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RELAÇÃO DOS MÚSCULOS DO QUADRIL E TRONCO COM O VALGO DINÂMICO DE JOELHO EM MULHERES JOVENS ASSINTOMÁTICAS

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Resumo: O valgo dinâmico de joelho em mulheres assintomáticas pode ser um fator de risco relacionado com queixas futuras de dor nessa articulação. O objetivo deste estudo é investigar a relação entre torque articular da musculatura estabilizadora do quadril e tronco com a cinemática do teste step down em mulheres jovens assintomáticas. Participaram deste estudo 22 mulheres, com idade média de 22,5 anos (±2,06), sem histórico de dor ou lesão em membros inferiores. Na primeira visita ao laboratório, as voluntárias realizaram anamnese, avaliação cinemática durante o teste step down frontal e lateral. No segundo dia, foi realizada a avaliação do torque articular isométrico máximo de rotação lateral, abdução e extensão do quadril e extensão de tronco, utilizando um dinamometro manual. Para análise dos dados, foi utilizado o pico de torque articular dos movimentos avaliados e em relação aos dados cinemáticos, foi calculado os ângulos de projeção de joelho no plano frontal, inclinação da pelve e tronco, por meio do software *Kinovea*. O teste de Correlação de Pearson não mostrou relação entre o torque muscular de quadril e tronco com os ângulos cinemáticos durante o step down frontal e lateral. Portanto, concluímos que o torque muscular máximo dos estabilizadores lombo pélvicos não estão correlacionados com o padrão de movimento cinemático durante o teste step down.

Palavras-chave: Biomecânica, Dinamômetro de força muscular, Fisioterapia.

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RELATIONSHIP OF THE HIP AND TRUNK MUSCLES WITH THE DYNAMIC KNEE VALGUS IN ASYMPTOMATIC YOUNG WOMEN

Abstract: The presence of severe dynamic knee valgus in asymptomatic women may be a factor related to future complaints of pain in this joint. The aim of this study is to correlate the strength levels of hip and trunk stabilizer muscles with knee valgus angles, pelvic and trunk tilt in asymptomatic young women. 22 young women with no history of lower limb pain or injury participated in this study. In the first visit to the laboratory, the volunteers performed anamnesis, kinematic evaluation of the dynamic knee valgus angle, pelvic and trunk tilt. Afterwards, familiarization with muscle strength tests was made. On the second day, the evaluation of the maximal isometric muscle strength of the hip stabilizer muscles (lateral rotators, hip abductors and extensors) and trunk extensors was performed, using a hand dynamometer. For analysis of muscle strength data, the joint torque peak was used and, in relation to the kinematic data, the knee projection angles in the frontal plane, pelvis and trunk tilt, through the Kinovea software. Pearson's Correlation test showed no relationship between the hip and trunk muscle torque and the kinematic angles during the frontal and lateral step down. The muscle torque of the hip stabilizers and trunk extensors are not related to the movement pattern of the volunteers during the step down.

Key-words: Biomechanics, Muscle strength dynamometer, Physiotherapy.

Introduction

The incidence of complaints of pain in the anterior region of the knee are frequent and recurrent in young women, and may cause difficulty in performing activities such as climbing/descending stairs, sitting/standing up from a chair, running, walking on inclined surfaces, among others[1]. Causal factors can be considered multifactorial, however proximal factors, the knee joint may be one of the mechanisms that most influence the proper misalignment between body segments of the lower limbs in the frontal and transverse planes during daily tasks[2].

The knee joint remains aligned mainly by the action of the hip controlling movements of the pelvis and femur, preventing injuries and pain. The gluteus maximus resists flexion and abduction movements, the gluteus medius and minimus resist hip adduction movements, the hip lateral rotators prevent the internal rotation of the femur during impact absorption, preventing exacerbated dynamic valgus[3,4]. By these biomechanical characteristics, the musculature of the hip joint is considered a factor of great influence in the pathologies of the knee joint.

In addition, the trunk stabilizer muscles also play an important role in joint alignment, since this musculature in dynamic movement together with the hip joint affects the biomechanics of the knee during functional tasks, that is, deficit of neuromuscular control in the trunk and the hip can increase the risk of injury to the knee joint[5]. The stability and muscle control of the lumbar-pelvic complex decreases the risk of knee injuries, especially in women[6].

Dynamic valgus is described as a misalignment seen in an anterior view while performing a movement, such as a single leg squat[7]. During this movement, the knee undergoes excessive abduction due to internal rotation and hip adduction and external tibial rotation, associated with a downward movement of the pelvis on the contralateral side[8,9]. Thus, it is believed that the weakness of the hip stabilizer muscles can contribute to the increase of this biomechanical compensation and also change the kinematics of the trunk, promoting greater mechanical stress on the soft tissue of the knee joint[10].

