Martial Arts for Health: Translating Research into Practice

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Published by **OMICS Group eBooks**

731 Gull Ave, Foster City. CA 94404, USA

Cover OMICS Group Design team

First published February, 2014

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Martial Arts for Health – Translating Research into Practice

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Introduction

Martial arts were developed for use on the battlefield in ancient times, and even in the modern world many people learn such skills for self-defense [1]. Despite their combative nature, training in marital arts is safe compared with many other contact sports. The use of protective equipment such as mouth guards and headgear is mandatory during sparring, and practitioners must follow strict competition rules in many types of martial arts [2]. In addition, some types of martial arts such as Tai Chi and Qigong are non-combative in nature, with practitioners focusing on coordinated movements and relaxation during practice – all of which are beneficial to practitioners' health [1,3].

These days, the popularity of martial arts is increasing, particularly among young people [4]. There are about 200 distinct martial arts types or disciplines around the world, each with its own training characteristics and philosophy [5]. Only the most common types of Oriental and Western martial arts and their associated health effects are introduced in this book. These martial disciplines include the internal (e.g. Tai Chi and Qigong) and external (e.g. Choy Lee Fut and Shaolin Kung Fu) Chinese martial arts, Taekwondo, Thai Boxing, Western Boxing, Wrestling and Fencing. The following paragraphs provide a brief introduction to these arts.

The Chinese Martial Arts

The Chinese martial arts are believed to be the oldest in the world and there are many different styles ranging from 'soft' to 'hard'. Most of the styles are linked to religions such as Taoism and Buddhism. Some Chinese martial arts practitioners use the yin/yang symbol to illustrate how power should be balanced with compassion and gentleness during practice, and this actually forms the foundation/training philosophy of these arts [5,6].

Taekwondo

Taekwondo, famous for its swift, high kicks, is a form of Korean martial art believed to be a modification and integration of the Japanese arts of Karate, Aikido, Judo and Kendo [6]. At present, there are two global Taekwondo organizations: the International and World Taekwondo Federations. The latter was largely responsible for the inclusion of this martial art as an Olympic sport [5].

Thai Boxing

Thai Boxing, also known as Muay Thai, is the national sport of Thailand. It is a hard-fighting martial art and its practitioners kick and punch very hard during training and competitions. In addition, punches, kicks, knee strikes and elbow strikes are allowed during matches. Although boxing gloves and groin guards are used, no other protective equipment is worn, making it one of the more dangerous of the traditional arts. More recently, a non-combat form of Thai Boxing called cardio kickboxing has been introduced in the fitness industry to improve the physical fitness of the general population [6].

Western Boxing

Boxing is a common combat sport in the West and was first accepted as an Olympic sport in 688 BCE. Boxers fight each other using various combinations of punching techniques [5]. It is similar to Thai Boxing, except that kicks, knee strikes and elbow strikes are not allowed during matches. There are two basic forms of Western boxing: amateur and professional. Only amateur boxers can compete in the Olympic Games while only professional boxers can fight for money prizes [7].

Wrestling

Wrestling is a grappling art commonly practiced at universities, colleges, high schools and middle schools in the United States. Emphasis is placed on learning how to control your opponent rather than executing explosive offensive techniques. During a match, a wrestler tries to pin down his opponent to score. This is a quite strenuous activity as the competitors are in constant motion. Bouts usually comprise three rounds [5].

Fencing

Fencing generally refers to the European style of swordsmanship and is now an Olympic sport. Olympic fencing uses an electronic scoring system to register the competitors' scores and determine the winner. To score a point, competitors must touch their opponent with the sword in a specific area. Fencing is a game of subtlety [5].

Who should read this book?

As mentioned above, each martial arts discipline has its own training characteristics and philosophy. Apart from a physical workout, some disciplines also emphasize spirituality. Therefore, the physical and psychological health benefits induced by martial arts training are undoubtedly discipline-specific [5,8]. This book provides an overview of the differential effects that practicing martial arts has on the practitioners' health. Parents and the general population should choose martial arts to suit their own or their children's needs. Coaches and instructors in the fitness industry have some scientific evidence for promoting health through martial arts exercises. Health care professionals may wish to consider recommending martial arts to patients as a form of therapeutic exercise. Thus, the information provided in this book is useful for people of all ages and fitness levels from all walks of life.

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Internal Chinese Martial Arts and Health - Tai Chi

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A Brief Introduction to Tai Chi

The concept of Tai Chi existed long before the establishment of *Tai Chi Chuan*. The term "Tai Chi" firstly appeared in the *Book of Yi*, a book on Chinese philosophy from over 3,000 years ago during the Zhou dynasty (1100–1221 BC). It recounts Tai Chi's splitting from one point into two extremities, or "poles". By that account, all change exists as a result of Tai Chi, which generates two opposites in everything. *Tai* in Chinese means "vast and all-encompassing", while *Chi* is "the ultimate or extreme point"[1], thus the concept of Tai Chi ("supreme ultimate"), in contrast with *wuji* ("without ultimate") which describes the vastness of the universe. Tai Chi's idea of opposites influenced early traditional Chinese philosophies, including those of Taoism, Confucianism, yin/yang theory and the meridians of traditional Chinese medicine.

The essential principles of Tai Chi are based on Taoist philosophy, which stresses the natural balance in all things and the need for living in spiritual and physical accord with the patterns of nature. According to this philosophy, everything is composed of opposites, but they are entirely complementary. The elements of yin and yang work in a relationship which is in perpetual balance. Based on Taoism, change originates in the Ultimate, which generated the two spheres—Yin and Yang. Afterwards, all things and all creatures were created. The sage used this theory to manage the flow of *qi* in the universe, including the circulation of the sun and the moon and other natural phenomena, all of which follow the motion of the universe. The sage taught people how to cultivate crops in their proper seasons and transmitted other vital knowledge to the people. Meanwhile, there is also a miniature aura inside and surrounding each person's body that moves with the rhythm of the universe. The head is as round as heaven; the feet are as square as the earth; the temperature of the abdomen is as warm as the spring and summer; the back is as hard as the autumn and winter. As the four seasons change with time, the five internal organs of the body and the five normal human relationships in the Chinese ethical tradition all respond to the concept of the five elements, the 24 hours in a day, the 12 months in a year, the 360 solar terms in a traditional Chinese year. The entire concept emphasizes living with the motion and rhythm of the universe.

Tai Chi Chuan

Tai Chi Chuan (TCC) (also spelled *Taijiquan* or *Tai Chi Quan*) is a martial art which has been practiced in oriental societies for many centuries. In English it is referred to simply as Tai Chi, the real origins of TCC are obscure. The more romantic and mystical accounts date back as far as the 15th, 12th or even the 8th century. Some prominent names are said to have been involved in its foundation. One is Chang San-Feng, a 13th century Taoist priest who is credited with developing an esoteric system combining techniques from various pre-existing styles of martial arts with Taoist breathing techniques. Nowadays, most styles of TCC claim Chang San-Feng as the founder.

Although it is not possible to identify precisely when TCC was created or by whom, it was developed using theories of Chinese philosophy like "the interchangeability of yin and yang" and taking into account the principles of body movement as well as breathing. A Tai Chi routine consists of a set patter of continuous movement involving between 82 and 150 postures, all regulated by yin/yang theory. The entire set of movements should be gentle, continuous, circular and harmonious, accompanied by deep and regular breathing when executed.

Tai Chi has developed over the centuries into many different styles, most bearing the family names of their originators. Most modern styles trace their developments to at least one of five traditional styles:

Chen style

Chen Wang-Ting (1600–1680), an army officer of the Ming dynasty, was deeply influenced by boxing techniques, particularly the style of Qi Ji-Guang. He selected 29 from among Qi's 32 boxing postures and combined them with control of breathing to develop several Tai Chi protocols including Five Routine TCC, 108 Form Long Fist and a more rigorous routine known as Cannon Fist. The Chen styles are characterized by including a motion termed Silk Reeling-slow and soft movements intermixed with bursts of power. Chen style is rich with combat techniques, which makes it more practical and effective for combat.

Yang style

Yang style is the most popular and most widely practiced worldwide today. Yang Lu-Shen (1799–1872) created Yang style in the early 19th century. As a youth, Yang loved martial arts and studied with many famous masters, including Chen Chang-Hsing, who was a very influential martial artist and teacher of TCC at that time. Yang eventually developed three major styles of TCC. Yang's styles are characterized by gentle, steady and slow movements, but still maintain certain the martial arts overtones. Yang and his descendants have made TCC more suitable for the general public and for promoting general health.

Wu (Hao) style

Wu style, also known as Hao style, was created by Wu Yuxiang (1812–1880) and passed on to Hao Weizheng (1849–1920), who significantly contributed to the style's development. This style is characterized by slow and internally loose movements which are close-knit in outward appearance. Great emphasis is placed on internal force and correct positioning. The motions of an expert performing the Hao style appear large and well rounded, as though inner power were projected beyond the outward physical shape of the body.

Wu style

Wu Quan-you (1834–1902), and later his son Wu Jian-quan (1870–1942), created another Wu style (homophones distinguished by different Chinese characters), which is characterized by softness and emphasis on redirecting incoming force. It has rich hand techniques. Wu style tends to have a slight forward leaning posture. The style is pleasant to look at and is rich in techniques.

Sun style

Sun style is the youngest of the major styles. It was created by Sun Lu-tang (1861–1932), a student of Hao Wei-zheng. Sun style is characterized by agile steps. Whenever one foot moves forward or backward, the other foot follows. Its movements flow smoothly like a river, and there is a powerful *qigong* exercise whenever the direction changes.

Tai Chi in all styles can be practiced easily without equipment. It is easily taught in groups or to individuals and regular practice is thought to facilitate a lifestyle which promotes wellness among both young and old. Practice of Tai Chi is intended to balance and soothe the emotions while strengthening the body.

