XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

ANALYSIS OF DYNAMIC VALGUS KNEE IN WOMEN WITH PATELLOFEMORAL PAIN SYNDROME DURING JUMP PREPARATION AND LANDING

[1]André Serra Bley, [1]Amir Curcio dos Reis, [1]Nayra Deise dos Anjos Rabelo, [2]Jeniffer Nunes Medrado, [3]João Carlos Ferrari Corrêa, [4]Paulo Roberto Garcia Lucareli
[1] MSc postgraduate student, Universidade Nove de Julho, UNINOVE, São Paulo, Brazil
[2] Graduate student, Universidade Nove de Julho, UNINOVE, São Paulo, Brazil
[3] Professor of Master and PhD in Rehabilitation Sciences - Universidade Nove de Julho, UNINOVE, São Paulo, Brazil
[4] Motion Analysis Laboratory - Universidade Nove de Julho, UNINOVE, São Paulo, Brazil
email: lucareli@uninove.br

INTRODUCTION

The key to load distribution in the knee is linked to the dynamic alignment of the lower limb in support activities. Misalignment generates disproportional load transfer to the joints [1] such as the mechanism of dynamic knee valgus (DKV).

Powers [2] reported that DKV is caused by excessive pronation of the foot, increased adduction, and medial rotation of the femur and the pelvis down the contralateral side when on single-leg support. These movements increase the stress forces of the patella with the femur, causing patellofemoral pain syndrome (PFPS).

The etiology of PFPS is multifactorial; however, the symptoms seem to be more evident in support activities associated with the repeated flexion of the knee, e.g., up and down stairs, running, and jumping [3].

Jump preparation and landing are situations that require great demands of the muscles, which can show potential changes in the kinematics of the lower limbs [4,5].

Therefore, the aim of this study was to analyze the presence and the biomechanical characteristics of DKV during jump preparation and landing in women with PFPS.

METHODS

This is a cross-sectional study, approved by the ethics committee conducted at the Motion Analysis Laboratory, Universidade Nove de Julho - Sao Paulo.

We included 13 women with PFPS that were not engaged in regular physical activity. Their mean age was 23.07 years (±4.03), mean body mass was 56.16 kg (±5.25) and mean height was 1.64 meters (±0.04). The volunteers showed anterior knee pain intensity with a mean of 55.16 mm (±13.57) on the visual analog scale, in at least two of the following activities: prolonged sitting, climbing up and down stairs, squatting, running, or jumping.

The study used SMART-D BTS (Milan, Italy) to collect the data for the kinematic system, which was composed of eight infrared cameras with a frequency of 100 Hz, and with a fourth-order Butterworth filter, and a cut-off frequency of 8 Hz. Retro-reflective markers were fixed at specific anatomic points in the body, using the Vicon Plug-in Gait model.

Volunteers were instructed to perform from the static position a single forward jump as far as possible with the symptomatic lower limb. After marker placement, volunteers became familiar with the activity and, when they felt comfortable, they performed the test 3 times, with an interval of about 2 minutes between each attempt.

The data collected were named and saved in TDF format (tab delimited files) and were subsequently exported to the C3D format by BTK Toolkit 0.1.10 (Biomechanical Tool Kit) into Matlab 2012. The marker labeling and processing of biomechanical models were performed by Vicon Nexus Software 1.5 and the Plug-in Gait model was also applied. The processed data for each condition were exported to Microsoft Office Excel.

The dependent variables of interest were highest angular hip adduction and internal rotation, knee flexion and valgus, contralateral pelvis drop, and trunk side flexion during the jump preparation and landing.

The *Shapiro-Wilk* test was used to test the normality of distribution of the data collected. Descriptive statistics were presented as mean and standard deviation (SD) for all variables assumed normal values. The dependent Student's t-test was used to compare the dependent variables. Statistical significance was set at 5% ($P < 0.05$). The analyses were performed using SPSS (Statistical Package for Social Sciences version 15.0).

RESULTS AND DISCUSSION

The comparison of the angle values that obtained maximum hip adduction and internal rotation, knee flexion, and contralateral pelvic drop results were higher during the jump preparation phase. The trunk obliquity was ipsilateral during jump preparation and contralateral during jump landing. The values of knee valgus and pronation showed no differences (Table 1).

