Proprioception

by the International Association for Dance Medicine and Science
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Proprioception – What Is It?

Dancers know where to place their arms in fifth position, even with their eyes closed. They also know just how to move smoothly and accurately in ensemble – standing, sliding, and turning – without bumping into other dancers. This inborn 'talent' for body awareness and knowing just where the body is in space is called "proprioception," from the Latin meaning "one's own." Dancers might be more accustomed to related terms to define this sense, such as "kinaesthesia," muscle sense, or simply sense of movement. Although slight nuances exist between the meanings of these terms, "proprioception" is the scientific term for the physical feeling of your moving body. If dancers didn't have proprioception, they would have to be constantly alert, consciously watching to see if they could execute even the simplest movement successfully. Proprioception not only helps with daily navigation, but also is integral to becoming a beautifully expressive dancer.

How Does Proprioception Work?

Proprioception metaphorically is called the "sixth sense," extending the classical five senses to include the body. This body sense is more than just a feeling of movement, however. It is intimately tied to our feeling of muscle tone, perceptions of effort and of balance. Specialized nerve endings originate in our muscles, fascia, tendons, ligaments, joints, and some scientists even include the skin. These "afferent" (sensory) receptors perceive deformation of tissue – the amount of pressure (stretch or simply, placement), speed at which movement is occurring and the rate at which the speed is changing (velocity), direction of movement, and – when deformation is extreme – pain. Massive proprioceptive input from sensory nerves embedded in muscles and joints enters the spinal cord (dorsal horn) and is carried towards subcortical and cortical parts of the brain. Many neural pathways synapse at various levels of the nervous system, integrating all this information to provide us with both a conscious and non-conscious sense of where we are and how we are moving. We know (are aware) we are moving and can turn our attention to the fine details of sensory awareness at any given time, as we do when we pay attention to movement refinement in dance. Thankfully, though, we also have a non-conscious sense of embodiment, essential for timely, appropriate neuromuscular coordination. Just as your foot "knows" the location of the step beneath it as you descend the stairs in the dark, your quadriceps and hamstrings know just when and how to contract to stabilize around the knee as you piqué onto one leg. Without this inner sense of timing and accuracy, the rate of injury would be a lot higher, and, of course, simple movements would take up an enormous amount of cognitive energy.

What Is Its Value for Dancers?

The innumerable sensations of movement dancers feel from dancing helps cultivate "kinesthetic resonance." Feeling, and becoming aware of the sensations of movement, helps with learning to dance, even when dancers are just watching someone else dance. Dancers learn not only by feeling their own movements, but by watching others move. The dance teacher's demonstrations in the classroom are not just accessed through vision alone, but felt and internalized. These sensations help motor learning. Practicing and refining the proprioceptive sense means greater speed, accuracy, and quality of movement as well as expressiveness. We learn to hone this sense not only by repeating movements but also by imbuing these movements with certain qualities and exploring various "efforts" (in the Laban sense).

How Do Dancers Know If Their Proprioceptive Sense Needs Additional Training?

Proprioception rarely is assessed in dance screenings, and often omitted in an overview of factors underlying dancers' fitness. Nor are accurate records kept regarding relationship between injury and proprioceptive impairments. Screening for intact proprioception should include at least one of the following tests for static joint position sense and joint movement: (1) Having the dancer sit with eyes closed while the tester passively positions one limb in space, and asks him or her to mimic the position with the opposite limb; and (2) Grasping the last phalange of the big toe or thumb of a seated dancer (eyes closed), moving it passively to a position in space (either up or down), and having him or her respond to which direction the digit is moving. Although relatively easy to execute, these tests are difficult to interpret if there are subtle impairments. A proprioceptive deficit – however minimal – compromises finely tuned motor control, increasing risk of injury. Such tests help determine gross neurological deficits but may not screen adequately for more subtle deficits in proprioception that may emerge under more active conditions of motor execution in dancers with and without injury.

