular balance was first performed with the help of Myotest Pro hardware and software that is able to evaluate muscular rehabilitation progress, both in sportspeople and in patients with muscular strength deficits, resulted from long term immobilization or inactivity in various groups of muscles. This software analyses three parameters, namely movement strength, power and speed. According to the method (12), the device is placed on the distal side of the investigated area while the patient is supposed to execute the movement one time, after hearing the

audio signal. The opposing force against which the movement acts is set up in Myotest device, for each patient aside, according to the functional deficit and the evaluation time as well as the intensity of the previously applied opposing forced during previous evaluations (pre- or postoperative, at 30 or 90 days).

Results

The gravity centre stabilometric analysis outlines significant changes of the barycentre in all patients involved in the study. During the postoperative evaluation, 30 days after the surgery, in 41% of the patients a slight movement of the barycentre towards the healthy side was noticed, as compared to the preoperative evaluation. This movement occurs due to the static and dynamic stereotype, which the patient adopts in a reflex way, so that he doesn't allow the artificial hip to bear the entire load. The patients who followed an intense recovery program recorded an improvement of the gravity centre position through the sustaining polygon, due to exercises performed on the stabilometric platform, which offer the patient the possibility to acknowledge the degree of joint load. Thus, in the case of patients from the witness lot, there were improvements recorded of over 2.5 units as compared to the control lot which recorded a barycentre recovery of less than 2.5 units, according to figure 1. The average recovery of the gravity centre position through the sustaining polygon is 4.17 units for the working group and 1.91 units for the control group.

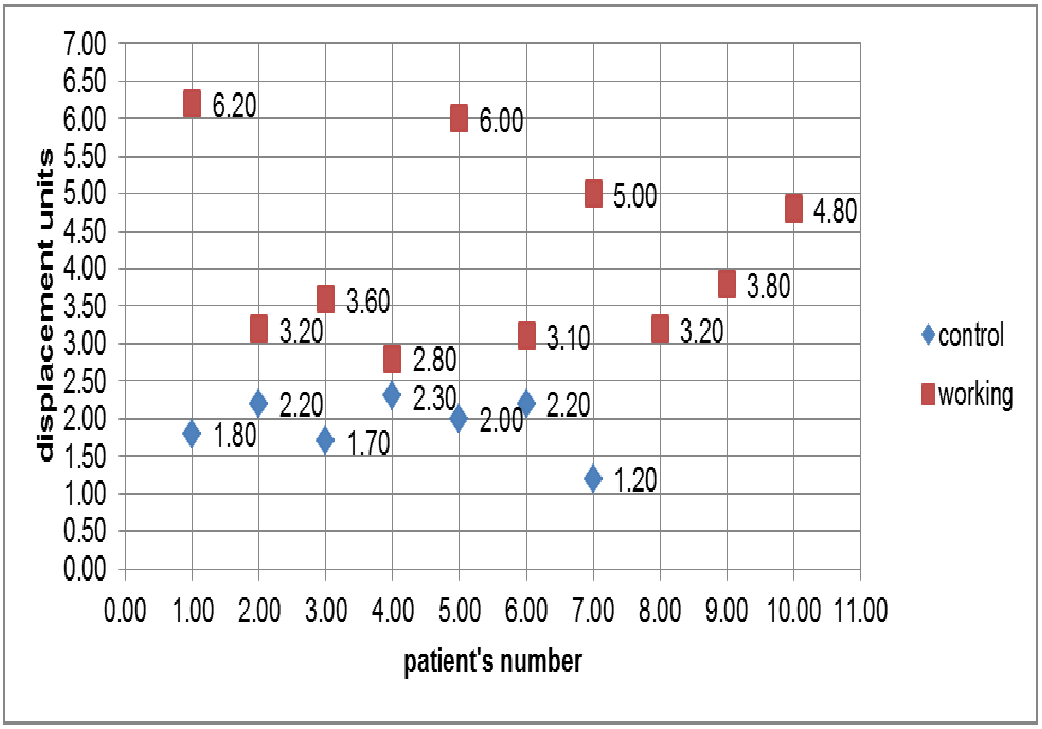

Figure 1. Graphic plot of gravity center displacement in the control and working groups

Regarding the mean difference of 1.91 units between the gravity center position at 90 days postop and the preoperative values in the control group, we have performed a One-Sample T-test to evaluate the mean value obtained for the working group, compared to the control test value.

