Original Article

MUSCLE STRENGTH IMBALANCE BETWEEN HAMSTRING AND QUADRICEPS AMONG PROFESSIONAL DANCERS

DESEQUILÍBRIO MUSCULAR ENTRE ISQUIOTIBIAIS E QUADRÍCEPS ENTRE DANÇARINOS PROFISSIONAIS

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ABSTRACT: The aim of this study was to evaluate the unilateral strength in knee flexion and extension, and the Hamstring/Quadriceps Ratio (H/Q Ratio), in dominant and non-dominant lower limbs in professional dancers. This was a cross-sectional study, carried out with 12 health adults (27.5±1.27years, 66.6±3.11kg, 173±0.02cm, 22.1±0.51kg/m^2), professional dancers of a national company. The volunteers, after physical measurements, were submitted to a 1 Repetition Maximum (1RM) test, unilaterally, in both lower limbs at Flexor and Extensor Bench seat exercises. After 1 week, a 1RM retest was carried out to confirm the real total load for each limb. The torque and H/Q Ratio were calculated unilaterally. In knee extension, the dominant limb presented strength 18.77% higher than non-dominant limb ($p<0.01$), and in knee flexion, the strength of the dominant limb was 16.38% higher than the non-dominant limb ($p=0.04$). The H/Q Ratio was higher in the non-dominant limb *90.12 ± 0.22% than dominant limb 86.36±0.37% (p=0.04)*. The results showed difference in the strength between dominant and non-dominant members in both movements, knee flexion and extension. The H/Q Ratio presented values that evidenced imbalance in lower limbs. The population of dancers under study presented risk for injuries in lower limbs, requiring a specific training intervention.

KEYWORDS: Functional performance. Kinesiology**.** M**o**tor behavior**.**

INTRODUCTION

The musculature around the knee is important to injuries prevention as well as in the enhancement of knee function (ZAKAS, 2006). To have a stable articulation is required not only strength, but also a proper muscle balance. A parameter that expresses this balance in the knee articulation is the proportion of the strength between the flexor/extensor muscles, which has been studied and provides important data for the prevention of injuries and measures in rehabilitation. The Hamstring/Quadriceps Ratio (H/Q Ratio) provides significant information about muscle balance (BARATTA et al., 1988; WELSCH et al., 1998). Traditionally the H/Q Ratio has been calculated through the division between the peak values of concentric torque of the Knee flexor and knee extensors muscles (AMÉRICO et al., 2011).

The strength imbalance between agonist and antagonist muscle increase the potential risk of injuries (BURKETT, 1969). In previous study, Croisier et al (2008) identified this imbalance in soccer players, evaluating the H/Q Ratio using torque analysis, and they observed imbalance in 7.50% of 462 subjects that completed the follow-up study. They showed that the evaluation is very important in the treatment of strength imbalance, what reduce, significantly, the risk of injuries.

The evaluation of muscles strength and balance are very important to prevent and treat injuries, and the isokinetic dynamometer is the gold standard in this kind of evaluation (STARK et al., 2011). Many studies evaluated the strength balance utilizing isokinetic dynamometer (BENNELL et al., 1998; DAUTY et al., 2003; MCCURDY E LANGFORD, 2005; TUNSTALL et al., 2005), but this equipment is not available for great part of the professionals that work with prevention and/or treatment of certain injuries due to the high cost.

To provide new accessible ways to evaluate the strength balance, using usual equipment at a gym in sports club, dance studios or clinics would make this knowledge more accessible for many

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exercise and sport professionals, what is proposed in the present study protocol.

Aiming the performance of professional dancers, this study proposes the application of an affordable protocol for assessing the balance of strength, using equipment that can be easily found in a gym, dance studios, or even rehabilitation clinics.

