

ORIGINAL RESEARCH

ISOKINETIC DYNAMOMETRY IN ELDERLY WOMEN UNDERGOING TOTAL KNEE ARTHROPLASTY: A COMPARATIVE STUDY

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OBJECTIVE: The present study assessed the reliability and validity of isokinetic dynamometry in the qualitative determination of the evolution of total knee arthroplasty. Cases: 20 patients whose mean age was 71.35 years, undergoing knee arthroplasty, and 25 controls whose mean age was 71.36 years.

METHOD: Computerized isokinetic assessment of flexor and extensor muscles using a CYBEX® 6000 dynamometer.

RESULTS: The total flexor/extensor effort ratio for the treated side of patients vs the nondominant side of controls was not significantly different. The flexion/extension ratio concerning maximum torque for the treated side of patients vs the nondominant side of controls was significantly different.

CONCLUSION: By detecting deficiencies in the balance of flexor and extensor muscles (a balance that is required for uniform gait), it will be possible to select specific rehabilitation exercises according to the individual needs of each patient undergoing surgery.

KEYWORDS: Geriatrics. Orthopedics. Rehabilitation.

INTRODUCTION

Total knee arthroplasty was developed in an attempt to improve the intense functional disability presented by patients with degenerative joint processes. It has become an increasingly used option, since the results are good and the incidence of complications is low.¹ Such satisfactory results are mainly due to better quality of prosthesis design, improvement of the employed material, more accurate instruments, and improved surgical technique, which leads to less pain and better correction of deformities.^{2,3} Although the major concern is pain relief, followed by gain of range of motion of the joint and alignment of the lower limbs, increasing attention has been given to the study of muscular performance deficit in these patients.^{4,5}

A proper balance of the muscular forces acting on the knee is important for the maintenance of articular stability.⁶⁻⁸ Studies have been published describing muscle evaluation in patients undergoing total knee arthroplasty.⁹⁻¹¹ However, most such studies consist of qualitative observations and subjective clinical evaluations.^{4,12,13} Muscle tests allowing objective evaluations are not commonly reported.^{14,15}

Isokinetic dynamometry is currently one of the most accurate methods of muscle assessment.^{16,17} Nevertheless, in addition to noting that few papers have been published on isokinetic dynamometry in patients undergoing total knee arthroplasty, it is worth noting the heterogeneity and existence of methodological problems (such as the lack of separate presentations of isokinetic dynamometry values for men and women) and controversial issues found in most of those papers.

The objectives of the present study are a) to determine whether isokinetic dynamometry is a reliable method for

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evaluating muscle strength in female patients undergoing total knee arthroplasty; and b) to establish whether, in relation to isokinetic values, the contralateral side is a good parameter for comparison in these patients.

PATIENTS AND METHODS

This was an observational controlled cross-sectional study involving 20 women (66–75 years) with primary osteoarthritis undergoing primary unilateral total knee arthroplasty with a total condylar-type prosthesis, whose postoperative clinical outcomes were rated good to excellent according to the Hospital for Special Surgery³ and the International Knee Society¹⁸ protocols as well as involving 25 controls (women who were participants in Hospital das Clínicas, the São Paulo University Medical School Volunteer Association, including caregivers and employees of the hospital). The criteria used for the selection of volunteers in this study¹⁹ were a) age = 65 to 75 years; b) female; c) sedentary lifestyle (no more than 1 hour of physical activity/week); d) no history of pain in any knee that limited habitual activities for more than 48 hours during the last 2 years; e) no history of previous musculoskeletal disorders and no nervous diseases or previous fractures in the lower limbs; f) no instability in any plane or angular deviations in the knees (varus or valgus larger than 10 degrees); g) no use of a pharmacological substance that might affect the mechanism of muscular contraction; h) no previous isokinetic assessment; and i) no unbalancing systemic disease, such as cardiac disease or hypertension.

All participants, both in the intervention and control groups, had a computerized isokinetic assessment of knee flexor and knee extensor muscles using a Cybex® 6000 dynamometer.

All participants were informed about the procedures they would be subjected to, after which they gave their written consent. The Ethics Committee for Analysis of Research Projects approved the assessment protocol.

The average postoperative period of the evaluated patients was 17.8 ± 6.8 months (range, 12–36 months).