Thus we have checked the mean variation for this index in the working group compared to the control group.

While Sig.(2-tailed)=0.000 and mean difference interval is different from zero, the two means are significantly different, by 2.46 units (figure 2).

Table I. One sample T-test for the working group gravity center position variation, expressed in units, according to the mean of the control group

One-Sample Test						
	Control Test Value = 1.91					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
working	6.319	9	.000	2.46000	1.5793	3.3407

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
working	10	4.3700	1.23112	.38932

At 30 and 90 days following surgery, we have observed an improvement in the barycentre position inside the sustaining polygon, mainly in patients who underwent a regular physical therapy program, combined with a rehabilitation program. The patients in the control group that underwent rehabilitation program for only 5 days postoperatively, in the hospital, still showed barycentre deviations, with values close to preoperative ones; only slight position improvements were recorded. The stabilometric evaluation throughout the preoperative, postoperative at 30 and 90 days evaluations is outlined in figure 2.

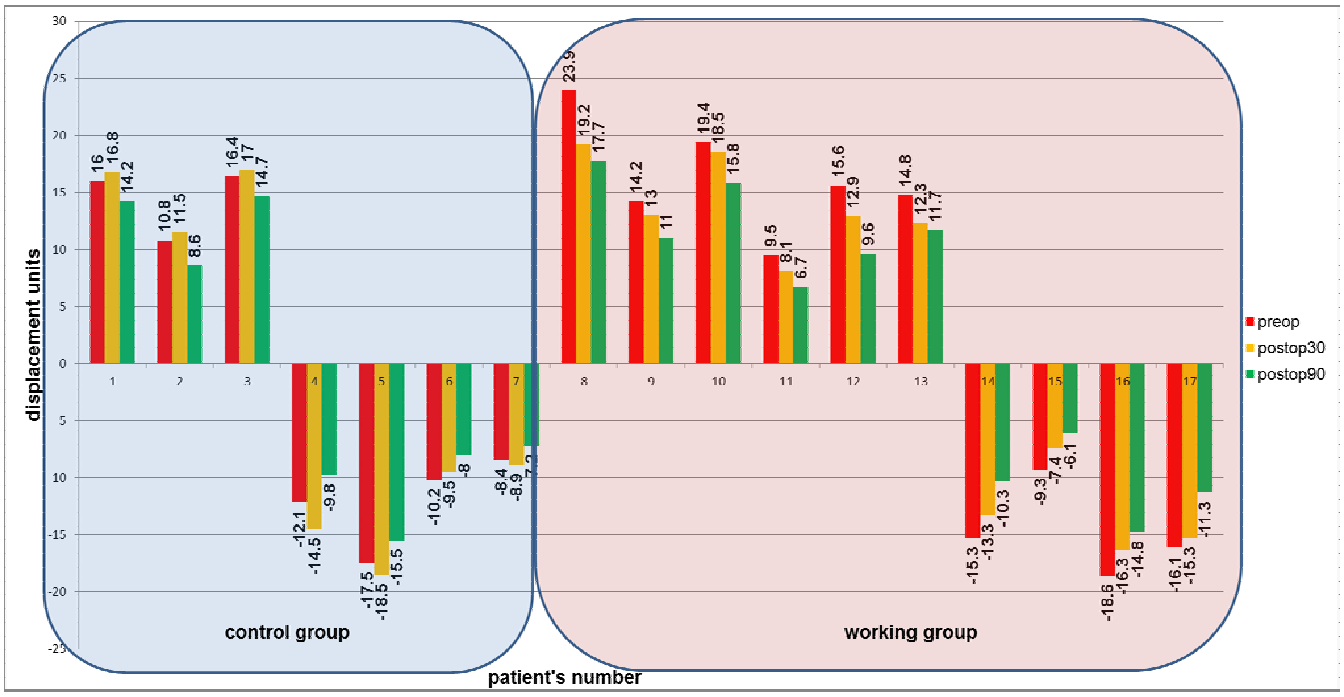

Figure 2. Individual values of frontal deviation throughout the three evaluations

The statistical evaluation of the barycentre, (table II), points out decreases in mean deviations of the barycentre throughout the three performed evaluations, but with no statistical significance (Sig. with equal variances assumed >0.05).