Knee valgus during functional movements alters the patellar alignment, and when in excess, increases the overload on joint structures such as the patellar retinacula, articular cartilage and fat pad, which may result in anterior pain in the knee[11]. Furthermore, patellar misalignment favors increased shear forces in the patellar tendon, which may contribute to the appearance of future patellar tendinopathies[12].

Although the presence of dynamic knee valgus is not an exclusive factor for future pain and injury in this joint, there is scientific evidence on the relationship of the hip musculature and the knee projection angle in the frontal plane[1]. In this sense, evaluate the levels of torque of the stabilizer muscles of the hip and trunk and its relationship with the kinematic movement pattern can help to understand the contribution of this musculature in the biomechanics of movement and, consequently, contribute to prevention strategies for future pain in the knee joint.

Therefore, the objective of this study is to correlate the isometric torque levels of the hip and trunk stabilizers with the kinematic pattern obtained during the step-down test. Our hypothesis is that the torque of the hip extensors, abductors and lateral rotators muscles as well as the trunk extensors will be inversely correlated with the projection angle of the knee in the frontal plane and with the inclination angle of the pelvis and trunk.

Method

Subjects

This cross-sectional study was developed at the Musculoskeletal Assessment Laboratory, UNESP, campus Marília. Twenty-two young women who did not have a history of pain or injury in the lower limbs participated in this study. Participants were recruited through personal communication, leaflets distributed at the university and through social networks. The eligibility criteria for this study were: female gender, age between 18-30 years, who did not have degenerative diseases in the knee and hip joints, history of injuries or trauma to the lower limbs, discrepancy in limb length and complaints of knee pain in the last three months. Table 1 shows the characteristics of the sample.

This study was approved to the local ethics committee (4.168.938) and all participants signed an informed consent form.

Table 1: Anthropometric characteristics

	Mean	Standard Deviation
Age (years)	22.54	2.06
Body Mass (Kg)	56.72	8.68
Stature (m)	1.60	0.06
BMI (kg/m^2)	21.82	2.42
Peak Torque		
Abductor Hip Right (Nm/Kg^{-1})	85.45	19.81
Adductor Hip Left (Nm/Kg^{-1})	82.71	15.92
Lateral Rotator Hip Right (Nm/Kg^{-1})	88.00	18.21
Lateral Rotator Hip Left (Nm/Kg^{-1})	80.62	16.53
Extension Hip Right (Nm/Kg^{-1})	150.93	29.38
Extension Hip Left (Nm/Kg^{-1})	144.30	19.85
Extension Trunk (Nm/Kg^{-1})	64.69	16.58

Valores de média±desvio padrão.

Assessment Procedures

The assessment procedures were carried out in two days. In the first visit to the laboratory, the volunteers underwent anamnesis, collection of anthropometric data, kinematic evaluation during the frontal and lateral step-down, and familiarization with muscle strength tests. On the second day, the isometric joint torque assessment of the hip stabilizer muscles (lateral rotators, abductors and hip extensors) and trunk extensors was performed. The order of the muscle groups evaluated was randomly determined. Assessments were performed on the dominant lower limb.

Kinematics

The kinematic evaluation was performed during the frontal and lateral step-down test. The volunteers were positioned with one foot on a step with a height corresponding to 10% of the volunteer's height. To perform the test, the volunteers were instructed to touch the heel of the limb suspended on the ground in front (front step down) and later, on the side (lateral step down), as shown in Figure 1. The volunteers were previously familiarized with the test. and then performed three repetitions of the movement with the dominant lower limb. A Sony® digital camera, with a sampling frequency of 60Hz, was placed 3 m from the volunteers to record the movement.

To determine the joint angles, photoreflective markers were positioned at the midpoint between the medial malleolus and the lateral malleolus, midpoint between the medial and lateral femoral condyle, both anterosuperior iliac spines and the manubrium of the sternum[13].

For the analysis of kinematic data the Kinovea software was used. The angle of inclination of the trunk was determined by the angle formed between the intersection of two lines, one between the right EIAS and the left EIAS and the second at the height of the umbilical scar to the sternum. The angle of inclination of the pelvis was determined by the angle formed between the intersection of two lines, one between the right EIAS and the left EIAS and the second line between the EIAS and the center of the knee[13]. For analysis of the angle of the knee in the frontal plane , the angle formed between the hip line (ASIA and knee center) and knee (knee center and midpoint between the malleolus) was calculated. The average of the angles of the three repetitions of the frontal and lateral step-down tests was performed.