The average score of patients according to the Hospital for Special Knee Rating System was 89.75 ± 3.80 points (range, 85–97 points).

The average score of patients according to the Knee Society Scoring System was 174.80 ± 11.52 points (range, 160–195 points).

The preferred kicking side of each volunteer was considered her dominant side (Table 1).²⁰

Exclusion criteria were partial arthroplasties or revision arthroplasties; total bilateral arthroplasties; muscle injuries, nerve injuries, and/or lower limb fractures before the test²¹;

presence of clinically uncompensated systemic disease (cardiopathies, HAS, etc); presence of phlogistic signs, or open surgical wounds, or any other type of wound in the limbs evaluated.²²

The inclusion criteria were female sex; sedentary (less than 1 hour of physical activity per week); asymptomatic, without history of injury; knee instabilities or angular deviations, without significant morbid past; and without history of isokinetic evaluation.^{22,23}

The extension and flexion testing were performed at an angular velocity of 60°/s. Each test was performed with the volunteer or patient in the sitting position, with belts positioned around the thorax, abdomen, thigh, and the region above the knee to be evaluated, aiming to limit the person's movements.²⁴ A device incorporated into the dynamometer made the correction for the effect of gravity.²¹

The tests were performed bilaterally both in patients undergoing total knee arthroplasty (Group 1) and in volunteers (Group 2) and started always with the side that had not been operated on in patients of Group 1 and with the dominant side in the controls of Group 2. The absolute values of maximum torque and total effort were measured, as well as their values adjusted for body weight in the two groups studied. Also measured were the flexion/extension ratio for maximum torque and total effort.

All values measured corresponded to concentric contractions.

We used statistical analysis to evaluate the following comparisons: the side undergoing total knee arthroplasty of patients vs the dominant- and nondominant limb of the control group and the untreated side of patients undergoing arthroplasty vs the dominant and nondominant side of the control group. Additionally, an intragroup comparison was made between sides.

Initially, all variables were analyzed in a descriptive manner. We recorded the maximum and minimum values of each measured variable and calculated the mean, standard deviation, and median. For the statistical analysis we used nonparametric tests, as follows:

- The Wilcoxon test to compare the treated and untreated sides of Group 1 and the dominant and nondominant sides of Group 2.
- The Mann-Whitney test to compare Groups 1 and 2. Here we compared the treated side of Group 1 with the dominant and nondominant side of Group 2, and the untreated side of Group 1 with the dominant and nondominant side of Group 2.

A 5% significance level was established for all comparisons ($P = 0.05$).

RESULTS

The results are summarized in Tables 2 and 3. The maximum flexor torque of Groups 1 and 2 were significantly different. The maximum flexor torque values of the treated side of patients was 79% of the values found in the dominant side of the control group and 82% of the values found in the nondominant side of the control group. The total flexor muscle effort values followed the same pattern, with a significant difference between the two groups evalu-

ated; the results achieved in the treated side were 66% of those found in the dominant side and 73% of those found in the nondominant side of the controls (Table 2).

Also, in the analysis of the extensor movement, a significant difference between Groups 1 and 2 was observed for both the maximum torque values and total effort values. The maximum extensor torque values for the treated side were 75% of those found in the dominant side and 74% of those found in the nondominant side of the controls, while the total extensor effort values were 75% of those

Table 1 - Group Characteristics

Group	Age (years) Mean ±SD	Weight (kg) Mean ±SD	Height (m) Mean ±SD
Intervention (Group 1)	71.35 ± 3.23	75.75 ± 9.47	1.56 ± 0.06
Control (Group 2)	71.36 ± 3.24	65.84 ± 10.27	1.55 ± 0.05
<i>P</i>	0.917	< 0.001	0.514

Table 2 - Descriptive statistics (absolute values) and results of statistical tests

