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ORIGINAL RESEARCH ARTICLE

Late Isometric Assessment of Hip Abductor Muscle and Its Relationship with Functional Tests in Elderly Women Undergoing Replacement of Unilateral Hip Joint

ABSTRACT

Melchiorri G, Viero V, Triossi T, Sorge R, Marchetti C, Arena NE, Tancredi V: Late isometric assessment of hip abductor muscle and its relationship with functional tests in elderly women undergoing replacement of unilateral hip joint. Am J Phys Med Rehabil 2015;94:758–767.

Objective: The aim of this study was to evaluate the recovery of muscle strength and measure autonomy 3 yrs after hip replacement surgery in a sample of patients.

Design: Seventy-eight female patients (70.7 ± 6.3 yrs old) operated on for hip replacement were evaluated. They underwent evaluation tests for hip abductor muscle strength on the healthy and operated limb using strength curves obtained with isometric assessments. Autonomy was evaluated with a rating scale Western Ontario and McMaster Universities Arthritis Index (WOMAC), Harris and MOS 36-Item Short-Form Health Survey (SF-36) and functional assessment (Timed "Up and Go" test).

Results: Three years after surgery, a muscle strength deficit was still noticeable on the operated limb compared with the healthy limb ranging from 9% at 5 degrees of adduction to 12% at 0 degree of abduction. The strength curves obtained on the operated side maintained the same descending trend as the healthy side. The authors found no significant correlations between the patient-reported functional measures and the hip abductor strength deficit. The Timed Up and Go test was moderately correlated with the muscle strength deficit. The association between the deficit and the Timed Up and Go test was statistically significant.

Conclusions: The evaluation of muscle strength and functional tests are more useful than the rating scales in patients 3 yrs after surgery. The strength curves are useful to have different levels of information and describe joint function.

Key Words: Hip Arthroplasty, Muscular Strength, Hip Rehabilitation, Strength Curve

Several authors have studied patient outcomes after total hip replacement. The authors reviewed these authors' work and found several measures used for evaluation, including gait analysis,[1,2] neuromuscular efficiency,[3] restoration of autonomy (measured by patient-reported scales),[4,5] and radiographic examinations.[6] With relation to neuromuscular efficiency, some authors[3] showed persistence of a deficit in hip abductor muscle strength after surgery, whereas others[7] showed full recovery of muscle strength; however, all authors agree on the important role that abductor muscles play in rehabilitation after hip replacement.[3,7–9] Weakness of the abductor muscles may influence efficiency in walking[2] and autonomy in routine daily activities[2,8] and is reported by some authors as a risk factor for aseptic loosening.[3] In the works cited, the evaluation of muscle strength was performed with the isometric and isokinetic method. The instrumentation required for the isometric test is less expensive and more readily available; however, it has been used in no more than one or two different joint positions.[7] Other authors have studied the recovery of muscle strength after total hip replacement with isokinetic testing.[10] The isokinetic evaluation, however, requires more expensive instruments that are not always available in the clinical setting.

The strength curve describes the relationship between muscle strength and range of motion because the force is measured at several points of the joint range of motion[11,12] and can also be obtained by measuring muscle strength using the isometric test.[11] The strength curve, depending on the joints studied, has a "descending" trend (an increase in the range of motion [ROM] leads to a decrease in the force produced), "ascending" (an increase of the ROM leads to an increase in muscle strength measured), or "ascending-descending" in which there is an increase in muscular strength at the initial increase of the joint range that tends to decrease upon further increase of the ROM.[13] A descending curve has been described for the hip in healthy subjects.[11] The strength curve allows a more detailed study of the neuromuscular efficiency of the skeletal muscle, because the force is measured at different points of the joint range.[11,12]

Several factors can influence the shape of a strength curve including psychological, physiological, and geometric factors related to positioning during the test.[11]

In the case of joint prosthesis, there are no contrary examples where the generated curve is abnormal compared with the normal subjects, but the geometric factors (axis of movement, muscular insertion, line of muscle action, range of motion), as described by Kulig et al.,[11] can determine an alteration of the shape of the strength curve. The assessment of muscle strength is also of great significance to the relationship described in scientific literature between better muscle strength and a reduced incidence of falls.[14,15] After literature review, the authors found no articles that have used the strength curves for evaluation of patient outcomes after total hip replacement.