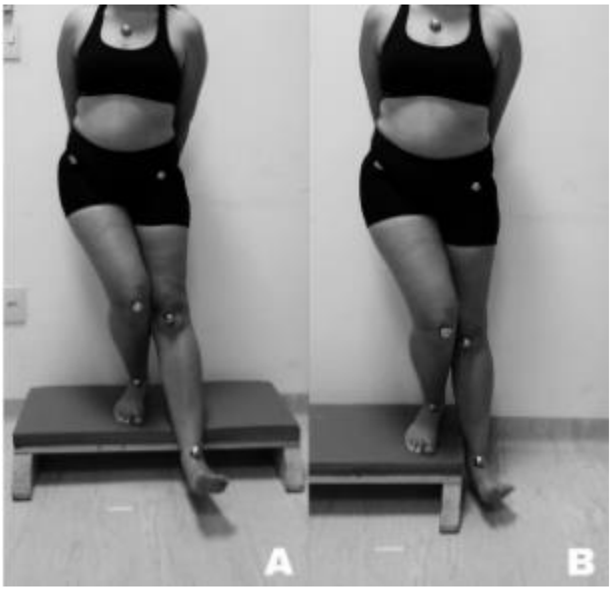

Figure 1: Kinematic evaluation was performed during the frontal (A) and lateral step-down test

(B).

Assessment of hip joint torque

The assessment of isometric hip torque was performed using a portable dynamometer from the Lafayette® brand. Before the beginning of the assessment protocol, a familiarization was made, consisting of 2 submaximal contractions of each muscle group evaluated[14]. Between familiarization and the beginning of the data collection procedures, an interval of 03 minutes was given in order to minimize the risk of fatigue muscle.

The evaluation protocol consisted of 3 maximal voluntary isometric contractions, for a period of five seconds, with an interval of thirty seconds between each contraction[15]. The joint torque data were normalized by the body mass of the volunteers. The peak torque was determined by the highest torque value obtained after the onset of muscle contraction and the mean of the values of the three contractions performed was calculated. The positioning of the volunteers for evaluation was:

- hip abductors: lateral decubitus, with the limb evaluated at 20° of abduction, 10° of extension and neutral hip rotation, with the knee in extension. The dynamometer was positioned 5 cm above the lateral malleolus[16].

- hip extensors: prone, with the limb evaluated at 10° of extension and knee flexed at 90°. The dynamometer was positioned 5 cm above the knee joint line[16].

- lateral hip rotators: prone, with the knee bent at 90°. The dynamometer was positioned 5 cm above the medial malleolus[16].

Torque assessment of trunk muscles

To assess the torque of the trunk extensor muscles, a traction dynamometer was used. The volunteers were positioned standing on the equipment platform, with the trunk flexed and the knees extended[17]. The volunteer was asked to perform trunk extension for a period of five seconds and the test was repeated three times.

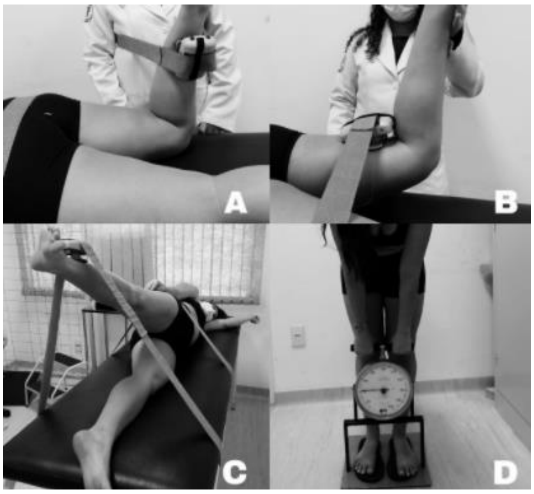

Figure 2: Assessment of isometric lateral hip rotators (A), hip extensors (B), hip abductors (C) and trunk extensor (D).

Statistical Analysis

Statistical analysis was performed using the PASW statistics 18.0® (SPSS) software. After verifying the normality of the data using the Shapiro-Wilk test, the Pearson correlation test was applied. For all statistical tests, a significance level of $p<0.05$ was adopted.

Results

Pearson's correlation analysis showed no relationship between the variables of hip and trunk joint torque and the kinematic movement pattern during the frontal and lateral step-down test, as shown in Tables 2 and 3, respectively.

Table 2: Correlation of joint angles with muscle torque during the frontal step-down test.