Group	Side	Maximum flexor torque Mean ± SD	Maximum extensor torque Mean ± SD	Total flexor effort Mean ± SD	Total extensor effort Mean ± SD	Maximum flexor/ extensor torque Mean ± SD	Total flexor/ extensor effort ratio Mean ± SD
Intervention (Group 1)	NOP	35.35 ± 9.52	74.65 ± 18.46	33.10 ± 12.7	71.50 ± 22.67	47.75 ± 9.46	45.75 ± 10.25
	OP	37.25 ± 7.97	64.25 ± 15.82	32.80 ± 9.57	63.80 ± 18.74	58.55 ± 9.54	51.75 ± 9.83
	<i>P</i>	0.266	0.053	0.776	0.130	< 0.001	0.0014
Control (Group 2)	DOM	47.16 ± 8.2	86.24 ± 14.54	49.40 ± 10.31	84.56 ± 14.78	54.76 ± 8.81	58.48 ± 11.15
	NDOM	45.56 ± 7.7	87.16 ± 15.30	45.24 ± 9.36	85.12 ± 15.62	52.32 ± 7.46	53.00 ± 8.10
	<i>P</i>	0.124	0.346	0.006	0.605	0.089	0.008
NOP X DOM	<i>P</i>	< 0.001	0.048	< 0.001	0.044	0.034	0.001
NOP X NDOM	<i>P</i>	0.001	0.02	0.002	0.049	0.128	0.006
OP X DOM	<i>P</i>	0.001	< 0.001	< 0.001	< 0.001	0.131	0.037
OP X NDOM	<i>P</i>	0.002	< 0.001	< 0.001	< 0.001	0.021	0.599

NOP = side not operated on; OP = side operated on; DOM = dominant side of controls; NDOM = nondominant side of controls

Table 3 - Descriptive statistics (absolute values) and results of statistical tests (values adjusted for body weight)

Group	Side	Maximum flexor torque Mean(SD)	Maximum extensor torque Mean(SD)	Total flexor effort Mean(SD)	Total extensor effort Mean(SD)	Maximum flexor/ extensor torque Mean(SD)	Total flexor/ extensor effort ratio Mean(SD)
Intervention (Group 1)	NOP	46.05(11.61)	97.85(23.23)	42.90(14.73)	93.60(28.99)	47.75(9.45)	45.75(10.25)
	OP	48.70(9.29)	84.10(17.89)	42.55(10.95)	83.45(21.30)	58.55(9.57)	51.75(9.83)
	<i>P</i>	0.316	0.051	0.887	0.121	<0.001	0.014
Control (Group 2)	DOM	72.00(13.09)	131.00(15.18)	75.56(17.12)	128.84(18.65)	54.76(8.81)	58.48(11.15)
	NDOM	69.36(10.36)	132.28(15.37)	69.00(14.26)	129.60(19.63)	52.32(7.45)	53.00(8.10)
	<i>P</i>	0.110	0.353	0.005	0.615	0.089	0.008
NOP vs DOM	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001	0.034	0.001
NOP vs NDOM	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001	0.128	0.006
OP vs DOM	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001	0.131	0.037
OP vs NDOM	<i>P</i>	< 0.001	< 0.001	< 0.001	< 0.001	0.021	0.599

NOP = side not operated on; OP = side operated on; DOM = dominant side of controls; NDOM = nondominant side of controls

for each side in the control group (Table 2).

Regarding flexion/extension ratio for maximum torque, there was a significant difference between the treated side of patients and the nondominant side of the controls. No significant difference was observed between the treated side of patients and the dominant side of the controls.

A statistical analysis of the total flexor/extensor effort ratio did not show a significant difference between the treated side of patients and the nondominant side of the volunteers.

DISCUSSION

In several papers published in the medical literature regarding isokinetic study of osteoarthritic patients undergoing total knee arthroplasty, the muscle torque of the treated limb versus the muscle torque of the contralateral side of these patients has been used as an evaluation parameter. However, this method has the limitation that a limb that may be impaired by clinically adverse conditions is used as a normality parameter; in many cases osteoarthritis is bilateral and symptomatic. Another factor that should be considered is that the untreated side, even if not affected, is subjected to a higher functional overload during the preoperative period, because of the presence of a painful limb during the normal daily life activities as well as during the immediate postoperative period due to the presence of the arthroplasty in the opposite side. Furthermore, data found in the literature show that the results of functional evaluations are not very reliable in patients with osteoarthritis of the knee, because of the presence of large individual variations in the measurements of the muscle torque in this type of patient.²⁵ The result can be an incorrect rehabilitation program.