The aims of this study were (1) to verify the applicability of the strength curve in the evaluation of patients with hip replacement, (2) to assess whether joint replacement could affect the characteristic shape of the strength curve of the hip (descending), (3) to verify whether a difference between the operated limb and the nonoperated limb persists for a long period after surgical replacement, and (4) to investigate possible relationships between patient autonomy and abductor muscle strength. Scientific significance of these aims is connected with the lack of literature data about applicability of force curves after hip replacement, about strength differences between the operated and unoperated sides, and the connection between muscular performance and patient autonomy. The answer to these aims could give new data of clinical relevance useful for the outcome evaluation in patients submitted to unilateral hip replacement.

METHODS

Subjects

Seventy-eight female patients, who had total hip replacement surgery for a mean of 35 mos (±5 mos) before the evaluation, were recruited for this study. All patients were operated on by the same surgeon, who used the modified direct lateral approach,[16] and were evaluated between 2008 and 2011. All patients were operated on for hip osteoarthritis and underwent a rehabilitation program with active and passive kinesiotherapy at the day hospital department, which involved walking training and hydrokinesiotherapy for 2 mos (6 days a week, 2 hrs a day). None of the patients recruited had absences exceeding 5% of available treatment days. The following patients were excluded from the study: patients operated on for femur or hip fractures, those with other severe diseases (rheumatologic, neurologic, cardiopulmonary) that could affect muscle recovery efficiency and autonomy, those with bilateral replacement or with other lower limb joint replacements, those who had hip replacement revision or hip dislocation, patients with a difference in leg length greater than 5 mm (assessed with a lower limb x-ray) or a prosthetic offset out of the reference range,[6] those with signs of aseptic loosening revealed by the x-ray examination carried out before the beginning of the evaluation, those with severe arthrodegenerative signs on a nonoperated hip (Kellgren-Lawrence index $\leq$ 2),[17] or those with periprosthetic heterotopic calcifications or a history of infections after surgery and cancer-related pathologies. Clinical examination included patient history about falls in the 3 yrs before surgery. Patients with traumatic fracture of the femur were excluded to give more homogeneity to the sample. None of the patients had recently fallen. All patients involved in the study were informed of the methods and aims of the study and read and signed the informed consent. The procedures were approved by the ethics committee of the university where the research was carried out. All procedures were carried out in accordance with the Declaration of the World Medical Association and with the Declaration of Helsinki guidelines.

Experimental Procedure

The recruited subjects were first called to carry out a medical examination and follow-up x-ray examinations. After radiographic examination, patients became familiar with the equipment and simulated testing. If they satisfied the inclusion criteria, patients were called back a second time, 7 days later, to fill out rating scales and to perform physical tests. All patients were assessed at the same time, between 3:00 and 6:00 p.m., at least 3 hrs after eating.

The physical evaluation included a standardized warm-up with 15 mins on the stationary bike at a speed of 65 r/min without external resistance. After the warm-up period, a full recovery of 5 mins was allowed. Three tests with recovery of 5 mins between trials were performed for each measurement of muscle strength, and the best result was used. All measurements were performed by the same operator. The multifactorial system proposed by Chapman et al.[18] was used to assess the dominant limb.

Timed "Up and Go" Test

The Timed Up and Go test is a reliable and valid test for quantifying functional mobility that may also be useful in monitoring clinical changes over time. The test is quick, does not require any special equipment or training, and may be easily included as part of the routine medical examination. The patient, who is seated in a chair with armrests, is required to get up, walk a distance of 6 m (3 m forward and back) at maximum speed, and sit back down in the same chair.[19] The use of the integration of a functional test such as the Timed Up and Go test and evaluation of the abductor muscle strength in the assessment of patients with hip arthroplasty has already been pointed out by Nankaku et al.,[20] and these measures have been used along with the most common rating scales of autonomy.

