ARE DANCERS SYMMETRICAL DURING SINGLE LEG AND DOUBLE LEGGED LANDINGS?

Cassandra K. Conway, Elizabeth J. Bradshaw, Vanessa J. Rice and Ross A. Clark

Australian Catholic University, School of Exercise Science, Melbourne, Australia

The effect of limb preference on lower extremity function and performance was examined in young healthy dancers. Fifteen elite adolescent dancers performed 15 consecutive single leg hops on each leg and 3 rebound jumps onto two triaxial force platforms. To identify limb preference the Waterloo Footedness Questionnaire was administered. Functional symmetry indices (SI) were calculated for the peak landing forces, and limb dominance was identified as the limb producing the greatest take-off power during the rebound jumps. Significant asymmetry was identified in the landing performance of the dancers. However no relationship was found between limb preference and limb dominance of the dancers. In conclusion, dance teachers should aim to achieve safer landing strategies by developing ambidextrous movement in young dancers.

KEY WORDS: Limb, Kinetics, Symmetry, Dance.

INTRODUCTION: Dance training incorporates highly specific movements that require precise spatial and temporal coordination of postural control with multi-joint limb movement to achieve a graceful aesthetic performance (Rein, Fabian, Zwipp, Rammelt & Weindel, 2011). As the dancer increases in age and skill level an asymmetrical body structure can develop; as well as a preference for learning and performing specific skills on one leg or side (Chatfield, Krasnow, Herman & Blessing, 2007). An increase in task complexity has been shown to produce lateral preference in university dancers (Kimmerle & Bowes-Sewell, 2001). A simple single leg balance task revealed that the dancers were symmetrical on both sides however when the dancers were asked to perform a more difficult task, a single leg relevé (rising action onto the ball of the foot), a stronger right bias was apparent (Kimmerle et al, 2001). For the purpose of this study lateral preference was defined as the ability of a limb to execute a manipulative or mobilising action while the other, non-preferred limb provides stabilising support (Gabbard & Iteya, 1996). Further, limb dominance was defined as the limb producing the greatest propulsive power (Previc, 1991).

An important part of the dancer's repertoire, across every age group, is the performance of jumping and leaping tasks. Mertz and Docherty (2012) reported that during a 1.5 hour technique class, over 200 jumps were performed. Of these observed jumps, 56% involved one-footed landings, placing high amounts of stress through the hip, knee and ankle joints. It was previously demonstrated by Kulig, Fietzer, and Popovich (2011) that the vertical ground reaction forces (GRF) experienced during both the take-off and landing phases of a pas de chat (a sideways jump landing on one leg) exceeds that of several other athletic activities. While both the take-off and landing phase of the pas de chat involves relatively large GRF's, the peak GRF was found to be 26% greater during landing. This may be a result of the upright posture required of dancers when performing these tasks. A forward inclination of the trunk during landing decreases the peak GRF due to greater flexion of the hips and knees (Blackburn & Padua, 2009). Due to the aesthetic requirements of dance, dancers are prevented from inclining the trunk resulting in a more extended hip and higher GRF's.

Clinical and objective measures of limb asymmetry in dancers are not well established in adolescent dancers (12-18 years). Identifying significant asymmetry related to limb preference and dominance will enable dance teachers and health professionals to identify adolescent dancers 'at risk' and adjust class structure, injury prevention programs and

rehabilitation accordingly. The purpose of this study was to determine the effects of limb preference and leg dominance on lower extremity asymmetry during hopping and jumping tasks in adolescent dancers.

METHODS: Fifteen dancers, from a talent-selected (elite) classical ballet school, including eleven males and five females, were recruited to participate in this study (mean±SD: age 15.9±1.24 years, height 172.6±6.86 cm and body mass 57.3±8.48 kg). The height (cm) and body mass (kg) of participants were measured at the start of the testing session, and the participants were asked to complete the Waterloo Footedness Questionnaire (Elias, Bryden, & Bulman-Fleming, 1998) to determine limb preference (footedness; also known as laterality). Participants wore their standard dance school uniform without ballet tights or leggings and shoes. Each participant was asked to complete rebound jumps (RJ) from a 50cm box. Instructions for the test included ‘‘drop off the box and immediately jump as high as you possibly can’’. This sequence was repeated three times with a rest interval of 30 seconds between each trial. Repeated single-leg hopping protocol (SLH) was followed according to a previously published protocol by Joseph, Bradshaw, Kemp, and Clark (2013). An audible digital metronome (Quartz QT-3, Quik Tune, California, USA) was set at 120 (2 Hz) beats per minute, with the participants landing on each beat for 15 consecutive hops. A trial was discarded and participants asked to repeat the trial if they lost their balance, if their hands came off their hips at any point during the trial, or if they failed to land back onto the force plates. The starting limb for the hops were block randomised between participants. Two triaxial force platforms (9286A, 600 mm x 400 mm x 35mm, 1000 Hz, Kistler, Switzerland) covered with sealed natural insertion rubber mats (45 mm thick, Clark Rubber, Australia) captured the first landing and rebound phase of the RJ and the ground contact phases of the SLHs.
The Waterloo Footedness Questionnaire scores were summed to determine each participant´s limb preference. A score of -20 to -7 indicated a left leg preference; a score of -6 to +6 indicated no preference for either leg, and a score of +7 to +20 indicated a preference for the right leg. The force/time curves for each leg were analysed using Bioware software (Kistler, Switzerland, version 5.03.0) to identify the peak vertical GRF during the hop landings and the first landing and rebound phase of the RJ. Peak power during the RJ was also determined in order to identify the dominant limb for each dancer (Zifchock & Davis, 2005). All GRFs were normalised to the participant´s body weight (BW) and power was normalised to the particpant´s body mass (W/kg). The Symmetry Index was then used to calculate each dancer‘s functional symmetry during the RJ and SLH tasks:

$$SI=[(XR –XL) / (0.5 x (XR + XL)] x 100$$

where XR and XL is the mean GRF for the right and left limb respectively (Sadeghi, Allard, Prince & Labelle, 2000). Functional symmetry refers to the percentage difference between lower limb forces during jumping and landing skills (less than 10% difference between limbs; Grace, 1985).
All statistical procedures were performed using SPSS for Windows (version 22.0). An alpha level of 0.05 was set for analyses. A repeated measures analysis of variance (RM ANOVA) with pairwise comparisons was used to identify the effect of limb preference or limb dominance on vertical GRF during both tasks. Finally a Pearson r correlation was used to analyse the relationship between limb preference and dominance.

