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REVIEW ARTICLE

The effect of Chinese martial arts Tai Chi Chuan on prevention of osteoporosis: A systematic review

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Bone mineral density;
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Summary *Background/Objective:* Tai Chi Chuan (TCC) is suggested to have beneficial effects on the musculoskeletal system. The aim of this systematic review is to evaluate the evidence of the effect of TCC on bone mineral density (BMD) and its potential for prevention of osteoporosis.
Methods: A literature search was conducted using PubMed, Embase, and Cochrane databases from inception to January 2017. Randomized controlled studies, case–control trials, prospective cohort studies, and cross-sectional studies which evaluated the effect of TCC on BMD were selected without any subject or language restriction.
Results: Nine articles met the inclusion criteria, including seven randomized controlled trials (RCTs), one case–control trial (CCT), and one cross-sectional study, encompassing a total of 1222 participants. Five studies showed statistically significant improvements in BMD after TCC, three studies showed nonsignificant intergroup differences, and one study provided no statistical evaluation of results. The studies with nonsignificant results tended to have a shorter total duration of TCC practice. Apart from dual-energy X-ray absorptiometry (DXA), two studies additionally used peripheral quantitative computed tomography (pQCT) which showed statistically significant positive effects of TCC on preventing osteoporosis.
Conclusion: TCC is beneficial to BMD and may be a cost-effective and preventive measure of osteoporosis. This beneficial effect is better observed in long-term TCC practice.
The translational potential of this article: The beneficial effect of TCC on BMD is suggested to be clinically translated to its potential for early rehabilitation and prevention of secondary

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osteoporosis in patients after surgical treatment of common osteoporotic fractures. The length of practicing TCC, the form and style of TCC, and the types of patient suitable for TCC are to be investigated in future studies.

Introduction

Tai Chi Chuan (TCC), a type of meditative and mind—body exercise, mainly consists of a series of slow, relaxed, and graceful physical movements connected together in a smooth and continuous manner [1—4]. Due to the fact that TCC requires little space and equipment, participants can practice it regardless of space and financial limitation [5]. Besides, due to the simple, smooth, and low-impact nature of movements [5], TCC is suitable for most, if not all, age groups with or without previous experience in sports activities.

TCC is beneficial towards balance and coordination of the extremities, with numerous multi-directional movements and positional changes between single- and double-leg stances [6]. It has also been known to contribute to an individual's postural stability and flexibility [7—9]. TCC was also found to be better at preventing risk of falls compared with performing stretching exercises or conventional physical therapy. A randomized controlled trial conducted by Li et al. [10] discovered that TCC resulted in fewer falls. Risk of multiple falls in the TCC group was 55% lower than the stretching control group. TCC participants also made improvements in functional balance, physical performance, and reduced their fear of falling. A similar result was obtained by Tousignant et al. [6].

Evident improvement in balance, strength, and mobility immediately postintervention was discovered in a prospective pilot outcome study by Murphy and Singh [11]. Thirty-one elderly women were involved a twice weekly, 12-week intervention. The Activities-specific Balance Confidence and One-Legged Stance Test were used as determinants of balance, Repeated Chair Stands for lower body strength, and Timed Up and Go Test for functional mobility. Only strength and mobility improvements were sustained up to 12-month postintervention follow up. The weakening of balance ability mirrors the decline in regular TCC practice, thus TCC must be practiced regularly or for a longer period of time to sustain TCC-associated benefits.

TCC is also shown to be beneficial to our cardiorespiratory functions. In the study of Lan et al. [12], TCC practitioners generally had a higher peak oxygen uptake (VO_{2peak}) during the peak of exercise when compared with their counterparts who had a sedentary lifestyle, with 19% higher VO_{2peak} in the male TCC group and 18% higher VO_{2peak} in the female TCC group. Moreover, TCC is found to be beneficial to other parameters of cardiorespiratory wellness such as blood pressure and lipid profile. In the investigation conducted by Tsai et al. [13], a group of participants with high-normal blood pressure or Stage I hypertension were asked to complete a 12-week TCC training. The systolic and diastolic blood pressure, as well as total cholesterol level decreased substantially in the TCC exercise group.

Owing to the multitude of benefits gained through regular practice of TCC, millions of people worldwide are practicing TCC. In view of the growing popularity of TCC, factions such as Yang-, Chen-, Sun-, and Yin-style which aimed at promoting TCC were established, with Yang-style being the most popular. Although the factions may possess unique features and integrate different elements into their own systems, the fundamental principles of TCC remain the same [4].

Osteoporosis is defined as "a disease characterized by low bone mass and microarchitectural deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk" [14]. Osteoporosis is a major health problem on both local and global scales—one in three women over the age of 50 years worldwide will experience osteoporotic fractures [15], whereas ~300,000 postmenopausal women in Hong Kong suffered from osteoporosis, with a projected increasing trend due to the ageing population [16].

Clinically, osteoporosis is diagnosed based on bone mineral density (BMD) assessed using the dual X-ray absorptiometry (DXA) at lumbar spine, proximal femur, and distal radius, based on T-score (T-score ≤ -2.5) [17]. DXA is of high precision and low radiation dose, but only provides a two-dimensional measurement of areal BMD (aBMD) and its value however, can be affected by body size and patient positioning. Contrastingly, high-resolution peripheral quantitative CT (HR-pQCT) and three-dimensional peripheral quantitative CT (3D-pQCT) allows true measurement of volumetric BMD (vBMD) and bone microarchitecture as well [18]. BMD is a resultant of both genetic and environmental factors. Accordingly, many factors may either be beneficial for or impair the bone. The major risk factors of osteoporosis are summarized in Table 1 [19—21].

Osteoporotic fracture is defined as "a fracture disproportionate to forces it is caused by, which occurs after a fall from one's own height, excluding other causes, e.g., the pathologic fracture", and is affected by risk factors for both osteoporosis and falling itself. Regarding imaging techniques, HR-qRT might be superior to DXA in terms for fracture risk prediction as it evaluates both BMD and bone quality based on available reports. Fracture risk assessment tool (FRAX) is one of the algorithm-based methods often used in conjunction with DXA for fracture risk estimation, taking into account various clinical risk factors such secondary causes of osteoporosis [22]. However, fall risks are determined by the factors shown in Table 1 [19—21].

Pharmacological options for treatment of osteoporosis could be classified as antiresorptive and anabolic

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