Strength Test

The test was performed with the patient in the standard supine body position. Each patient was asked to perform a maximum isometric contraction at five values (in random order) of the joint range in abduction, starting with a first measurement of 5 degrees of lower limb adduction (−5 degrees) up to 20 degrees of abduction (−5, 0, 10, 15, and 20 degrees of abduction). The length of the lower limb was measured by x-rays, and the push point was measured with a dynamometer standardized for each patient on the operated side (OS) and on the non-OS (NOS), using an anatomic landmark placed on the external malleolus as reference. An isometric dynamometer (Lafayette Instrument, model 01163) was used to measure muscle strength, which has a selectable range between 0 and 136.1 kg or between 0 and 22.6 kg, accuracy of ±1% in both range, and precision of the values of 0.2 kg in the range between 0 and 136.1 kg and 0.1 kg in the range between 0 and 22 kg. The dynamometer was attached to the measuring table with a support specifically made for the instrument. The joint range was measured with a goniometer used in accordance with the American Medical Association guidelines.[21] The Timed Up and Go test was used before the strength test in all patients.

Barthel Index

The Barthel scale or Barthel activities of daily living index is an ordinal scale used to measure performance in routine daily activities. It is one of the most commonly used clinical instruments for general assessment of physical function, especially in rehabilitation. Although more specific for neurologic diseases, in this study and other[22] studies, it was used for global functional status evaluation. The maximum score is 100 and indicates autonomy in all routine daily activities.[4]

TABLE 1 $N = 78$ patients

	Mean ± SD
Age, yrs	70.7 ± 6.3
Weight, kg	70.5 ± 12.1
Height, cm	165.9 ± 7.3
BMI, kg/m^2	25.1 ± 5.5
Time after surgery, mos	35 ± 5
Operated limb, left	40,6% (DOM, 40%; NONDOM, 60%)
Operated limb, right	59.4% (DOM, 57.7%; NONDOM, 42.3%)
Dominant limb, left	41.9%
Dominant limb, right	58.1%

Description of the sample. Time after surgery is months after the day of surgery for total hip arthroplasty.
BMI, body mass index; DOM, dominant limb; NONDOM, nondominant limb.

Harris Score

The modified Harris hip score was used to evaluate clinical and functional aspects. It is a specific questionnaire consisting of eight questions regarding pain, walking distance, use of walking aids, presence or absence of limp, climbing stairs, ability to put on shoes and socks, sitting in a low chair and remaining seated, and the capacity to use public transport, which allows the subject's functionality to be identified. The maximum score on the Harris score is 91 points, and in this case, there is no difficulty in performing these functions.[23,24]

Western Ontario and McMaster Universities Arthritis Index

Western Ontario and McMaster Universities Arthritis Indexes (WOMAC) score is a specific test for clinical and functional evaluation of the knee and the hip.

The score is the result of four sets of questions with five possible answers. Questions were concerning the feeling of symptoms, joint stiffness, pain, and joint function while carrying out daily activities. The best score is 100, which indicates a situation with no symptoms, pain, stiffness, or difficulty in performing routine daily activities,[25] and is used by some authors in outcome evaluation after hip replacement.[26]

MOS 36-Item Short-Form Health Survey

MOS 36-Item Short-Form Health Survey (SF-36) is a questionnaire that many authors have used for a variety of diseases but is not specific to the hip or osteoarthritis.[5,24] The SF-36 is made up of 36 questions belonging to eight interest groups called "domains," four of which are related to physical health (physical activity, health and physical role, body pain, general health, and change in health status) and four are related to psychomental health

TABLE 2 Values of force (Newton) measured at various degrees of abduction range in the hip joint

