Yang Weicheng, Dancer / Dance Instructor.
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Balance – Where does it come from and how does it help us?

Charmaine Tay, October 2020

Pirouettes, handstands, head spins- they are all types of balance we do in dance. Balance ability is an example of sophisticated learned motor skill that is developed through training[8]. It provides the foundation for mobility and functional independence[17]. Dance practice can autonomously provide effective balance training. However, do we know how we can improve our balance as dancers? Let's look into the biomechanics of what makes balance.

The biomechanics of balance

Balance is the process of maintaining body's centre of gravity (COG) within base support[9]. The body's COG rests slightly above the pelvis. When the COG is displaced beyond vertical projection of the base of support, the body will begin to fall [14]. In dance, our base of support constantly changes from one, to two feet, from one arm to another, or even your head. So, how do we remain stable as we move within and beyond our base of support when dancing?

Balance is both a static and dynamic process comprising of several components:

1. Sensory detection of body motions

Vision: The oculomotor system (What you see and how the eye moves) measures orientation of eyes and head in relation to surrounding objects. The eye muscles stabilizes the gaze by countering movement of the head so objects stays stationary[11]. This gives us information about the orientation of surrounding objects in relation to our head movements.

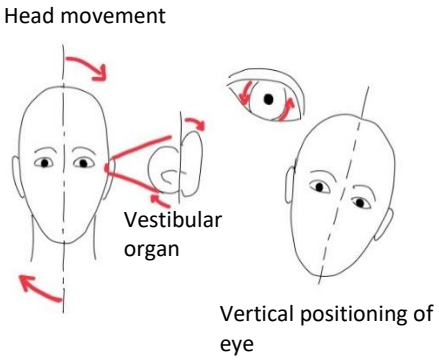


Figure 1. Effects on oculomotor control

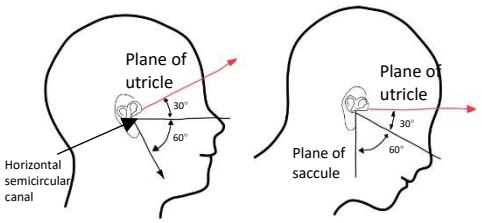


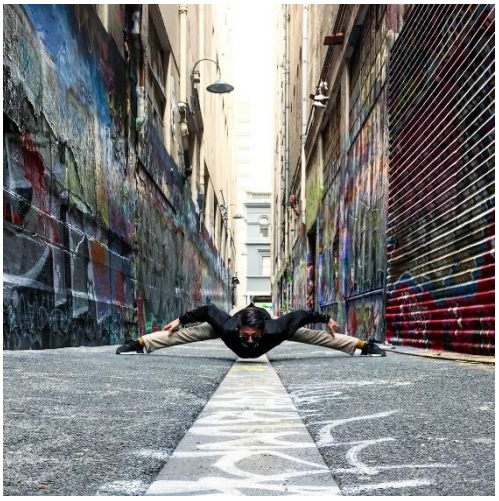
Figure 2. Understanding the function vestibular

Vestibular: Your inner ear mechanism provides information to your brain dealing with gravitational linear and angular accelerations of the head with respect to inertial space[6]. When you move your head, the two sensory organs in your inner ear, saccule and utricle, sense the change and produce basic automatic reflex responses. The reflex responses are projected to the spinal cord that sends a signal to your muscles to adjust the position and tone of the muscles in your limbs to keep the COG within base[2]. This means that if you tilt your head sideways, your body will produce a reflex to step to the same side your head is tilted, in order to widen the base beneath the COG, and keep you balanced! (It is probably why you end up in a wide stance when falling out of a pirouette)

2. Musculoskeletal coordination

Mechanoreceptors in your body provides information concerning relative position of body parts to support surfaces, integrating sensorimotor information with the central nervous system. Your muscles, tendons, ligaments, joints and skin have specialised mechanoreceptors that fire with mechanical stimuli (movement), detecting intra and extra personal sensations of static positions and movement[13]. Peripheral input from these sensory nerve endings enter the spinal cord and carries them towards the subcortical and cortical parts of the brain that is responsible for conscious recognition of joint position sense (proprioception) and movement sequences (kinaesthesia). Once the cortex of the brain has acknowledged the mechanical stimuli, it sends appropriate efferent signals via motor neurons to maintain equilibrium. Read the previous article here on muscle memory for a breakdown of this section.

