

RESOURCE PAPER FOR DANCERS AND TEACHERS

Bone Health and female dancers: Physical and nutritional guidelines

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INTRODUCTION

In addition to technical training, it is essential that dance instruction involve education with respect to the well-being of the whole dancer. Preparing the dancer must include strategies to maintain physical and mental health. The bone health of dancers has long been a topic of concern to dance medicine researchers. Poor

nutrition, disordered eating, and excessive training can lead to hormone imbalance followed by delayed menarche (onset of menses) or amenorrhea (loss of menstrual cycle) which can frequently cause sub-optimal bone mineral density in the young dancer. Longitudinal research also indicates that low bone density is most evident in advancing years, following retirement. Thus, a balance between healthy nutrition and training is essential for building strong bones. This should be emphasized by dance teachers to both the developing and mature artist and should be supported by experienced health professionals.

Diminished bone density is defined in two ways. Osteopenia refers to bone mineral density (BMD) which is lower than the expected BMD (for a particular age) but not low enough to be classified as osteoporosis. Osteoporosis is a progressive disease characterized by low bone mass and deterioration of bone tissue, leading to skeletal fragility and increased risk of fracture.

Although men are also at risk for diminished bone mineral density and have the potential to develop osteopenia and osteoporosis, it is generally at a lower rate than for women because men's bones are larger and stronger and their maturing hormonal systems less fragile. This paper will focus on female dancers, although most of this information holds true for men as well.

BONE STRUCTURE

Healthy bones are formed from calcium and other minerals (about 65% by weight; these give bone its strength), and from a matrix of collagen and other proteins (about 35% by weight; these give bone its flexibility). The level of calcium in the blood controls the amount of parathyroid hormone (PTH) in the body. If the level of calcium in the blood decreases, more PTH is secreted, triggering the leaching of calcium from bones to correct the deficit in the blood. This situation contributes to the development of diminished bone density, osteopenia, and ultimately osteoporosis.

The collagen matrix is also crucial for maintaining bone flexibility, and may be more essential to preventing fractures than calcium content. Without the matrix, bones rich in calcium can be dense, hard and brittle, thus at higher risk for fracture.

Fifty to sixty percent of bone mass is developed during puberty (approximately age 11 to 15 years) with peak bone mass being produced before the age of 20. Bone density in women peaks at about age 35 and bone loss starts a few years later. The loss increases during the first 3 to 5 years after menopause.

ELEMENTS THAT ENHANCE BONE FORMATION

Calcium is the primary nutrient that contributes to strong healthy bones but it relies on the presence of other nutrients and hormones to do this (see below). Calcium is absorbed from the blood into the bone in conditions of calcium sufficiency.

Vitamin D's major biologic function is to maintain normal levels of calcium and phosphorus in the blood. Vitamin D promotes calcium absorption and works in concert with a number of other vitamins, minerals, and hormones to promote bone mineralization. Vitamin D is produced in the skin in response to ultraviolet light exposure. Only 10-15 minutes a day of partial-body exposure (hands and face) to bright sunlight are needed to make high amounts of vitamin D. In children, deficiency of vitamin D leads to rickets, seizures, fractures, lower-limb deformities, abnormal dentition and delayed development. Vitamin D deficiency also predisposes children to respiratory infections. Dancers who spend long hours training indoors often have difficulty in achieving adequate exposure to the sun (and therefore vitamin D). The problem increases when they adopt "sun-safe" habits recommended for skin cancer prevention, such as wearing hats and sunscreen. Safe

exposure to the sun may be supported by dance schools by organizing some short periods of time outside each day as part of the dance or education program, i.e., fitness, between classes, or during lunch break. Protein and vitamin C stimulate collagen matrix formation. (For more information on protein, see IADMS' Nutrition Fact Sheet: Fueling the Dancer.)

Magnesium increases calcium absorption. Magnesium is also one of the minerals that make up bone and is important in conduction of nerve impulses to the heart and other parts of the body. Phosphorus helps in the formation of normal bone by enabling mineralization of soft osteoid bone. Mechanical strain, stress on the bone, exercise and movement also help to increase bone deposition. Potassium contributes to proper acid balance in the blood, and to nerve conduction and muscle contractions. Individuals with eating disorders may be at risk of bone loss and serious cardiac problems due to limited potassium in the body.