	−5 Degrees, Mean ± SD	0 Degree, Mean ± SD	10 Degrees, Mean ± SD	15 Degrees, Mean ± SD	20 Degrees, Mean ± SD
Operated limb, N	57.8 ± 10	51.0 ± 9	46.2 ± 7	42.0 ± 5	39.2 ± 7
Nonoperated limb, N	63.5 ± 12	57.1 ± 10	50.0 ± 6	44.6 ± 6	41.4 ± 5
ΔO-NO, %	−9	−12	−8	−6	−5
Sig.	0.01	0.002	NS	NS	NS
Effect size, *d* value	−0.5	−0.6	−0.6	−0.4	−0.3
Correlation between operated limb and TUG, *r*	0.68	0.70	0.71	0.66	0.70
Correlation between operated limb and TUG, *P*	0.002	0.001	0.001	0.01	0.01

Measurements taken on the operated and nonoperated limbs: −5 degrees, five degrees in adduction from the neutral position; 0 degree, neutral position; 10 degree, abduction of ten degrees from the neutral position; 15 degrees, 15 degrees of abduction from the neutral position; 20 degrees, 20 degrees from the neutral position of abduction.

Sig., significance level in the difference measured between the operated and nonoperated limbs at the same level of joint range in abduction; ΔO-NO, percentage difference between the values measured on the operated and nonoperated limbs; TUG, Timed Up and Go test.

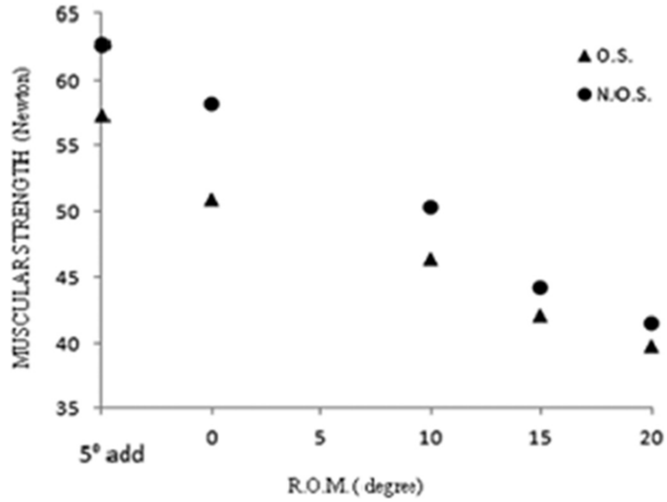

FIGURE 1 *Strength curve on OS and NOS. Figure shows a typical descending curve on both sides.*

(vitality, social activities, role and emotional state, and mental health).[27,28]

Statistics

Results are shown as mean and standard deviation. The percentage values were used to describe the difference in strength measured on both sides. The number of patients recruited (below 100) was expressed without a decimal place. The authors verified that their data fit the normal distribution by means of a normal plot and the Shapiro-Wilk test. Pearson correlation coefficient (and the corresponding 95% confidence interval) was used to examine correlations between the parameters. The paired t test was used to evaluate the differences in strength between the operated and nonoperated limbs. The multivariate analysis of variance (ANOVA) test and the Bonferroni post hoc test were used to study relationships between other variables. Significance was set at 0.05 ($P < 0.05$).

In the cases where occurrence and comparisons between percentage values had to be measured, data were compared using the χ^2 test or Fischer's exact test. SPSS 19 (IBM Inc, Armonk, NY) was used for statistical calculations.[29]

RESULTS

The descriptive data of the sample have been reported in Table 1 as mean and standard deviation. The authors evaluated 140 female patients, but only 83 of them met the study inclusion criteria for research and were recruited for the study. Five subjects withdrew from the study for personal reasons not related to the experimental procedure, and 78 patients participated in the study. All subjects who started the procedure concluded the experimental phase. Table 1 shows the descriptive data of the study sample, including the frequency of dominant and nondominant limbs. The study evaluation was carried out for a mean ± standard deviation of 35 ± 5 mos after surgery in patients who had resumed all routine daily activities. Body mass index was representative of the population and did not seem to affect autonomy. The frequency of surgery on the lower right and left limbs and on dominant and nondominant sides was evaluated with χ^2 test. The authors found no statistical significance in the observed ratio of operated limb to limb dominance, which indicates that limb dominance does not affect muscle strength.