Jumping capacity depends on a combination of physical attributes (e.g., power, strength, and body composition) [6]. In this study, the variables that characterize DKV showed higher values during the preparation phase than the landing phase. This could be related to the different demands of the muscles involved in each jump phase.

The lower strength and neuromuscular control presented by trunk flexor side and hip in individuals with PFPS contribute to change in the kinematics of a jump [7,8]. In this study, the strategies adopted by the trunk were reversed, probably due to the different mechanical demands of each phase evaluated.

Pollard et al. [9] reported that the jump absorption mechanisms increase frontal plane hip motion when the hip flexion and knee are decreased. Thus, the smaller knee flexion may be an attempt to minimize patellofemoral stress, but highest hip adduction is the main mechanism of DKV.

It the present study, the lower range of knee flexion observed during landing did not follow the highest range of hip adduction. We believe the highest amplitudes achieved in the preparation phase may show that it is necessary to ensure amplitude's advantage in the production of muscle power.

The increase in adduction and internal rotation are the main features of DKV, which are responsible for the patellofemoral joint stress [8]. It was not possible to compare the time in which the jump increased stress on the joint, independent of the amplitudes achieved. The strategies adopted during the jump preparation and landing showed DKV were different in their amplitudes. These strategies can contribute mechanically to causes of PFPS.

CONCLUSIONS

Women with PFPS exhibit changes in lower limb alignment, characterized by dynamic valgus during forward jumping preparation and landing phases. The preparation phase has higher angular peaks, but we cannot say that this phase may cause more damage to the patellofemoral joint than the landing phase.

ACKNOWLEDGEMENTS

We thank the Universidade Nove de Julho - UNINOVE and the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for the master's degree scholarship (number 2012/08909-5).

REFERENCES

1. Sharma L, et al. The Role of Knee Alignment in Disease Progression and Functional Decline in Knee Osteoarthritis. *JAMA*. **286**(2):188-195, 2001.
2. Powers CM. The influence of altered lower-extremity kinematics on patellofemoral joint dysfunction: a theoretical perspective. *J Orthop Sports Phys Ther*. **33**(11):640-646, 2003.
3. Souza RB, Powers CM. Differences in hip kinematics, muscle strength, and muscle activation between subjects with and without patellofemoral pain. *J Orthop Sports Phys Ther*. **39**(1):12-19, 2009.
4. Willson JD, et al. Lower extremity jumping mechanics of female athletes with and without patellofemoral pain before and after exertion. *Am J Sports Med*. **36**(8):1587-96, 2008.
5. Earl JE, Monteiro SK, Snyder KR. Differences in lower extremity kinematics between a bilateral drop-vertical jump and a single-leg step-down. *J Orthop Sports Phys Ther*. **37**(5):245-52, 2007.
6. Weiss LW, et al. Comparative effects of deep versus shallow squat and leg-press training on vertical jumping ability and related factors. *J Strength Cond Res*. **14**(3);241-47, 2000.
7. Cowan SM, et al. Altered hip and trunk muscle function in individuals with patellofemoral pain. *Sports Medicine*. **43**(1):584-588, 2009.
8. Powers CM. The influence of abnormal hip mechanics on knee injury: A biomechanical perspective. *J Orthop Sports Phys Ther*. **40**(2):42-51, 2010.
9. Pollard CD, et al. Limited hip and knee flexion during landing is associated with increased frontal plane knee motion and moments. *Clin Biomech*. **25**(2):142-6,2010.

Table 1. Maximum values (degrees) of three-dimensional angular kinematics during jump preparation and landing. Values are mean (±SD).

		Preparation phase	Landing phase	*P**
Hip	adduction	19.9 (4.03)	10.3 (2.22)	<0.0001
	internal rotation	18.61 (6.33)	12.55 (3.31)	0.009
Knee	flexion	63.72 (3.67)	47.83 (2.81)	<0.0001
	valgus	7.55 (3,27)	8.36 (2.28)	0.22
Foot	Pronation	13.19 (3.04)	10.63 (4.36)	0.09
Pelvis	Obliquity	14.81 (3.05)	7.33 (2.09)	<0.0001
Trunk	Side flexion	14.66 (4.66)	(-) 9.24 (2.49)	<0.0001

* $P<0.05$ (significant difference between jump phases after two tail dependent t test).