3. Muscular strength



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In order to sustain vertical projection of the COG over the base of support, dancers need to have enough muscular strength to maintain stability in their joints when performing a balance[5]. In other words, the different segments of the body have to be strengthened by means of isometric contraction of active muscle groups to hold the joints in place. Since the body's COG lies slightly above the pelvis, strength in the core muscles can help increase balance and stability in movements[16].

Balance comprises of an integration of several bodily sense such as cutaneous (skin) feedback, proprioception, visual and vestibular input. The brain's processes for balance are always at work, attuning to your body's need for stability through changes in environments or task demands[8]. Dance training expands our body's capabilities to map out these responses, refining sensory capabilities that help calibrate and control forces both within the body and in space for an increased mastery of balance and coordination over time.

Balance in Dance

When doing partnering work or movements requiring extensions of the limbs away from the midline of the dancer, an opposing force has to be created in the opposite direction with an equal amount of magnitude in order to maintain equilibrium (Newton's third law)[7]. Performing a balance, such as a relevé in ballet, which is a basis for pirouettes, dancers need to be able to keep the axis vertical while turning, adjusting the distribution of forces generated by movements to keep in line of gravity within the base[10]. This also requires sufficient muscular strength to sustain an isometric contraction of the muscles surrounding the spine (including neck), hips, knees and ankle, while the turn is being executed. Once any of those segments shift out of vertical projection over the base of support (the feet) the dancer will start to fall.

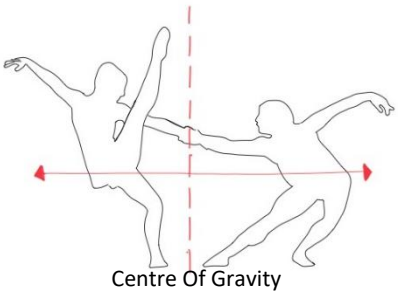


Figure 3. example of opposing forces in dance

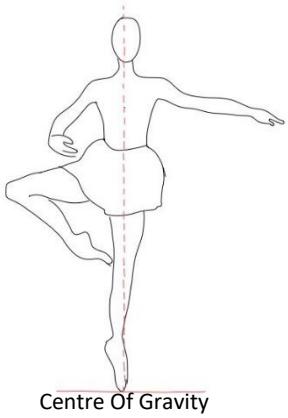


Figure 4. example of balance in dancers

When performing a handstand, whether in contemporary or break dancing, the configuration in a handstand position is therefore similar to the one in an upright position with the wrist functions being similar to the ankle functions. Elbows are similar to knees and shoulders are analogous to hips[3]. However, since the area of support is smaller, the distance between the base and the centre of gravity is greater due to a support of extended arms, this increases the level of instability[15]. This will require an extraordinary amount of strength in the upper extremities to carry the dancers' weight while stabilising the shoulder girdle, which would substitute for the anti-gravitational task of lower extremities. Although the muscle activity of upper extremities is more precise, they do succumb to fatigue faster than our lower extremities.

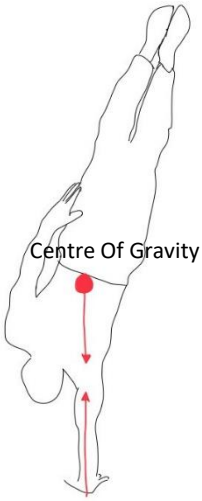
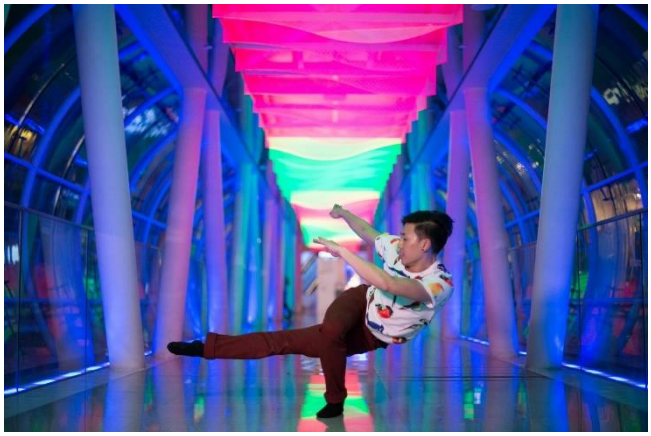


