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Understanding Core Stability: A New Approach to Ballet Training

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Abstract. With the rise of dance science in ballet, professionals have increasingly focused on exploring advanced training methods. Core stability, an essential component of ballet training, has sparked widespread discussions in the industry. This study is a literature review of the fields of dance, sports science, and anatomy, summarising and analysing research trends in core training, to offer new perspectives on traditional ballet core stability training. Traditional core training methods focus primarily on enhancing abdominal muscle strength. However, this study highlights the limitations and potential risks associated with muscle-centric training. To further investigate the optimal way to achieve core stability, this study integrates anatomical and kinematic theories, proposing that, under the premise of diaphragmatic breathing to establish intra-abdominal pressure, the use of a holistic movement pattern can effectively improve core stability. This study offers theoretical and innovative insights into ballet core training.

Keywords: ballet, core, ballet training, core stability, intra-abdominal pressure

1. Introduction

The term ‘core stability’ is frequently used in the field of dance, and ballet training highly emphasises core stability. Ballet core training has achieved certain results by drawing on traditional sports training methods. However, research on core stability remains relatively limited, particularly in terms of correct core training tailored to the specific needs of ballet. Therefore, it is necessary to analyse and integrate related studies to provide a reference for peer teaching and research.

2. Core Stability

Regarding the concept of core stability, some scholars have attempted to provide conceptual definitions or list the relevant muscles of the abdomen, emphasising the tightening of certain muscles to provide stability and protection to the spine rather than defining it as an overall function [9]. The concepts of core stability and strength first appeared in the field of medical rehabilitation and were later introduced to sports. The widely accepted core concept refers to the central body region consisting of the waist, pelvis, and hips [4]. This central region is a cylindrical muscle functional unit composed of the abdominal muscles in the front, paraspinal muscles in the back, diaphragm at the top, and pelvic floor muscles at the bottom [13]. Core stability is defined as the ability to control the position and movement of the trunk relative to the pelvis and limbs to achieve optimal force, movement generation, transmission, and control [13]. Hodges and Richardson [6], in their study on the sequence of muscle activation during full-body movements, found that some core stabilising muscles (i.e., transversus abdominis, multifidus, rectus abdominis, and obliques) were activated prior to any limb movement. These findings support the theory that motor control and stability develop through core-limb (proximal-distal) and head-tail (head-toe) sequences. Therefore, core stability plays a significant role in providing local strength and balance, and is a key component of all kinetic chains in daily activities and sports.

3. Core Stability Required in Ballet

Research suggests that core stability refers to the ability to maintain the stability of the pelvis and trunk during movement, thereby coordinating the force generated by the upper and lower limbs and providing support points for movement. A good and stable support point forms the foundation for all movements and serves as the starting point for power output [14]. Ballet, a blend of physical movements and artistic expression, is a comprehensive manifestation of aesthetics and muscular ability. Weak core stability can lead to compensatory biomechanical changes in the trunk, which indirectly affect the lower limbs, resulting in power

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deficits and injuries [14]. Therefore, muscle strength of the hip, pelvis, and waist is crucial for stability, balance, and coordination during performance [11].

However, when consulting books on ballet pedagogy, we find that authors typically explain the meanings of various ballet terms and the steps involved in performing movements but seldom cover the specific requirements and methods for training core stability. Owing to the lack of clear pedagogical guidance, ballet teaching can only address core exercises through the inheritance of traditional teaching methods and references to practices from other sports fields. Common verbal cues for core engagement in class include 'tighten the stomach', 'engage the abdominal muscles', and 'squeeze the abs', while training exercises typically include sit-ups, crunches, and plank to strengthen abdominal muscles.

The concept of dance science has recently gained attention, with an increasing number of teachers and dancers placing greater emphasis on health and scientific principles during their training. In the book Anatomy for Dancers, Haas (2010) states that all dance movements originate from the trunk, which forms the foundation of a dancer's physical expression. A solid foundation promotes body awareness and spinal stability, whereas an inability to use a core to protect the spine results in loose and weak movements. Classical ballet creates the illusion of weightlessness and lightness using diverse styles, yet the foundation of its movement evolution is still derived from the five positions of the feet achieved through the rotation (turnout) of the legs. This requires a high level of core control. A stable core is also essential for body alignment, turns, jumps, and even point work. The author argues that for ballet dancers, it is necessary to understand the anatomical structure of the core to activate the relevant muscles to form a solid and stable core, strengthen these muscles, and apply them in dance movements (2010). In the training section of the book, she suggests abdominal and back muscle exercises focusing on 'deeply contracting the core muscles', such as Trunk Curl, Oblique Lift, Side Lift, and Coccyx Balance.