RESULTS: The limb preference, limb dominance, GRF’s and SI’s results are summarised in Table 1. Of the 15 participants, eight dancers showed right leg preference (53%), six dancers had an equal preference for each limb (40%), and one dancer preferred the left leg (7%). Limb preference (footedness) was not related to limb dominance (greatest propulsive power output). Over half of the dancers (n=9, 60%) were identified as right limb dominant with the remaining 6 dancers (40%) being left leg dominant.

Statistical asymmetry was established in the overall ground reaction forces for SLH and RJ ($F(6,9) = 107.58$, $p<0.005$). On average between the two jumping tasks the preferred leg during the rebound jump experienced forces of 2.82 BW ± 0.64, significantly higher than the preferred limb during hopping (2.43 BW ± 0.33, $p<.05$).
The symmetry index (SI) was calculated for each task, with the averages for each individual displayed in Table 1. Seven out of the 15 dancers tested had functionally symmetrical results during the RJ. The SI indicated eight dancers had an average asymmetry in their RJ loading patterns of over 10%, with the highest asymmetry observed being 35%. During SLH, the SI indicated three of the dancers had an asymmetry over 10%.

Table 1
Peak vertical GRF (BW) and symmetry index (SI) data for the rebound jump (RJ) and single leg hop (SLH) tasks. Negative SI values indicate that the left leg produced the higher GRF value.

Dancer	Limb Preference	Dominant Limb	SLH Vertical GRF (BW)			RJ Vertical GRF (BW)		
			Left Leg	Right Leg	SI (%)	Left Leg	Right Leg	SI (%)
F1	Equal	Right	2.45	2.79	13	3.10	3.07	-0.80
F2	Equal	Left	2.71	2.61	-3.7	4.65	4.01	-14.80
F3	Right	Right	2.71	2.62	3.6	3.45	3.00	14.00
F4	Equal	Left	2.21	2.21	0.1	2.32	2.74	-16.80
M1	Right	Right	2.75	2.96	-7.23	3.43	3.35	2.40
M2	Right	Left	2.40	2.38	1	2.37	2.37	0.10
M3	Right	Right	3.15	2.72	14.5	2.42	2.64	-8.50
M4	Equal	Left	2.04	2.12	-3.5	2.62	2.66	-1.40
M5	Equal	Right	2.50	2.60	4	2.57	3.12	19.20
M6	Equal	Right	2.86	2.33	20.3	3.79	2.94	25.40
M7	Right	Left	2.50	2.67	-6.5	2.83	3.44	-19.20
M8	Equal	Right	2.36	2.56	-8	2.63	1.85	34.80
M9	Equal	Right	2.10	2.13	-1.6	2.47	1.83	29.70
M10	Right	Left	3.13	3.05	2.7	3.03	2.83	-6.90
M11	Left	Right	2.51	2.44	-2.8	3.05	3.26	6.90
Average	n/a	n/a	2.56	2.55	1.73	2.97	2.89	4.27
SD	n/a	n/a	0.33	0.28	8.36	0.64	0.57	17.06

Only one dancer (7%) had a SI that corresponded to their preferred and dominant limb. Seven of the 15 dancers (47%) had a significant SI that was opposite to their preferred limb. The remaining seven dancers had mixed preferred and dominant limbs due to their SI containing both positive (right side) and negative (left side) values for SLH and RJ.

DISCUSSION AND CONCLUSION: Considering the extreme accuracy and precision required to perform at an elite level, in combination with the long training hours and highly repetitive nature of each dance task, it is perhaps not surprising that a significant difference was identified between limb loading patterns for double legged (RJ) and single leg tasks (SLH).
Previous research has demonstrated in a ballet trained population of 10-12 years, 76% demonstrated a right leg jumping and landing bias (Golomer & Féry, 2001). This may be further influenced by 26% higher prevalence of right sided movement over the left during a single dance class (Farrar-Baker & Wiimerding, 2006). Due to the higher prevalence of right

sided movement in dance, the percentage of our dancers with a preference for the right limb (53%) compared to the left (7%) is consistent with previous findings. The increase (53% to 60%) of dancers with right side dominance is supported by Sadeghi et al. (2000). It was identified that once limb preference is developed, greater proficiency for task performance will occur in that limb and therefore dominance has been established. This leaves one side of the body weaker and imbalanced and unable to absorb high amounts of force required by dance movements.

Lower extremity movement patterns when controlling eccentric load during the various jumping and landing tasks, frequently used by dancers, leads to clear asymmetrical loading patterns. In order to minimize the effect of the asymmetrical loading patterns, dance teachers should try to develop some degree of bilateral movement during a dance class for the developing dancer. Preventive strategies should be employed by dance teachers by alternating task performance between limbs or even teaching new skills on the non-preferred limb. Further research that includes examining limb preference specific to dance tasks and comparing loading between limbs during a variety of dance leaps and jumps is needed. These studies should also include a larger sample size in order to more rigorously test the relationship between laterality and dominance.

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