Undoubtedly, the fundamental indication for total knee arthroplasty is pain—chronic, progressive, and refractory to conservative treatment—followed by severe deformity and functional disability. The mere relieving of such pain, together with the gain in articular range of motion and gait improvement, already validates the surgery performed. However, although the recovery of the deficit of muscle performance is not the main purpose of rehabilitation of patients undergoing total knee arthroplasty, increasing attention has been given to the study of muscle deficit during the postoperative period of this type of surgery,⁴ and relevant data have been published showing a progressive, significant increase of isokinetic parameters, not only on the side of the arthroplasty, but also on the untreated side.²⁵ Therefore, it is clear that if the untreated side is also benefited by surgery, it is at least prudent to adopt a comparison parameter capable evaluating the function of this limb

during follow-up. For these reasons we decided to create a control group formed by female volunteers to represent the elderly women in the same age group but without knee affections, to serve as a comparison parameter for patients undergoing this type of surgical procedure. In order to show that comparison with the untreated side is an incorrect parameter, we also conducted comparisons with this group.

In a previous paper¹⁹ we showed that the elderly could not be considered a single homogeneous group. From this perspective, one of the important steps for the development of this study was the definition of criteria to be used to form the group of female volunteers. We tried to form the most homogeneous group aged between 65 and 75 years, without knee affections.

The angular speed employed was 60 degrees/second. This speed was chosen because it is considered safe and appropriate and allows a complete, correct evaluation of all the patients involved, with reproducible results for the type of patients participating in this study.¹⁴ Moreover, it has the advantage of being one of the angular speeds that causes the fewest changes in the patellofemoral joint²⁷; additionally, it can be compared with data published in literature.^{14,28} However, published reports do not provide a standardized angular speed for isokinetic evaluation in patients undergoing total knee arthroplasty. Given the higher potential for injury presented by eccentric contractions on the assessed structures of joints (which would be even greater in a group of female elderly patients undergoing surgical procedures as serious as total knee arthroplasty), we chose to evaluate only the concentric contractions. Additionally, eccentric contractions are more difficult for the individual being assessed to understand and perform, with the consequence that the resulting data will have large variations, which makes eccentric contractions less reliable and valid than concentric evaluations.

It is worth emphasizing the importance of separately presenting the values from isokinetic studies in male and female patients;²⁹ differences between these groups are noticed mainly in the parameters related to muscle strength generation, although this value is not measured directly, but rather by means of the torque that is generated.

Although it is reliable, we did not use muscle perimetry in this study as an ad hoc method to infer the ability to develop muscle strength because we agree with Gross et al²¹ in the sense that the panniculus adiposus can alter this measurement and that muscle perimetry applies better to the individual control of clinical evolution than to a population study. Therefore, this measurement would not provide supplementary or more accurate information than that obtained using our type of evaluation. Although Clarkson et al³⁰ emphasized the high correlation between measure-

ments of maximum torque and perimetral measurements, these measurements depend on many variables (such as the kind of measuring tape employed, the limb site where the measurement is made, the tension applied during the measurement, the size of the panniculus adiposus, and hormone variations), which makes it difficult to compare these values with others from scientific studies and compromises their reproducibility.

It was very difficult to compare the results from this study with data found in the literature, due to the small number of published articles concerning isokinetic dynamometry in women undergoing total knee arthroplasty. Moreover, the presence of gross methodological errors in some studies (lack of separate presentation of isokinetic values for men and women, omission of the angular speed value/type of prosthesis employed in the evaluation); the nonexistence of a standardized angular speed for this type of study; and the fact that several studies based their research only on the determination of maximum torque values (in some cases, only the maximum torque of the extensor is measured) greatly complicates the comparison of results.

The parameters evaluated were maximum torque, total effort, and the flexion/extension ratio concerning maximum torque and total effort. Although a significant difference was shown concerning the weight of Groups 1 and 2, the values of maximum torque and total effort adjusted for body weight according to the mathematical function, *value of the parameter evaluated divided by the subject's body weight in kg, multiplied by 100 and expressed in percent*, which is automatically provided by the isokinetic dynamometer, followed the same pattern of the absolute values that were measured.

Maximum torque is the most quoted parameter in the literature when it comes to isokinetic dynamometry. It is considered to be the most reliably measured parameter, in addition to being easy to determine. However, some authors criticize its use as the single parameter for functional assessment of muscular activity, since it represents only 1 movement during the entire arc of movement and often will not reflect the patient's performance throughout the test.³¹ Based on this, we chose to use as complements the values of total effort because, since they measure the force of muscular contraction applied during the entire arc of movement, they provide much more representative interpretation and evaluation of results concerning the total functional ability of female patients.