Assessment of maximum leg strength balance between hamstrings and quadriceps in high performance professional dancers is yet to be investigated. On the basis of previous research and to our knowledge, this is the first study that addresses strength balance in dancers, using easily and useful methodologies out of laboratories. Thus, the purpose of this study was to evaluate the strength and flexor/extensor ratio in dominant and non-dominant lower limbs in high performance professional dancers of an important Brazilian dance company. This study aimed to contribute to the improvement of the performance of professional dancers, in the question of activation, motor control and symmetry of the lower limbs.

MATERIAL AND METHODS

This was a cross-sectional study carried out at a Gym and a professional studio of dance, in an important dance company in Brazil. The study protocol followed the principles of the Declaration of Helsinki and was approved by the institutional research ethics committee (Register number 1986-11). Furthermore, all subjects read and have given their informed consent for participation in the research study.

Study subjects and group assignment

The study sample consisted of 12 dancers (4 women; 8 men), health adults enrolled at a Brazilian professional dance company. Subjects were eligible if they signed an informed consent form; were 20 to 35 years old; systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg in the pre-study assessment. The study exclusion criteria included time of dance < 4 years and >10 years, body mass index (BMI) ≥30 kg/m^2; diabetes mellitus; any cardiovascular or metabolic disease; orthopedic impairment in the previous 6 months; and any physical or mental limitations preventing them from engaging in a strength exercise test.

Potential subjects were asked to attend an on-site visit before the experiment. During this visit, the study procedures were explained and those who agreed to participate signed an informed consent form. An interview was performed with questions about medical and disease history; symptoms and others. The institution data was checked and a physical and clinical evaluation was done: body weight, height, tibia length, body mass index and blood pressure were measured.

Procedures

In the first visit after initial pre-test evaluations, all participants were conducted to a gym. All subjects were asked to come in the same day time for a familiarization and the 1 Repetition Maximum (1RM) test was carried out for two exercises: Knee Extension (KE) and Knee Flexion (KF). The sequence and side were alternated between participants, where the first one started in KE, with the left side. After one week, without exercises and training, a 1RM retest was carried out to confirm the load. Before each session, a warm-up was carried out in the specific machines that were used in the actual study. During the strength assessment each subject followed the procedures while supervised by the investigators. The limb that presented higher strength was considered the dominant.

The 1RM testing protocol was described by Kraemer and Fry (1995). The participants performed a 1RM familiarization before testing, with an emphasis on the specific technique of the study exercises. The heaviest load achieved was considered the 1RM load. To minimize the error during the 1RM tests, the following strategies were adopted (SIMÃO et al., 2007): standardized instructions concerning the testing procedures were given to participants before the test; standard verbal encouragement was provided during the testing procedure. The 1RM was determined in 5 attempts with a rest interval of 5 minutes between them. To apply the 1-RM test, was used the flexor and extensor bench seat of LifeFitness® (USA). The subjects performed the movement in a seated position in 0-90 degrees angle in the flexor bench and 90-0 degree in extender bank. In order to standardize the test run, the participants were informed about the ideal position in the flexor and extensor bench, getting seated properly, with your lower back supported on the bench seat back, holding the side handles of the apparatus with both hands. The appliance was positioned in the tibia five centimeters above the lateral malleolus, being later the tibia in flexor and former bank tibia in extensor bench seat.

From this sequence of activities, the torque was established: First, the mass of the leg, which, according to Winter (2009), equivalent to 6.1% of the total body mass, was calculated.

According to Américo et al (2011) protocol, to perform the gravity correction, in the flexor bench, it is necessary subtract the estimated mass of the leg from the 1RM load found in this exercise. In the extensor bench the estimated mass of the leg must be added in the 1RM total load of this exercise. After this, the values were multiplied by 9.81 m/s^2 (corresponding to the gravity acceleration), thus transforming the load of exercise in weight. This weight was multiplied by the length of the tibia and after multiplied by 100, providing the torque values. The torque was normalized by dividing the results by the individual's weight, in order to find comparable values between participants. The H/Q Ratio was calculated by dividing the flexor torque by the extensor torque, multiplying the result for 100. To analyze the dominant and nom-dominant lower limbs, they were separated based in the maximum load found in the 1RM test.