Tai Chi Fundamentals

Yin and yang

According to the concept of yin and yang, all phenomena are shaped by the interaction of two opposite cosmic energies termed yin and yang. Yin represents the negative, the dark and the feminine, while yang is bright, positive and masculine. Their interaction is thought to maintain the harmony of the universe and to influence everything within it. Yin and yang are the roots of creation and at the root of all things in the world. The well-known circle divided into two equal halves by a curved line symbolizes yin and yang (Figure 1) and is also used to describe Tai Chi. One half is black (yin) and the other white (yang). The white dot in the black area and the black dot in the white area represent the coexistence and unity of the opposites which form the whole. The curved line in the symbol suggests that there is no absolute separation of the opposites. Apart from Tai Chi, the symbol represents how yin and yang relate to the dual nature of everything in this world, and to duality, paradox, unity in diversity, flexibility and harmony [2].

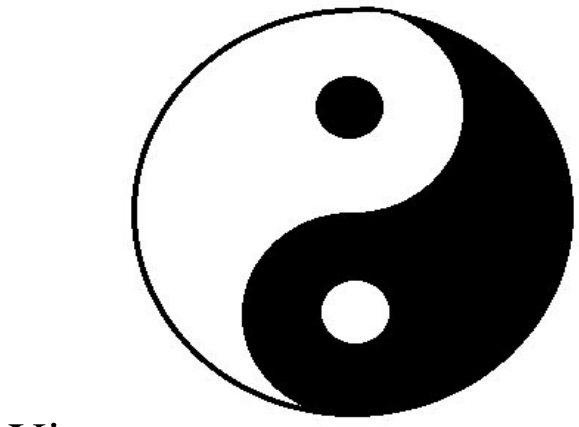

Figure 1: Yin and Yang.

As Chang San-feng explained in his *Treatise on Tai Chi Chuan*, "The inherent energy or potential of action (movement) and inaction (serenity and stillness) is the mother of yin and yang." Yin and yang have no absolute beginning, so action and inaction in TCC also do not have a beginning. Tai Chi provides the inherent energy needed to promote yin and yang to react each other. The root of yang is tin and the root of tin is yang. The same principle can be observed during TCC exercises-the movement and stillness have the same origin. We seek serenity and stillness in action, while seeking motion in stillness. Stillness and movement are opposites, and their relationship in Tai Chi can be explained in terms of yin/yang theory. Movements are up and down, forward and backward, left and right. The opposite of motion is stillness. In all this, yin and yang coexist. Therefore, there is neither absolute stillness nor movement in TCC. When there is apparent stillness and no action, there is still action within the body-controlled breathing and the movement of *qi*.

Coordinated breathing

In Tai Chi, proper breathing is an important element of technique. Breathing should be deep, slow, abdominal and well-regulated. This is important because the mind should concentrate with the head held upright, allowing the spirit to rise to the top of the head. At the same time, energy should move down the body's dan tien meridian, so the back should be straight even as it deviates from the vertical. The abdomen should be full of qi. The chest must be relaxed so the breathing will be smooth, slow and deep. This abdominal breathing should be a natural and not a forced expansion of the abdomen. All movement and stillness in TCC should be combined with a natural breathing rhythm. Inhale, for example, while raising the left foot and stepping to the side, exhaling when placing it down again. Inhale while raising the arms, a yin movement, then exhaling while extending them and opening the palms, a yang movement coupled with a yang exhalation.

Every movement in Tai Chi is dictated by the waist; the waist is said to be the leader of the body. It should be relaxed and loose, allowing the legs to provide a solid foundation for the rest of the body as it releases power. The waist is the primary storage site for all vital energy. Movements may lack force or power if there is weakness in the waist and legs. A leg bearing the body's weight is termed "solid". If one leg bears the body's weight, that leg is solid, while the other is termed "empty".

In Tai Chi, outward, opening movements are described as the internal directing the external. Internal strength is transferred and expressed in the motion. Inward movements are the external leading the internal. They guide the proper breathing, thus inducing internal exercise and the storage of internal strength. One opening movement and one closing movement accompanied by one exhalation and one inhalation complete one respiratory cycle.

Smoothness and continuity

All Tai Chi routines begin with stillness. The individual starts not with muscular force, but with inner energy and concentration. All TCC movements are then performed with control of the inner force. This allows performing the routine in a smooth, relaxed way which will lessen tension and promote relaxation, which will in turn help concentration and clear thinking. That is the main characteristic distinguishing TCC from other martial arts. There is smooth constant motion like a flowing fluid. This means that the movement of the feet and hands must be perfectly coordinated throughout. The hand movements must finish simultaneously with the shifting of the weight from one leg to the other.

Concentration

As has been discussed, stillness and movement coexist in TTC as yin and yang coexist in the universe. While performing the actions of a Tai Chi routine, seeking serenity (stillness) is a requirement. Action allows the mind to retreat into tranquility, because it is fully concentrated on one thing. Concentration on the routine means the mind is untouched by any other thought and becomes totally absorbed by stillness in movement. Performing TTC this way will lead to peace and serenity. Many researchers have reported that TTC training helps cultivate the habit of seeking a peaceful and calm mind, which can alleviate high blood pressure. Practice can become a vehicle for meditation and relaxation, promoting spiritual well-being [3]. This can have significant health effects.

In summary, TCC not only teaches how to move, it emphasizes the principles of collaborating with nature and the universe. Practicing TCC allows individuals to be calm and balanced, in addition to strengthening the physique. When people start to practice TCC, they already start to live harmoniously with the universe.

Bio-physiological Effects of Tai Chi

TCC has long been practiced worldwide for its health benefits and in an effort to extend the life span [4]. In addition to being a form of therapy for many diseases including traumatic brain injury, rheumatoid arthritis, diabetes and cancer, TCC could also a preventative measure.

Neuro-rehabilitation

Stroke leaves many survivors with mental and/or physical disabilities. Similarly, injuries to the brain and common neural disorders such as Parkinson's disease will lead to the loss of balance control. Rehabilitation aims to hasten and maximize recovery and help restore movement and functional independence, leading to reintegration into community life.

Prospective controlled clinical trials have shown positive effects among stroke survivors with neural patients who practice Tai Chi. Practice can improve balance control, mental health and general quality of life. Gatty and Woollacott [5] have suggested that TCC practice might enhance neuromuscular responses, control of the ankle joints and balance by drilling neuromuscular mechanisms and stepping with a swinging leg. Their research employed repetitive exercises using TCC motor and biomechanical strategies, techniques, and postural elements. The results showed that balance-impaired older adults significantly improved their neuromuscular control of the ankle muscles during perturbed walking, with responses up to 50 milliseconds faster than before training. Reduced co-contraction of agonist and antagonist muscles and better muscle response organization were also found in those peoples who had received TCC training. Significant improvements on four clinical measures of functional balance were also found—functional reach, one-legged stance time, tandem stance time and the timed up and go test.

In addition to physical disability, stroke often leaves survivors with mental problems including memory loss, depression, disturbed sleep and cognitive deficits [6]. A study conducted by Taylor-Piliae [7] enrolled 28 subjects who were at least three months post-stroke and divided them into 2 groups. One attended group classes in Yang style TCC three times a week for 12 weeks, while the other received weekly phone calls along with written materials promoting community-based physical activity. The findings indicated that practicing Tai Chi tended to improve physical health, mental health, depression, and sleep quality.

Most studies [4,5,8–10] have focused on evaluating the physical and mental balance of stroke survivors, and most have revealed significant differences between the Tai Chi group and the control group. The alternating weight shifting and the concentration seem to provide useful training for the nervous system, the skeletal muscles and the joints, promoting more flexible, balanced and harmonious movements. TCC may be useful as an effective group therapy in stroke rehabilitation and for the prevention of falls among the elderly.

Cardiovascular rehabilitation

An ample number of studies have considered TCC as an effective aerobic exercise, demonstrating that TTC has potential benefits for patients with cardiovascular diseases. Aerobic exercise engages the major muscle groups so respiration increases and the heart rate rises to between 50 and 80 percent of its (age–related) maximum [11]. The duration of exercise at this level should be a minimum of 20 minutes and up to 60 minutes in order to achieve cardiovascular benefit. The exercise intensity of TCC is low to moderate, depending on the training style, posture and duration. For example, in the classic Yang style with 108 postures, a training session typically consists of 20 minutes of warm up (low back and hamstring stretching, gentle calisthenics and balance training), 24 minutes of practice, and 10 minutes of cooling down. The intensity would not normally exceed 55% of maximum oxygen intake [12], and 56% to 70% of maximum heart rate [12-14]. Intensity is similar across different ages for each gender.

Chang has shown a six-month cardiac rehabilitation program based on TCC is associated with improvements in the product of peak

heart rate and blood pressure and in reserve peak rate-blood pressure product among patients with coronary artery disease (CAD). A TCC exercise program can lead to a better prognosis for cardiac events among such patients [15]. A decrease in systolic blood pressure of 15.6 mm Hg and in diastolic blood pressure of 8.8 mm Hg has been observed after 12 weeks of Tai Chi training [14]. Serum total cholesterol decreased to 15.2 mg/dL and high-density lipoprotein cholesterol increased to 4.7 mg/dL. Liu has suggested that TCC exercise might be an effective alternative to the traditional fitness training for patients who are in phase II and III cardiac rehabilitation programs because of its positive effects on the cardiovascular and musculoskeletal systems [16]. Various studies have documented TCC's positive effects on the physiological functioning and quality of life (QoL) of patients with heart disease.

Cancer rehabilitation

Cancer is a leading cause of death worldwide. In Hong Kong, altogether 26,390 new cancer cases and 13,076 deaths were registered in 2010 [17]. Surgery, radiotherapy, and chemotherapy are traditional treatments for cancer patients. Radiotherapy and chemotherapy eradicate tumor cells, restricting their ability to grow or reproduce. Traditional treatment that destroys cancerous cells is not without side effects such as anemia, nausea, vomiting or diarrhea. Use of complementary therapies to alleviate the side effects of cancer therapy has been steadily increasing over the past decade [18,19]. Cancer survivors have multiple needs related to physical deconditioning, cardiovascular disease risk, and psychological stress. TCC may be a form of complementary therapy which can provide physiological and psychological benefits to cancer survivors.

