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THE EFFECT OF NEUROMUSCULAR TRAINING ON THE KNEE ANGULAR VELOCITY: DESCRIPTION BY QUATERNIONS REPRESENTATION

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SUMMARY

The aim of this study was to verify the effect of neuromuscular training versus strength training in single-leg drop landing pattern and potential differences between males and females. Five female participants were recruited to participate in the present study (age 19 .8 ± 2,04years, mass 65.34 ± 0,08 kg, 1.66 height ± 0,04 m). Every participant performed 'five single-leg drop landing' from the platform of 40 cm. The motion capture system with (12) OptiTrack™ infrared cameras were used to obtain three-dimensional coordinates of markers fixed on the anatomical points of interest. The values founded in this study suggest that the intervention program improve dissipation of body weight on the ground during single leg drop landing with possible reduction of risk factors for injury.

INTRODUCTION

The high rate of injuries of the non-contact anterior cruciate ligament (ACL) in women is a source of curiosity among scientists, who attribute the predisposition of drop landing to that risk of injury. In order to improve the movement pattern several training protocols have been used as the intervention and the results were diverse. Some studies have shown that the degree of dynamic valgus during landing can be altered by appropriate interventions, such as neuromuscular training programs that include exercises of balance (static and dynamic), plyometric and strength decrease the incidence of ACL injury in womem [3.2.1].

This study suggests that neuromuscular training can change the movement pattern of young women knee rotation through motor learning and performance improvement resulting in leg landing task.

METHODS

Five female participants were recruited to participate in the present study (age 19 .8 ± 2,04years, mass 65.34 ± 0,08 kg, 1.66 height ± 0,04 m)Kinematic data were obtained from the 6 retro-reflective markers (15 mm diameter) placed on the following anatomical landmarks: greater trochanter, lateral and medial femoral epicondyles, fibular condyle, medial e lateral malleolus and the 1st metatarsal heads (to verify the contact on the ground). Data were collected with a passive 12 camera OptiTrack Motion Capture System (NaturalPoint®, Oregon, USA), at 250 Hz with an average accuracy of 0.55 mm. Before all analyses, the data were filtered using a 4th order Butterworth digital filter with 10 Hz of cut-off frequency. Each participant performed five single-leg drop landing test from a platform of 40 cm height in the pre and post training. After first evaluation and data collection was started the neuromuscular training with durability of 7 weeks completing ± 14 sessions per participant and each session lasted on average 50 minutes. The exercises of the training are showed at the table 1.

Table 1. Exercises of the training

1 ˚Exercise - stability on uneven surfaces: standing, with the support of two feet in half Swiss ball and maintain balance.
2 ˚ Exercise - jumping rope: perform 14 repetitions.
3 ˚ Exercise-roll on the mat: making rotational movement about the axial axis of the trunk with trunk support of the soil. When passing through the phase of raising prone members doing an extension column and go through the stage of supine elevate the limbs and torso support only keeping the pelvis (ischia) in the soil. Run 14 sequences.
4 ˚ Exercise in agility-ladder strips the soil "ladder drill": every square foot of the ladder switch support, while the other foot rests off the ladder sideways doing a hip abduction. Moving ahead to finish the sequence of squares of the ladder. "Icky shuffle"
5 ˚Agility exercise "ladder drill": place 2 feet within two feet of the stairs outside the square towards the right side to the left side complete to make sense.
6 ˚ Exercise-landing double jumps with legs hip-width apart: wear resistance "Theraband" tied at the ankles, making hip abduction and return to starting position.
7 ˚ Exercise-leg squat: perform squats unilateral limb starting right ahead doing 10 reps with alternating displacement member left and right ahead.
8 ˚ Exercise-landing jumps alternating with double-sided: run displacement ahead, 14 repetitions.
9 ˚Exercise up and down stairs: up and down stairs.
10 ˚ Exercise -jumps: jumping and landing with both limbs forward and backward, through which a rope is extended on soil. Perform 7 times to one side and 7 to the other.

Routines were used in the *software* MatLab® (Matchworks Inc., Natick, MA, USA) to smooth the raw data with the

cubic splines function, and to create coordinate systems of the thigh and shank to extract the unit quaternions from the knee joint observed in the task.