Although the values of maximum torque of the treated side did not reach the values of the dominant and nondominant sides of the controls, the outcomes in this study were superior to those reported by Berman et al.¹⁴ Our results become even more relevant if we observe that

those authors did not provide separate isokinetic values for men and women that, most certainly, would show an even more pronounced difference.

The untreated side has been shown in this study not to be a good comparison parameter for female patients undergoing unilateral total knee arthroplasty, since a significant difference occurred in almost all evaluated isokinetic parameters when compared with the control group (except for the flexor/extensor ratio for maximum torque when compared with the nondominant side of the controls). It should also be noted that we evaluated only results considered good and excellent according to clinical evaluation systems, which eventually led us to form a more or less homogeneous contralateral group in good clinical condition, since these evaluation systems assign points to a functional score (such as ability to walk and go up and down stairs). Most certainly, studies that do not meet these inclusion criteria will find even more evident results due to the presence of a more heterogeneous group.

We decided to compare the female patients undergoing surgery with both the dominant and nondominant sides of the female volunteers, because the literature does not provide a fully accepted standard. However, concerning dominance, the results showed no significant differences between the values of maximum torque of the dominant side and those of the nondominant side in the control group. This was true both for the maximum flexor torque and the maximum extensor torque.

Although a significant difference was found for the flexion/extension ratio for maximum torque between the treated side of patients and the nondominant side of the controls, this did not occur when we compared the treated side of patients with the dominant side of the controls. Also, the values found for the treated side of patients are close to the values reported by Berman et al¹⁴ and are within the values considered normal by some authors.^{14,32,33}

As mentioned before, the main purpose of rehabilitation of patients undergoing total knee arthroplasty is pain relief, followed by the gain of range of motion of the joint and gait improvement. However, it is possible that in selected women (that is, cooperative, clinically stable individuals used to a slightly higher level of physical activity), perhaps it would be beneficial to give more attention to the recovery of their muscular performance deficit. It is in the recovery of these patients that the benefits provided by information collected using isokinetic dynamometry would be more easily observed.

Isokinetic dynamometry allows a more direct view of the studied joint, allowing objective and isolated assessment of the true functional capability of the treated knee. Thus, the effects of degenerative changes of other muscular joints

and systems (common in osteoarthritic patients) are minimized, making it possible to conduct more judicious planning for the rehabilitation program. The contribution to the planning of the rehabilitation program is the main practical application of this type of evaluation, since by detect-

ing the deficiencies concerning the balance of flexor and extensor muscles (a balance that is required for uniform gait), specific rehabilitation exercises may be emphasized according to the individual needs of each woman undergoing total knee arthroplasty.

RESUMO

Aquino M de A, Garcez-Leme LE. Dinamometria isocinética na determinação da evolução da artroplastia total do joelho em mulheres idosas: um estudo comparativo. Clinics. 2006;61(3):215-222.

OBJETIVO: O presente estudo avaliou a dinamometria isocinética na determinação qualitativa da evolução da artroplastia total do joelho.

CASUÍSTICA E MÉTODO: Vinte pacientes com média de

71, 35 anos, submetidas a artroplastia de joelho e 25 controles com média de 71,36 anos. Foi utilizada avaliação isocinética computadorizada para os músculos flexores e extensores dos joelhos num dinamômetro marca CYBEX® 6000.

RESULTADOS: A análise estatística dos valores da relação entre o trabalho total flexor e extensor não demonstrou diferenças significativas entre o lado operado das pacientes e o lado não dominante das voluntárias. A relação flexão/ extensão do torque máximo demonstrou uma diferença

significativa entre o lado operado das pacientes e o lado não-dominante das voluntárias.

CONCLUSÃO: Por detecção de deficiências do equilíbrio dos músculos flexores e extensores (equilíbrio este necessário para uma marcha uniforme), poderão ser

ênfatisados exercícios de reabilitação específicos conforme a necessidade de cada paciente operada.

UNITERMOS: Artroplastia. Envelhecimento. Dinamometria Isocinética. Reabilitação.

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