Other studies have suggested that improving core strength has a positive effect on core stability; however, it is important to note that enhancing core stability is more about improving control over the trunk than increasing trunk muscle strength (Charmaine, 2021). For example, performing a pirouette does not require powerful abdominal muscles but demands strong balance, control, and coordination. This is the correct understanding of core stability in ballet training, where having 'six-pack abs' does not necessarily mean possessing core stability (Charmaine, 2021).

Further analysis of dance science research indicates that it is crucial to comprehensively engage all muscles involved in movement to improve core ability. Isolated muscle training is not only inefficient but also leads to compensatory actions, which negatively affect overall stability. For instance, superficial abdominal muscle training, such as performing sit-ups that involve repetitive bending of the spine and hip joints, can affect the strength and flexibility of the torso, leading to muscle imbalance and excessive fatigue of the back. Although core stability exercises effectively enhance overall fitness and help prevent lower back pain, it is important to avoid exercises that impose excessive compression on the lumbar spine [2].

4. Breathing and Core Stability

Jennifer Jackson, a former dancer with the Royal Ballet and now a teacher at the Royal Ballet School, suggested that finding and maintaining deep core support is especially important in ballet training. The Royal Ballet School advocates the use of a breathing technique based on deep core support, which, when integrated into daily ballet training, helps develop the core stability required for ballet performance. Although Haas (2010) briefly mentions breathing in her book, noting that it plays an important role in strengthening the trunk, she believes that the deeper the breath, the greater the engagement of the abdominal muscles. The expansion of air from the lungs generates intra-abdominal pressure. In terms of specific breathing techniques, Haas recommended inhalation through the nose while expanding the ribs outwards. During exhalation, she suggested contracting the deep abdominal muscles as if tightening a corset, while ensuring that the spine remained in a neutral position, avoiding excessive stiffness or tension. However, Jackson disagreed with the idea of contracting the abdominal muscles during exhalation. She proposed that the correct breathing method involves feeling the activation of the transverse abdominal muscles and gentle 'lifting and drawing of' the pelvic floor muscles, maintaining only approximately 20% contraction strength. During this process, breathing occurs as the ribs expand backward and sideward, with the abdomen remaining softly contracted. This method helps provide core stability, maintains the spine in the correct neutral position, and avoids tension and restricted breathing. More importantly, using this breathing technique, dancers can maintain deep core support while performing back-bending movements. This not only aids in the flexibility of movement, preventing excessive use of the back muscles, but also helps to maintain the correct position of the pelvis and spine.

Experts at the Royal Ballet School unanimously agreed that training without deep abdominal core support can lead to lower back tension and injury because the deep core muscles are not activated, causing the back muscles to overcompensate. Overuse and continual contraction of all abdominal muscles can also lead to increased body tension, which may affect the aesthetic quality of the dancer's movements and result in shortness of breath or restricted breathing owing to the inability of the ribs to expand freely [7].

5. Diaphragmatic Breathing and Intra-abdominal Pressure

However, how exactly do the breathing techniques mentioned above contribute to core stability? In her work, Diaphragmatic Breathing: The Foundation of Core Stability, Nelson (2012) outlines diaphragmatic breathing as the fundamental function of the core. The mechanism that most effectively reflects this stabilising function is intra-abdominal pressure. Ben Kibler also summarised in The Role of Core Stability in Functional Movement suggests that the core must provide the foundation for the body's movement, and intra-abdominal pressure is the key to providing that foundation [9].