		Inclination of Trunk	Inclination of pelvis	Valgus of Knee
Abductors of Hip	r	-0.281	-0.035	-0.139
	p	0.206	0.876	0.537
Extension of Hip	r	-0.283	0.221	-0.340
	p	0.202	0.323	0.122

Lateral Rotators of Hip	r	-0.134	0.059	-0.067
	p	0.553	0.795	0.767
Extension of Trunk	r	-0.335	-0.166	0.087
	p	0.128	0.461	0.702

r= correlação de Pearson

Table 3: Correlation of joint angles with muscle torque during the lateral step-down test.

		Inclination of Trunk	Inclination of pelvis	Valgus of Knee
Abductors of Hip	r	0.200	0.147	-0.006
	p	0.373	0.513	0.979
Extension of Hip	r	-0.168	0.043	-0.216
	p	0.455	0.849	0.335
Lateral Rotators of Hip	r	-0.180	-0.044	-0.204
	p	0.423	0.846	0.363
Extension of Trunk	r	-0.128	-0.144	-0.085
	p	0.571	0.521	0.708

r= Pearson correlation

Discussion

The aim of this study was to correlate the torque levels of the stabilizer muscles of the hip and trunk with the kinematic angles during the step-down test. Our findings refute the initial hypothesis, since there was no correlation between the peak torque of the hip extensors, abductors and lateral rotators muscles, as well as the trunk extensors with the knee projection angles in the frontal plane, pelvis tilt and of the trunk.

The findings of the present study showed that the maximum isometric torque of the lumbopelvic stabilizer musculature does not correlate with the movement pattern during the single leg squat. These data corroborate Almeida et al., who found no correlation between peak isometric torque of hip abductors and Q angle of the knee, indicating that control of the knee projection in the frontal plane does not depend on the torque generation capacity of the hip musculature, but on the neuromuscular control of the lower limbs to perform this movement[20]. In addition, it was believed that the dynamic valgus angle of the knee would present a negative correlation with hip strength, due to the ability of these muscles to control knee angulation in the frontal plane. However, the results found do not support this hypothesis.

The lack of correlation between hip joint torque and kinematics during the single leg squat agrees with the findings of Dix et al., who observed that the relationship between hip stabilizer muscle strength and dynamic knee valgus is task-dependent[21]. That is, this relationship is present when the task requires greater challenge to the lower limbs, such as landing in single leg support. As for simple tasks such as single leg squats, this correlation is not present[21]. Furthermore, this lack of correlation can also be explained by the fact that the single leg squat is characterized as a low load task with slow movement, therefore a simple task to perform and which results in small knee valgus angles[22].

Regarding the influence of the trunk on the kinematics of the lower limb during step down, the findings did not show a significant relationship between trunk inclination and the capacity to generate strength in the spinal extensor muscles. According to Wilczyński et al., the lack of neuromuscular control of the trunk observed through lateral bending during the single leg squat predisposes to a shift in the center of gravity farther away from the knee, increasing the overload in this joint[22]. In addition, according to Chuter et al., the trunk muscles act together with the pelvic stabilizer muscles to maintain the pelvis horizontally aligned during unipodal activities, thus avoiding excessive adduction of the femur[23]. The influence of the trunk during the single leg squat was not confirmed in the present study, however, it is suggested that an electromyographic analysis of this musculature could provide more representative information of the influence of this musculature in performing this task, in which the pre-activation of the spinal stabilizers can occur before lower limb movement.

The findings of this study differ from the results of Nakagawa et al. who found a significant correlation between trunk lateral tilt kinematics and knee valgus during the single leg squat in asymptomatic women[24]. The difference in relation to the results can be explained by the the fact that the authors used 3D kinematic analysis that allows a more refined evaluation of the movements, while this study performed a 2D evaluation of the movement. Nakagawa et al (2015) and Nakagawa et al (2018) emphasize the importance of neuromuscular control of the hip and trunk working together to maintain knee stabilization during activities such as single leg squats[24,25].

Finally, the authors emphasize the importance of understanding the relationship between the kinematic pattern of the knee, pelvis and trunk during unipodal support, given that they can influence the risk of future symptoms in the knee joint, in addition to being considered the main injury mechanism of lower limbs.

It is important to emphasize that the present study has some limitations. Analyzes were performed with 22 volunteers, with a small sample. In addition, muscle torque was assessed isometrically, with the eccentric torque being the most representative of the control of the kinematic pattern of movement of the lower limbs. It is suggested that further studies be carried out addressing activities of greater biomechanical demand as well as functional activities, in addition to including the evaluation of the eccentric torque of the hip muscles.

Conclusion

No correlation was found between hip, knee and trunk kinematics during the single leg squat and the ability to generate strength in the lumbopelvic stabilizing muscles. It is suggested that the assessment carried out in this study be applied to tasks of greater demand, in order to understand the relationship between the strength generation capacity of lumbopelvic stabilizers and performance in more challenging situations for the musculoskeletal system.

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