Evaluation of hip adductor and abductor muscles using an isokinetic dynamometer

Fábio Teodoro Coelho Lourencin[1], Osmair Gomes de Macedo[2], Ennio da Silveira Scarpellini[3], Júlia Maria D'Andrea Greve[4]

ORIGINAL ARTICLE

ABSTRACT

Objective: To evaluate the activity of the adductor and abductor muscle groups of the hip in young adults by using an isokinetic dynamometer. **Method:** 20 male volunteers were selected, with ages varying between 21 and 30 years for evaluation on a Cybex 6000 isokinetic dynamometer, at angular speeds of 60°/s and 120°/s. **Results:** In relation to the dominance, it did not show any statistically significant differences at the two studied speeds. At these two speeds the maximum torque, the total work, and the average power presented statistically significant differences in all the comparisons. Comparing the muscle groups revealed statistically significant differences for the total work, with higher average values in the abductor muscle group studied at both speeds and the average power found higher mean values at 120°/s in the same muscle group. **Conclusion:** There was no statistically significant difference in relation to dominance. When comparing speeds, all variables showed a statistically significant difference in the prevalence of maximum torque and total work at 60°/s and average power at 120°/s. The statistical comparison between muscle groups showed significant differences for the total work at both speeds and the average power at a rate of 120°/s.

Keywords: biomechanics, hip joint, muscle strength dynamometer

[1] Physical therapist, Professor at the Faculdades Integradas de Bebedouro - FABIBE (Integrated Colleges of Bebedouro).
[2] Physical educator and Physical therapist, Assistant Professor at the Physical Therapy course from the Faculdade de Ceilândia (FCE) (Ceilândia College) at the Universidade de Brasília (UnB) (University of Brasília).
[3] Physical therapist, Specialist in Physiology of Exercise by the Universidade Federal de São Carlos (UFSCar) (São Carlos Federal University).
[4] Physiatrist, Professor at the Faculdade de Medicina da Universidade de São Paulo (University of São Paulo - College of Medicine), Chief of the Laboratory for Studies of Movement from the Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (Orthopedics and Traumatology Institute at the Clinics Hospital - University of São Paulo - Medical School).

Mailing address:
Fábio Teodoro Coelho Lourencin
Rua Paulo Setubal, 166
CEP 15014-160
São José do Rio Preto - SP
E-mail: fabio@fisionet.com.br

Received on November 1, 2011.
Accepted on December 1, 2011.

DOI: 10.5935/0104-7795.20120004

INTRODUCTION

The concept of isokinetic exercise was developed by James Perrine, in 1960, and was a revolution in the preparation of exercise and rehabilitation.[1]

From that, equipment that allowed the determination of articular movement was developed, whose main characteristic is the maintenance of the constant angular velocity in the joint evaluated for any level of force exerted. This characteristic inherent to isokinetic dynamometers allows the overload of a muscle to 100% of its maximum capacity over its entire range of motion, making the instruments very useful for evaluation and exercise.[2]

The parameters evaluated by isokinetic dynamometry allow the verification of some muscular characteristics with precision, such as maximum torque, indices of resistance and muscle fatigue, total work, average power, and ratio of agonist and antagonist action, among others.

Isokinetic dynamometry is safe and allows a more complex and reliable evaluation of the muscles, and probably represents the "gold standard" in the evaluation of the open kinetic chain isolated in the muscular strength tests in current rehabilitation.[3]

There is also an important aspect during the test that is the presence or absence of verbal encouragement, which can have a dramatic effect on the ability to produce maximum exertion. This encouragement is probably stimulating to perform the maximum exertion during any type of performance evaluation.[4]

Much is known about isokinetic dynamometry on certain joints and various articles are found in the literature, where we can highlight some of the works made by the College of Medicine at the University of São Paulo, which studied the feet of adult males, the strength of flexor and extensor muscles of the knee in both amputated patients and normal individuals, and the flexor and extensor muscles of the trunk.[5-7]

The hip muscle group has been little tested and rehabilitated with isokinetic dynamometry and there are few published articles.[1]

In a study made at the Federal University of Minas Gerais, in Brazil, the authors report that muscular weakness of lower limbs, especially the hips, has been considered a risk factor for the occurrence of falls, but that this statement is based on a manual muscular test and not on isokinetic measurement, and that no significant differences have been found between the hip muscle function of elderly who have fallen and those who have not when submitting them to isokinetic evaluation.[8]