The quaternions was calculated and utilized to investigate the differences of knee rotation movements in pre and post training. Thigh and shank coordinate systems were defined by the three-dimensional coordinates of markers and their relative rotation calculated by means of a rotation matrix, afterwards converted to a unit quaternion. The angular velocity is calculated in only one way when using quaternions.

The quaternions had been used to describe the rotational component of the joints during human movements with advantages since are singularity-free, and thus do not present the phenomenon of gimbal lock, several different rotation sequences might be related to one single rotation, fewer coordinates used to [2], greater ease in finding the angle of rotation about the axis occurs when the rotation [7], and multiplication performed more efficiently [3].

RESULTS AND DISCUSSION

The mean of angular velocity peak increased and the mean time to reach the peak velocity decreased of the knee joint on initial contact during single-leg drop landing in post training compared to pre training (table 2).

Table 2. Comparing pre x post training voluntaries

	Total angular velocity peak (º/s)			Total time (s)		
	Pre	Post		Pre	Post	
Mean	516,076	574,945	-58,869	0,056	0,049	0,006
Standard deviation	67,561	64,708	104,948	0,010	0,009	0,001
Paired t test	0,009	Result	1	0,007	Result	1

In the present study results was demonstrated that neuromuscular training intervention increased the mean peak of knee joint angular velocity and it is presumed that the vertical ground reaction force decreased during the single-leg drop landing, these factors contribute to decrease the load on the ACL.

Some studies have shown the relationship between angular velocity of the knee joint vertical ground reaction force [5.6]. One of factors that contribute to increase ground reaction force is the decrease of angular velocity during the initial contact single-leg drop landing. [9]

It was demonstrated previously that neuromuscular training can reduce impact landing forces[4.8]. Some authors relate improve force dissipation strategies at the landing with balance exercise [7].

CONCLUSIONS

Considering the partial results of this study, the intervention during 7 weeks of neuromuscular training resulted in differences in the values of angular velocity peak and time to reach peak of young women during single leg drop landing. The values suggest that the intervention program improve dissipation of body weight on the ground during single leg drop landing with possible reduction of risk factors for injury.

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REFERENCES

1. Baldon, R D M, et al., Effect of Functional Stabilization Training on Lower Limb Biomechanics in Women. Medicine & Science in Sports & Exercise. 44:135-145, 2012.
2. Bloomenthal J, Calculation of reference frames along a space curve. In: GLASSNER, A. S. (Ed.). Graphics gems. Boston: Academic Press, 1990. p.567-571.
3. Gomes et al., Fundamentos da Computação Gráfica. Rio de Janeiro, RJ, Brazil: IMPA, 2008.
4. Hermam D C, et al., The effects of strength training on the lower extremity biomechanics of female recreational athletes during a stop-jump task. American Journal of Sports Medicine. 36: 733-740, 2008.
5. Hewett T E, et al., Neuromuscular control and valgus loading of the knee predict ACL injury risk in female athletes. Medicine and Science in Sports and Exercise. 36:287-S287 2004.
6. Hewett T E, et al., Plyometric training in female athletes. Decreased impact forces and increased hamstring torques. Am. J. Sports Med. 24:765-773, 1996.
7. Kuipers J B, Quaternions and rotation sequences: a primer with applications to orbits, aerospace, and virtual reality. Princeton, N.J.: Princeton University Press, 1999
8. Li-I W, et al. The lower extremity biomechanics of single- and double-leg stop-jump tasks 10:151-156, 2011.
9. Malinzak R A, et al., A comparison of knee joint motion patterns between men and women in selected athletic tasks. Clinical Biomechanics. 16:438-445, 2001.
10. Myer G D, et al., The effects of plyometric versus dynamic stabilization and balance training on lower extremity biomechanics. Am J Sports 34:445-55, 2006.
11. Yeow C H, Sagittal knee joint kinematics and energetics in response to different landing heights and techniques. The Knee. 17:127-131, 2010.
12. Yu B, et al., Lower extremity biomechanics during the landing of a stop-jump task. Clinical Biomechanics. 21:297-305, 2006.