FOOT ALIGNMENT AND UNIPODAL POSTURAL STABILITY OF DANCERS TRAINED IN CLASSICAL BALLET.

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Eight female dancers (mean ± SD age 21.6 ± 3.0 years; body mass 55.4 ± 4.4 Kg) and eight female physically active non-dancer controls (age 20.5 ± 1.8 years; body mass 66.5 ± 8.6 N) participated. Dancers had 15.6 years of classical ballet training and currently performed 3.5 hours of ballet per week. In walking gait the dancers right foot progression angle (mean ± SE) was greater at 9.7 ± 1.3O than that of the left foot 7.2 ± 1.2O (P<0.05). Less out-toeing was recorded in the physically active control group with smaller progression angles (4.4 ± 1.20 right foot and 2.9 ± 1.50 for the left foot). For both the dancer and control groups the right and left unipodal postural sway were not significantly different, indicating that the morphological differences did not influence stability.

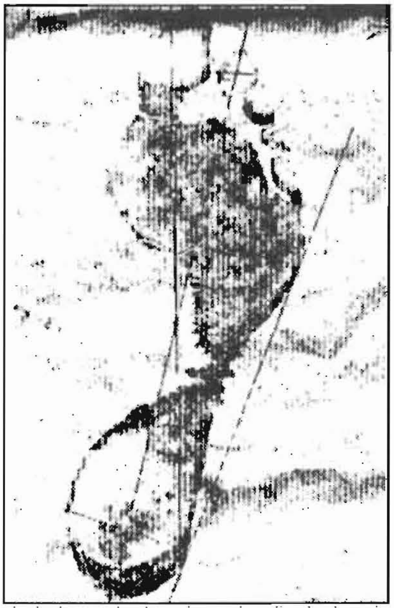
KEY WORDS: footprint, dance, sway, training, turnout.

INTRODUCTION: Athletes who frequently train using specific types of activity usually experience particular physical training adaptations (Wilmore & Costill, 1999), and it is suggested create muscular imbalances that in turn may create postural mal-alignment (Soloman et al., 2000). Misalignment in one area causes the need for compensation in adjacent areas and the kinetic chain (Sevey Fitt, 1988). In 1994 Soloman et al. reported evidence of greater out-toeing in female ballet students. Lower extremity turnout is emphasized in the execution of crucial classical ballet positions such as 1st, 2nd, 3rd, 4th and 5th. Ideal turnout requires both lower extremities to be externally rotated including a 90o hip angle and feet rotated 180o away from one another on the longitudinal axes (Gilbert et al., 1998). The intense nature of performing turnout positions within classical ballet can promote development of specific muscles, tendons and tissues within ballet dancers' lower extremities (Micheli et al., 1984; Bennell et al., 1999).

The aims of this study were to examine lower limb foot alignment and postural stability in a group of dancers who had participated in classical ballet training, which expressed the repetitive performance of 'turnout'. Comparison of these measures with an active control group, who had not been exposed to such specific activity related training within right and left sides, will support the case for the recognition of training specific morphological change syndrome and indicate whether functional performance of a ballet relevant task is influenced.

METHODS: Sixteen healthy female participants (8 controls, 8 dancers) were recruited. All participants were free of injury and gave written informed consent to participate in the study following an explanation of the testing procedure. They completed questionnaires determining the duration, intensity and type of ballet training, activity levels and previous or current lower limb injuries. On average, dancers had 15.6 ± 2.7 years of classical ballet training and currently perform 3.5 ± 0.5 hours of ballet per week. The control group were physically active college sports students who had not participated in classical ballet training. The physical characteristics for the control group were age 20.5 ± 1.8 years; body mass 66.5 ± 8.6 N. (mean SD), and for the dancer group 21.6 ± 3.0 years; body mass 55.5 ± 4.4 Kg.

To determine foot progression angle (FPA) a modification of that used by Solomon et al. (1994) was adopted. Subjects had their bare-footed soles coated with water based blue paint. Starting with the left foot, participants were asked to walk naturally towards a designated position across a 6m length of brown paper. Depending upon subjects' stride length, trials of 6-8 footprints were imprinted with the fourth right and fifth left footprints used for analysis. A five-step process was used to determine the lines forming FPA.