The variables examined were normally distributed; therefore, the tests used were all parametric. In comparing the OS with the other limb, the authors found that the operated limb had less measured strength of hip abduction. The differences ranged between 5% and 12%, but only two of the five measured joint angles showed statistical significance (see Table 2).

The values of muscle strength recorded along the motion range in abduction of the hip on the OS

TABLE 3 The values of the scales (Harris, WOMAC, Barthel, and SF-36) and the Timed Up and Go test in the study sample

	Mean ± SD
Harris	61.8 ± 18
WOMAC	80.4 ± 12
Barthel	87 ± 9
SF-36	37.6 ± 6.9
Timed Up and Go Test, sec	9.8 ± 3

and on the NOS show that the strength curve has a similar trend on both sides (descending curve) (Fig. 1), as described by Kulig et al.[11] in healthy subjects. The regression equations from the study data were $y = -0.87x + 65.4$ and $r^2 = 0.97$ for the OS and $y = -1.033x + 73.21$ and $r^2 = 0.98$ for the NOS. The slope values were -0.87 ± 0.08 *vs*. -1.03 ± 0.11 for NOS, $P = 0.005$ The comparison between measurements taken at the same range of motion have been used for the comparison between the operated limb and the healthy limb. Figure 1 shows a reduction of the same amount of muscle strength with increasing ROM, on the OS and healthy side. Both on the OS and NOS, muscle strength decreases from the point at 5 degrees of adduction (−5 degrees) to that at 20 degrees of abduction. The difference between these two points is 34% ± 3% on the OS and 32% ± 2% of the NOS and was not statistically significant ($P = 0.16$).

Table 3 shows results of functional scales.

In all ranges of motion the authors tested, the authors found that the strength of the operated limb was less than that of the NOS. Muscle strength of the OS correlated with the walking efficiency as measured by the Timed Up and Go test. There were no significant correlations between the strength measured on the healthy limb and the Timed Up and Go test. No significant correlation was found between the strength measured, on both the healthy side and OS, with the Harris and WOMAC scales and the total score of SF-36. The values of the healthy side, although insignificant, were, however, always greater than the OS. In comparison with the OS, the strengths measured at 5 degrees of adduction ($r = 0.61, P = 0.01$), that at 0 degree ($r = 0.58, P = 0.03$), that at 10 degrees ($r = 0.65$, $P = 0.01$), that at 15 degrees ($r = 0.68$, $P = 0.002$), and that at 20 degrees ($r = 0.63$, $P = 0.02$) were significantly correlated with the values of social activity described in SF-36. No other correlations were found between the values of muscle strength described by the strength curve on the OS and the other "domains" (physical activity, physical role, body pain, and vitality) of the SF-36 scale. No correlation was found between the force values measured on the healthy side and the domains of the SF-36. Table 4 shows the correlation matrix of all variables.

DISCUSSION

The authors were able to measure a range of hip abductor strength settings from −5 to 20 degrees in a sample of female patients and compare the unoperated limb to the OS. None of the recruited patients discontinued the trial for reasons related to performing the muscle strength test at various degrees of joint range of motion, thereby confirming (35 ± 5 mos after surgery for hip replacement) applicability of the strength curve for evaluating muscle strength in the outcomes of hip replacement in the study sample. However, additional studies done earlier in the course of rehabilitation would be useful to verify the applicability of the muscle strength curve in the more immediate postoperative time interval. In relation to the second objective of this research, data show that the curves obtained on the OS have the same descending trend as those on the NOS. This finding had not been previously noted by other authors.

