MAXIMUM HEIGHT OF A DANCE JUMP IN DIFFERENT JAZZ SHOES

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Jumping is a key skill in dance and the effect of different dance shoes on jump performance is not known. Female pre-professional and professional dancers (n=14) were recruited to perform consecutive maximum vertical jumps in second position in four types of jazz shoes and barefoot, with and without music. An overall effect of the jazz shoes was found both with and without music (p<0.001), and music reduced jump height significantly (p<0.001), although no interaction was found between music and shoe condition. High-heeled shoes reduced maximum jump height, while the other jazz shoe styles were not significantly different to barefoot. The results of this study assist dancers, teachers and clinicians with shoe selection. Future research should examine the mechanisms of takeoff and landing in dance jumps in different shoes.

KEYWORDS: footwear, performance, motion analysis.

INTRODUCTION: In dance, a key skill to master is jumping with many variations and types. The most basic jump is a sauté, a vertical jump with two-footed take-off and landing. This jump is commonly performed consecutively with a rebound quality or as a preparatory jump prior to a larger jump.

The effect of dance shoes on performance has not been researched extensively (Fong Yan, Hiller, Vanwanseele, & Smith, 2011). Studies examining the effect of shoes on jump performance mainly focus on the landing phase with jump height a lower priority variable (Brizuela, Llana, Ferrandis, & Garcia-Belenguer, 1997; Liederbach, 2008).

For pre-professional and professional dancers the shoes worn in class, rehearsal and performance will vary. There is a wide range of jazz shoe styles available and shoe selection is dependent on factors such as cost, comfort, fashion, and more importantly, whether the shoe meets the performance needs of the dancer. For a jazz dancer, performances may be performed in high heel shoes, but in rehearsals, jazz sneakers or thin-soled leather jazz shoes are worn more often. Previous research has shown that the varying designs of jazz shoes reduced the degree of observed plantarflexion in the foot compared to barefoot (Fong Yan, Smith, Vanwanseele, Hiller, & Sinclair, In Press). It would be of interest to discover whether the constraint in observed foot motion translates to restrictions in dance performance.

The aim of this study was to investigate the effect of different jazz shoe designs on maximum height in a dance jump both with and without the constraints of music. We hypothesised that the barefoot condition would display greater jump height than the shoe conditions and that performing sautés in time with the music would limit jump height so there would not be any significant difference between shoe conditions.

METHODS: Fourteen female dancers (25 ±5.7 y, 57.2 ±6.8 kg, mean standing sacrum height: 92.8 ±4.3cm) volunteered for the study. All participants were required to have attained a minimum of Intermediate standard according to the Royal Academy of Dance Syllabus (RAD) or equivalent to ensure consistent and proficient technique execution. Dancers were excluded if they had a current injury which reduced their class or performance participation. All participants gave informed consent and the study was approved by the University of Sydney Human Research Ethics Committee.

The participants were instructed to perform eight sautés in second position. For the first condition, dancers performed sautés in time with RAD Grade 1 music. For the second condition no music was used and participants were instructed to jump as high as they could

whilst retaining the proper ballet technique and using whatever timing they felt was necessary to achieve maximum height. The consecutive jumps were performed in second position with maximal external rotation of the hips, feet slightly wider than shoulder-width, evenly distributed weight between the feet. Dancers were required to have maximally plantarflexed feet and extended knees during flight phase, toe strike upon landing with emphasis on "rolling through the feet" and a have quiet controlled landing phase, ensuring the heels make contact with the floor. During stance phase, a half squat, *demi-plié,* is performed while keeping the heels on the floor. Erect posture was maintained throughout the task. Participants were not allowed to use their arms to assist the jump and were instructed to keep their hands on their waist.
Dancers were given ample time to warm up and practice. The task was performed in each of the five shoe conditions (barefoot, high heel and three split sole designs) in a randomised order (Table 1, Figure 1).

Table 1: Description of shoe conditions.