To consider strength side-to-side, was used the parameter adopted by Kannus (1994) and Zakas (2006), which consists in a maximum difference from 10% between limbs. In the H/Q Ratio was defined the mean parameter used by Croisier et al (2008), consisting in an average of 56%.

Statistical Analysis

A descriptive analysis of the central tendency and variance of the data over the average and standard deviation of torque measurements normalized by body weight of the flexors and knee extensors and the H/Q ratio was conducted. Since the variables didn´t show a normal distribution (Shapiro Wilk test, $p < 0.05$) comparisons among the group were performed with the Kruskal-Wallis test and post hoc Dunn. The Statistica 10.0 software (Statsoft, Dell, USA) was used for statistical analysis, and significance level was set to $p< 0.05$.

RESULTS

Characteristics of the participants: age, body weight, height and BMI are described in Table 1.

Table 1. Anthropometric characterization of 12 dancers (4 women; 8 men) selected health adults enrolled at a professional Brazilian dance company

Variables	Average ± standard error
Age (years)	27.50 ± 1.27
Body Weight (kg)	66.60 ± 3.11
Height (cm)	173.00 ± 0.02
BMI (Kg/m^2)	22.10 ± 0.51
Time of dance (Years)	10.00 ± 0.3

The strength dominance was equal for the same side as in the KF as in the KE for each studied individual. There was significant difference in both evaluated movements, in the KE, the dominant limb presented strength of *545.01±6.90Nm*, being 18.77% higher than non-dominant limb ($p<0.01$), as presented in Figure 1.

In the KF, the dominant limb presented maximum torque of *470.66±0.64Nm*, being 16.38% higher than non-dominant limb ($p=0.04$), see figure 2. In both movements, there was difference.

Conform presented in table 2, there was a difference between limbs in the torque in KF and KE, and in the balance between Hamstring and quadriceps strength, but presented strength imbalance in the dominant limb.

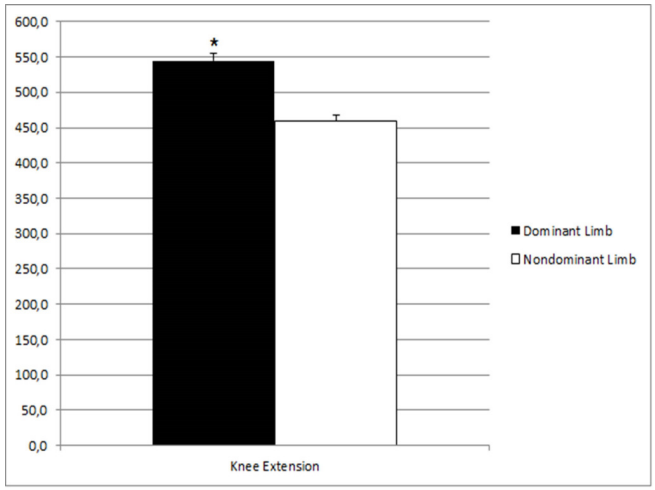

Figure 1. Maximum torque in knee extension in dominant and non-dominant limbs, from12 dancers (4 women; 8 men) selected health adults enrolled at a professional Brazilian dance company
* p< 0,05 post hoc Dunn in dominant x non-dominant limb comparison.

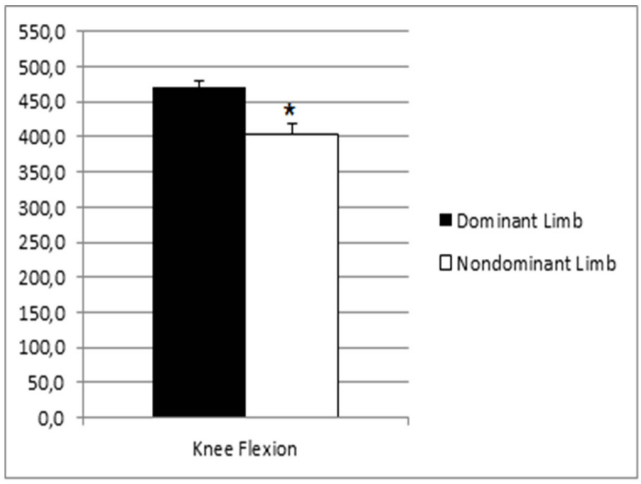

Figure 2. Maximum torque in knee flexion in dominant and non-dominant limbs, from 12 dancers (4 women; 8 men) selected health adults enrolled at a professional Brazilian dance company.
* p< 0,05 post hoc Dunn in dominant x non-dominant limb comparison.

