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Science-Empowered Dance Pedagogy: Theoretical Construction and Practical Translation of Sports Biomechanics

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Abstract. This paper discusses how sports biomechanics pushes dance teaching from "experience inheritance" toward an "evidence-oriented" paradigm shift. Traditional master-apprentice teaching depends on oral transmission and personal demonstration and on the ethic of "enduring pain and practicing hard," and it brings about a high injury rate, the neglect of individual differences, and the "black box" difficulty that training effects are hard to quantify and to reproduce. Sports biomechanics, through analyzing the kinetic chain, load thresholds, and mechanical mechanisms, provides a scientific basis for injury prevention, efficiency improvement, and individualized training, and it carries out "teaching according to age" in the dialectic of universality and particularity. Taking the seven-year continuous program of Taipei National University of the Arts as the field of observation, this paper proposes a systematic construction of the teaching model: the scientific reconstruction of warm-up, the integration of body-mind techniques such as breathing training, the Alexander Technique, the Feldenkrais Method, and Ideokinesis, and an inquiry-based course structure centered on "movement understanding." The deeper meaning of this transformation lies in the renewal of educational philosophy—moving from the "instrumentalized body" toward dancer-centered whole-person education that cultivates the "aware body," letting experience and science be driven by two wheels, and realizing dance education that is safe, excellent, and sustainable.

Keywords: dance science, sports biomechanics, body-mind techniques, injury prevention

1. Introduction

Traditional dance education is rooted in an experience system of oral transmission and personal teaching, demonstration and imitation, and repeated drilling. This model cannot be replaced in maintaining the style of dance genres and the content of skill; however, as the professionalization of the discipline and the diversification of performing arts place higher demands on the dancer's physical capacity, expressive depth, and career sustainability, its limits become increasingly visible: a high injury rate, training effects that are hard to quantify, the lack of countermeasures for individual differences, and even "pain-enduring training" being sanctified as professional spirit. The "black box" training that over-relies on bodily feeling and experience both weakens movement

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cognition and the path of optimization, and blocks the accumulation, reproduction, and testing of knowledge.

Dance science thereby brings about a deep change of concepts: teaching thinking moves from "skill inheritance" toward "evidence orientation," and from the ethical logic of "talent—hard practice" toward the rational thinking of "mechanism—strategy" [1]. Sports biomechanics, through analyzing the kinetic chain in which bones, joints, and muscle groups work together, reveals the mechanical laws behind technique, and lays the foundation for injury prevention, efficiency improvement, and individualized training. Since the 1980s, the introduction of body-mind techniques such as Ideokinesis [2] and the Feldenkrais Method is exactly the concrete embodiment of this paradigm shift, and it pushes the dancer to leap from "bodily perception" to "scientific awareness."

2. The limits and crisis of "experience inheritance"

In "master-apprentice" teaching, the teacher relies on the technique, style, and aesthetic criteria accumulated from personal bodily experience, and guides students to imitate and internalize through demonstration, oral instruction, and correction by touch. This model emphasizes intuitive perception and the ethic of "diligent and bitter practice," and has played a key role in ballet, modern dance, and body training; as technical requirements become increasingly fine and loads keep rising, its fundamental problem is fully exposed—treating the dancer's body as a carrier that can be endlessly carved, and ignoring objective principles such as human body structure, the timetable of development, and load thresholds.

2.1. Neglect of individual differences

Traditional training often takes a single "ideal body" as the standard, insisting on 180-degree turnout and extreme flexibility, but it does not consider the innate differences in bone alignment, joint range of motion, muscle group coordination, and neural control. If age and developmental stage are also ignored, the consequences are especially serious: the growth plates of students in the senior-high stage[1] of the seven-year continuous program have not yet closed, and bearing adult-level loads before bone development is complete causes joint and spine injuries that are often permanent.

2.2. The culture of "pain means professionalism" becomes a cause of injury

Traditional concepts treat pain as a symbol of "breaking through the bottleneck" and "tempering the will," making dancers ignore the warning function of pain and force themselves beyond physiological load, leading to overuse injuries such as hip impingement, lower back pain, and ankle instability; long-term accumulation further brings psychological pressure and career anxiety, forcing some dancers to leave the stage early. Its root is exactly the scientific neglect of load thresholds and tissue tolerance.

[1] Here "senior-high stage" refers to the first three years of the seven-year continuous program of the School of Dance, Taipei National University of the Arts, which correspond to senior high school; students are about 15 to 18 years old, and the epiphyseal plates of the long bones are in most cases not yet fully closed.