As mentioned in the introduction, some geometric factors can affect the shape of the strength curve; however, the study data did not reveal a difference in the ability to apply strength in the joint range. In fact, the differences found are not related to the shape of the curve but the magnitude of the strength produced. Despite that approximately 3 yrs had passed after surgery and the patients showed a good level of recovery and autonomy, differences in the abductor muscle strength between the healthy side and OS are still evident, which are also described by the slope values (-0.87 ± 0.08 *vs*. -1.03 ± 0.11 for NOS, $P = 0.005$). Although not statistically significant, the difference found in 5 degrees of adduction and 10 degrees from the neutral position is approximately 10%. Therefore, the differences in this percentage are to be considered during the planning of rehabilitation. Given the age of the patients, the lack of muscle strength is important because of the correlation that muscle strength generally has in the elderly with balance when walking and for the prevention of falls.[29]

The analysis of the study data in relation to the assessment of muscle strength obtained on the OS and NOS showed that, despite the long period after surgery, muscle strength differences persist between the two sides. The differences are statistically significant at the two positions of the joint range (−5 degrees or 5 degrees in adduction and 0 degrees, the neutral position), and the analysis of the differences in muscle strength between the two sides in the same position tends to decrease with increasing of the joint range. The descending trend with the two curves has different slope: -0.87 ± 0.08 on the healthy side and 1.03 ± 0.11 on the OS. The two values are statistically significant ($P = 0.005$). The data suggest that, if you wanted to make a measurement of muscle strength in less time, it may be evaluated in the first degrees of range of motion, where there was a greater difference. Unfortunately, the study data do not give

TABLE 4 Correlation matrix

		Harris	WOMAC	−5 Degrees, O	0 Degree, O	10 Degrees, O	15 Degrees, O	20 Degrees, O	−5 Degrees, C	0 Degree, C
WOMAC	*r*	0.881								
	Sig.	0.000								
−5 degrees, O	*r*	0.090	0.102							
	Sig.	0.661	0.619							
0 degree, O	*r*	0.223	0.190	0.896						
	Sig.	0.275	0.353	0.000						
10 degrees, O	*r*	0.186	0.148	0.885	0.879					
	Sig.	0.364	0.471	0.000	0.000					
15 degrees, O	*r*	0.227	0.202	0.833	0.810	0.892				
	Sig.	0.265	0.324	0.000	0.000	0.000				
20 degrees, O	*r*	0.251	0.235	0.791	0.765	0.828	0.889			
	Sig.	0.226	0.259	0.000	0.000	0.000	0.000			
−5 degrees, C	*r*	−0.206	−0.171	0.673	0.618	0.749	0.630	0.587		
	Sig.	0.312	0.403	0.000	0.000	0.000	0.000	0.001		
0 degree, C	*r*	−0.129	−0.150	0.629	0.536	0.594	0.490	0.403	0.846	
	Sig.	0.530	0.463	0.000	0.002	0.000	0.004	0.024	0.000	
10 degrees, C	*r*	−0.086	−0.063	0.666	0.656	0.721	0.621	0.572	0.889	0.826
	Sig.	0.676	0.761	0.000	0.000	0.000	0.000	0.001	0.000	0.000
15 degrees, C	*r*	−0.201	−0.239	0.583	0.625	0.693	0.593	0.582	0.804	0.685
	Sig.	0.325	0.240	0.000	0.000	0.000	0.000	0.001	0.000	0.000
20 degrees, C	*r*	−0.270	−0.227	0.603	0.600	0.721	0.621	0.604	0.772	0.641
	Sig.	0.182	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Timed Up and Go test	*r*	−0.578	−0.487	−0.680	−0.700	−0.710	−0.660	−0.700	−0.256	−0.192
	Sig.	0.003	0.016	0.002	0.001	0.001	0.010	0.010	0.179	0.319
Physical functioning	*r*	0.729	0.765	0.156	0.265	0.342	0.226	0.242	0.045	−0.060
	Sig.	0.000	0.000	0.428	0.172	0.075	0.248	0.225	0.819	0.763
Role, physical	*r*	0.523	0.475	0.272	0.340	0.353	0.304	0.260	0.021	−0.049
	Sig.	0.007	0.017	0.161	0.077	0.065	0.115	0.160	0.916	0.803
Bodily pain	*r*	0.500	0.548	0.346	0.304	0.341	0.250	0.320	0.144	0.090
	Sig.	0.011	0.005	0.071	0.053	0.075	0.199	0.073	0.464	0.649
General health	*r*	0.138	0.319	0.003	0.013	−0.041	−0.003	0.040	−0.101	−0.146
	Sig.	0.511	0.121	0.987	0.949	0.837	0.986	0.843	0.611	0.460
Vitality	*r*	0.496	0.600	0.256	0.250	0.194	0.216	0.286	0.059	0.082
	Sig.	0.012	0.002	0.189	0.199	0.322	0.270	0.148	0.767	0.680
Social Functioning	*r*	0.318	0.328	0.610	0.580	0.650	0.680	0.630	0.269	0.231
	Sig.	0.121	0.109	0.010	0.030	0.010	0.002	0.020	0.166	0.237
Role, emotional	*r*	0.338	0.436	0.238	0.255	0.172	0.215	0.358	−0.001	−0.075
	Sig.	0.098	0.029	0.222	0.191	0.382	0.272	0.067	0.998	0.706
Mental health	*r*	0.559	0.619	0.147	0.208	0.182	0.209	0.316	0.006	−0.031
	Sig.	0.004	0.001	0.455	0.289	0.353	0.286	0.109	0.974	0.876
SF-36	*r*	0.644	0.680	0.233	0.317	0.369	0.195	0.317	0.067	−0.020
	Sig.	0.002	0.001	0.296	0.150	0.091	0.385	0.161	0.766	0.930
Barthel	*r*	0.610	0.580	0.331	0.216	0.312	0.118	0.410	0.267	0.278
	Sig.	0.004	0.001	0.150	0.234	0.106	0.450	0.765	0.561	0.110