Table 2. Descriptive data of the torque flexion, extension and the H/Q Ratio in Dominant and Non-dominant limb, from 12 dancers (4 women; 8 men) selected health adults enrolled at a professional Brazilian dance company.

Variables	Dominant Limb (Average ± standard error)	Non-dominant Limb (Average ± standard error)	*p value*
Torque Flexion	*470.66 ± 0.64*	*404.39±0.69*	*0.04**
Torque Extension	*545.01 ± 6.90*	*458.86±6.56*	*< 0.01**
H/Q Ratio (%)	*86.36 ± 0.37*	*90.12 ± 0.22*	*0.04**

* p< 0,05 post hoc Dunn in dominant x non-dominant limb comparison

DISCUSSION

The aim of the present study was to evaluate the strength and H/Q Ratio in dominant and non-dominant lower limbs in professional dancers of an important national dance company of the country. The sample under study presented strength differences in the KE and KF in both, dominant and non-dominant limbs. In the H/Q Ratio analysis was observed significant imbalance in both, dominant and non-dominant limb.

In this study, the population presented significant strength difference between dominant and non-dominant limb, being 18.77% and 16.38% the difference side-to-side in maximum torque for KE and KF, respectively, according to many other

studies(BURNIE; BRODIE, 1986; MASUDA et al., 2003; ZAKAS, 2006), considering a strength difference (KANNUS, 1994; ZAKAS, 2006). Masuda et al.(2003) did not find differences between dominant and non-dominant isokinetic leg strength during knee flexion/extension, hip flexion/extension, and hip abduction/adduction in university soccer players. In contrast to these findings, Hunter et al. (2000) found higher dominant knee extension isometric torque, compared to the non-dominant in non-athlete women, of different ages, similar to the results of the present study. It's important to emphasize that the muscle imbalance between limbs is also thought to be related to an increase risk of injury (AGRE; BAXTER, 1987).

Isokinetic and isometric strength are commonly measured with an open kinetic chain, single-joint test. There is not a pattern in the studies comparing unilateral strength in the dominant and non-dominant limbs. Burnie and Brodie (1986) showed that isokinetic knee flexion/extension strength difference was not found between the dominant and non- dominant leg in the studied preadolescents.

In this study was found imbalance between hamstring and Quadriceps strength, in both, dominant and non-dominant limbs, with values of 86.36% for dominant and 90.12% for non-dominant. It is described in the literature that the relationship agonist/antagonist tends to be approximately 60% in healthy adults (DIAS et al., 2004). A stable articulation requires not only strength, but also a proper muscle balance. The H/Q ratio provides important data for the prevention of injuries and measures in rehabilitation (AMÉRICO et al., 2011). Assessment of 1RM leg strength can provide valuable assessment data to determine functional strength capacity. At the same time, statistically defined cutoffs are rarely described for the H/Q ratio, leading to subjective interpretation of this essential parameter.

According to results, Kong et al (2010) also found strength imbalance in H/Q Ratio in physically active adults. But differently, others (SIQUEIRA et al., 2002; DIAS et al., 2004; AMÉRICO et al., 2011) did not. Was found an important imbalance in the H/Q Ratio in dominant and non-dominant limbs of the studied dancers, what can predispose them injury problems in lower limbs.

Croisier et al (2008) found significant correlation between strength imbalance by H/Q ratio and injuries in soccer players. They also observed that once the imbalance was identified and treated, the injuries decreased significantly.