Beyond these basic tests, dancers ideally should have a full balance screen by a sports or dance physical therapist. At a minimum, dancers should be able to stand on one leg with their eyes closed for at least 30 seconds. Additional challenges to this simple test should include timed standing with eyes closed on different surfaces (foam pad, rug, balance beam, or rocker board), with different base of

support – parallel feet, first position, demi-pointe, and finally pointe. The five-star balance test used in sports also is useful for testing standing balance by having the dancer stand on one leg and target eight points in space with the free leg. Static standing tests should progress to walking heel-to-toe (tandem) with eyes closed for a distance of 10 to 20 feet (3 to 6 meters), or walking at various speeds while multi-tasking (counting backwards from 100 by three's or carrying a full glass of water). Of the more reliable and valid methods of testing sensory deficits the "clinical test of sensory organization and balance," or "Foam and Dome," requires little equipment and is easy to administer. This balance inventory tests the individual in six different conditions that discriminate potential somatosensory (collectively muscle, joint, and skin) deficits from visual and vestibular. Platform posturography (such as the Balance Master® or the NeuroCom® balance system) uses a moving force platform and visual surround to quantify balance deficits. Although much more expensive, it is an accurate, method of distinguishing limits of stability and sensory organization. Since none of these tests have been validated for dancers, dance-specific batteries need to be developed and validated which also test dancers in traditional foot positions.

If the Dancer Becomes Injured

Knowing where the body is located in space is integral to the sense of balance and underscores the sense of safety and security in the world. An injury such as an ankle sprain – no matter how mild – affects the whole body, jeopardizing stability and balance. Researchers suggest that if a proprioceptive deficit goes undetected, it can lead to adaptations in alignment, localized weakness, and altered central motor programming. The psychosocial impact of proprioceptive deficits is important, too. If proprioception is insufficiently restored post-injury, even when rehabilitation outcomes successfully are met, the dancer may lack confidence to move fully and safely. Not only peripheral nerves may be damaged with injury, but the strain also lies in the brain. With lack of appropriate input coming from the peripheral to the brain, the central "map" of the kinesthetic "self" is altered with injury. This compromised map of the "self" can predispose the dancer to re-injury.

Guidelines for rehabilitation can be gleaned from the cumulative evidence in sports and dance medicine. Retraining proprioception post-injury must address all three levels of central nervous system mediation: (1) reflex spinal level, (2) brain stem level, and (3) cortical level. Reflex spinal level rehabilitation would include (1) addressing the tissue level of proprioceptive restoration through physical modalities (ice, ultrasound), manual therapy, and other "receptive" body therapies and passive maneuvers, (2) augmenting joint position sense and muscular co-activation for joint stabilization (*e.g.*, static uni-legged standing for ankle injuries), and (3) increasing the number and speed of mechanoreceptor recruitment and increasing the speed and duration of reflex stabilization of the affected joint by employing sudden alterations in joint direction and speed of movement. Brain stem level activities include the vestibular and visual (as well as somatosensory) input that helps maintain posture and balance. A more comprehensive approach to balance testing and training, then, would be an improvement over more static ways of improving proprioception, such as single leg stance on a stable surface. Exercises here could include wobble boards, Pilates reformer training, plyometric training, and mini-trampoline exercises with additional challenges of body positioning, range of motion, and cognitive- and manual interference (*e.g.*, talking while catching a ball on a wobble board).

Proprioceptive training instituted early in rehabilitation is beneficial to bring the dancer back to full level of technique and performance and prevent re-injury. Known benefits of proprioceptive training include improved postural stability, joint position sense, movement- and reaction time, strength, and flexibility. Dance medicine programs and clinics are reputed to offer proprioceptive training, but reports in the literature on the effects of targeted proprioceptive exercises on dance technique are few and evidence-based guidelines for proprioceptive training protocols need to be validated. Inferences can be made, however, from clinical research in both sports and dance medicine for proprioceptive training for the injured and non-injured dancer.

Isn't Dancing Enough to Train Proprioception?

One could infer that proprioceptive "acuity" is integral to how dancers attend, learn, and self-correct, potentially providing dancers with an advantage in motor planning, motor control, and postural stability. Since the body is the vehicle of expression, it would seem likely that dancers would have an augmented inner body sense compared to non-dancers. Howard Gardner's schema of multiple intelligences suggests that dancers emphasize "bodily-kinesthetic" intelligence, using the whole body (or its parts) to solve problems. Presumably, professional dance training strengthens the accuracy of proprioceptive input and shifts the tendency to depend on vision for motor control to a more internally-based system of reference (proprioception). Researchers have shown that dancers demonstrate increased accuracy of position-matching when compared with gymnasts and untrained controls. Research on dancers' proprioception and balance outcomes is controversial, however. A summary of research findings showed: (1) Ballet training alone without concurrent additional coordination training did not lead to improvements in ankle joint position sense or post-rehabilitation measures of balance; (2) Trained dancers exhibit perceptual and balance errors in quantitative testing; (3) Dancers performed less well on balance outcome measures compared to judo practitioners; and (4) Professional dancers' performance deteriorated on balance tests (posturography) as the base of support was narrowed (from flat foot to demi-pointe and pointe) during eyes-closed conditions (*i.e.*, demanding increased proprioceptive strategies for balance). In summary, it appears that dancers need to continue to train all senses (visual, vestibular, and somato-sensory) to adapt to changing conditions of technique and environment and to rehabilitate from injury.