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2.3. The teaching black box that is hard to pass on

Teachers' instructions are mostly abstract images—"lift the qi upward," "relax a little more," "reach out but do not use force"—which can evoke bodily feeling, but lack the analysis of kinesiology and movement mechanism, so students have difficulty matching them to physiological mechanisms and easily develop understanding deviations and even wrong patterns. This kind of "black box" training is not favorable to the precise transmission of method, and also makes it hard for the new generation of teachers to build a verifiable educational framework.

When "bodily feeling" overrides "movement mechanism" and "enduring pain" replaces "understanding load," the dancer is placed at the edge of career depletion. The intervention of dance science is therefore not only a supplement to teaching, but also a necessary structural correction and paradigm shift.

3. Dance science: the theoretical construction of sports biomechanics

Among the many branches of dance science, sports biomechanics, because of its deep deconstruction of the essence of human movement, has become the core pillar of teaching modernization.

3.1. The mechanical basis of human body structure and function

Dance movement is not an abstract aesthetic symbol, but a dynamic process made up of physical parameters such as joint angle, muscle tension, torque transmission, and ground reaction force [1]: the stability of turning depends on the mechanical coupling of the pelvis and the spine, and the height of a jump and the safety of landing depend on the buffering mechanism of the knee and ankle. On this basis, the teacher can give precise guidance on posture adjustment, rather than relying only on vague "feeling" [3]. This analysis also provides an objective basis for talent selection and the technical path—each dancer's joint range of motion, muscle fiber type, and limb proportion differ, and the teacher can abandon the myth of the "standard body" and help the dancer develop a "technical style that fits his or her own structure," which both raises efficiency and avoids the structural injuries of forced imitation.

3.2. The dialectical unity of universality and particularity

The principle of universality points to the mechanical commonalities that all dancers must master: center-of-gravity control, momentum transfer, pivot switching, and the command of force, which make up the "universal grammar" of technique [4]. However, emphasizing only universality easily falls into mechanization, so the principle of particularity requires individualized design according to age, gender, physical condition, and psychological state. Taking the seven-year continuous program of Taipei National University of the Arts as an example, the researcher found through observing contemporary dance technique classes and talking with teachers: in the senior-high stage (Guan 1 to Guan 3)[2] the joints are still developing and the ligaments are relatively fragile, so warm-up intensity and technical load need strict control; in the university stage (Guan 4 to Guan 7) the body's

[2] "Guan 1 to Guan 7" are the grade names used in the seven-year continuous program of the Department of Dance, Taipei National University of the Arts: Guan 1 to Guan 3 correspond to the three years of senior high school, and Guan 4 to Guan 7 correspond to the four years of university.

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adaptability improves, and combinations of higher intensity and complexity can be introduced. This kind of "teaching according to age" is exactly the model by which biomechanics turns "teaching according to the individual" into an operable strategy, and realizes "creating within norms, being free within limits."

3.3. The mechanical mechanism of trauma prevention

Injury has long been regarded as the "price of the profession," but biomechanics research reveals that most injuries come from preventable mechanical errors and occur at the moment of "exceeding the tissue load threshold" [5]. Through mechanical models, the pressure distribution of a given movement on the joints and muscles can be quantified: ignoring the anatomical limits of the hip joint and forcing 180-degree turnout will lead to acetabular impingement; knees caving inward on landing will greatly increase the force on the anterior cruciate ligament. On this basis the teacher can identify high-risk patterns and correct them in real time, and can also move prevention forward—strengthening the gluteus medius to improve knee alignment, training proprioception to improve landing stability, and designing exercises that balance flexibility and strength. Biomechanics does not only explain "why injury happens," it also writes the prescription for "how to avoid it," turning prevention from passive response into active design.

3.4. The scientific basis for improving teaching methods

In the past teachers designed training by experience; now they can intervene precisely according to mechanical principles. The speed of fast turning comes from the coordination of the scapular stabilizers, the deep core, and the fine-tuning muscles of the ankle joint, not only from the large muscle groups producing force, so special strength exercises for the small muscle groups can markedly raise movement speed; jump height can be optimized through the momentum contribution of the "swing leg," and on this basis the teacher designs exercises for hip flexor explosive power and swing-leg rhythm control, rather than generally asking the student to "jump higher." Sports biomechanics upgrades teaching from "artistic intuition" to "scientific design," so that every instruction and every set of training has mechanical logic supporting it.