Besides its important role in improving the cardiovascular system, the relaxation, deep and regulated breathing and slow movements of TCC may have additional benefits for the psychological health and symptoms of cancer patients. Currently, psychosocial support is widely accepted as important for enhancing their self-esteem and health related quality of life (HRQL) [20-23]. HRQL comprises psychological functioning, social adjustment, functional ability, and disease and treatment-related symptoms. Mustian's research group compared the efficacy of TCC and psychosocial support therapy for improving HRQL and self-esteem among breast cancer survivors [20]. In that study, women diagnosed with breast cancer, who had completed treatment within the previous 30 months, were randomized to receive either 12 weeks of TCC or just psychosocial support. The results showed that the TCC group exhibited improvements in HRQL and self-esteem while the psychosocial support therapy group exhibited declines. Similar improvements in HRQL have been found in other research [21] along with improvements in physical functioning, role limitations, social functioning and general mental health.

The study team led by Fong has demonstrated TC Qigong's ability to improve shoulder mobility, muscular strength and the overall quality of life of breast cancer patients who had received a mastectomy and chemotherapy and/or radiation [22]. This study involved practicing 18 Forms Tai Chi Internal *Qigong* over a period of at least six months. Good shoulder rotation is vital for many everyday activities, but breast cancer patients may experience weakened shoulder internal rotators after a mastectomy due to pectoral nerve damage in the surgery, affecting their QoL [20–26]. Fong's group found that breast cancer patients who practiced Tai Chi *qigong* were able to develop significantly greater isokinetic peak torque with their shoulder internal and external rotator muscles than those control subjects. They also recorded significantly better QoL scores, particularly in terms of functional well-being. Self-assessed FACT-B subscale ratings also showed that Tai Chi *qigong* training was associated with less worry about the disease [22].

Cancer and its treatments tend to impair QoL by creating inflammation, as indicated by metabolic biomarkers. TTC training might contribute to improving QoL through its effect on inflammatory biomarkers such as IL-6 and IL-8 [21]. It has been reported that the ratio of T helper to suppressor cells (CD4:CD8) increases significantly with regular TCC exercise. Following a 12-week schedule of TCC training, production of the regulatory T cell mediators which are responsible for transforming growth factor b and interleukin 10 under specific antigen stimulation (varicella zoster virus) also showed a significant increase [27]. Another study [28] has shown that TCC training can help stabilize insulin levels within the normal range over 12 weeks of practice. As with breast cancer patients, the physical activity component of TCC may reduce inflammation through the release of IL-6, promoting anti-inflammatory processes and lowering insulin and IGF levels. That would help maintain normal cell proliferation, and a healthy body weight, perhaps inhibiting cancer recurrence.

In summary, TCC is a safe, and it has demonstrated a potential to improve the aerobic capacity, muscular strength and quality of life of cancer patients.

Psychological Effects of Tai Chi

Exercise at low or moderate intensity has been shown to bring positive effects on the quality of life of different populations. TCC and *qigong* (similar to TCC), as mind-body exercises, have also proven beneficial to psychological well-being. Unlike aerobic or resistance exercise, they emphasize relaxation, concentration and focus. These characteristics might potentially promote psychological health. Scientific research concerning the psychological effects of TCC and *qigong* has dealt with emotional well-being, self-perception, bodily well-being, general perceptions of health and perceived social support.

Depression, anxiety, stress, tension and anger all compromise perceptions of emotional well-being. Scientific studies have addressed the effect of TCC and *qigong* practice on all of these items. TCC or *qigong* training has been shown to alleviate depression in healthy university students [29], adults [30], the frail elderly [31], wheelchair-bounded nursing home residents [32] and the elderly [33,34]. One or the other has been shown to improve burnout symptoms [35], sleep disorder [36], fibromyalgia [37–39] and diabetes mellitus (DM) [40,41]. In other studies, however, TCC was not more effective in reducing depression than playing mahjong [42], hydrotherapy [43] or other balance training [44].

TCC training has been shown to decrease anxiety in populations with clinical symptoms, including patients with fibromyalgia [38], human immunodeficiency (HIV) [45] and others in distress [46]. It also reduced significantly the anxiety of adolescents with attention deficit hyperactivity disorder [47] and adults at risk of cardiovascular disease [48,49]. TCC is not appropriate, however, for reducing depression in those with dementia [42]. Because they have difficulty learning TCC routines [50], which requires memorizing forms and sequences. Similar studies testing for any effect of *qigong* have not produced statistically significant improvements.

Reduced stress level have been found after TCC or *qigong* in healthy adults [51], students [29,52], hospital staff [53], distressed adults [46], patients with DM [40,41], female population [54,55], or osteoarthritis (OA) [56]. Brown and his colleagues have also found that TCC significantly promoted psychological well-being among females, but not among their male counterparts interestingly [30].

On the other hand, other studies have found no significant impact on stress level. Fransen and colleagues found no significant

improvement after 12 weeks of Sun style TCC among patients with OA [43]. Though this was contradicted by the results of another study employing the same Tai Chi form and similar training dosage, it is involving only female OA patients [56]. The difference is hard to explain because Fransen's team did not analyze their data separately by gender. Lee and colleagues found no improvement in stress level among junior secondary school students after practicing Chen style Tai Chi for 10 weeks [57]. The students focused on memorizing the movements and sequence, which might have increased perceived stress at the beginning of the training.

Again, two other studies have found no significant effect of 6 weeks of *qigong* training among computer users [58,59]. The short intervention period could be the reason.

Better mood and reduced anger and tension have also been demonstrated after practicing TCC [30]. Significant effects on mood and tension have been demonstrated with HIV patients [45]. Better mood was also achieved by students [60] and patients with chronic heart disease [61]. Lower anger levels have also been found in distressed adults after TCC exercise [46] and among wheelchair-bounded nursing home residents after *qigong* training [32].

Both TCC and *qigong* practice are effective in promoting self-esteem [62] and self-perceptions of efficacy among the elderly and patients with different medical or psychological illnesses [31,63]. Both exercises have demonstrated clinical efficacy for adults at high risk of cardiovascular disease [48] and among those with chronic heart failure [61], fibromyalgia [38,39] or breast cancer [64]. They have also proved effective with the depressed elderly [34] and those suffering from burnout [35]. Healthy young adults, however, do not benefit significantly [52,60,65] in these respects.

Bodily well-being is an area less well studied than emotional well-being and self-perceptions. Significant fatigue reduction has been found in patients with fibromyalgia [38], sleep disorders [36] or burnout [35], but not among female cancer patients [55]. Either TCC or *qigong* training has been found to improve the perceived quality of sleep among university students [60], nursing home residents [32], women with chronic fatigue symptoms [66] and patients with fibromyalgia [39]. TCC has been adjudged superior to low intensity exercise for the elderly with sleeping problems [36], there no significant effect was found among healthy hospital staff [53]. A short intervention period is a possible explanation.

Perceived quality of life is commonly assessed using the SF-36 health status survey or its short version, SF-12. Both assessments are composed of 2 subscales: physical health status and mental health status. Scores on both components have been found to improve significantly after either TCC or *qigong* training for nursing home residents [62], elderly persons with sleeping problems [66], OA patients [23] and those with fibromyalgia [39]. Mental health status, but not physical health status, has been improved in burnout [35] and DM patients [40] after *qigong* training and vice versa for the depressed elderly after TCC training [33]. In addition, some other studies have shown improvement in sub-items of the SF-36 [49,53,65,67–69].

TCC and *qigong* have less effect on perceptions of social support from family and friends. Lee and colleagues concluded that the group practice resulted in a lack of interaction between the Tai Chi instructor and the students [63], many of whom may have belonged to other social support groups [70]. Positive results were found, nevertheless, among adults with cardiovascular risk after practicing TCC [48].

Many explanations have been proposed for the observed positive effects of TCC and *qigong* training. Both encourage deep breathing and being relaxed and calm. Practitioners should also focus on their own movement and eliminate all unrelated thoughts during the exercise. These factors might contribute to reducing anxiety, depression and stress [48,71]. Moreover, cortisol is released when one experiences acute stress [72] and Jin has shown that salivary cortisol was decreased in experienced TCC practitioners after a stressful event [73]. Smaller cortisol level increases after the Trier Social Stress Test were also found in healthy adults with only 12 weeks of TCC training compared with matched controls [51]. Decreased salivary cortisol level was also evident after *qigong* training [29]. As there is an increase in cortisol release when one experiences acute stress [72], results of these studies, thus, supported the stress reduction effect of TCC and *qigong* exercise.

Taylor-Pilar and colleagues attributed the improvement in self-perceptions of efficacy to the progressive learning and the slow movements of TCC and *qigong* [48]. Another study by Tsang and his team have found a significant correlation between depression and efficacy self-perceptions such that improved self-perceptions after learning *qigong* contributed to a decreased level of depression [34]. An activated sympathetic nervous system is one of the causes of chronic insomnia in older adults, and Irwin and colleagues have suggested that decreased sympathetic output after TCC training is related to a better sleep quality [36]. There is evidence that parasympathetic activity is heightened while sympathetic activity is suppressed in healthy adults [74] and in older adults [75], but further investigation is needed as no direct relationship between TCC training, sleep quality and activation of the sympathetic nervous system has been shown with different populations.

In summary, despite of the different population groups, exercise dosage, types of TCC and qigong, and the different outcome measurements employed, the majority of studies have support the existence of psychological benefits from TCC or *qigong* training.

Balance Control

The effects of TCC practice on balance have been studied extensively since the 1990s. Kutner and colleagues have demonstrated that after 15 weeks of training, TCC practice can changes one's perception of balance control more effectively than receiving conventional balance training [76]. In 1997, Wolf's group compared TCC exercise with computerized balance training for improving the postural control of older adults. After exercising twice a week for 15 weeks, the participants in their TCC group reported less fear of falling and demonstrated a delayed onset of falls [77]. In a cross-sectional study, elderly TCC practitioners have shown significantly better balance confidence than those of age-matched controls when engaging in daily activities [78]. An intervention trial studied the effects of Tai Chi training on frail adults 70–97 years old. After 48 weeks of training, their average balance score was significantly higher than that of controls, indicating decreased fear [79].