In another study, made in Germany, the authors show little knowledge of hip muscle strength, especially when an endoprosthetic implant is used.[9]

An important work made by the Orthopedic Department at the Mayo Clinic in Minnesota performed a quantitative evaluation of hip strength in 72 individuals, with 37 females and 35 males, whose ages ranged from 20 to 81 years. Without taking into consideration the age and gender, the hip extensors were the strongest muscle group, followed by the flexors, adductors, abductors, and then the rotators.[10]

OBJECTIVE

This study sought to evaluate the maximum torque, total work, and average power of the abductor and adductor hip muscle groups in young adults, comparing the result in relation to dominance, the angular velocities used, and the muscle groups studied, in addition to establishing normative data for the population studied.

METHOD

For the study 20 male volunteers were selected, with ages ranging from 21 to 30 years, with normal joint mobility, without any limitation on lower limbs, and without any history of orthopedic disease on the lower limbs and hips.

Their data was verified: height, weight, age, dominant limb-determined as the preferred side for kicking, whether they practice any physical activity - they were permitted to practice physical activity up to 3 times per week during 1 hour.[5]

Individuals who regularly practiced some sport modality, athletes, and carriers of systemic diseases were not accepted.

The present study was approved by the Ethics Committee of the College of Medicine at the University of São Paulo, consonant with Resolution 196/96 of the National Health Council. All the participants were only included in the study after signing the Free and Informed Consent Form.

After adapting the volunteers to the above parameters, the evaluation of the adductor and abductor hip muscle groups was begun through isokinetic dynamometry.

Initially each volunteer warmed-up their lower limbs for 5 minutes on an Inbramed model 10.200 treadmill with no inclination and at a constant speed of 5 km/h.

The volunteer was then laid on his side with the limb being tested on top, on the UBXT testing table (Lumex Corp. of Ronkokoma, New York), an accessory of the Cybex model 6000 equipment. The equipment was calibrated before the beginning of the study and at weekly intervals during the testing period.

The volunteer had his trunk turned toward the equipment; the long arm of the machine with a padded end was selected and coupled with the distal region of the thigh of the limb to be tested. Two belts were used at the levels of the waist and knee to secure the volunteer to the table so that he would not move during the test. The lower limbs remained in full extension while the hip joint axis remained aligned with the dynamometer axis allowing an ideal lever arm with a long arm that was adjusted to the equipment. The rotation axis was above and medial to the great trochanter. The height of the dynamometer was also adjusted.

The tested limb was weighed in the position of 30° abduction to eliminate the gravity effect, with this calculation made by the equipment itself, and the maximum amplitude established was 45° abduction, from the initial position of 0°.

The speeds adopted were 60°/s (4 repetitions) for the strength parameters and 120°/s (15 repetitions) for the muscular power parameters. Before the tests, the volunteer performed 3 submaximal repetitions at both speeds to become familiar with the test. test started from the full adduction of the lower limb until reaching 45° of abduction. The speed and amplitude of movement was suggested by the equipment's manual for this joint.

During the test the volunteer was motivated, through verbal encouragement, to exert his maximum capacity during the movement.[4]

The results were grouped and studied from the statistical point of view to determine absolute values and the muscular understanding of the adductor and abductor muscle groups.

The comparisons between correlated parametric samples were made with the paired *Student t* test. In the comparisons between the two independent parametric samples, the non-paired *Student t* test was used. In all the tests a significance level of 5% was adopted.

RESULTS

Regarding dominance, the maximum torque readings (Newtons/meter), total work (Joules), and average power (Watts) did not present any statistically significant difference between the dominant and the non-dominant abductor muscle groups, nor between the dominant and non-dominant adductor muscle groups, with average readings greater on the dominant side (data not shown).

According to the velocities studied, the maximum torque readings - Newtons/meter, Total work - joules, and average power - watts (Table 1), showed statistically significant differences when compared to the velocities of 60°/s and 120°/s with greater average readings at the velocity of 60°/s for maximum torque and total work, and greater average readings at the velocity of 120°/s for average power.

In the comparison between the abductor and adductor muscle groups, no statistically significant difference was observed for the maximum torque readings, with average value greater in the adductor group at the velocity of 60°/s and greater in the abductor group at the velocity of 120°/s. However, a statistically significant difference was observed for the total work and average power readings in the abductor muscular group at both the velocities studied (Table 2).