Figure 5. example of balance in dancers

Research in balance amongst dancers

Research have shown that dancers are significantly less dependent on vision and more reliant on their sense of proprioception than non-dancers[1]. Professional dance training appears to have shifted sensorimotor dominance in dancers from visual and oculomotory mechanisms, to proprioceptive strategies[1] .Conversely, dancers who are more visually dependent have been found to be less stable[1]. In fact, dancers should learn to disregard the visual input they receive to prevent dizziness, especially during turns. One study in 2015[12] showed that dancers' brains have adapted to spinning and have been found to suppress the feeling of dizziness through "spotting' technique during pirouettes, minimizing head movement when performing turns. The more experienced the dancer, the more desensitized their brains are to vertigo. Scientists are now studying dancers' brain to find a cure for patients suffering from chronic dizziness!



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End.

Currently a dance science and anatomy lecturer at the dance department, as well as a body conditioning, advance ballet and jazz at the musical theatre department of LASALLE College of The Arts. Charmaine also coaches competition group and elite programme at City Ballet Academy for local and international dance competitions. Charmaine is currently serving on the Dance Educator Committee of the International Association of Dance Medicine and Science

References

1. Golomer, E., & Dupui, P. (2000). Spectral analysis of adult dancers' sways: sex and interaction vision-proprioception. *International Journal of Neuroscience*, *105*(1-4), 15-26.

2. Guskiewicz, K. M., & Perrin, D. H. (1996). Research and clinical applications of assessing balance. *Journal of Sport Rehabilitation*, *5*(1), 45-63.

3. Hedbávný, P., Sklenaříková, J., Hupka, D., & Kalichová, M. (2013). Balancing in Handstand on the floor. *Science of Gymnastics Journal*, *5*(3).

4. Kahle, N. L., & Gribble, P. A. (2009). Core stability training in dynamic balance testing among young, healthy adults. *Athletic Training and Sports Health Care*, *1*(2), 65-73.

5. Koutedakis, Y., Stavropoulos-Kalinoglou, A., & Metsios, G. (2005). The significance of muscular strength in dance. *Journal of dance medicine & science*, *9*(1), 29-34.

6. Laurens, J., Straumann, D., & Hess, B. J. (2010). Processing of angular motion and gravity information through an internal model. *Journal of neurophysiology*, *104*(3), 1370-1381.

7. Laws, K. (2002). *Physics and the art of dance: Understanding movement*. Oxford University Press.

8. Learning, D. M. Motor Learning and Teaching Dance. IADMS 2009.

9. Lephart, S. M. (2000). Proprioception and neuromuscular control in joint stability. *Human kinetics*, 405-413.

10. Lott, M. B., & Laws, K. L. (2012). The physics of toppling and regaining balance during a pirouette. *Journal of Dance Medicine & Science*, *16*(4), 167-174.

11. Martinez-Conde, S., Macknik, S. L., & Hubel, D. H. (2004). The role of fixational eye movements in visual perception. *Nature reviews neuroscience*, *5*(3), 229-240.

12. Nigmatullina, Y., Hellyer, P. J., Nachev, P., Sharp, D. J., & Seemungal, B. M. (2015). The neuroanatomical correlates of training-related perceptuo-reflex uncoupling in dancers. *Cerebral Cortex*, *25*(2), 554-562.

13. Proske, U. (2006). Kinesthesia: the role of muscle receptors. *Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine*, *34*(5), 545-558.

References

14. Roberts, T. D. M. (1995). *Understanding balance: the mechanics of posture and locomotion*. Nelson Thornes.

15. Slobounov, S. M., & Newell, K. M. (1996). Postural dynamics in upright and inverted stances. *Journal of Applied Biomechanics*, *12*(2), 185-196.

16. Watson, T., Graning, J., McPherson, S., Carter, E., Edwards, J., Melcher, I., & Burgess, T. (2017). Dance, balance and core muscle performance measures are improved following a 9-week core stabilization training program among competitive collegiate dancers. *International journal of sports physical therapy*, *12*(1), 25.

17. Yim-Chiplis, P. K., & Talbot, L. A. (2000). Defining and measuring balance in adults. *Biological research for nursing*, *1*(4), 321-331.