Static single-leg standing tests have been widely used in TCC studies. Standing time has been shown to be strongly related to the incidence of falls among the elderly, and Tai Chi routines include lots of single leg standing, so single-leg standing studies of TCC tend to give conclusive results. In a cross-sectional study, Tse and Bailey found that elderly TCC practitioners (with more than a year of recent experience) had significantly longer single-leg standing times on both legs with their eyes open than matched controls [80]. Hong's group similarly found that TCC practitioners achieved significantly longer single-leg standing times than control subjects with their eyes closed.

Their TCC practitioners had an average of 10 years of Tai Chi experience [81]. Schaller conducted a 10-week Tai Chi intervention with 24 older adults and found that their average single-leg standing time improved more than 50% whereas that of the controls decreased 2% [82]. Another study of arthritic older women found that after 12 weeks of TCC training their average single-leg standing time had increased significantly. Their symptoms and physical functioning improved as well [83]. A group led by Li subsequently demonstrated that 6 months of TCC training improves single-leg standing time significantly more than simply stretching [84].

Studies using a sensory organization test have shown that fallers sway significantly more when standing on a force plate in an environment designed to deliver conflicting sensory cues. A group led by Wong compared 25 elderly TCC practitioners with 14 healthy controls and found no difference in their average static postural control under normal conditions, but when standing on a sway-referenced surface with their eyes closed or in a swaying visual surround, the TCC practitioners swayed significantly less than the control subjects [85]. Similar results were found in a study by Tsang and Hui-Chan. TCC practitioners had better balance control under conditions that relied on vision and the vestibular system, and their balance performance could even be comparable to that of young, healthy control subjects [86]. A prospective study by the same research group found that after 2 months of intensive TCC training, the average vestibular ratio was 22% greater than that of a control group which received only wellness education [87], while in another study with 6 months of training the average ratio increased by 47% compared with the control subjects [88].

The limits of stability test is a dynamic postural test that assesses subjects' voluntary weight shifting in different directions within their base of support and their ability to briefly maintain stability in those positions [89]. A force plate records the displacement of the subject's center of pressure during intentional weight shifting. Conventionally, the subject's reaction time, maximum excursion and directional control are measured to reflect dynamic balance performance. Studies have shown that elderly TCC practitioners can react faster, can lean farther without losing their balance and can maintain better control of their leaning trajectory than matched controls. Indeed, their maximum excursions and directional control are comparable with those of young, healthy control subjects [87]. In a prospective study, after 1.5 hours of Tai Chi training in 6 sessions per week for 4 weeks, the trainees had improved control of their leaning trajectory significantly and to the point that their performance was comparable to that of TCC practitioners with 10 years of experience. The improved balance persisted for up to 4 weeks after the training had stopped [90].

Perturbed single-leg standing is a comparatively challenging test of balance. It is based on the idea that falls rarely happen from double-leg stance and that in daily life people are often called upon to stand on an unstable platform. TCC movements involve a lot of single-leg standing which the participants must practice in a closed kinetic chain. The leg muscles are required to co-contract in order to stabilize and maintain balance in such postures. Increased muscle strength in the lower limbs facilitates better balance in single-leg standing, and a study by Tsang and Hui-Chan [78] has shown that the benefits extend to dynamic conditions. They measured their subjects' muscle strength and their control of body sway angle during single-leg stance on a moving platform and found that TCC practitioners displayed less anteroposterior body sway than their counterparts. Muscle strength around the knee was negatively correlated with body sway angle in the perturbed single leg standing tests.

Tse and Bailey found that experienced TCC practitioners took significantly more steps in a tandem walking test than non-practitioners [80]. However, in some interventional studies TCC practitioners have demonstrated no faster 8-meter walking velocity [91] and their time to complete a 50-meter walk was similar to that of controls [92]. These results may be explained by the short duration of those intervention studies and the slow speed of TCC movements. In a randomized and controlled trial, 256 physically inactive, community-dwelling adults aged 70 to 92 years were taught either TCC or stretching exercises 3 times a week for 6 months. The TCC subjects improved their Berg Balance Scale scores, dynamic gait index values and functional reach significantly more than the stretching group [84].

In summary, practicing TCC has been shown to improve balance control, especially for older adults. The intensive training program Tsang and Hui-Chan adopted improved balance performance in just 4 weeks [90]. TCC is a mind-body exercise and its practice is thought to involve a close relationship between the cognitive and physical elements. A natural question is whether Tai Chi practice can benefit both mind and body simultaneously. Recent evidence has begun to show some such interaction in community-dwelling older adults. Employing a dual-task protocol, subjects were asked to step down of a step with and without having a concurrent auditory response task to perform [93]. Elderly Tai Chi practitioners showed better postural stability after stepping down as well as better performance in the selective attention test than healthy controls. The better performance that is manifested by dual cognitive-motor task performance may point to the benefits of Tai Chi being a mind-body exercise. However, that was only a cross-sectional study. A randomized clinical trial should be conducted in the future.

Conclusions

Tai Chi's characteristics of yin/yang, coordinated breathing, smoothness, continuity and concentration attract millions of people around the world practicing it. With recent scientific investigations, its therapeutic values are gradually revealed. In this chapter, the bio-physiological and psychological effects of Tai Chi to different patients' groups are described. Phenomenological evidence shows that Tai Chi practice can have positive effect to a variety of pathological conditions. However, the underlying mechanism of how Tai Chi works will be the next phase of investigation.

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External Chinese Martial Arts and Health

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Abstract

Martial art which includes a series of disciplines, schools and traditions is originated in China. Nowadays, it has become one of the world famous sports. This article will firstly give an introduction about Kung Fu (martial art) and distinguish between the "external/ hard" style Kung Fu and the "internal/soft" style Kung Fu, followed by highlight some of the characteristics that make external/ hard style Kung Fu unique. After reviewing the health benefits, including the physical, mental, and social benefits of external/ hard style Kung Fu, the author then give some basic ideas on training principles of external/ hard style Kung Fu and the recommendations on designing effective external/ hard style Kung Fu training programs.

Keywords

Chinese martial art;Hard styles martial art; Kung Fu;Mental; Physical;Social benefits

Introduction of Chinese Martial Arts

Martial art is body, mind, and spiritual practices that originated in China and it has a history of thousands of years [1], it was first developed to defend oneself from physical threat [2]. According to Chow & Spangler, martial art was developed out of the necessity of the Chinese people to defend themselves from the harms of nature and attacks of other human [3].

Martial art is a general term that includes a series of disciplines and there are about 200 of them, each discipline has specific schools called styles or systems, which have their own traditions of training and philosophy [2]. Unfortunately, many of them no longer exist nowadays because: (a) the core principles of some disciplines have not been systematically organized and recorded; (b) some disciplines are conservative and the master will only teach secretly; (c) some master passed on the higher-level skills only to the best students with good moral constitution [4].

However, some of the Chinese martial arts are still famous and there are numerous martial art schools worldwide [5]. Today, martial art is studied not only for self-defense, but also for sports, fitness, combat skills, meditation, character development, self-confidence [2] and treated as an alternative therapy for some medical conditions [6]. A study among member countries of the European Physical Education Association (EUPEA) indicated that martial art is introduced during physical education classes in secondary schools in most countries [7], whilst it is the third most prevalent non-team sport for youth in Australia, after swimming and tennis [8].

Today, the term "martial art" not only refers to the Chinese traditional one, but also others like Judo and Karate from Japan, Taekwondo from Korea, boxing and wrestling from the Western countries [9]. In this article, the author refers the "Chinese martial art" to "Kung Fu" and it is interchangeable with the term "Wu Shu" in China.

Distinguish between "External/Hard" and "Internal/Soft" Style of Kung Fu

Traditional styles of Chinese martial art can be categorized into "external/hard" or "internal/soft" styles, and there are many different classifying systems. Weiser et al. defined soft style Kung Fu as those emphasize philosophy and meditation, while hard style as those emphasize competition and combat [10]. On the other hand, Brudnak et al. defined soft style Kung Fu as those based on redirecting the opponent's energy/attack and using less powerful punches and kicks, such as Tai Chi Chuan; while the hard style one based on using powerful blocks and punches that can crush bones or body parts of an enemy [11]. Similarly, O'Donovan et al. (2006) classified rigid stances, powerful strikes and meeting hostility with speed, power and a proactive approach as hard style Kung Fu; while slow with soft and evasive techniques which meet aggression with subtle redirection as soft style [12].

Another classification of Kung Fu disciplines incorporates a certain proportion of hard and soft elements. For example, Wing Chun is a type of Kung Fu which incorporates both hard and soft elements. Due to the complex classification system, the author simply distinguishes the two styles based on the presence or absence of internal energy, the "qi", in this article. Soft style Kung Fu is defined as those incorporate breathing control or training and utilization of internal energy; while the hard style does not. Tai Chi Chuan, Qi Gong and other soft style Kung Fu are excluded in this article.

What Makes External/Hard Style Kung Fu Different from Other Types of Sports/Exercises?

Kung Fu not only focuses on physical but also mental, cognitive and spiritual aspects. Focusing not only the skills, martial art also emphasizes mindset and philosophy, including the inner feelings and overall fighting spirit of the practitioners [4]. Traditional martial arts schools often incorporate mental or meditative training into their practice to encourage positive personal transformation [13], and many researchers have proved the psycho-social benefits of Kung Fu [10,13,14].

As mentioned, Kung Fu is originated and developed as a mean of self-defense, which is different from other sports which are designed for health, fitness, recreation and competition. Along with the health benefits, Kung Fu becomes an enjoyable alternative to "traditional exercise" and offers unique opportunities to learn self-defense and new skills in a group setting [13]. Nevertheless, the benefits of Kung Fu is not as immediate as other exercises such as weight lifting and running, rather, it is a complex and long term process which progresses slowly [10]. It requires long term commitment, aims to become a way of life [15] and there is no short cut.