Vitamin K contributes to the production of collagen, a component of cartilage, connective tissue and bone. The best food sources are dark green leafy vegetables. The American College of Sports Medicine recommends 60-90 mg per day as adequate for bone health. Sex hormones produced in a normal menstrual cycle increase bone deposition.

ELEMENTS THAT INCREASE THE RISK OF DIMINISHED BONE DENSITY

High caffeine intake (more than two cups of coffee per day), high alcohol intake, smoking, anti-convulsant (seizure) medication, and heredity may all contribute to low bone density. Foods containing oxalates may inhibit calcium absorption. Oxalates bind to calcium and are removed through the digestive tract, and therefore should be eaten in moderation. Oxalates are found in night shade vegetables (eggplant, peppers, tomatoes and potatoes), in varying amounts in sweet potatoes, okra, collards, berries, chard, tea, and minimally in chocolate.

Due to various individual and cultural reasons, the nutritional practices of dancers may be suboptimal, even if the school provides comprehensive nutrition education. Furthermore, dancers who do not have enough natural exposure to the sun (at least 15 minutes daily) may need to be encouraged to achieve some daily sun exposure. It is essential that dancers be educated about the very grave risks that inadequate amounts of calcium, vitamin D, magnesium, phosphorus, or potassium can have on their short- and long-term physical health and thus on their careers.

NUTRITIONAL FACTORS

Energy availability is defined as energy intake minus energy expended. Dancers at greatest risk of low energy availability are those who restrict energy intake, who exercise for prolonged periods, who are vegetarian, and who limit the types of food they eat. Low energy availability can frequently occur unintentionally during periods of high energy output and may therefore not necessarily be due to dietary restriction. However, regardless of how the low energy availability arises, it is essential that experienced dance medicine professionals and teaching staff help the dancer adjust energy intake and output. The most common early symptoms of low energy availability are fatigue, lowered concentration and loss of menstrual cycle. However, it is important to note that dance performance is not always impaired, so performance should not be only the basis for decision- making by the dancer, their teachers, and their health-care team.

Dancers with low energy availability, with or without disordered eating habits, risk early bone loss and osteopenia or osteoporosis. Dancers who have a diet with low caloric intake and low calcium intake have a relatively high incidence of stress fractures and scoliosis. Disordered eating habits can include fasting, binge

eating, purging, the use of diet pills, laxatives, diuretics, enemas and, in the extreme, the psychiatric disorders of anorexia nervosa and bulimia nervosa.

Young dancers need energy from food to meet daily energy needs such as basic functioning (breathing, walking, brain function, etc.) and for higher energy activities such as dance. Additional energy is also required for optimal hormone functioning and menstruation. In cases where energy intake may be sufficient for daily functioning and activity but not sufficient for optimal hormone function, the result is reduced estrogen production and amenorrhea (loss of menstrual cycle). The menstrual cycle may be delayed (primary amenorrhea), may commence but be lost (secondary amenorrhea) or be irregular (dysmenorrhea). Any of these menstrual irregularities may lead to reduced bone density. A lack of estrogen may in turn cause bone loss, again because of a coupled increase in parathyroid hormone (PTH) circulating throughout the body. Estrogen is needed for calcium absorption and for calcium deposition in bone. Because dancers are active, their bones must endure more mechanical stress. Under normal circumstances, physical activity enhances bone density, but restricted energy intake may blunt these effects. If dancers develop diminished bone density, osteopenia or osteoporosis in their teens they may never regain their previous bone densities even if their diet and vitamin intake improve.

RELATIVE ENERGY DEFICIENCY IN SPORT (REDs)

Historically, when low energy availability is accompanied by amenorrhea and osteoporosis it was referred to as the “Female Athlete Triad.” In 2007, the American College of Sports Medicine redefined this concept to describe three interrelated components: (1) energy availability, (2) menstrual function, and (3) bone health. Each of these components exists on a continuum from optimal health to clinical dysfunction, emphasizing that athletes may fall anywhere along each spectrum. Dancers, in particular, must be aware of the risks associated with progressing toward the negative end of these spectrums and take proactive steps, supported by medical and teaching staff, to maintain physiological well-being throughout training.