4. Practical translation of scientific guidance: the systematic construction of the teaching model

4.1. The scientific reconstruction of warm-up

In traditional classes, warm-up is often seen as a formal transitional segment; scientific warm-up is the three-dimensional integration of "physiological start-up, psychological switching, and educational stage-appropriateness." On the physiological level, the core of warm-up is overcoming "physiological inertia": gradually raising body temperature by 1—2°C, promoting blood circulation, lubricating the synovial fluid of the joints, and starting up the neuromuscular system. Related research points out that sufficient warm-up can effectively prevent ligament stretching injuries and reduce the articular cartilage damage caused by intense exercise; the time should take up 10%—20% of total class time, with "slight sweating" as the intensity indicator [6]. On the psychological level, warm-up is a process of translation from everyday consciousness to "creative concentration": through rhythmic movement, body imagery, and breathing guidance, the dancer opens the door of inner observation—feeling the fine tension of the muscle groups, observing the resonance of breath

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and bones, and asking oneself "where is the center of gravity? where does the source of power come from? is the movement intention to extend, to gather, or to transform?" The power, path, and purpose of movement are thereby transformed from vague "feeling" into clear inner cognition, and the dancer changes from "a person who does movements" into "a person who is aware of how movement happens." Educational stage-appropriateness implements the principle of particularity: the senior-high stage emphasizes flexibility and basic coordination and avoids high-impact movements; the university stage can introduce dynamic stretching, neural activation, and special preparatory exercises.

4.2. The integrated application of multiple body-mind techniques

Bringing Pilates, the Alexander Technique, the Feldenkrais Method, and Ideokinesis systematically into teaching is not a denial of tradition, but a refinement and sublimation of it—turning the dancer from the "instrumental body" that passively executes instructions into the "aware body" that actively understands, perceives, and controls movement. As for breathing training, breathing can regularly calm body and mind, handle stress, and regulate physiological function; seen from anatomy, the coordination of the diaphragm, the intercostal muscles, and the abdominal muscles not only regulates gas exchange, but also directly affects spinal stability and core control [7]; the "lateral thoracic breathing" used by Pilates expands the two sides of the ribs and the back while inhaling and at the same time keeps the abdominal wall contracted, ensuring that the core is not loosened by breathing, and it emphasizes the pre-activation and continuous support of the deep trunk muscle groups. The Alexander Technique was developed by the Australian actor Alexander (F. M. Alexander) at the end of the 19th century, with "inhibition" and "direction" as its core, helping the learner recognize and stop habitual wrong movement patterns and rebuild the dynamic balance of "head—neck—back" [8]; in dance education, it effectively improves the compensatory tension that dancers develop from pursuing "extension" or "posture," returns them to natural alignment, and prevents the chronic injuries caused by long-term bad posture. The Feldenkrais Method was founded by the Israeli-born engineer Feldenkrais (Moshe Feldenkrais, 1904—1984), with "Awareness Through Movement" (ATM) and "Functional Integration" as its two axes; through slow, subtle, non-habitual movement exploration, it awakens the nervous system's awareness of movement patterns and guides the learner to reorganize neuromuscular coordination out of automatic, low-efficiency habits; it is especially suited to the stage of body-easing exercises and movement deconstruction, and pushes the dancer from "imitating outer form" toward "understanding how movement is generated inside the body"—this transformation from "behavior" to "perception" is exactly the key to the construction of body knowledge.

The three techniques each have their own emphasis but share the same orientation: breathing training lays down core support, the Alexander Technique corrects habitual alignment, and the Feldenkrais Method deepens movement awareness; the three together point to the same goal—making the dancer the understander and the controller of his or her own movement.

4.3. The scientific logic of course structure

The scientifically guided class is no longer the linear flow of "teacher demonstrates—student imitates," but inquiry-based learning centered on "movement understanding." First, biomechanics becomes the language of teaching: the teacher no longer only says "raise the leg higher," but explains "how the hip flexors drive the thigh and how the gluteal muscles stabilize the pelvis," and on the basis of understanding "why to move this way" the student actively corrects himself or

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herself. Second, injury prevention is built into regular training: landing buffering and knee alignment exercises are added before jump combinations, turnout training emphasizes "functional turnout" rather than extreme angles, and prevention becomes the built-in logic of the course. Finally, body-mind techniques become an organic part of technical training: warm-up uses ATM to raise awareness, technical combinations bring in the imagery of the "nine lines"[3] to optimize alignment [9], and the cool-down stage uses breathing and the Alexander Technique to release tension.

Through this, the teaching model realizes a threefold leap: from "experience intuition" to "rational design," from "body as tool" to "aware subject," and from "technical imitation" to "movement understanding."

5. Renewal of concepts: from the instrumentalized body toward a dancer-centered educational philosophy

The deep change brought by dance science lies in the turn of educational philosophy—from treating the body as a passive tool for achieving technical perfection toward dancer-centered whole-person education. The old saying "one minute on stage, ten years of practice off stage" often makes dancers be required to "push through pain" and "break through limits," while the structural limits of the body and its physiological signals are systematically ignored.