Values of correlation (*r*) and significance (Sig.) between the studied variables. Values of force measured at various degrees of abduction range in the hip joint (−5 degrees, five degrees in adduction from the neutral position; 0 degree, neutral position; 10 degrees, abduction of ten degrees from the neutral position; 15 degrees, 15 degrees of abduction from the neutral position; 20 degrees, 20 degrees from the neutral position of abduction). Physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health are the eight domains of the SF-36.

Barthel indicates Barthel scale; C, healthy side; Harris, Harris scale; O, operated limb; WOMAC, WOMAC scale.

information to explain why the two curves are nearer to the higher grades of abduction.

The last objective of this study was to assess whether and what relationships exist between the autonomy of the subjects examined (routine daily activities and walking) and muscle strength. Autonomy has been described with the use of rating scales as shown by other authors,[29,30] which showed the efficacy of the combined use of scales and strength measurement in the assessment of outcome on rheumatology patients.

The rating scales showed a sample with a good recovery of autonomy in routine daily activities (mean Barthel value of 87 ± 9), SF-36 (mean, 37.6 ± 6.9), Harris scale (61.8 ± 18), and the WOMAC scale (80.4 ± 12). The data indicate no relationships between the

10 Degrees, C	15 Degrees, C	20 Degrees, C	Up and Go Test	Physical Functioning	Role-Physical	Bodily Pain	General Health	Vitality	Social Functioning	Role-Emotional	Mental Health
0.843											
0.000											
0.732	0.851										
0.000	0.000										
−0.297	−0.353	−0.282									
0.117	0.060	0.138									
0.121	−0.048	−0.023	−0.615								
0.540	0.807	0.906	0.001								
0.061	0.091	0.071	−0.459	0.619							
0.758	0.646	0.718	0.018	0.000							
0.260	0.154	0.107	−0.685	0.608	0.399						
0.181	0.433	0.588	0.000	0.001	0.035						
0.021	−0.149	−0.166	0.155	0.266	0.454	0.081					
0.915	0.449	0.397	0.451	0.172	0.015	0.683					
0.101	0.044	0.024	−0.537	0.513	0.687	0.608	0.334				
0.610	0.826	0.904	0.005	0.005	0.000	0.001	0.082				
0.258	0.385	0.387	−0.460	0.362	0.484	0.364	0.065	0.466			
0.186	0.043	0.042	0.018	0.058	0.009	0.057	0.741	0.012			
0.038	0.064	0.056	−0.452	0.441	0.539	0.645	0.322	0.677	0.560		
0.847	0.745	0.777	0.021	0.019	0.003	0.000	0.095	0.000	0.002		
0.049	0.057	0.057	−0.676	0.606	0.603	0.549	0.132	0.651	0.681	0.698	
0.804	0.774	0.772	0.000	0.001	0.001	0.002	0.502	0.000	0.000	0.000	
0.181	−0.044	−0.045	−0.649	0.839	0.737	0.648	0.477	0.559	0.143	0.296	0.313
0.421	0.847	0.841	0.002	0.000	0.000	0.001	0.025	0.007	0.525	0.181	0.157
0.310	0.170	0.194	0.510	0.550	0.280	0.618	0.217	0.610	0.520	0.321	0.218
0.088	0.214	0.113	0.002	0.031	0.124	0.002	0.189	0.001	0.030	0.456	0.231