More recently, the International Olympic Committee (IOC) has expanded this framework to recognize that low energy availability has consequences that extend beyond reproductive and skeletal health. This broader syndrome is termed Relative Energy Deficiency in Sport (REDs). According to the 2023 IOC consensus statement (Mountjoy et al., 2023), REDs encompasses a wide range of health and performance impairments; including metabolic, cardiovascular, immunological, and psychological consequences, resulting from a mismatch between dietary energy intake and energy expended during exercise and daily life.

Given the complexity of REDs, a multidisciplinary approach is recommended. Management often involves coordinated care from a registered dietitian, mental health professional, and physician, with careful consideration of training modifications that support recovery. For dancers, understanding and addressing REDs early is essential for sustaining long-term health and performance.

For a more comprehensive understanding of this topic, readers are encouraged to consult:

Mountjoy M, Ackerman KE, Berman S, et al. IOC consensus statement on relative energy deficiency in sport (REDs) 2023. *Br J Sports Med.* 2023;57(11):592–607.

NATURAL SOURCES OF VITAMINS AND MINERALS

Nutrient	Sources
Calcium	Yogurt, cheeses, broccoli, collards, kale, mustard greens, turnip greens, bok choy or Chinese cabbage, salmon, sardines, tofu

Vitamin D	Dairy products (cheese, butter, cream, fortified milk), fish, oysters, fortified cereals, margarine
Magnesium	Soy products (such as soy flour and tofu), legumes, seeds, nuts (such as almonds and cashews), whole grains (such as brown rice and millet), fruits and vegetables (such as bananas, dried apricots, and avocados)
Phosphorus	Meat, milk
Potassium	All meats (red meat and chicken) fish (salmon, cod, flounder, and sardines), soy products, veggie burgers, broccoli, peas, lima beans, tomatoes, potatoes (especially their skins), sweet potatoes, winter squashes, citrus fruits, cantaloupe, bananas, kiwi-fruit, prunes, and apricots (dried apricots contain more potassium than fresh apricots), milk, yogurt, nuts
Vitamin C	Green peppers, citrus fruits and juices, strawberries, tomatoes, broccoli, turnip greens and other leafy greens, sweet and white potatoes, cantaloupe, papaya, mango, watermelon, Brussels sprouts, cauliflower, cabbage, winter squash, red peppers, raspberries, blueberries, cranberries, and pineapples

Table 1: Natural Sources of Vitamins and Minerals

SUPPLEMENTATION

Dancers should be encouraged to acquire as many essential nutrients through diet as possible. However, some physicians and allied health professionals may recommend supplementation for young dancers, especially in the winter months when dancers may not be exposed to the sun as much and may be more susceptible to illness. These supplements often include multi-vitamins and minerals to “top up” any nutrients that drop below the levels recommended for dancers. Teachers who are dancers and dancing professionals over age 50 may also need additional supplementation. Anyone contemplating supplementation should seek medical advice.

PHYSICAL ACTIVITY

Bone mass increases or decreases according to the demands placed on the body. Weight-bearing exercise is thought to be protective of bone density, and early research indicated that athletes in weight-bearing sports such as dance had higher bone density than non-athletes. Although the total amount of calcium in the bones increases with exercise, muscle strength and bone mineral content in specific bones vary according to activity patterns. Generalized bone loss occurs in response to weight loss, even a moderate loss of 3 kg (6 pounds), possibly due to a combination of the reduction in mechanical strain on the skeleton and lowered nutrient availability. Excessive exercise results in weight loss and may also trigger low estrogen and loss of normal menstrual cycle. Adequate calcium intake (up to 1500 mg per day for amenorrheic athletes) must be ensured under the guidance of medical and nutrition professionals.

It is recommended that dance teachers and professionals make a concerted effort to support the health of dancers by:

- promoting healthy attitudes towards body physique;
- informing dancers of the relationship between energy intake and energy availability;
- promoting adequate nutrition and other factors benefiting bone health;
- being aware of early signs of problems with the spectrum of eating behavior, menstrual health and bone health;
- referring at-risk dancers to appropriate help;

- supporting regular medical checkups to track hormone function and the menstrual cycle; 📅
developing guidelines to support optimal health and well-being of each dancer.

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