Zakas (2006) studied the H/Q balance in professional soccer players of the Greek first division, using the isokinetic dynamometer, and observed no imbalance in these individuals, in dominant and non-dominant limbs. Other study with healthy young adults men found a ratio of 60,3% for jumpers athletes, 56,4% for running athletes and 57% for non-athletes (SIQUEIRA et al., 2002). An increased H/Q ratio is related to higher risks of injuries (CROISIER et al., 2008). A decreased H/Q ratio can indicate predominance in the KE strength or deficit in KF strength and a high H/Q ratio can indicate predominance of the KF or deficit in the KE (AMÉRICO et al., 2011), what suggest that the professional dancers of the present study can have a predominance of the KF strength in relation to KE strength.

The isokinetic dynamometer is considered the gold standard for measurements of this kind of variables (STARK et al., 2011), and this is a limitation of the present study, because this equipment was not used. On the other hand, this is an expensive machine, restricting the large use in many other places where an analysis of strength balance are necessary, like rehabilitation centers, gyms, dance studios, sports center, among others. To know new alternatives are very important for popularize this individual conduct among professional that does not have an isokinetic dynamometer in their work resources, what will contribute to the prevention and treatment of injuries. The sample size also is a limitation of the present study.

Various studies (SIQUEIRA et al., 2002; DIAS et al., 2004; ZAKAS, 2006; AMÉRICO et al., 2011) may be associated to innumerable research-related variables (way of measuring; presence or absence of problems in the group being studied; age; type of exercise or sport trained; and state of training). It is thus a difficult task to compare these studies since their methodological characteristics are so varied.

CONCLUSIONS

There were significant differences between limbs, in both evaluated movements.

Relative to H/Q Ratio, there were strength imbalances in both limbs, with high values, suggesting that the professional dancers of the present study can have a predominance of the KF strength in relation to KE strength in dominant limb.

Even using a method which does not have a rigorous laboratory, it can be observed an unusual difference in muscular strength between quadriceps

and hamstrings, and asymmetry between the legs. Thus, this tool may be used by physical educators and physiotherapists for the purpose of muscle strengthening, motor control increase and hence injuries prevention.

The population of dancers under study presented risk for injuries in dominant lower limbs, requiring a specific training intervention aiming to prevent possible injuries.

RESUMO: O objetivo deste estudo foi avaliar a força de flexão e extensão do joelho, de forma unilateral, e a relação Isquiotibiais-Quadriceps (relação I/Q), nos membros inferiores dominantes e não dominantes de dançarinos profissionais. Este foi um estudo transversal, realizado com 12 dançarinos profissionais adultos saudáveis (27.5±1.27anos, 66.6±3.11kg, 173±0.02cm, 22.1±0.51kg/m^2), de uma empresa de dança brasileira. Após as avaliações antropométricas, os indivíduos foram submetidos ao teste de uma repetição máxima (1RM) na cadeira extensora e flexora, unilateralmente, em ambos os membros inferiores. Após uma semana, um reteste de 1RM foi realizado para confirmar a carga total para cada membro. O torque e relação I/Q foram calculados de forma unilateral. Em extensão do joelho do membro dominante apresentou força 18,77% superior ao membro não dominante ($p < 0,01$), e na flexão do joelho, a força do membro dominante foi 16,38% maior do que a força do membro não dominante ($p = 0,04$). A Relação I/Q foi maior no membro não-dominante *90.12 ± 0.22%* do que no membro dominante *86.36±0.37%* ($p = 0,04$). Os resultados mostraram diferença na força entre os membros dominantes e não dominantes em ambos os movimentos, na flexão e extensão do joelho. A relação I/Q apresentou valores que evidenciaram desequilíbrio nos membros inferiores. A população de dançarinos em estudo apresenta risco de lesões nos membros inferiores, necessitando de uma intervenção formação específica.

PALAVRAS-CHAVE: Desempenho funcional. Cinesiologia. Comportamento motor.

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