In addition to the comparisons, it was possible to establish the normative readings for the age and gender of the population studied (Table 3).

DISCUSSION

The normative data collected in this study in open kinetic chain and concentric movements reveals importance to the age studied, as for maximum torque, total muscular work, and power, as well as their comparisons on dominance, different velocities, and between the abductor and adductor muscle groups.

The relevance of establishing normative readings for the hip abductor muscle group is justified by the important function of this muscle group in maintaining the leveling of the pelvis during gait through concentric contraction at the moment when one of the lower limbs is in the support phase, allowing the harmonious balance of the contralateral lower limb. The loss of this harmony is observed in people who show Trendelenburg gait due to paralysis or weakness of the gluteus medius and gluteus minimus muscles, the main abductors of the hip.[11-13]

As for the importance of establishing normative readings for the hip adductor muscle group, these may contribute to future studies with athletes to establish proposals of muscle adaptation in the prevention and rehabilitation of athletic pubalgia, since the pubis deals with forces from tendons of the rectus anterior muscles of the abdomen, oblique, transverse, and thigh adductors.[14]

Isokinetic dynamometry is a valuable instrument used to quantitatively evaluate the strength, power, and the muscle endurance. A study made at the São Carlos Federal University (UFSCAR) showed that this method is capable of providing measurements with a good degree of agreement for the concentric torque of the adductor and abductor hip musculature, allowing for reproducible readings. Those authors used a different dynamometer and different velocities from what was used in the present study.[13]

To minimize the loss of performance effects due to not knowing the task before the evaluations, the study subjects were submitted to a pre-test, repeating the movements three times to adapt themselves to the equipment, and during the test they were verbally encouraged to exert the maximum of their capacity in the course of the movement.

As for dominance, it was observed that the side seen as dominant, that is, the side most preferred and most used by the individuals in their activities, had more torque, total work, and power, however, this did not reveal any statistically significant difference between the dominance of the lower limb and the muscle characteristics studied in this work.

In relation to the two velocities studied, the maximum torque and total work readings were greater at the 60°/s velocity and presented a statistically significant difference when compared with the 120°/s velocity readings. The maximum torque as much as the total work diminished as the velocity was increased from 60°/s to 120°/s, showing that the capacities to produce maximum torque and work are greater in low velocities of joint movement. This decrease in peak torque and total work with the increase of angular velocity go against the study made at UFSCar[13] that observed lower peak torque and average peak torque readings

Table 1. Comparison between the maximum torque (Newtons/meter), total work (joules), and average power (watts), between the velocities of 60°/s and 120°/s of the dominant and non-dominant abductor and adductor groups

	Dominant Abductor 60°/s	Dominant Abductor 120°/s	Non-dominant Abductor 60°/s	Non-dominant Abductor 120°/s	Dominant Adductor 60°/s	Dominant Adductor 120°/s	Non-dominant Adductor 60°/s	Non-dominant Adductor 120°/s
Maximum torque	199.4 ± 30.35	169.75 ± 25.57	188.4 ± 37.28	160.15 ± 35.90	206.3 ± 58.31	167.2 ± 53.04	189.15 ± 60.46	157.1 ± 48.84
Total Work	82.6 ± 13.36	67 ± 10.52	80.45 ± 13.71	65.65 ± 14.75	70.5 ± 13.70	54.4 ± 18.48	65.55 ± 16.99	48.8 ± 16.83
Average power	113.55 ± 26.60	172.2 ± 25.85	106.35 ± 26.13	166.35 ± 37.50	99.50 ± 25.86	140.3 ± 50.17	94 ± 26.21	123.5 ± 42.87

Data expressed in: Average ± standard deviation, "*t*" test

Table 2. Comparison between the maximum torque (Newtons/meter), total work (joules), and average power (watts), between the dominant abductor and adductor groups at 60°/s and at 120°/s, and between the non-dominant abductor and adductor groups at 60°/s and at 120°/s