1) A straight line was drawn to connect the outermost lateral borders of the forefoot and the heel.
2) Using a T-square, the greatest breadth of the heel perpendicular to this line was measured, and bisected to determine the midpoint of the heel.
3) The greatest breadth of the second toe was determined and bisected, and a line was drawn from this point to the midpoint of the heel; this line defined the longitudinal axis of the foot.
4) Using a parallel double ruler, a second line-the line of progression-was brought in parallel to the margin of the paper and made to intersect the longitudinal axis of the foot, thus forming the foot progression angle.
5) A protractor is used to measure the FPA; in-toeing was expressed in negative degrees, out-toeing (or turnout) in positive degrees" (Soloman et al., 1994. p250).

Figure 1: A dancer's right footprint displaying the five step lines used to form the foot progression angle.

Postural sway measurements were determined with subjects standing on a Kistler 9851B piezoelectric force plate. This was connected to a 9865 Kistler amplifier (Kistler, Alton, UK) and an Amplicon 16 bit analogue to digital converter (Amplicon, Brighton, UK). A Provec 5.0 software package (MIE Medical Research Ltd. Leeds, UK) running on a Viglen 4DX266 computer sampled and recorded centre of pressure force components at 100Hz. Subjects were required to maintain 24 sec static unipodal balances standing on the plate barefoot (with remaining leg bent behind and arms naturally extended) whilst looking at a directed spot ahead. Subjects were instructed to stand on the force plate in a known position prior to testing to aid habituation and relaxation into position. Order of foot testing within participants, left or right, was randomized to avoid any learning effects. Each participant was tested until a total of six measurements were obtained, one trial for the left and the right foot was then selected for data analysis. The experimenter selected the trials based upon the criteria, firstly there was no bipodal foot touch within the unipodal balance test and secondly the most stable recording was selected. Ranges of centre of pressure movements in the horizontal plane were analysed.

RESULTS AND DISCUSSION: Within the dancers the progression angle analysis (mean ± SE) and analysis of variance showed significantly greater out-toeing for the right foot (9.7 ± 1.3O) than the left foot (7.2 ± 1.2O) in walking gait ($P<0.05$). Out-toeing in the dancer group ranged from 16 O to 5 O. Less out-toeing was recorded in the physically active control group with smaller mean progression angles of 4.4 ± 1.20 for the right foot and 2.9 ± 1.50 for the left foot. These control group values were of the order of those cited for normal subjects by Soloman et al. (1994), who also cited out-toeing of 160 for ballet dancers. Such differences in right and left foot position might be enhanced by classical ballet training, since not only is turnout emphasised but also that the left leg acts as a support leg while the right performs gestures.

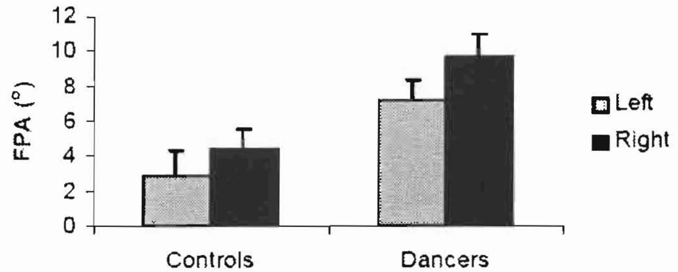


Figure 2: Comparison of left and right foot progression angles (mean ± SE).

Mean postural sway was similar in both the physically active control group and the dancers as indicated in table 1. Analysis of variance confirmed that the postural sway did not differ between the dancers and the physically active control subjects, and that there was no significant difference between the left and right foot unipodal postural sway stance in either the dancer or control groups.

Table 1 Postural sway (mean SD cm) of the right and left feet.

Subject	Anterior-Posterior		Medial-lateral	
	left	right	left	right
Controls	3.65 ± 0.76	3.61 ± 1.64	2.92 ± 0.35	2.93 ± 0.54
Dancers	3.51 ± 0.62	3.27 ± 0.84	2.88 ± 0.87	2.91 ± 0.45

CONCLUSION: In walking gait the dancers right foot showed significantly greater out-toeing than the left foot. For both the right and left side mean foot progression angles were greater in the dancers trained in classical ballet than in the control group. However, these observed morphological differences did not influence incidences of optimal postural sway during unipodal stance since similar left and right postural sway were recorded in the dancer and control groups.

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