Health Benefits of External/Hard Style Kung Fu

According to the World Health Organization (2003), "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [16], encouragingly, many studies have proved the health benefits of practicing Kung Fu in physical, mental and social aspects, such as increasing anaerobic capacity [17], muscle strength [12], balance [18], flexibility [19], self-confidence, mood [13,14], responsibility, honesty and communication [10]. These benefits are applicable to anyone with appropriate Kung Fu training (which will be discussed later), but are not limited to young people, although they are the majority in Kung Fu training. Douris et al. showed that Kung Fu training improved the aerobic capacity, balance and strength in middle-aged participants [19] while Brudnak et al. revealed improvement in the strength of trunk flexion and balance among elderly participants [11]. The health benefits of hard style Kung Fu are categorized into the following sections: (a) cardiovascular/aerobic fitness; (b) body composition; (c) muscle mass, muscle strength and movement speed; (d) other physical benefits; (e) mental health benefits; and (f) social benefits.

Cardiovascular/aerobic fitness

Is hard style Kung Fu training a kind of aerobic exercise? A systematic review showed that the "forms training" (will be discussed later) of Kung Fu is in moderate or vigorous aerobic intensity, depending on the disciplines [20]. Many studies demonstrated the aerobic training effects of forms training [17,21-23]. For example, Stricevic et al. concluded that the cardiovascular fitness could be improved by participating in three to four training sessions per week [24]. However, Zhuo et al. concluded that Tai Chi Chuan (a soft style Kung Fu) was a moderately intense exercise and not strenuous enough for healthy young adults to improve their aerobic fitness [25].

Still, Kung Fu training needs to follow the principles of aerobic training which involve large muscle groups, long duration and repetitiveness with a regular pace [26], in an attempt to elicit cardiovascular benefits. A study which investigated on Kam Lau Fu or Wing Chun disciplines suggested that novice practitioners performing the same techniques had higher oxygen consumption than the experienced practitioners, and the intensity was not high enough to elicit cardiovascular benefits in the latter group [27]. This may partly due to the freedom of the practitioners to perform the forms at their own pace, but not in a set pace with the flow of movements restricted. In conclusion, one must remember the parameters of aerobic exercises and adopt the right frequency, duration; intensity and type of exercise in order improve the cardiovascular fitness through hard style Kung Fu.

Body composition

Few studies examined the effects of Kung Fu training on body weight management and most studies combined Kung Fu with other physical activities in their interventions [28-30]. The study of Tsang et al. was the first randomized placebo-controlled trial to examine the effects of Kung Fu training on body composition of obese adolescents. After a 6-month Kung Fu training (Choy Lee Fut Hung Sing Gwoon discipline) with thrice one-hour sessions weekly, no significant reduction in percent body fat was observed in the Kung Fu group. The authors attributed the reasons to the intermittent nature of the training session in which the instructor regularly corrected, explained and demonstrated techniques rather than aiming to maximize energy expenditure of the practitioners. It was concluded that an intermittent Kung Fu training session may not be sufficient to induce an energy deficit and thus fat loss [31].

Consequently, it is important to adopt proper exercise dosage for weight reduction (will be discussed later). In fact, hard style Kung Fu training involves most major muscles and it is an aerobic exercise which helps weight reduction.

Muscle mass, muscle strength & movement speed

According to Neto et al., effective mass of impact is a measure of body's inertial contribution to the transfer of momentum during a collision. In Kung Fu, it can be seen as "the mass of an imaginary rigid body that could replace the striker and with the same speed as the hand speed before the impact produce the same effect on the collision as the striker would". Results of their study showed that a well-trained practitioner had a higher effective mass which, in addition to the correct bone alignment and muscle contraction timing, is one of the important elements to minimize the risk of injury in Kung Fu practices [32]. The high effective mass also contributes to a higher movement speed. In the same study of Neto et al., the hand speed performance of practitioners was twice as the non-Kung Fu practitioners. This suggested that Kung Fu practitioners transferred their kinetic energy into the ball more effectively at all speeds [32]. Similarly, O'Donovan et al. concluded that Kung Fu practitioners were able to move their limb faster than the non-practitioners [12].

Other than effective mass, Kung Fu practitioners also showed significant higher muscle strength in isometric knee flexion and extension [12,33]. All these suggested that hard style Kung Fu as a good mean for movement speed and strength training for both upper and lower limbs and the training of Kung Fu is beneficial to the performance of other sporting activities which involve striking of a mass, such as baseball, golf and tennis [32].

Other physical benefits

The bone mineral density of Kung Fu practitioners were investigated in the study of Zhao. A significantly greater bone mineral density was shown, comparing to subjects with sedentary lifestyle or who participated in other sports such as basketball and long

distance running. However, the study had not taken into account in terms of genetic, age, diet and habitual activity levels among the subjects, which may also contribute to the difference in bone mineral density [34].

Other physical benefits include lower blood pressure [35], better flexibility [19,36,37] and balance [18,19], and fall prevention [13]. The details of the studies are not discussed here due to the follow reasons: some studies did not distinguish between hard and soft style Kung Fu in examining the parameters; among those which focused only on hard style, martial art from other countries such as Taekwondo, Karate were also examined; some studies even focused on martial art as a whole entity; and most studies were not randomized controlled trials.

Mental health benefits

Apart from physical health, mental health benefits are also widely reported in Kung Fu studies. Studies have long been showing that long term participation in Kung Fu could increase self-esteem and self-confidence, improve management of aggression, feelings of vulnerability and fear, facilitate mood and mental performance and concentration, decrease sleep disturbance, depression, tension, stress, anxiety and hostility [38-42]. The benefits were not immediate but manifested slowly and those having practiced longest showed the highest self-esteem [43-44]. Trulson et al. also reported that hostility and anxiety levels were negatively correlated with belt ranking [45].\

Traditional martial artists are portrayed as aggressive and violent in Hollywood movies [46] and some people argue that hard style Kung Fu promotes an aggressive behavior. In fact, hard style Kung Fu did not promote aggression; rather, it may be used as a treatment modality for youth who are at risk for violence [13]. In the study of Duthie et al. [44], results showed that Kung Fu training could reduce the levels of aggression and hostility of the practitioners and the effect increased with time. Knoblauch (1985) also reported that beginning external stylists were more dominant and competitive, but were not more aggressive than beginning internal stylists [47]. Moreover, in most of the Kung Fu schools, the instructor would ask students to leave if their behavior or attitude is not compatible with the philosophy of the school [13]. The mental benefits were not limited to soft style Kung Fu, although some scholars believed that it was the breath control training in soft style Kung Fu that help in relaxation and decreased depression and sleep disruption [48-49]. Yet, other elements of Kung Fu training, such as meditation, philosophy learning, and practicing in an controlled, disciplined environment also help in promoting psychological well-being [41].

According to Bin et al., traditional training approach emphasizes self-improvement and focuses more on spiritual development and discipline than physical fitness while the non-traditional training approach (sporting and efficiency) emphasizes on physical fitness over the other two [2]. Still, all approaches help in cultivate positive traits of the practitioners and can be applied to everyday life [50]. The details of different training approaches will be discussed later.

Social benefits

Social benefits are correlated with mental health benefits, for example, better self-control [51] and reduced aggression [10] contribute to a harmonic society. Studies revealed that the positive attitudes and values that emphasized in Kung Fu, such as respect, humility, responsibility, perseverance, honor, sportsmanship, could be taken up by the practitioners and generalized to other areas of life [52-53]. Similarly, Columbus and Rice suggested that Kung Fu participation can take on the meaning of an emancipatory practice, where obstacles and challenges in other areas of life are easier to deal with [54]. Other social values such as honesty, directness, assertiveness, concentration, and communication skills can also be strengthened through Kung Fu training [10].

"Sport is not good or bad, but it has the potential to generate both positive and negative outcomes" [55]. In an attempt to achieve the positive social-psychological benefits, one should take into account the types of Kung Fu discipline, approach of training, aims of the instructors, type of guidance, characteristics of the participants, and social context including beliefs and values of the parents and socio-economic status [9].

External/Hard Style Kung Fu Training

Specificity is one of the physical training principles and it is critical to choose the right Kung Fu training [56]. Specific goals or health benefits can only be achieved through a specific and appropriate Kung Fu discipline with an appropriate school as well as training approach. According to Vertonghen and Theeboom, a distinction should be made between different kinds of disciplines and training approaches before choosing the appropriate Kung Fu for a specific goal [9].

In general, there are three different approaches of Kung Fu training, including sporting, efficiency and traditional [57]. Sporting approach stresses the sport and competitive aspects and focuses only on the physical aspects [58] and the techniques are strictly practiced according to specific competition rules. The efficiency approach emphasizes the efficient application of techniques in a real fight and Kung Fu is mainly practiced for the reason of self-defense [57]. In the traditional approach, it focuses not only on the techniques, but also on meditative aspects, self-control, conflict avoidance, respect for others, kata training, and the study of philosophy [40,57,59]. The latter one is suggested to have a profound positive psychological effect on the practitioners [9].

Even though there are different emphasis and goals in the three training approaches, an orthodox Kung Fu training consists of some common parts: (a) basic Kung Fu training; (b) basic skills training; (c) weapons training; (d) two-person fixed-set training; (e) two-person free-skills training; and (f) qigong training in soft style [4]. Basic Kung Fu training includes relaxation skills, stretching, and enhancing internal force of body parts such as feet and palm, and conditioning exercise [4]. Basic skills training (forms training) refers to the practicing of single technique one by one and repetitively, such as punch and kick. It starts with the development of proper techniques and coordination, and grasping the right feeling of the action, before progressing to full contact striking with proper force, timing and angles, application in combat, possible changes and variations. Most often, bags or padded posts are used for practice [4]. In contrast, weapons training are similar to a basic skills training but with weapons such as swords, daggers and spear which are not applicable to all Kung Fu disciplines [13].

