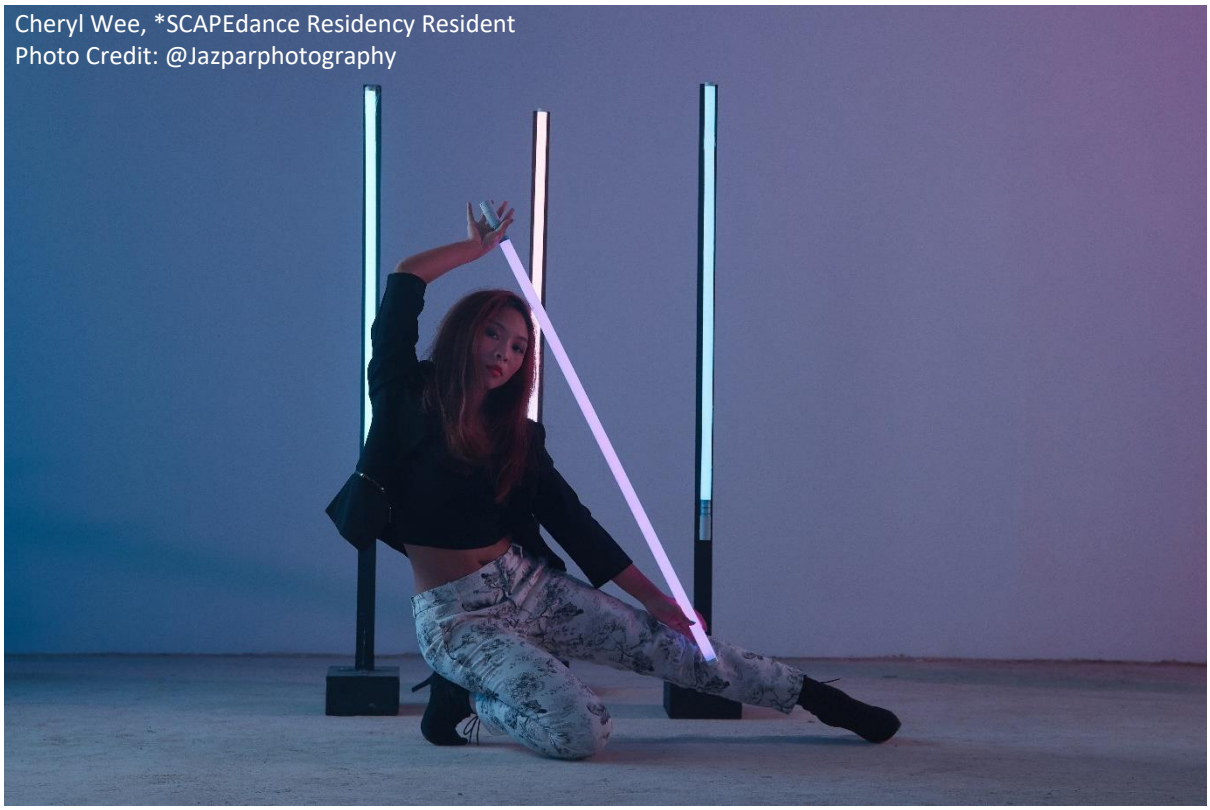
Cheryl Wee, *SCAPEdance Residency Resident
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How Does an Elevated Heel Impact Me?

Trina Wong, August 2021

Rising on to one's forefoot or toes is a common movement observed in various forms of dance. It can take the form of a technical movement as in the demi-pointe position in classical ballet or bouncing on the forefoot from one leg to another in local ethnic dances. It is also observed when using footwear with different heel-forefoot drop as in popular social dances or street dance.

While this is executed to elevate and characterise the dance performance, elevating the heel results in different kinematics and kinetics from a plantigrade foot (when the plantar aspect including the heel contacts with the ground during movement) and these will be explored further in this article.

Biomechanics of Demi-Pointe

Movement such as dorsiflexion (flexed feet) and plantarflexion (pointed feet) in the 1st Metatarsophalangeal Joint (MTPJ) (big toe joint) is required for pushing the body forward in various forms of ambulation (also known as toe-off). However, a significantly greater dorsiflexion range of 30.7- 54.3 degrees was observed when executing various forms of demi-pointe as compared to 20-40 degrees reportedly required for other forms of ambulation such as walking, running and vertical jumping[6]. This same study also observed significantly different forces being applied to the 1st MTPJ depending on concurrent positions when performing demi-pointe.

Cheryl Wee, *SCAPEdance Residency Resident
Photo Credit: Shaun Ho

Rising up and down while remaining in the same position (*relevé*) had a peak net moment of 0.13Nm/kg, landing on the forefoot in small jumps (*sauté*) had a peak net moment of 0.22Nm/kg while landing on the forefoot in higher, longer jumps (*saut de chat*) generated peak net moments of 0.48Nm/kg. While these forces are not atypical for the movement performed (e.g. comparing the force of landing from a *saut de chat* from that of a horizontal jump), one might consider the frequency and repetition of such movements on the 1st MTPJ from an injury- prevention perspective when perfecting the technique.