Training Proprioceptive "Acuity"

Whether you are injured or not, there are a number of things you can do to improve your proprioceptive sense to become a better dancer.

- Establish a proprioceptive baseline by getting tested by a dance or sports physical therapist, especially if there is a history of injury.
- Train actively and dynamically. Dancers should remember that practicing stretches that exploit reflex levels of receptor sensitivity is insufficient for full motor control. Exploiting reflexes to gain flexibility (PNF contract-relax stretching) or stimulating reflex contraction or relaxation through self-employed manual therapeutic procedures (*e.g.*, pressing on a tendon to relax a muscle), do not have lasting value in motor (re)programming. Receptors perform differently under active (as opposed to passive) conditions that are goal-directed. Flexibility exercises should be incorporated into dance-specific training with real space-time values, where motor programming is achieved through repetition of goal-directed movements in which dancers exploit multiple degrees of freedom to stimulate different neuromuscular pathways. In other words, practice a variety of moving positions, taking all muscles from full shortening to full lengthening, and returning to the neutral resting length of the muscles and joints during an embedded rest period (constructive rest).
- Teachers, watch your cues and instructions!
  - Avoid imagery that upsets the balanced neuro-muscular coordination of the movement. For example, "Let your feet press the floor away while sitz bones rise," results in better neuromuscular efficiency in rising from a plié, than "squeeze the inside leg muscles," which tends to isolate out one set of muscles (the adductors) from the rest of the thigh musculature.
  - Offer cues like "good" (positive reinforcement) or corrective instructions at the end of a number of repetitions of movement ("summary feedback"). Less effective feedback occurs when dance teachers continually applaud ("good, good!") or correct dancers at the end of each set of repetitions. Instead, dance teachers should allow enough time between movement repetitions or sets (*i.e.*, adequate pausing or resting phases) for the dancer to sense movement feedback and render it meaningful.
  - Promote autonomy by letting dancers decide for themselves how to organize the specifics of movement. Examples include: (1) Keeping your cues simple and spatially-connected, leaving room for sensory exploration on the part of the dancer ("Sweep a large open space with your arm as you raise it to the side"); (2) Avoiding constantly counting out loud, which appears to interfere with the dancer's developing an internal sense of timing; and (3) Avoiding using the mirror as the only or main source of learning in the classroom. Letting dancers learn to "feel" rather than just see what they are doing will help hone kinesthetic awareness and ability to work alone and in ensemble in performance when the mirror is no longer available.
- Encourage an external focus. The question as to whether instructions should focus on an internal focus (the body) or external focus (outside of the body) is an intriguing and unresolved one. Researchers have shown that using an external focus renders a more effective performance than an internal one (particularly focusing on details of body sensations). An internal focus can interfere with automatic motor control processes. This would suggest that if dancers were to trace a figure-eight pattern with their arm in space, better coordination might result if dancers imagine holding a light pen while tracing the "8," rather than attending to the muscular sensations inside their arm.
- Practice somatic education methods. Somatic education methods are designed to refine sensibility and alter habitual postures and movement through sensory awareness. Many ancient (yoga, tai chi) and contemporary somatic practices already popular with dancers have principles that complementary with those of motor learning. Ideokinesis (mental practice of kinesthetic or visuomotor imagery), Alexander Technique, Feldenkrais Awareness Through Movement, and Body-Mind Centering involve conscious attention to refining visual and proprioceptive feedback to induce change. Studies have shown increased use of muscular efficiency from somatic education methods and higher retention of rehabilitation benefits when somatic practices were combined with manual therapies.

In summary, how a movement is organized, how it is recalled from motor memory, how it goes wrong, and what is done to correct it, are all questions that remain unanswered in terms of the role of proprioception. Both dance educators and scientists have a lot more investigating to do!

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