In two-person fixed-set training, both offensive and defensive perspectives are focused and there are some fixed routines standardized for every specific technique. A single technique is practiced first, before progressing to two to five combined techniques. The goals are to increase striking power and reflexes, which increase speed and reduce reaction time. Body protectors are often used to avoid injury [4]. In

two-person free-skills training, each partner is free to use any skills and the practitioner do not need to inform his partner what he is going to do, which is similar to a real fighting. However, skills, tactics and emotional control are emphasized instead of winning [4].

In conclusion, there are lots of styles and schools under the same discipline and none of them is right for everyone. Schools vary in their style, training approach, philosophy, quality of instruction, money cost and expectations to the students. Prospective practitioners are recommended to visit several schools and choose the right one that best fit their needs [13].

Design an External/Hard Style Kung Fu Training Program

As mentioned, Kung Fu has been proved to elicit cardiovascular benefits. However, it depends heavily on the intensity and duration of the training session. According to the guidelines of ACSM (2010), cardiovascular fitness can be trained through participating in aerobic activities with moderate intensity for 20 to 60 minutes in three to five days per week. It can also be done in 10-minute periods intermittently [26]. Form of training is repeated and continuous in nature, but it is common to be interrupted by the instructors for corrections of techniques [31]. As the focuses of forms training are teaching and training martial art techniques instead of maximizing energy expenditure or improving fitness or body composition, a specific program is needed to meet the goals of aerobic training, i.e. practices lasting at least 10 minutes continuously.

Concerning the intensity issue, it should be high enough to elicit cardiovascular benefits to the practitioners, i.e. moderate intensity. According to Centers for Disease Control and Prevention (2011), a moderate intensity aerobic activity causes harder breathe and faster heartbeat. The participant will be able to talk, but unable to sing a song [60]. Previous studies have reported that the intensity of Kung Fu ranged from moderate to vigorous, while that of Tai Chi Chuan was low [20]. Apart from workload determination, some studies suggested the importance of attaining other key parameters such as metabolic demand, heart rate [22] and blood lactate [17,61-62]. Ribeiro et al. suggested that practitioners should attain 89% of age-predicted heart rate maximal in forms training of Kung Fu (Changquan and Daoshu) [56], a level of workload that is in the range recommended by ACSM to train aerobic fitness.

With appropriate parameters, Kung Fu training can also be used as a mean to control or reduce body weight. According to the ACSM's guidelines in 2010, a cardiovascular exercise program of 150 to 250 minutes per week should be conducted in order to reduce body weight. Each exercise session should last for at least 20 to 30 minutes, at a minimum of 60% of heart rate maximum, i.e. moderate intensity exercise [26]. Significant weight loss can be achieved with 250 minutes or more of exercise per week, however, weight loss should not exceed 2.2 lb per week. The Kung Fu training program should also be accompanied with strength training for the development of lean muscle mass, as well as a good diet that provides a minimum of 1200 calories per day for normal adults [26].

Forms training are also proved to be effective in training muscle strength, endurance and speed [12,32], motor control, balance and coordination [46]. It also serves as a moving meditation to develop harmony of body and mind [46]. In contrast, practicing competition may serve a different purpose, like improving mental health, learning to cope with fear, stress and lose, enhancing self-confidence and self-control [10]. According to the ACSM's guidelines for strength training, a healthy adult is recommended to complete 8 to 12 repetitions of 8 to 10 exercises for two to three days a week [26]. Apparently, the training regimes are different between improving muscle strength, power or endurance and further adjustment is needed in regard of a specific goal, muscle and age group.

Other than the training protocol, the teaching style and quality of the instructor should be taken into consideration. Cox proposed that the variation in the quality of instruction, both philosophical and technical, could influence the outcome of personality state of the practitioners [46]. Similarly, Jones et al. claimed that the teaching and communication style of the instructor were very important in enhancing student motivation in practicing Kung Fu, and the response of the practitioners always alter dependent on the attributes of the instructor [63]. In summary, after determining an appropriate Kung Fu discipline and school, practitioner has to choose the suitable training approach and instructor which can meet their special goals, and most importantly, the training program should be individualized according to the baseline, goals and ability of the practitioner.

Recommendations

There is no short cut in Kung Fu training as physical health benefits such as aerobic capacity and bone density, and psychosocial benefits such as self-confidence and obedience require long term adherence [20]. Yun & Clark believed the practitioners should emphasize on the inner feelings and overall fighting spirit in order to achieve high level of skills [4]. Taking Shaolin Kung Fu as an example, the Maling Shaolin Kung Fu Academy China provides training programs vary in length, i.e. one month, three months, half year and a year. It takes at least a year to get familiar with all the customs and ideas and skills of the Shaolin Kung Fu, and further time is needed to enhance the skill levels and apply them in a real right. The students are trained for eight hours a day from Monday to Friday in the Shaolin temple in China [64]. Apparently, this is a kind of traditional training approach and focus on mastering the real Kung Fu philosophy and skills. In fact, Kung Fu learning is an endless process and benefits can only be seen with long term adherence.

Another issue is safety and injury. There are limited data about the injury rate in Kung Fu [20]. Blijd et al. revealed that the majority of injuries reported were not serious and were mainly contusions [65]. Similarly, Woodward believed Kung Fu is relatively safe compared to many other sports, and most injuries are comparatively minor [13]. He also recommended that the risks of injury can be reduced by limiting exposure of inexperienced students, and making use of protective equipment including headgear, eye or face protection, mouth guards and padding [13]. Similarly, O'Donovan et al. advocated the inclusion of trunk stability exercises in Kung Fu training to reduce the likelihood of injury or incidence of low back pain [12]. It is because in Kung Fu the abdominal and back muscles are required to stabilize the body, i.e. during kicking and punching. Good core stability can maximize the effectiveness of force transfer onto the target [66-67]. Other exercise principles such as progressively increase the workload, avoid over-training and have enough rest period between training sessions should also be taken into consideration.

In conclusion, Chinese martial art has long been recognized to improve physical, mental and social well-being, and its popularity is increasing worldwide. Even though Wu Shu is not among the 28 official Olympic sports, it was a demonstration sport in the 2008 Beijing Olympic Games [68]. The hard style Kung Fu is beneficial to health and self-defense and is a fun exercise. With appropriate disciplines, teaching approaches, instructors and training programs, Kung Fu could provide as much benefits as all other kinds of exercises and sports.

Future randomized controlled trials or studies with case-control designs in good quality are needed to further provide a theoretical base of hard style Kung Fu.

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Korean Martial Arts and Health - Taekwondo

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Abstract

Taekwondo (TKD) is a globally popular martial art characterized by fast, high kicks. This chapter summarizes the potential beneficial effects of TKD training based on recent research findings. At present, most of the proposed physical benefits, such as improving flexibility, muscular strength, aerobic and anaerobic fitness, body composition and bone mineral density, have not yet been confirmed. Some studies have suggested that TKD may improve reaction times and psychological well-being in young people and solid evidence has been found to support the beneficial effects of TKD training in improving body balance and sensory organization in young people with and without developmental coordination disorder (DCD). Therefore, further research is required before claiming that "TKD is good for physical fitness" or "TKD is a sport for all." One can only conclude that TKD is an effective exercise for children with DCD who wish to improve their body balance and the sensory organization of postural control.

Keywords

Marital art; Physical fitness; Psychological health; Taekwondo; Therapeutic exercise

Introduction

Taekwondo (TKD), a Korean word meaning the way of kicking and punching, is a martial art that originated in Korea and has become a globally popular sport. According to figures from the World Taekwondo Federation (WTF) and the International Taekwon-Do Federation (ITF), over 80 million people practice TKD in approximately 182 countries around the world [1,2]. Despite its combative nature, TKD is relatively safe because training is progressive and protective gear and helmets are mandatory. In addition, TKD athletes must follow strict rules during free-sparring tournaments. Therefore, the injury rate among TKD practitioners tends to be lower than that of other martial arts [3].

TKD training is not hazardous to the practitioners' health. It may even generate a number of physiological and physical benefits, such as improved flexibility, muscular strength and endurance, anaerobic and aerobic capacity, body composition, reaction time, body balance and bone mineral density in different populations [4-16]. Psychologically, TKD may improve mood, self-concept and self-control without increasing aggressiveness in its practitioners [17-21]. TKD is thus suggested to be an ideal exercise for improving physical and psychological well-being among people of all ages. This chapter provides an overview of the aforementioned benefits.

Potential Health Benefits of Taekwondo

Flexibility

TKD is characterized by fast, high kicks. Its training routine places a great deal of emphasis on developing flexibility in its practitioners [22]. Numerous studies have demonstrated that adult TKD practitioners are actually more flexible in their hamstrings and lower back muscles compared with the norm [23-25] and non-practitioners [26]. The hip adductor muscles of well-trained TKD practitioners may also be more flexible than those of TKD novices [27].

In the elderly population, TKD may slow down biological deterioration in body flexibility [4]. Brudnak et al. [28] conducted the first longitudinal study of elderly practitioners of TKD and reported an increase in hamstring and lower back flexibility after 17 weeks of TKD training. This finding was reinforced by Cromwell et al. [26], who included a control group for the pre- and post-test comparison of flexibility. It seems that TKD training may benefit both young and old practitioners in terms of developing lower body flexibility.

However, contradictory findings do exist [12,27]. Fong et al. [12] used sit-and-reach and leg split tests to determine that there is no difference in hamstring, lower back and hip adductor flexibility between young recreational TKD practitioners and non-practitioners. This discrepancy in findings could be explained by the differences in participant characteristics (e.g., TKD training level, training volume, age and sex) among the studies. Thus far, no strong evidence or randomized controlled trials have been presented that show that TKD improves the flexibility of specific joints and in specific populations. Most of the available studies are cross-sectional in design, and thus the reported results must be interpreted with caution.