Are there any compensatory loading of the smaller 2nd-4th MTPJs in the foot if the 1st MTPJ does not have the range required for executing the movement?

While such compensatory 'rolling out' or 'rolling too far' in the smaller foot joints may be too minute to be accurately determined by the naked eye, wear patterns on the training footwear (e.g. non-uniform bottoming out of inlay material) or dermatological changes of the foot (e.g. callus growth or consistent blisters at a specific location) may provide clues of compensatory kinematics and unexpected kinetics prior to training-related injury.

To understand that force generated for the demi-pointe do not just occur within the foot, an earlier small study found asymmetrical peak joint moments and trajectory patterns of the ankle between the dominant and non-dominant side while performing a seemingly symmetrical *relevé* movement[5].

Will this asymmetry in motor movement patterns when performing a repetitive task predispose to injury?

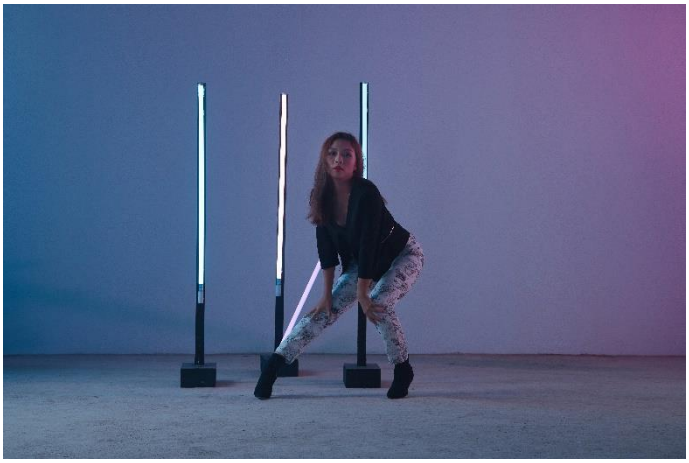
A 2011 literature review[8] found that elite dancers do demonstrate superior motor strategies compared to novices where dance teachers may benefit from an appreciation for optimal and accurate biomechanical function during teaching. This emphasises the need for training safely and holistically. This is especially so for adolescent dancers where a systematic review identified intrinsic risk factors relating to reduced neuromuscular control and stability which enables dancers to perform safely (see table below).

Intrinsic Risk Factors during Adolescents[14]
1. Decrease in knee joint stability during landing from a jump
2. Decreased neuromuscular control of the knee
3. Inability to improve neuromuscular control due to pubertal changes
4. Decrease in dynamic stability of the knee
5. Increase dynamic peak knee adduction moment
6. Increase in joint laxity and hormonal changes associated with maturation in females

Being aware of these risk factors may encourage the use of realistic milestones in the development of some of these aspects as well as variations in training to include proprioceptive training not typically confined to the dance arena, thereby encouraging safe development.

Footwear and Heel Lifts

Amongst local dancers, the injury incidence of 53-59.9%[4,16] is slightly lower than that of international elite pre-professional/ professional levels[1]. However, over-use foot and ankle injuries remain one of the most common injury types[4,5,13]. This is unsurprising in dance as the foot and ankle play a dual function of responding to the kinetics of ground reaction forces while executing precise artistic movements not normally used in the integration of these forces as in day-to-day ambulation.



Cheryl Wee, *SCAPEdance Residency Resident
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Footwear can have a force dissipation function as well as a stabilising effect on the midfoot for effective force translation[3,10]. However, these may be at odds with its other functions of aesthetic fluidity and flexibility when executing the dance. As such, dance footwear (if used) attempt to balance these dual functions with footwear catered for different dance types[7].

In exploring the biomechanics relating to heel lifts, a systematic review[12] found that when walking/ running, heel lifts of 15mm decreased maximum ankle dorsiflexion angle and heel lifts of 12 and 18mm decreased gastrocnemius (calf) muscle tendon unit length. Hence, in exploring its impact, one would consider if such a range is needed for the footwork performed[11]. Interestingly, heel lifts of less than 10mm are incorporated in the short-term treatment of lower limb injuries such as insertional Achilles tendinopathy with the aim of adjusting kinematics of the region to simulate healing.

Conversely, increased heel height is also associated with increased instability about the ankle with an increased risk of acute ankle sprains[2]. The balance in optimizing a shoe function when performing a repetitive technical movement is not just limited to dance. A recent study[15] found that a more flexible or minimalist shoe improved running economy but also induced greater loading of the ankle, 1st MTPJ and Achilles tendon compared to conventional shoes. Thicker midsoles where found to attenuate ground reaction forces during impact but also decreased plantar sensations.

As such, a good understanding of the biomechanics required of the dance (especially movements that are repeated) and a good understanding of one's natural biomechanics (range of motion, strength, previous injuries and other medical conditions) will be helpful in choosing the right type of footwear and emphasis of training to develop and perform optimally.

End

Ms Trina Wong, Senior Podiatrist, Tan Tock Seng Hospital

Graduating with a BSc(Hons) Podiatry, Trina went on to complete her MSc in Sports Medicine & Exercise Health and research thesis on lower limb biomechanics at University College London. She is currently practicing at the Podiatry Services of Tan Tock Seng Hospital.

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