5.1. Reconstruction of the view of the body

Science confirms that the individual differences of bones and joints are not defects, but unique biomechanical assets. The purpose of training is not to force a unified "standard body," but to help the dancer understand and make good use of his or her own conditions, and to treat the body as a living subject worthy of respect, not as a tool waiting to be carved [10].

5.2. Transformation of the teaching relationship

In the master-apprentice system the teacher is absolute authority, and demonstration is truth; under scientific guidance, the teacher changes from a "demonstrator" into a "guide" and a "co-learner," and not only transmits "how to do it," but also explains "why to do it this way." Through methods such as breathing awareness, imagery guidance, and ATM, students are encouraged to take part in the construction of the body with the mind, to develop the ability of self-monitoring and decision-making, and to truly become the subject of training.

5.3. Expansion of the goal system

Traditional teaching is guided only by "stage performance"; scientific guidance establishes multi-dimensional goals in which artistic expression, bodily safety, psychological well-being, and career sustainability are all given equal weight. The dancer is first of all a "person," and only then a performer.

[3] The "nine lines" (nine lines of movement) are nine sets of imagination lines used in Ideokinesis to guide bone alignment; they adjust the center of gravity and the posture through imagery rather than through muscular force.

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5.4. Objectification of evaluation standards

Past evaluation methods relied heavily on the teacher's subjective feelings, such as "it does not feel released enough" and "the line is not long enough"; scientific guidance advocates introducing movement analysis, such as the comprehensive assessment of joint angles, the trajectory of the center of gravity, physical data (flexibility, explosive power), injury records, and artistic expression. This not only lets students know their own state clearly, but also gives a basis for the adjustment of teaching strategies.

This renewal raises the dancer from a passive executor to an active constructor, and turns teaching from one-way infusion into two-way dialogue, forming an educational philosophy that respects the laws of art and even more reveres the laws of life.

6. Challenges and prospects

Putting dance science into practice faces three challenges: the insufficient literacy of teachers, the high cost of equipment, and the worry in the art world that rationality will weaken sensibility [11]. The way to break through lies in pragmatic integration: bringing science into the core of teacher training, promoting low-cost tools such as phone-based analysis, and advocating "evidence-based artistic practice," establishing science as a rational framework for optimizing movement and preventing injury [1]. The ideal educational ecology should have experience and science driven by two wheels, letting experience carry aesthetics and creative intuition, and science provide support for safety and efficiency. The two confirm each other and nourish each other, and only then can a new era of dance education that is excellent and sustainable be realized on the premise of protecting the well-being of dancers.

7. Conclusion

Dance science with sports biomechanics at its core is reshaping contemporary dance education, systematizing warm-up and posture adjustment, and internalizing them into the logic of teaching. Its key value lies in cultivating the "aware body," letting the dancer rise from imitation to an inner dialogue of understanding momentum and spinal alignment, and developing a safe and unique artistic vocabulary under the condition of respecting the individual. This paradigm shift is not a denial of tradition, but a refinement of experience by science, turning intuition into knowledge that can be passed on. In the end, this evolution points to a future that gives attention to both bodily well-being and artistic extremity, letting the warmth of experience and the precision of science be driven by two wheels, and realizing a new era of dance education that is excellent and sustainable.

References

[1] Sports Anatomy Editorial Group. (2018). *Sports anatomy* (2nd ed.). Beijing Sport University Press.
[2] Sweigard, L. E. (1974). *Human movement potential: Its ideokinetic facilitation*. Harper & Row.
[3] Wang, Y. (2023). *Movement analysis: Understanding the body, understanding oneself*. Academic Publishing Department, Airiti Digital Co., Ltd.
[4] Yang, O. (2009). *The study of dance training*. Shanghai Music Publishing House.
[5] He, J. (2003). *Art and medicine shining upon each other*. Sichuan Science and Technology Press.
[6] Xu, P., Henriques, P., Zhao, S., & Liu, H. (2019). A quantitative study on the load of pre-match warm-up activities of high-level young male football players. *Sport Science Research*.
[7] Du, B. (2017). *Pilates body-mind therapy*. Taipei National University of the Arts Press.

DOI: 10.54254/2753-7064/2026.38586

[8] Alexander, F. M. (2019). *The Alexander technique: The way of using body-mind optimization*. (J. Peng & S. Huang, Trans.). PsyGarden Publishing.
[9] Franklin, E. (2007). *Dance imagery and body training*. (W. Lin, Trans.). Yi-Hsuan Publishing.
[10] Shen, D. (2022). The body action method of contemporary technique: An interpretation of the body view of the Chinese diaspora dancer Zhang Xiaoxiong. *Journal of Huaqiao University (Philosophy and Social Sciences Edition)*.
[11] Wen, R. (2008). *Research on the current situation and development of dance human body science*. Beijing Dance Academy.