ACUTE EFFECT OF QUADRICEPS PASSIVE-STATIC STRETCHING ON KINEMATIC VARIABLES DURING LANDING

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Stretching exercises are a widespread preparation practice before sport activities that involve landings. Therefore the purpose of this study was to verify the instantaneous effect of quadriceps passive-static stretching on kinematic variables of landings after a fall of different heights (30, 50 e 70 cm). Thirty male physical education students were divided into an experimental (with previous stretching exercises) and a control group (without previous stretching exercises) and landed after falls from a box with 30 cm, 50 cm and 70 cm height. In the experimental group alterations of the movement technique after stretching were found for the landings of 50 and 70 cm. These changes of kinematic parameters seem to be an adaptation of the motor system in order to optimize the absorption of the ground reaction forces during landings.

KEY WORDS: Landings, Flexibility, Kinematic variables.

INTRODUCTION:

The aim of warm-up and preparation exercises preceding sport activities is the physical preparation for performance optimization and the reduction of injury risks. The use of stretching exercises is a widespread manner of preparation for sport activities with landings, such as basketball, volleyball, handball and others. Since movement technique of landings is one of the factors that influence the impacts of ground reaction forces and injury risk (Self & Paine, 2001), the effect of stretching exercises on landing technique should be investigated. As an acute effect, stretching exercises may influence the viscoelastic properties of the muscle-tendinous system that results in an increase of the range of motion (ROM) and a decrease of the passive stiffness of the muscle-tendon unit (Taylor et al., 1990; Magnusson et al., 1996,1998; Weijer, Gorniak & Shamus, 2003, 1996; Kubo, Kanehisa & Fukunaga, 2002). Since no studies could be found investigating the acute effect of stretching exercises on landing technique, the purpose of this study was to verify the acute effect of quadriceps passive-static stretching on kinematic variables during landings after a fall from different heights.

METHOD:

Data Collection: The volunteers of this study were 30 male physical education students with an average age of 24.6 ± 4.4 years, body mass of 71.2 ± 8.2 Kg and height of 175.3 ± 7.2 cm. The inclusion criterion was the absence of injuries of the lower limbs or hips. The experiment was performed on two consecutive days. On one day, the experimental design of landings after stretching and on the other day the control design of landings without stretching was conducted. The sequence of the different designs was randomized and counterbalanced among the volunteers, so that all of them performed the same number of landings with and without preceding stretching exercises. The individuals were instructed to keep their daily activities and not to perform any kind of physical training on the day before the experiment.

During the stretching exercise the m. quadriceps of both legs were stretched by passive-static technique. The flexibility test performed immediately before and after the flexibility training, however, was only performed for the right leg. The duration of flexibility tests and flexibility training was 20 min. The landings occurred immediately before and after stretching exercise. Landings without flexibility training were performed before and after a 20 min rest interval.

Landings: The subjects performed landings after falls from boxes with 30, 50 and 70 cm height. The individuals were instructed to land simultaneously with both feet and to keep their hands on the hips in order to avoid upper limbs' movements. The individuals used the same model of unused, new sport shoes designed for volleyball (Olympicus – evaflow).
The landings were filmed in the sagittal plane by a high speed camera (Basler A602f) working at 100Hz in order to determine the following variables at the moment of the lowest position of the Center of Gravity (CG):
- Angle of the ankle (φ_a),
- Knee angle (φ_k),
- Hip angle (φ_h)
- Times between first ground contact and the lowest position of the GC (t_{CG})

The software used for digitalization was SIMI Motion 7.2 (SIMI Reality Motion Systems GmbH, Germany). The variables could be measured to 0,01 degrees.
Flexibility test: The assessment of flexibility of the quadriceps was performed by an Active-Knee-Flexion Test (AKF) on a Bench for Quadriceps Stretching (BQS) as shown in Figure 1.

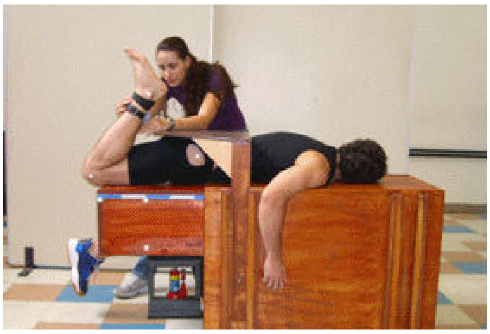

Figure 1: Assessment of maximal active knee flexion on the bench for quadriceps stretching

The individuals performed the flexibility test in order to determine the maximal ROM before and after the stretching exercises and to verify possible effects of these exercises. The maximal knee flexion was maintained for about 2 seconds so that the maximal ROM measured by a flexometer (Leighton – model 01146) fixed on the ankle of the lower limb above the medial and lateral malleoluses could be registered. This procedure was repeated three times and the mean value was used for further statistical analysis.
Stretching exercise: The quadriceps stretching exercise was performed on the BQS in the same positioning as the Active-Knee-Flexion Test. This position allows the application of the tension caused by the stretching mainly on the quadriceps, which is the primary muscle for knee extension. The passive stretching was performed by the examiner. The volunteer was directed to not to resist to the stretching, by keeping the musculature relaxed. The flexion movement continued until the subject reported discomfort, thus reaching maximum tolerance of stretching. This position was kept for 20 seconds. The whole stretching program consisted in 4 repetitions with intervals of 20 seconds between them.