Shoe Name	Description
Barefoot	Control condition
Chorus	High heeled court shoe with ankle strap
Elastabootie	Slim line leather jazz shoe with minimal outsole and separate forefoot and rearfoot sections (split sole design)
Evolution	Split sole design jazz sneaker with low profile moderate thickness outsole and additional divisions in the forefoot section
Boost	Split sole design jazz sneaker with thick outsole

3D motion analysis captured the height of the sacrum when standing in each shoe condition, feet hip-width apart, and during the jump tasks (Leard, Cirillo, Katsnelson, Kimiatek, Miller, Trebincevic, & Garbalosa, 2007). A dancer's jump height was normalised to the standing sacrum height for each shoe condition. To determine the effect of the shoes on jump height when using music, mean jump height for the rebounding jumps in each shoe condition were taken. For the maximum jumps without music, each dancer's highest jump out of the eight consecutive jumps was taken as their maximum. Repeated measures ANOVA's were performed with a Bonferroni adjustment to account for the number of tests.

Figure 1: Jazz Shoes (from left to right): Chorus, Elastabootie, Evolution and Boost.

RESULTS: Music significantly reduced the mean jump height by 4.6cm ($p<0.001$, effect size=0.684, power=0.998) and the jazz shoes significantly reduced mean jump height ($p<0.001$, effect size=0.963, power=1.00). However, no significant interaction was found between shoe condition and whether the sautés were performed to music or not ($p=0.598$, effect size=0.137, power=0.091).
Within-subjects contrasts showed that compared to barefoot, jump height was reduced in the Chorus shoes ($p<0.001$), the Elastabootie shoes ($p=0.028$) and the Boost sneakers (0.024). Pairwise comparisons revealed the Chorus shoes further reduced jump height compared to the Elastabootie shoes ($p<0.001$) and the Boost sneakers ($p<0.001$) (Figure 2).

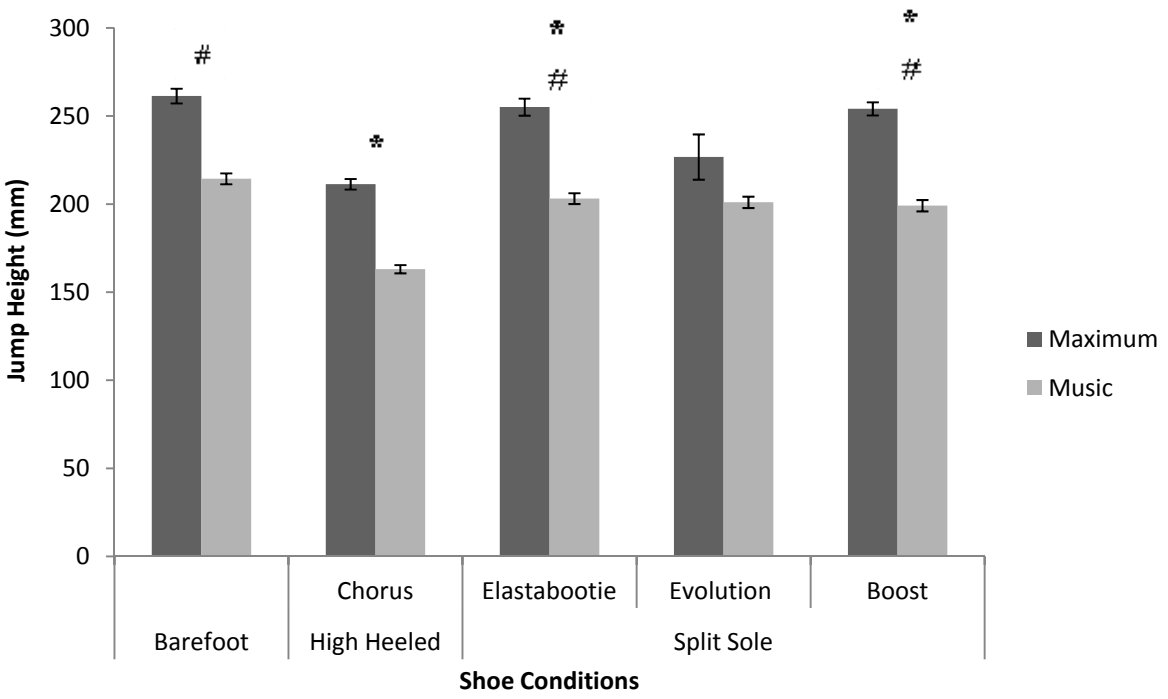

Figure 2: Jump height achieved with and without music in each shoe condition (mean ±SD); Statistical results of ANOVA combining music conditions where * denotes a significant difference to barefoot, *p*<0.05. # denotes a significant difference to Chorus shoe, p=0.009.