Table II. Statistical indicators of frontal deviation of the barycentre throughout the three evaluations in the control and working group

Group Statistics					
	group	N	Mean	Std. Deviation	Std. Error Mean
preop	control	7	13.0571	3.54582	1.34019
	working	10	15.6700	4.37316	1.38292
postop30	control	7	13.8143	3.86455	1.46066
	working	10	13.6300	3.89959	1.23316
postop90	control	7	11.1429	3.52792	1.33343
	working	10	11.5000	3.73274	1.18040

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Conf. Interval	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
preop	Eq.var. assum.	.000	.999	-1.305	15	.212	-2.61286	2.00202	-6.88006	1.65435
postop30	Eq.var. assum.	.115	.740	.096	15	.925	.18429	1.91485	-3.89712	4.26569
postop90	Eq.var. assum.	.131	.723	-.198	15	.845	-.35714	1.79982	-4.19336	3.47908

Muscular evaluation. During the preoperative evaluation of the affected lower limb's muscles, significant hypotonicities can be observed at the level of thigh and torso muscles, as a result of lack of their mechanical activity.

The decrease in muscular activity is due to a reflex mechanism that appears as a consequence of algesic events on hip level and also due to ROM (range of motion) reduction. Both intermediate and final evaluations show a trend to muscular strength increase, mainly in patients who have pursued a regular physical therapy program, as compared to patients who have performed in-home rehabilitation exercises only, without professional primary health care. The muscles which recorded a significant increase of muscle strength were the hip abductors and flexor muscles as well as the knee extensors, as these groups showed more important hypotonicity which were afterwards intensely reeducated.

Because these muscles were the most affected, it was insisted on their reeducating, by means of rotations and extensions, which were the only movements allowed following arthroplasty, having an outstanding role in maintaining biped posture and walking biomechanics.

Throughout hip evaluation monitoring, significant increases Power-W were recorded (figure 3), with large numeric variations; statistically significant differences were recorded for the average Power-W scores in hip, at 30 and mainly 90 days from surgery, as shown in table III.

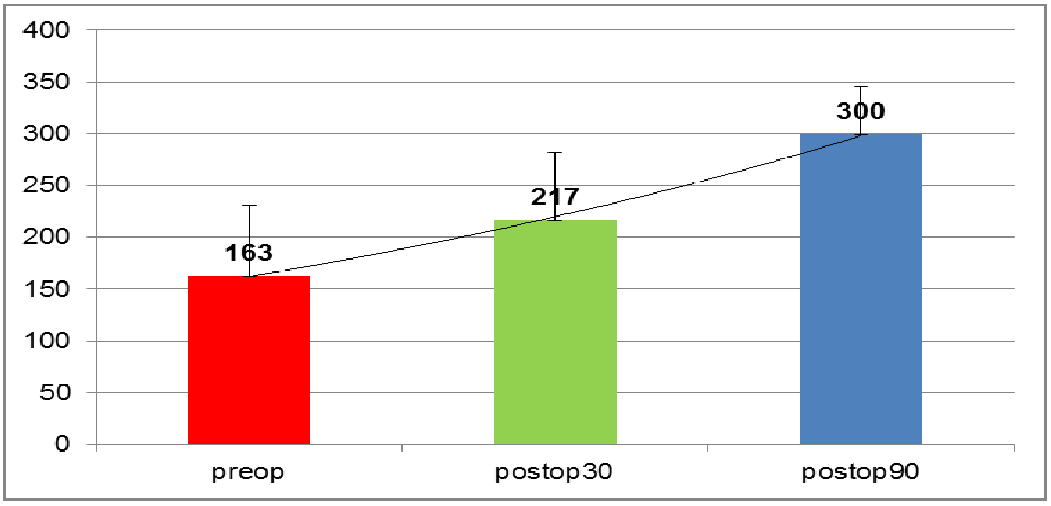

Figure 3. Hip average values for Power-W test (expressed in units) throughout the three considered evaluations. Error bars represent standard deviations, also depicted in table below.