values of muscle strength and rating scales. The domains on social activities present in the SF-36 show that better social activity (60.5 ± 16.1) was associated with the highest values of muscle strength on the OS ($r = 0.66$, $P = 0.001$). This is odd, and the authors can suppose that social activities include more various and less stereotyped activities than those studied in WOMAC and Harris scales. However, this aspect needs further studies considering also the floor-ceiling effect of the scales after a long time from surgery as shown by the study sample.

For specific assessment scales (Harris and WOMAC) and general scales (Barthel and SF-36), there were no statistically significant relationships between the questionnaires and the measurement of muscle strength.

The data thus would seem to indicate that evaluation with questionnaires is useful to classify the severity of the disease but provides little information for planning and monitoring the effectiveness of rehabilitation treatment.

The statistical correlation between muscle strength and the Timed Up and Go Test confirms that a physical test, rather than a questionnaire, is able to provide better information for patients 3 yrs after surgery. Therefore, in this sense, especially a long time after surgery, functional assessment measurements such as muscular strength measurement and the physical efficiency test (Timed Up and Go test) seem more useful. Muscle strength could be influenced by dominance, but no relationship between dominance and the incidence of hip replacement was found in the study subjects. Therefore, the differences measured are attributed to surgery.

The Timed Up and Go test includes multiple aspects (standing, proper step mechanisms, speed associated with efficient propulsion) that depend on good efficiency of the hip abductor muscles and that may explain the strong correlation found between the evidence and all values of muscle strength measured on the OS.[30] The authors presume that the relationship found between the Timed Up and Go value and the measured strength of the operated limb could be due to that the abducted musculature is involved in the standing up movement and walking typical of the Timed Up and Go.

Long-term hip joint replacement does not affect the characteristic shape of the decreasing strength curve, and therefore, any changes to the shape of the curve could be a sign of imperfect restoration of normal joint biomechanics. Despite that nearly 3 yrs had passed after surgery and patients had restored a sufficient degree of autonomy, a deficit in muscle efficiency was shown. This fact emphasizes the importance of the strength exercises by the abductor muscles, to reach autonomy maintenance and prosthesis damage prevention.[3,6] However, it should be continued because of the proven preventive effect on falls in elderly patients.[29,30] The discrepancy between force measures and sufficiently reached autonomy level of the examined patients could be ascribed to the floor-ceiling effect of the scales. According to the aims in the Introduction, the study results give to the physician useful suggestions in the post–hip surgery patient evaluation: (1) the usage of force curves use in the muscular strength measurement, (2) the descending curve registered in these patients is the normality, (3) the small-medium effect of the strength lack of the operated hip with respect to the unoperated side is to be waited, and (4) the strength evaluation is to be preferred to the scales evaluation.

A limit of this work is that it used only women sample. This is because, where this research took place, the women patients' frequency was three times higher than men patients. Actually, Kulig et al.'s[11] article about the force curves does not show differences between men and women, but further studies are needed. Another limitation of this study is that it considered only patients submitted to hip replacement for arthrosis. Further studies on different kinds of patients are needed.

CONCLUSIONS

The use of strength curves in assessing muscular effectiveness after hip replacement allows us to have double information from a single test: the size of any muscle strength deficit and proper joint function by means of the strength curve trend. The use of functional tests is recommended in the case of clinical assessment after several months from surgery.

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