Intra-abdominal pressure is primarily dependent on the diaphragm. During the descent, the diaphragm creates a piston-like action. Combined with eccentric contractions of the pelvic floor muscles, transverse abdominis, and obliques, this increases intra-abdominal pressure, provides appropriate stiffness, and enhances spine stability [9]. Correct breathing techniques allow the diaphragm to descend, generating intra-abdominal pressure and thus enabling it to maintain both postural stability and respiratory function [9]. When the intra-abdominal pressure system is functioning properly, the result is optimal force distribution and maximum power generation, while minimising compressive, shear, or translational forces at the joints of the kinetic chain, thereby providing 'proximal stability and distal mobility' for limb movement [1]. Therefore, diaphragmatic breathing techniques may be important components of core strengthening [1]. Furthermore, Karel Lewit points out, 'Without a healthy breathing pattern, there is no such thing as a correct exercise pattern'. Lewit also states, 'Breathing is likely to be considered a fundamental ability, upon which further movement development is based. Thus, the development of an efficient breathing pattern should be prioritised' [9].

6. Achieving Intra-Abdominal Pressure

As the importance of intra-abdominal pressure (IAP) and diaphragmatic breathing for core stability has been clarified, we need to further explore how breathing can generate intra-abdominal pressure. The human abdominal cavity contains several organs, including the stomach and liver, and the pressure within the abdominal cavity is referred to as intra-abdominal pressure (IPA). The IAP is a physiological characteristic that changes in response to a variety of activities. Given that the abdominal cavity is a confined space, its volume changes with breathing, muscle contraction, and posture. When IAP is high, inhalation causes the diaphragm to move downward, thereby reducing the volume of the abdominal cavity. As the abdominal cavity is compressed, the pressure within the cavity increases [9]. However, the position and shape of the diaphragm are not fixed and vary with the breathing stage. During full inhalation, the diaphragm flattens, moving down from the chest to the level of the ribs in the front, and descending to the level of the 12th rib in the back. During full exhalation, the diaphragmatic dome reaches the fourth intercostal space. Although the breathing process seems unconscious, the normal function and mechanical efficiency of the diaphragm largely depend on its anatomical relationship with the lower ribs. The area of attachment between the diaphragm and ribs is known as the Zone of Apposition (ZOA). This area is controlled by the abdominal muscles that guide the diaphragm downward to create tension. During breathing, when the diaphragm contracts and moves downward into the abdominal cavity, the intra-abdominal pressure increases, causing the abdominal wall to expand in three dimensions, accompanied by rib expansion. The abdominal wall resists the action of diaphragm through the eccentric contraction of all abdominal muscles, thus controlling the length tension relationship of the diaphragm. This eccentric contraction ensures that the dome of the diaphragm is maintained and that the Zone of Apposition remains sufficiently long to allow the ribs to expand backwards and laterally, which helps increase diaphragm strength. This effect is reversed during exhalation. The abdominal muscles contract concentrically, pulling toward the internal organs, thus forcing the diaphragm to contract upward toward the head, with the ribs rotating inwards [8]

As the IAP increases, the trunk and spine, as the core of the body, are supported. This increases spinal stability, making it possible to maintain good posture and a stable base for movement. Moreover, as trunk and waist stabilities are enhanced during various movements, the effectiveness of exercise and physical activity is improved. An important concept of 'intra-abdominal pressure' is that it does not generate rigid stability. In contrast, it provides buoyancy and elasticity for axial anti gravity control. The overall balance of abdominal muscle activity offers an ideal thoraco pelvic alignment for the generation of IAP and postural control [9]. Therefore, diaphragmatic breathing should be used rather than chest or traditional abdominal breathing to achieve IAP. Unlike other types of breathing, the key feature of IAP breathing is that both inhalation and exhalation continually increase abdominal pressure and activate the surrounding muscles. The abdomen does not collapse or retract [5].

Combined with the anatomical theory of the diaphragm, when practising IAP, it is important to maintain a neutral spine and allow the ribs to sink. If there is any Costal Valgus due to inhalation or excessive tension, it will affect the downward movement of the Zone of Apposition and increase intra-abdominal pressure. By keeping the ribs downward, the body forms a 'cylinder' from the diaphragm to the pelvis. During inhalation, one should feel a three-dimensional expansion of the abdomen rather than simply upward arching. This sensation is similar to that of a balloon expanding with air in its core. Inhalation should also not involve 'pulling in the stomach', because IAP breathing requires the abdomen to fill with air to increase intra-abdominal pressure (2020, Chiropractic, Lifestyle, Physical Therapy). As the characteristic of IAP breathing is that the abdomen does not retract during exhalation, abdominal compression should be avoided to prevent the abdominal muscles from shortening and to maintain the circumferential tension of these muscles around the abdominal cavity (McGill & Norman, 1993). By breathing in this manner, one can stabilise the pressure inside the abdominal cavity, thereby enhancing spinal and body stability and reducing unnecessary or ineffective muscle tension [5].