Table III. Statistical indicators of Power-W on hip throughout the three evaluations (Descriptive statistics and Anova evaluation)

Evaluation time	N	Min	Maximum	Mean	Std. Dev.	Variance	Mean Sq.	F	Sig.
Preop. vs 30 days	17	89.0	366.0	163.118	69.6284	4848.110	5145.184	13.125	.214
Preop. vs 90 days	17	130.0	380.0	217.176	66.7956	4461.654	67.6284	6.700	**.001**
30 days vs 90 days	17	214.0	400.0	299.588	46.9868	2207.757	66.7956	4.180	**.048**

During the monitoring, there were no significant increases of Force-N parameter, except for the case preoperative vs 90 days, even if the variances were very large according to figure 4 and statistical data shown in table IV.

This progress is mainly due to the fact that the patients underwent a specific rehabilitation program, more intense in first postoperative month and due to increased motivation to restore their functional and social independence as soon as possible.

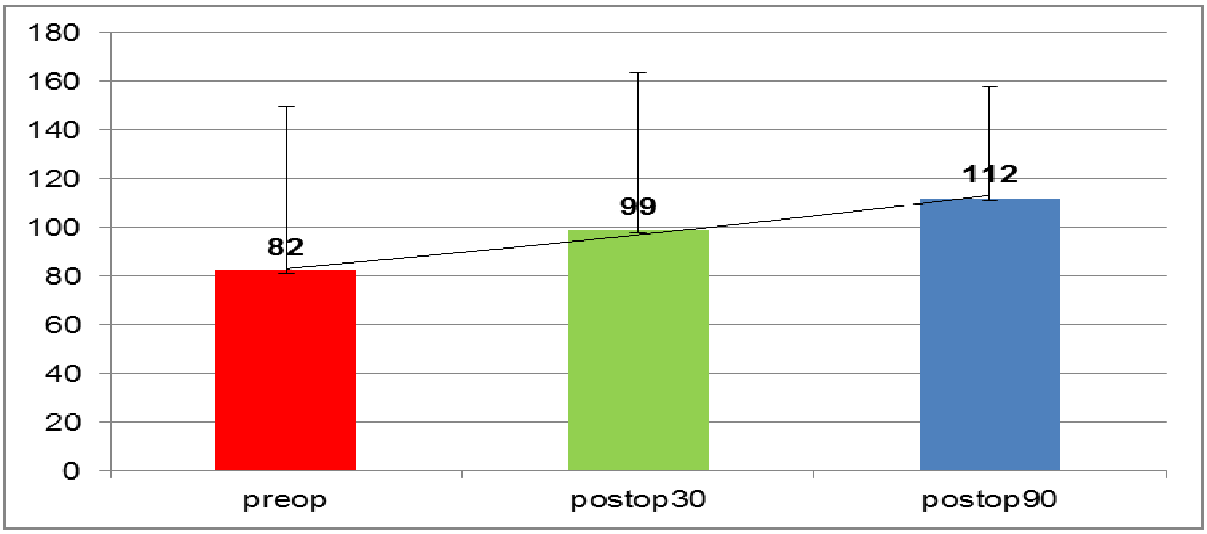

Figure 4. Hip average values of Force-N parameter for thigh flexion (impaired low limb) throughout the three Considered monitoring sessions. Error bars represent standard deviations, also depicted in below.

Table IV. Statistical indicators of Force-N – thigh flexion (the impaired low limb) throughout the three considered monitoring sessions (Descriptive statistics and Anova evaluation)

Evaluation time	N	Min	Max	Mean	Std. Dev.	Variance	Mean Square	F	Sig.
Preop. vs 30 days	17	63.5	130.0	82.253	14.7801	218.450	232.948	237.702	.051
Preop. vs 90 days	17	84.3	152.0	98.929	15.7790	248.977	14.7801	3.160	.049
30 days vs 90 days	17	12.3	193.0	112.041	36.0065	1296.468	15.7790	1.370	.666

Although having very large value series, throughout the monitoring sessions there were significant increases of the preoperative speed parameter vs 30 or 90 days according to figure 5 and the statistical data in table V. The value of muscular strength speed improves due to pain relief in hip joint and mobility improvement.