Muscular strength

Possessing strong muscles is important for the execution of explosive kicks, jumping and balancing movements during TKD training [29]. Therefore, a number of studies have investigated the limb and trunk muscular strength among TKD practitioners [6,13,23,27,25,30,31]. However, the methods of muscular strength measurement employed in these studies are diverse enough to render

direct comparisons among studies difficult. The assessment of muscular strength can be categorized into two types: field and isokinetic testing. In field-test results, adult TKD practitioners appear to have greater isometric muscular strength during arm flexion, knee extension, hand grip and explosive leg power than the norm [23]. In addition, experienced (black belt qualified) TKD practitioners have been found to have greater lower body muscular strength than beginners [27]. Based on these cross-sectional studies, we cannot conclude that TKD training improves muscular strength in general. Again, negative findings exist in the literature. For example, Thompson and Vinueza [25] did not find any muscular strength improvement with TKD training. Therefore, further longitudinal studies are needed to confirm the results. Isokinetic testing results may provide some insights into the effect of TKD training on muscular strength.

Using isokinetic testing to assess muscular strength in TKD practitioners is more objective and reliable [32] than field testing. Pieter et al. [30] first reported that adult TKD athletes had higher isokinetic peak torque during knee flexion at moderate to fast movement speeds than tennis players. Our research team's recent findings actually concur with and supplement Pieter's preliminary findings [6,13,31]. We found that adolescent TKD practitioners demonstrated higher isokinetic peak torque values for knee extension and flexion than the control group at a high movement velocity (240˚/s) only. No difference in knee muscular strength was found between TKD-trained and non-trained subjects at lower movement velocities [6,13]. Additionally, the more time the athletes spent training in TKD, the greater isokinetic knee muscular strength they developed [31]. To the best of our knowledge, no longitudinal studies have investigated the effect of TKD training on improving isokinetic muscular strength. More research is needed to find the causal relationship between TKD training and muscular strength among adolescents and adults.

Anaerobic capacity

Governed by the competition rules set by the WTF [2] and the ITF [1], modern TKD competitions consist of very short periods of intermittent, high-intensity movements that require energy supplied by anaerobic energy (phosphogen and lactic acid) systems [23,33,34]. Many studies have revealed that practitioners' blood lactate concentration does increase significantly after TKD tournaments [23,33,35,36]. Therefore, repeated TKD free-sparring practice may strengthen the anaerobic power of practitioners. Indeed, a high anaerobic power has been found in elite TKD athletes of both genders [23,24].

Among recreational TKD practitioners, 8 weeks of TKD form (poomsae) training has been shown to increase anaerobic power, as demonstrated in a Wingate Bike test [37]. To the best of our knowledge, no study has reported a negative effect of TKD training on the anaerobic performance of its practitioners. Further randomized controlled studies are nevertheless required to confirm whether the higher anaerobic capacity found in TKD athletes is due to "nurture" (i.e., TKD training) or "nature" (i.e., genetically determined).

Aerobic fitness

TKD is considered to be a mixed aerobic and anaerobic sport because during competitions, moderately intense movements (e.g., bouncing and shuffling continuously) are punctuated by short bouts of fast, high-intensity maneuvers (e.g., kicking and punching) [22]. Practitioners' heart rate responses during TKD matches have been reported to exceed the aerobic training threshold [38]. Therefore, it is reasonable to postulate that TKD training improves the aerobic fitness of its practitioners.

Indeed, a number of studies have reported that elite TKD athletes have a higher maximum oxygen uptake (VO_{2max}) than the norm [23,24,35,39]. However, the findings from these cross-sectional studies do not reflect the true effect of TKD training in the general population. Revealing data collected from recreational TKD athletes have shown that VO_{2max} was actually lower in TKD-trained subjects than in sedentary subjects [25]. Another (longitudinal) study reported that 8 weeks of TKD poomsae training may not improve cardiovascular fitness (as measured by VO_{2max} and resting heart rate) in male adolescents [37]. Based on this inconclusive evidence, we cannot determine whether TKD training is effective in improving aerobic fitness in the general population. Further studies are thus required.

Fat loss

According to the American College of Sports Medicine (ACSM) guidelines, exercise at an energy level of 300 kcal for a minimum of 3 days per week can induce fat loss [40,41]. The caloric expenditure of a 20-min bout of TKD training requires 316.5 kcal in men and 194.8 kcal in women. Therefore, 30 minutes of TKD practice 3 times per week could theoretically enhance fat loss [42].

To prove this assumption, several investigators have examined the anthropometric profile of TKD practitioners and found that both amateur and elite TKD athletes have a lower percentage of body fat than the population norm of the same sex [24,27,42,43]. However, all of these studies were cross-sectional in design, and the nutritional profiles of the TKD athletes were not reported. Therefore, a causal relationship between TKD training and fat loss cannot be established.

Two studies have generated opposite findings. Thompson and Vinueza [25] reported that experienced TKD practitioners have more body fat than sedentary subjects. Fong et al. [12] also found no significant difference in the percentage of body fat between TKD practitioners and non-practitioners. These inconsistent findings could be attributed to the different TKD training modes and subject characteristics. Nevertheless, we cannot conclude that TKD training induces fat loss based on the existing evidence.

Reaction time

Reaction time reflects sensory-motor performance and is a predictor of sports injury risk. Therefore, it is an important health indicator for both professional and recreational athletes [44]. There are two types of reaction time: simple and choice. Simple reaction time is the period between the appearances of a general stimulus to the onset of force production by the corresponding muscles. It is primitive and cannot be trained [45]. Choice reaction time is the shortest interval needed to respond to a specific stimulus that is presented as an alternative to a number of other stimuli [46]. Evidence supports that choice reaction time can be trained [47]. For both types of reaction time, there are two time components: premotor reaction time and electromechanical delay or movement time. Premotor reaction time describes the latency between the appearance of a stimulus and the onset of electromyographic (EMG) activity [48]. Electromechanical delay or movement time refers to the interval between the onset of the EMG signal and force production, and indicates the neuromechanical properties of the muscles [49].

Previous studies have revealed that professional TKD practitioners react faster to TKD-specific stimuli [50]. In addition, martial arts practitioners including TKD practitioners exhibit shorter movement time compared with controls [51]. O'Donovan et al. [51] and Song and An [52] agreed that 7 months of TKD training could improve movement time in youths with intellectual disability. Recently,

our research team found that simple reaction time was shorter in teenage TKD practitioners than in controls, but we not sure whether it is due to a faster movement time or a shorter premotor reaction time [12]. Further studies might fruitfully differentiate which type of reaction time and which time component would be improved through TKD training.

Postural control

Postural control or body balance is a fundamental motor ability that is developed during the first year of life and is refined during childhood. It is essential for the development of all motor skills such as independent walking, hopping and running in children [53]. With respect to TKD training and competition, balance is the determinant of success [54]. It is thus an important topic to study.

The maintenance of body balance requires the interaction of many bodily systems including the sensory system, central nervous system and musculoskeletal system, among others. In terms of the sensory component of postural control, the somatosensory, visual and vestibular systems are essential for providing sensory inputs to the central nervous system (CNS). The CNS then selects and integrates these senses to generate appropriate motor outputs [55]. Our research team found that Taekwondo training effectively improved sensory organization and postural control, especially among young people. We carried out a series of studies to investigate the differential effects of TKD training on postural control and sensory-motor development among adolescents [5-9,14]. The major findings are summarized as follows.

(1) Adolescent TKD practitioners generally rely more heavily on vestibular input to maintain balance and have better single-leg standing balance than their non-trained counterparts. It seems that TKD training may speed up the development of vestibular function and postural control in adolescents [9].

(2) Short-term practitioners of TKD (1-4 years of TKD experience), but not long-term practitioners (5-9 years of TKD experience), rely more heavily on visual and vestibular input to maintain balance than control subjects. Both short-and long-term TKD practitioners sway slower than untrained subjects when balancing on one leg [6,7].

(3) In addition to exhibiting superior unipedal standing balance, TKD practitioners also demonstrate a faster turn time and lesser turn sway during the step/quick turn test than the control subjects [8].

(4) TKD-trained subjects also display a shorter time to stabilization during the drop test, indicating better balance control [14].

(5) Compared with tennis players, TKD practitioners rely less heavily on visual input to balance but they are more stable when standing on one leg [5].

Our findings in young people actually echo some of the previous findings in the elderly [26,28]. In older adults, there is a natural regression in balance ability that leads to falls, injuries and hospitalization [53,56]. Preliminary evidence has shown that TKD training may slow down the deterioration in the balance ability of older adults by improving their single-leg standing balance [28], multi-directional reaching ability and walking ability [26]. However, due to the combative nature of this martial art [22], the appropriateness of using TKD as an intervention to improve balance and prevent falls in the senior population has yet to be confirmed.

Bone mineral density

Although TKD training involves numerous high-impact striking maneuvers, not much research (in the English language) has investigated its effect on bone strength. Seong [15] first reported that healthy TKD-trained middle-school boys had a higher total body bone mineral density than controls. Byun et al. [16] also found that female high school athletes who engaged in combat sports training (Taekwondo and Judo) showed a higher bone mineral density in the lumbar spine, femoral neck, Ward's triangle and trochanter compared with long-distance runners or swimmers. Based on the current evidence, it seems that TKD training may aid bone acquisition during childhood and adolescence. Further prospective, randomized and controlled trials are needed to confirm its effectiveness in improving bone strength.

Psychological health

TKD not only improves practitioners' physical health, it also improves their psychological well-being. Evidence has suggested that TKD training may improve college women's self-concept [17], decrease anxiety in adults [18], improve self-regulation and classroom conduct in school-aged children [19], induce positive mood state changes in college-aged students [20] and even reduce juvenile delinquent tendencies [57]. Although TKD is a combat sport, long-term training is associated with a lower level of aggressive fantasy [21]. It is thus an ideal exercise for all ages from the psychological point of view.

Taekwondo as a therapeutic exercise for clumsy children

Our research team pioneered an investigation into whether TKD is suitable for children with Developmental Coordination Disorder (DCD) or clumsy children, given its dynamic and physically challenging characteristics. We carried out a randomized controlled trial to prove its effectiveness in improving balance control, sensory organization and knee muscular strength among children with and without DCD. The results were quite encouraging and had considerable clinical influence. We found that only three months of TKD training improved sensory organization, specifically visual and vestibular functions, unipedal and bipedal standing balance and isokinetic knee muscular strength at 180˚/s in children with DCD. Therefore, clinicians can confidently suggest TKD as a therapeutic leisure activity for this particular group of children [10,11].