	Dominant Abductor 60°/s	Dominant Adductor 60°/s	Non-dominant Abductor 60°/s	Non-dominant Adductor 60°/s	Dominant Abductor 120°/s	Dominant Adductor 120°/s	Non- dominant Abductor 120°/s	Non-dominant Adductor 120°/s
Maximum torque	199.4 ± 30.35	206.3 ± 58.31*	188.4 ± 37.28	189.15 ± 60.46*	169.15 ± 25.57	167.2 ± 53.04*	160.15 ± 35.90	157.1 ± 48.84*
Total Work	82.6 ± 13.36	70.5 ± 13.70	80.45 ± 13.71	65.55 ± 16.99	67 ± 10.52	54.4 ± 18.48	65.65 ± 14.75	48.816.83
Average power	113.55 ± 26.60	99.5 ± 25.86	106.35 ± 26.13	94 ± 26.21*	172.2 ± 25.85	140.3 ± 50.17	166.35 ± 37.50	123.5 ± 42.87

Data expressed in: Average ± standard deviation; * $p > 0.05$, "*t*" test

Table 3. Normative readings for age and gender of the population studied in relation to maximum torque (Newtons/meter), total work (joules), and average power (watts) of the dominant abductor and adductor muscle groups at 60°/s and at 120°/s and between the non-dominant abductor and adductor muscle groups at 60°/s and at 120°/s

	Abductor 60°/s	Adductor 60°/s	Abductor 120°/s	Adductor 120°/s
Dominant Side				
Maximum Torque	199.40	206.30	169.75	167.20
Total Work	82.60	70.05	67.00	54.50
Average Power	113.55	99.50	172.20	140.30
Non-dominant Side				
Maximum Torque	188.40	189.15	160.15	157.10
Total Work	80.45	65.65	65.65	48.80
Average Power	106.35	94.00	166.35	123.50

at the 90°/s velocity than at 30°/s, and also against the study made at the University of Liverpool[15] that found similar results and reported that from 60°/s, increases in the angular velocity produce a decline in torque of the concentric contractions. Such results were already expected considering the known relationship between force versus velocity, which establishes that if the velocity of shortening is low, the tension that can be developed is high and, on the other hand, if the velocity of shortening is high, the tension that can be developed is low.[13]

However, the average power readings were higher at the 120°/s velocity when compared with the readings at 60°/s velocity and show a statistically significant difference, which was also expected, since the average power is directly proportional to changes in the angular velocity, that is, the greater the angular velocity, the greater the power.[16]

The absence of a statistically significant difference being observed for the maximum torque readings and presence of a statistically significant difference being observed for the total work readings when comparing the abductor and adductor muscle groups can demonstrate the importance of not disregarding the muscle behavior during the entire arch of movement to the detriment of the point of greater joint movement.

As for the comparison between the muscle groups, it was observed that the peak torque showed average readings greater in the adductor group than in the abductor group at the velocity of 60°/s. The same result was observed in the UFSCar[13] study when these muscle groups were studied at the 30°/s and 90°/s velocities, reporting that the same had been observed by other authors.[17-20]

A study made at the Mayo Clinic Orthopedic Department, in Minnesota[10] observed that the hip extensors were the strongest muscle group, followed by the flexors, adductors, abductors, and rotators, without taking age or gender into consideration.

In the present study, the fact that the peak torque showed a greater reading in the abductor group than in the adductor group at the velocity of 120°/s stands out and suggests that at angular velocities higher than 90°/s there may be more efficiency in the hip abductor muscle group. This exchange in performance between the muscle groups with the increase of angular velocity was not observed in the total work and in the average power, which represent greater readings in the abductor muscle group at both velocities studied, showing a statistically significant difference.

Having little participation in the gait during the oscillation phase as well as in the support phase, the abductor and adductor muscle groups are more recruited when the body is submitted to a situation of lateral loss of balance. The results found in the comparison of the abductor and adductor muscle groups allow us to believe that the balance shown between these muscle groups can be one of the factors that favor the pelvis stabilization function.

The need for future studies of these muscle groups in other populations and at different velocities and movements is suggested, so that the hip muscular activity can be better understood.

CONCLUSION

The abductor and adductor muscle groups show greater maximum torque, total work, and average power on the dominant side, however, without any statistically significant difference.

In both muscle groups and on both sides, the maximum torque and total work were greater at the 60°/s velocity, and the average power greater at 120°/s, all with a statistically significant difference.

The maximum torque was greater in the adductor group at the 60°/s velocity, and greater in the abductor group at the 120°/s velocity, however, without any statistically significant difference.

The total work was greater in the abductor group with a statistically significant difference at both velocities.