Statistical Analysis: The paired t-Test was used to compare the maximal ROM before and after stretching and to compare the kinematic variables of the landings with and without preceded stretching. The statistical analyses were performed by SPSS 11.0.

RESULTS:

Flexibility: The stretching program resulted in a significantly higher maximal ROM (30.9º ± 8.7º before and 36.8º ± 8.6º after stretching, $p < 0{,}001$).

Landings: *Landings of the control design without stretching:* For landings with 30 cm and 70 cm falling height before and after a 20 min rest interval no significant differences concerning the analyzed kinematic variables could be found. For the landings with 50cm falling height, a significant lower knee angle at the moment of the lowest position of the GC was found after the rest interval.

Landings of the experimental design after stretching: For landings with 30 cm falling height, no significant differences could be found between landings with and without preceding stretching exercises, whereas significant differences for landings with 50 cm and 70 cm falling height were found for the angles of the knee and ankle (50 cm falling height) and for the hip and knee (70 cm falling height) at the moment of the lowest position of the GC (Table 1).

Table 1 Mean and SD (°) of kinematic variables for the control and experimental design

		Control design		Experimental design	
	Variables	**pre**	**post**	**pre**	**post**
30 cm Falling height	φ_h	141,01±19,62	138,76±19,93	144,09±17,29	144,31±14,55
	φ_k	117,12±23,37	115,52±24,12	120,10±18,91	118,56±17,79
	φ_a	97,95± 9,79	96,65±11,14	98,12± 8,41	96,77± 9,18
	t_{CG}	0,16±0,08	0,17±0,07	0,15± 0,06	0,15±0,06
50 cm Falling height	φ_h	132,12±21,97	128,33±23,77	131,04±21,02	129,31±19,36
	φ_k	107,37±20,78	101,72±20,86**	107,30±16,98	102,06±16,42**
	φ_a	95,14± 8,22	93,51±8,62	95,23±7,03	92,73± 7,38**
	t_{CG}	0,17±0,08	0,19± 0,08	0,17±0,08	0,19±0,07
70 cm Falling height	φ_h	120,09±25,08	119,99±23,06	123,53±22,42	119,30±20,97*
	φ_k	95,34±20,11	93,70±19,55	97,87±15,60	92,98±17,48**
	φ_a	92,78± 6,53	93,59± 6,92	92,78±7,50	92,41±7,28
	t_{CG}	0,20±0,09	0,20±0,09	0,20±0,09	0,20±0,07

φ_a - Angle of the ankle; φ_k - Knee angle; φ_h - Hip angle; t_{CG} - Times between first ground contact and the lowest position of the GC.

* Significant difference ($p < 0,05$).

** Significant difference ($p < 0,01$).

DISCUSSION:

The results show that four 20-second passive-static stretching exercises of the m. quadriceps increase significantly the maximal ROM. The increase of approximately 6° corresponds to the results of other studies (McNair & Stanley, 1996; Weijer, Gorniak & Shamus, 2003).

The increase of ROM during landings after dropping from 50 cm (angle of the ankle and the knee) and 70 cm height (angle of the knee and of the hip) can be explained by the increase of the muscle-tendon unit after stretching (Gajdosik, 2001; Taylor *et al.*, 1990). However, the stretching exercises did not cause significant changes of the kinematic variables of landings after a 30 cm fall. Since the mechanical load imposed to the body during landings increase with increasing falling height (Santello & McDonagh, 1998), probably the magnitude of the applied forces after a 30 cm fall does not represent a sufficient demand for the adjustment of the kinematic variables. The landing technique after falls from 50 cm and 70 cm was probably changed as a result of the higher flexibility of the m. quadriceps so that the forces applied during the landings could be absorbed during a greater range of movement.

CONCLUSION:

Based on the results of the present study, it can be concluded that the acute effect of the passive-static stretching of the m. quadriceps does not influence the movement technique for landings after falls from lower heights than 30 cm. Higher dropping heights, as e.g. 50 cm and 70 cm, that represent a greater demand on the muscular-skeletal system, lead to instantaneous movement pattern changes after preceded stretching increasing the range of movement. These movement pattern changes are caused possibly by the changes of mechanical properties of the previously stretched muscle.

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