DISCUSSION: Our hypothesis that a reduction of observed range of plantarflexion and performing sautés to music may translate to a reduced jump height was found to be true.

The reduction in mean jump height when performing sautés to music indicates the effect of faster tempo music compared to the dancers preferred tempo on the ability for the dancers to generate jump height. Future analysis into differences in impulse between the music conditions will give further information as to the mechanism of the reduction in jump height. In practical terms, dance is performed mostly with music and further investigation of the sautés using only the with-music data found the barefoot condition did not produce a significantly greater jump height compared to any of the split sole design jazz shoes. These results mean that choreographers and teachers should be aware that creating a routine without music may result in higher jumps, and that subsequent performance with music will alter the timing and height of the jumps. Dancers can be assured that their jump height will not be affected when performing with music in bare feet or in split sole design jazz shoes.

Irrespective of music condition the high heeled Chorus shoes produced significantly lower jump height than the other shoe conditions. Dancers must strive for controlled and quiet landings for their jumps. To accomplish a quiet landing when wearing high heels and still make heel contact, dancers may subconsciously reduce their jump height and spend more time in the eccentric phase of landing.

In high heeled shoes the ankle is already plantarflexed when the heel first makes ground contact, reducing the muscle length of the extrinsic plantarflexors. The effectiveness of the stretch-shorten cycle may be reduced, hence the amount of power that can be generated at the ankle joint will be reduced (Komi, 2000), and jump height limited. The plantarflexed ankle position during stance phase reduces the range of motion available in the half squats between jumps. A previous study has found that a reduction in ankle range of motion leads to reduced jump height (Brizuela, et al., 1997).

Stiff shoes can reduce foot motion when walking (Wegener, Hunt, Vanwanseele, Burns, & Smith, 2011; Wolf, Simon, Patikas, Schuster, Armbrust, & Döderlein, 2008). Since the intrinsic muscles of the foot are important for propulsion in running, walking and jumping, particularly when the ankle is plantarflexed (Palastanga, Field, & Soames, 2006), any reduction in foot motion will lead to a reduction in energy generated by the intrinsic muscles (Smith & McConnell, 2007). A significantly greater shoe bending stiffness at the

metatarsophalangeal (MTP) region has previously been reported in the Boost compared to the Elastabootie and the shoe stiffness reduced observed active plantarflexion at the MTP joint (Fong Yan, et al., In Press). This could lead to a reduction in plantarflexion at the metatarsophalangeal joint due to shoe design could translate to a reduction in jump height. However, only small differences in jump height were found between the Elastabootie, Evolution and Boost in the with-music condition, which has great practical significance. Perhaps the contribution of the intrinsic plantarflexors to jump height is only small in dance, and a shift in muscle recruitment from the intrinsic to the extrinsic plantarflexors may occur in order to achieve greater jump height. Future analysis of the kinematics and kinetics of the take-off and landings will help to characterise the effect of the different jazz shoe designs on jump performance and reveal the mechanisms at work.

CONCLUSION: Researchers have found that the Chorus shoes significantly reduced the height of a sauté compared to barefoot and other styles of jazz shoe both with and without the constraints of music. Despite varying thickness in the outsole of the other jazz shoes, no significant difference in jump height was found. Dancers can be confident that jump height will not be affected when switching between barefoot and jazz shoes of varying designs, except for the high-heeled Chorus shoe, which is advantageous for dancers with injuries who may have to change shoe types. Choreographers and teachers must be aware of the changes in jump height and landing mechanisms in high-heeled shoes, particularly with faster tempo music. An area of interest for future investigation is the kinematic and kinetic analysis of the take-off and landing phases of the sauté.

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