The average power was greater in the abductor group at both velocities, with a statistically significant difference at 120°/s.

The normative data collected in this study is of great importance in the rehabilitation and understanding of these muscle group characteristics for students and clinicians.

REFERENCES

1. Davies GJ. A compendium of isokinetics in clinical usage and rehabilitation techniques. Onalaska: S & S; 1984.
2. Batistella LR, Shinzato GT. Avaliação do desempenho musculo-esquelético. In: Lianza S. Medicina de reabilitação. 2 ed. Rio de Janeiro: Guanabara; 1995. p. 33-42.
3. Davies GJ, Wilk K, Ellenbecker TS. Assessment of strength. In: Malone TR, McPoil T, Nitz AJ. Orthopedic and sports physical therapy. 3 ed. St. Louis: Mosby; 1997. p. 225-57.
4. Perrin DH. Principles of isokinetic testing and exercise. In: Perrin DH, editor. Isokinetic exercise and assessment. Champlain: Human Kinetics; 1993. p. 35-71.
5. Imamura M. Avaliação isocinética dos pés de homens adultos normais [Dissertação]. São Paulo: Universidade de São Paulo; 1994.
6. Greve JMDA. Avaliação isocinética dos músculos flexores e extensores do tronco [Tese]. São Paulo: Universidade de São Paulo; 1998.
7. Pedrinelli A. Estudo comparativo da força dos músculos flexores e extensores do joelho pela avaliação isocinética entre pacientes com amputação transtibial e indivíduos normais [Tese]. São Paulo: Universidade de São Paulo; 1998.
8. Pinho L, Dias RC, Souza TR, Freire MTF, Tavares CFE, Dias JMD. Avaliação isocinética da função muscular do quadril e do tornozelo em idosos que sofrem quedas. Rev Bras Fisioter. 2005;9(1):93-9.
9. Horstmann T, Martini F, Knak J, Mayer F, Sell S, Zacher J, et al. Isokinetic force-velocity curves in patients following implantation of an individual total hip prosthesis. Int J Sports Med. 1994; 15 Suppl 1:S64-9.
10. Cahalan TD, Johnson ME, Liu S, Chao EY. Quantitative measurements of hip strength in different age groups. Clin Orthop Relat Res. 1989;(246):136-45.
11. Nadler SF, DePrince ML, Hauesien N, Malanga GA, Stitik TP, Price E. Portable dynamometer anchoring station for measuring strength of the hip extensors and abductors. Arch Phys Med Rehabil. 2000;81(8):1072-6.
12. Norkin CC, Levangie PK. Articulações: estrutura e função, uma abordagem prática e abrangente. Rio de Janeiro: Revinter; 2001.

13. Filippin NT, Vieira WEB, Costa PHL. Repetibilidade de medidas isocinéticas dos músculos adutores e abdutores do quadril. Rev Bras Educ Fís Esp. 2006;20(2):131-9.
14. Vieira PR, Alonso AC, Gonçalves JAF, Sousa JPG. Pubalgia. In: Greve JMDA. Tratado de medicina de reabilitação. São Paulo: Roca; 2007. p. 1107-15.
15. Kellis E, Baltzopoulos V. Isokinetic eccentric exercise. Sports Med. 1995;19(3):202-22.
16. Terreri ASAP, Andrusaitis FR, Macedo OG. Cinesioterapia. In: Amatuzzi MM, Greve JMDA, Carazzato JG. Reabilitação em medicina do esporte. São Paulo: Roca; 2003. p. 61-78.
17. Burnett CN, Betts EF, King WM. Reliability of isokinetic measurements of hip muscle torque in young boys. Phys Ther. 1990;70(4):244-9.
18. Ihara FR, Cevales M, Pinto SS. Avaliação muscular isocinética da musculatura abdutora e adutora da coxa em atletas de natação do estilo peito. Rev Bras Educ Fís Esp. 2000;6(3):93-8.
19. Kea J, Kramer J, Forwell L, Birmingham T. Hip abduction-adduction strength and one-leg hop tests: test-retest reliability and relationship to function in elite ice hockey players. J Orthop Sports Phys Ther. 2001;31(8):446-55.
20. Ryser DK, Erickson RP, Cahalan T. Isometric and isokinetic hip abductor strength in persons with above-knee amputations. Arch Phys Med Rehabil. 1988;69(10):840-5.