

# Kinematic Analysis of the Gait in Professional Ballet Dancers

## *The Effect of Rehabilitation Intervention on Movement of Lower Limbs and Pelvis during the Gait in Professional Ballet Dancers*

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### 1 OBJECTIVES

Professional ballet dancers could be compared to high-performance athletes (Leanderson et al., 1996). Ballet position on the top of the foot (en pointe) requires extreme plantar flexion and foot pronation (Lung, Chern, Hsieh & Yang, 2008). This is a special situation that distinguishes dance from other sports (Miller, 2006). This increases the risk for overused injuries (Gilbert, Gross, & Klug, 1998). These undesirable effects of ballet can be translated to performance of common daily activities like walking.

The aim of this study was to assess the effect of rehabilitation intervention on kinematic parameters during the gait in ballet dancers.

### 2 METHODS

Thirteen professional ballet dancers (5 males, 8 females; mean age  $25.8 \pm 5.6$  years; height  $172.8 \pm 8.1$  cm; weight  $59.8 \pm 12.2$  kg) participated in this study. This experimental group participated in rehabilitation intervention for six week. Rehabilitation program consisted of neuromuscular exercise techniques and manual therapy. We evaluated performance of the gait in dancers before and after this rehabilitation.

The experimental group was compared with the group of twelve controls (3 males, 9 females; mean age  $24.3 \pm 2.75$  years; height  $173.3 \pm 6.01$  cm; weight  $72.2 \pm 12.73$  kg). The exclusion criteria for all subjects were any serious musculoskeletal injuries or surgery of the lower limbs. Additionally, control group had no ballet experience. Kinematic data were obtained using the optoelectronic system Vicon MX (Vicon Motion Systems, Oxford, London). Reflective markers of kinematic model PlugInGait were placed at the pelvis and the lower limbs. Each participant performed five successful trials of gait at self-selected walking speed.

Angle variables of lower limbs and pelvis were evaluated in all three planes. The data was evaluated in Statistica (Version 9.0, Stat-Soft, Inc., Tulsa, OK, USA) using Wilcoxon test ( $p < 0.05$ ) for comparison of differences between dancers before and after rehabilitation and Mann-Whitney test ( $p < 0.05$ ) for comparison of dancers and control group.

### 3 RESULTS

Selected kinematic variables in the observed groups are shown in Figures 1–2 and Table 1. To compare the experimental group before and after rehabilitation, dancers demonstrated decreased hip adduction ( $p < 0.05$ ) after intervention. Dancers also demonstrated significantly greater maximal ankle dorsal flexion during the stance phase ( $p < 0.05$ ) as well as greater maximal hip abduction ( $p < 0.01$ ) before and after rehabilitation compared to the control group. Dancers reached significant greater internal knee rotation ( $p < 0.05$ ) and smaller external rotation ( $p < 0.05$ ) after rehabilitation in comparison with the control group. The other kinematic variables were not statistically significant.

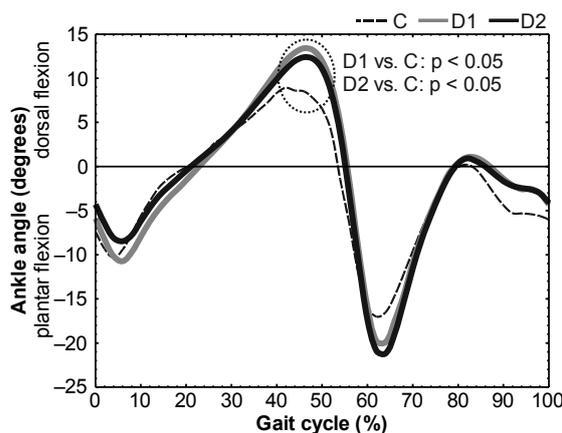


Figure 1: Ankle movement in the sagittal plane during gait (C – controls; D1 – dancers before rehabilitation; D2 – dancers after rehabilitation).

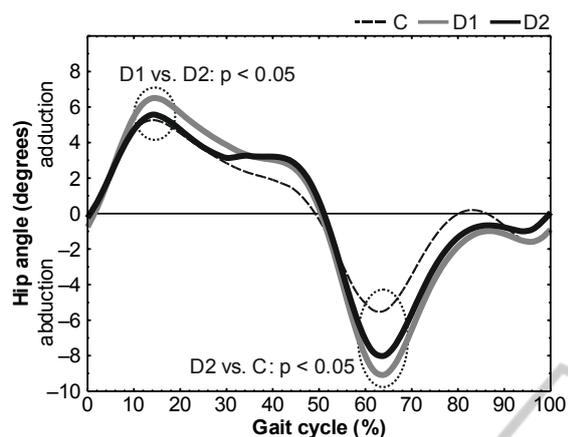


Figure 2: Hip movement in the frontal plane during gait (C – controls; D1 – dancers before rehabilitation; D2 – dancers after rehabilitation).

Table 1: Maximal values (mean±SD) of selected kinematic variables.

Variable	C	D1	D2
Ankle dorsal flexion*/&	7.8±7.5	14.2±3.3	13.5±3.1
Knee internal rotation *	23.0±8.7	14.9±8.3	23.9±21.3
Knee external rotation *	0.9±6.4	-7.1±6.8	-1.1±11.2
Hip abduction * / &	-6.1±2.3	-9.3±2.0	-8.6±1.8
Hip adduction #	5.6±3.0	6.8±1.5	5.8±1.8

Legend:

C – controls; D1 – dancers before rehabilitation;

D2 – dancers after rehabilitation;

Statistically significant differences ( $p < 0.05$ ):

\* between controls and dancers before rehabilitation;

& between controls and dancers after rehabilitation;

# between dancers before and after rehabilitation.

## 4 DISCUSSION

The observed increased dorsal ankle flexion in dancers can be explained by special ballet position (e.g. grand plié, demi-plié), which require excessive range of dorsal ankle flexion. If the foot is frequently forced into extreme range of movements, it loses ability to support the medial arch and act as a shock absorption. Dancers subsequently overload the medial part of the foot. This causes increased pronation (Russell, 2010). Insufficient range of movement in hips together with hyperpronation is compensated by increased external tibia rotation, which was demonstrated in dancers before rehabilitation. This causes greater medial load of the knee, which can predispose to injury (Cimelli and Curran, 2012; Clippinger, 2007). In addition, chronic ankle instability is often associated with hip abductor weakness (Russell, 2010). The increased

range of hip can be caused by inadequate coordination between adductors and abductors.

The results show that six-week long rehabilitation did not affect performance of walking in professional dancers. However, the observed parameters in dancers after rehabilitation can predict improved alignment of these joints during gait, which may reduce stress load being applied on the lower limb's structures. The results confirm that the long-term rehabilitation should be a necessary part of comprehensive care about dancers to improve their ballet techniques and prevent injuries.

## ACKNOWLEDGEMENTS

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