7. Exploring Core Training Methods

Therefore, does successfully established IAP breathing imply that one can maintain core stability? Research has indicated that a lack of sufficient coordination within the core muscles can lead to reduced exercise efficiency and compensatory patterns, which can cause strain. Simultaneously, spinal stability depends not only on muscle strength, but also on proper sensory input, which reminds the central nervous system of the interaction between the body and the environment, providing continuous feedback and making movements more precise. Therefore, to achieve optimal spinal ability, a comprehensive core stability program should consider the sensory and motor components of these system [1]. Josephine Key believes that 'Ideally, we should demonstrate 'central intelligence' in the trunk movements – balancing upright control and breathing effectively'. Deep core stabilising muscles, including the diaphragm, facilitate postural reflexes and provide internal support and control of the axial skeleton. Research by Hodges [6] also supports this concept, asserting that these muscles should be activated before movement, which helps stabilise the trunk while allowing for adjustments, thus providing an optimal foundation for larger prime movers [9].

In addition, Akuthota et al. [1] suggested that core training programs should be staged and progressive. The first stage involves restoring normal muscle length and range of motion to correct existing muscle imbalances. Appropriate muscle length and flexibility are necessary for joint function and efficient movement. Trunk stabilisation exercises should be used to teach individuals how to activate the deep core muscle groups. Once mastered, higher-level core stability exercises can be performed by using a yoga ball. Finally, training should transition to standing positions by incorporating functional movement exercises to promote balance and coordination of precise movements. The goal of advanced core stability training is to train functional movements rather than isolated muscles [1].

A similar viewpoint suggests that core stability training requires the core to respond quickly to changes in posture and body load. Therefore, core stability training should not be limited to only static postural exercises. Simple planks, which stabilise the spine using the abdominal muscles, are not the most effective method for core training. It is necessary to introduce dynamic movements to improve spinal stability. For example, a leg is lifted to the side of body during a plank movement. Although these exercises may seem simple and may not induce muscle soreness or fatigue typically caused by larger muscle groups, they are highly effective in stabilising the spine and pelvis in various dynamic postures. By properly developing core stability, dancers can gain precise control over movement changes and necessary control during movement [2]. Accordingly, core stability training should not only focus on strengthening the core muscles but also include comprehensive exercises for stability, balance, flexibility, and coordination [4]. Especially in ballet training, dancers should avoid excessive abdominal muscle exercises and instead focus on identifying weak points in both localised and integral muscles to train and perform safely and effectively. Combining endurance, strength, speed, and proprioceptive training can effectively enhance coordinated movement patterns [2].

8. Conclusion

In this paper, we first clarify the concept of the core and core stability, defining the core as the central part of the body, from the waist to the pelvis. This area, which consist of the diaphragm, abdominal, back, and pelvic floor muscles, forms the core muscle functional unit. Core stability is achieved by stabilising the trunk and pelvis, thereby providing a solid foundation and force output for limb movements. In ballet training, core stability not only protects the spine from injury but also contributes to the execution of technical movements and high-quality and diverse artistic expressions. However, to enhance core stability, simply strengthening the abdominal and back muscles or seeking breakthroughs solely through breathing techniques will not achieve true core stability. These methods may also impair the strength and flexibility of relevant areas, leading to localised muscle tension and overall muscle compensation.

Based on relevant research and the integration of anatomical and sports science theories, the study demonstrate that the core stability required for ballet training should first be established through proper breathing techniques to generate intra-abdominal pressure. This should be combined with external loads produced by postural changes along with training that incorporates resistance, endurance, power, coordination, control, balance, and overall movement patterns that promote proprioception. This approach maximises the functional potential of core stability, minimizes movement restrictions and tension, and enables ballet dancers to better control and adapt to different techniques, ultimately focusing more effectively on achieving artistic accomplishments during stage performances.

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