These improvements are statistically significant at 30 and 90 days postoperatively compared to preoperative parameters.

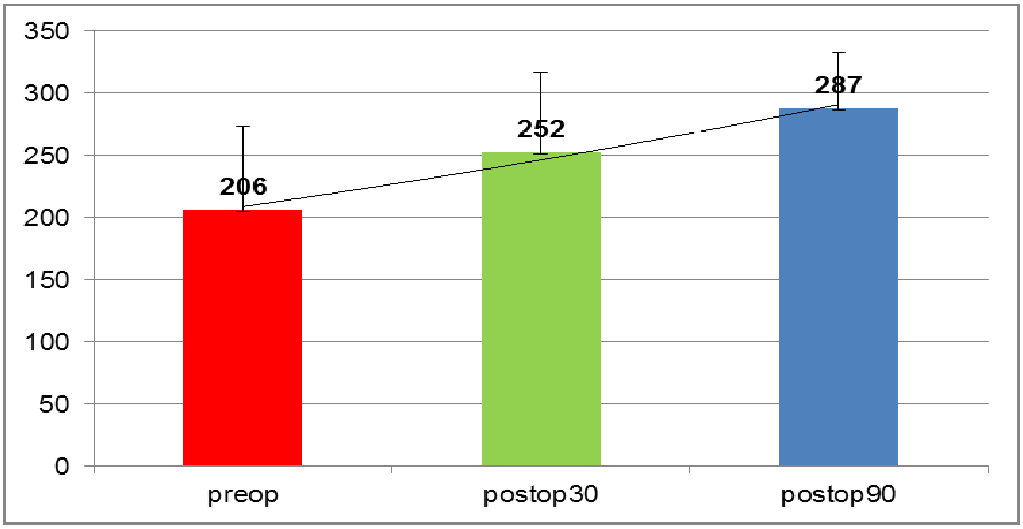

Figure 5. Hip muscular strength speed average values throughout the three considered monitoring sessions. Error bars represent standard deviations, also depicted in table below

Table V. Statistical indicators of hip muscular strength speed throughout the three considered monitoring sessions (Descriptive statistics and Anova evaluation)

Evaluation time	N	Min	Max	Mean	Std. Dev	Variance	Mean Square	F	Sig.
Preop. vs 30 days	17	150.0	412.0	206.353	62.2262	3872.100	232.948	2.150	.050
Preop. vs 90 days	17	173.0	422.0	252.382	66.5880	4433.963	14.7801	3.660	.049
30 days vs 90 days	17	179.0	425.0	287.388	67.2564	4523.417	15.7790	1.520	.666

Conclusions

Hip arthroplasty represents the ideal key for patients involving degenerative/traumatic pathology, or deformities, by offering life quality parameters close to normal, by means of complete pain relief and functional rehabilitation.

It is mandatory to have a detailed, preoperative, clinical/functional evaluation of the hip joint biomechanics in order to define the patient functional impairment and to select the most effective rehabilitation procedures.

Precise individualization of the physical therapy treatment, according to the functional deficit will considerably reduce recovery time.

The hip pain relief by means of arthroplasty does not necessarily lead to improvement of the gravity centre position, due to the incorrect dynamic stereotype, more emphasized in the first 7 postoperative days as a consequence of the contraindication to full load bearing on the operated hip. Reeducation of old habits and of the incorrect static and dynamic stereotype,

which moved in a reflex way the body weight on the healthy low limb, thus overloading the healthy joint, leads to a decrease in mechanical activity of the healthy hip and to a torso rebalancing. This recovery is achieved only through physical therapy and psychomotive rehabilitation.

Early start of recovery treatment lead to improvement in hip joint biomechanics and in walking activities, reducing the degree of wear on prosthesis, on contralateral healthy hip and other joints in the lower limbs.

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Received: 02 April 2012
Accepted: 15 May 2012