Conclusions

Based on the existing evidence, most of the potential benefits of TKD, such as improving flexibility, muscular strength, aerobic and anaerobic fitness, body composition and bone mineral density, are not yet confirmed. Some evidence suggests that TKD may improve reaction time and psychological well-being in young people. Solid evidence has been presented to support the beneficial effects of TKD in improving body balance and sensory organization in young people with and without DCD.

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Thai Martial Arts and Health - Muay Thai

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Abstract

Muay Thai is originated from Thailand (formerly known as Siam) and has been developed over centuries. It is now a sport in many international multi-sports games under patronage of the International Olympic Committee. This article will first briefly introduce the history and popularity of Muay Thai. Then, the characteristics of Muay Thai including its fighting rules and unique pre-fight ritual will be highlighted. Health issues like sports injury, protective equipment and the potential benefit of Muay Thai training will also be discussed. After reviewing the routine of conditioning and training, the author further discuss and give recommendations on common issues in conditioning of Muay Thai including the control of body weight, carry-over training, sports specificity and injury prevention.

Keywords

Carry-over training; Conditioning; Health benefit; Muay Thai; Sports injury

Introduction of Thai Martial Arts

History

Muay Thai is one of the several Thai (Formerly known as Siam) martial arts, such as *Krabi-krabong* (sword and staff fighting using prearranged sets), *Lerdrit* (empty-hand battlefield art), *Chuparsp* (weaponry), *Thaiplum* (grappling), *Kemier* (ninjutsu-like stealth and survival art) and *Thaiyuth* (Thai skills combat which includes Muay Thai) [1].

Muay Thai has been developed over centuries in Southeast Asia. Precise information on the origin remains unavailable, as all Siamese records were purportedly burned by Burmese in 1770s. According to one story, a Siam soldiers, Nai Khanom Tom was captured by the Burmese in the 1770s. He was given the opportunity to gain his freedom by fighting the greatest Burmese soldier. Finally, he defeated more than nine fighters one after another with his remarkable fighting techniques. He was then given back his freedom. A yearly tournament is held every year at the Lumpini Stadium in Bangkok till now, in honor of this great fighter's name [1,2].

Popularity

Over hundred of years, Muay Thai became a practical technique for use in actual warfare, at the same time, a sport in which the fighters combat in front of spectators who went to watch for entertainment. It then became an integral part of local festival and celebrations, especially those held at temples, known as *Muay Boran*. In the last two decades, with the success of Muay Thai fighters in the Western-ruled boxing & mixed martial arts competitions, Muay Thai became one of the popular martial arts training world-widely. Now, it is a sport with inclusion in Sport Accord, full recognition by the Olympic Council of Asia, and inclusion in many multi-sports games, such as the Asian Indoor and Martial Arts Games, the Southeast Asian Games, Arafura Games, and the Sport Accord World Combat Games, under patronage of the International Olympic Committee. On the other hand, the sports have been generalized to public from professional fighting club to studio fitness classes for workouts in all ages with different fitness levels [3].

Importance of health issues in Muay Thai

There are more and more people practices Muay Thai for general fitness, as well as competing in professional bouts. It is important to review health issues including the potential risk and benefit of Muay Thai training. Common issues in conditioning of Muay Thai will be discussed in this chapter, which are important for coaches and fighters for better performance and to avoid sports injury.

Characteristics of Muay Thai – What are the Differences between Muay Thai and other Kickboxing?

Use of 8 weapons

Muay Thai is a striking art for ring fighting that uses the fists, elbows, knees, and feet. Therefore, it is referred as "the sciences and art of eight weapons (limbs)" [1,2]. It is considered as a hard martial art, because it is often more emphasize on parrying or just directly blocking an attack, but not using the strength of the opponent or neutralization the energy that utilized in soft martial art (eg. Aikido) [4].

Characteristics

Fighting techniques are quite similar in full-contact karate, western-style kickboxing, Chinese Sanda and Muay Thai. In full-contact karate, no kicking is allowed below the waist. In western-style kickboxing, leg kicks are allowed. In Chinese Sanda, punches and kicks are legal anywhere except back of the head, throat, spine and groin. In Muay Thai or Thai boxing, except the groin region, punches and kicks are legal anywhere. Moreover, elbow and knee techniques, as well as grabbing and holding are permitted in Muay Thai. The

aggressiveness of attacking in Muay Thai is considered to be extremely high, even higher than Chinese Sanda, as elbow and knee strikes are banned in some rules of Sanda competitions [5,6].

Rules of fight

In the past, the combat, with no arrangement of weight division, was a fight "to the finish" as long as a fighter was said to have left the arena on a bamboo stretcher. In modern competitions, the fights last five rounds of three minutes each with two-minute rest periods in between. There is a center referee who issues a ten count for knockdowns. Three knockdowns in a single round can end the match. Two judges score the fight on points, unless there is a knockout or the referee stops the contest [1].

Pre-fight ritual

The pre-fight ritual is an important part of Muay Thai. It is a slow motion, ballet-like set of steps and motions often ridiculed by foreigners ignorant of its significance. First of all, the *"Wai Kruh"*, the fighter shows obedience to the teacher with bowing. Then the fighter starts the "Rum Muay", a boxing dance. It also serves as pre-fight warm-up exercise and can last as long as 5 minutes. Thai music played by a four-piece orchestra consisting of a Javanese clarinet, drums and cymbals. It accompanies the whole process of this pre-fight ritual, and it lasts till the end of the competition. The rhythm of this music varies according to the movement of the players, giving an energetic atmosphere to both the fighters and the spectators [1,2].

Health Issues of Muay Thai

Sports injury

Injury rate of Muay Thai in competitions: As mentioned before, the aggressiveness of attacking in Muay Thai is relatively high among all martial arts sports. Are the fighters in high risk of injury? Gartland et al. (2001) reported a retrospective study on the epidemiology in Muay Thai kickboxing [7]. One hundred fifty-two boxers (19 beginners, 82 amateurs, 51 professional) were questioned in various gyms and competitions in United Kingdom and a Muay Thai gala in Holland. For the beginners, the annual injury rate was 13.5 /1000 participants; for the amateurs and professionals, the annual injury rates were 2.4 and 2.8/1000 participants respectively. Few years later, Gartland et al. (2005) reported a prospective study on the injury rate of amateurs-level Muay Thai boxers, who participated in competitions in the United Kingdom, organized by the International Amateur Muay Thai Federation [8]. There were 92 participants categorized into four weight categories (24 lightweight, 60 middleweight, 4 heavyweight, 4 super heavyweight). The average age was 17.3 years, and the average previous number of bouts was 3.9. A total of 588.5 minutes of competition time was assessed during a total of 10 events. Injury rate were 1.3 injuries/100 minutes of competition in the lightweight category, 2.25 injuries /100 minutes of competition in the middleweight category, 30 injuries/100 minutes of competition in the heavyweight category, and 2.54 injuries /100 minutes of competition in the super heavyweight category. This group of researchers suggested that boxers with less experience and younger age have relatively higher risk of injury, which is cohesive to the trend of epidemiology studies in other martial arts sports [9-15]. Also, they suggested that the injury rate in Muay Thai boxers was quite similar to those found for karate and taekwondo. However, the number of boxers included in the study was quite limited especially in the beginner group in the earlier study and the heavyweight group in the later study. In the study of Gartland et al. (2005), it seems that the injury rate was extremely high in the heavyweight group. It was due to the fact that 2 players injured in the study period, out of totally only 4 subjects in this heavyweight group. Therefore, we should take precaution on the generalization of the results reported. Zazryn et al. (2003) reported an epidemiology study of injuries on professional kick boxers in the state of Victoria, Australia over 16 years period [16]. They reported a total of 382 injuries were recorded from 3481 fight participations, at an injury rate of 109.7 injuries per 1000 fight participations. Therefore, there were around 7.5 injuries per 1000 fight participations per year. This reported figure was a bit higher than that reported by Gartland's research group. However, as the database had documented kickboxing fights for a number of different kickboxing styles & rules (Australian, American, international, Muay Thai), the exact injury rate in Muay Thai style kickboxing was not specified. Laoruengthana et al. (2009) reported the injury rate of Muay Thai in the Thailand National Game 2008. There were 7 injuries being recorded in 165 Muay Thai participants resulting in an injury rate of 4.2 injuries per 100 athletes. When compared with those being recorded in Pencak Silat (the highest injury rate among the martial-arts full-contact sports in the National Game, with 24.4 injuries per 100 athletes), Karate-do (8.7 injuries per 100 athletes), Taekwondo (2.6 injuries per 100 athletes), the injury rate of Muay Thai seems to be comparable to Karate-do and Taekwondo [17].

Head injuries: For the nature and region of injuries reported in previous studies, soft tissue trauma including haematomas and lacerations over the head region was very common, which account for more than 50% [7,8,16,17]. In Muay Thai, there is a strong desire for competitor to target primarily the head region especially when attempting a knockout [8]. Most of the head injury happened in the non-protected area, resulting epistaxis or lacerations over the face. However, we cannot underestimate the impact of repeated head injury. This has been reported to be related to higher risk of encephalopathy and the symptoms can remain hidden for years [18]. Lolekha et al. (2010) reported that the number of professional bouts is a risk factor among Muay Thai boxers, suggesting that repetitive head trauma may pose an additional risk to certain individuals who are already susceptible to Parkinson's disease [19]. Tanriverdi et al. (2007) suggested that kick boxers are at risk of pituitary dysfunction caused by traumatic head injury, especially isolated growth hormone deficiency and, therefore, should be screened for these condition. Therefore, consistent use of protective headgear may be useful [20].

Lower leg injuries: The second common site of injury is the lower leg. Muay Thai utilizes the shin as one of the important weapon for attacking and so bringing about laceration, contusion and haematomas on the lower leg [7,16]. Surprisingly, the injury pattern reported by Gartland et al. (2005) among the amateurs-level boxers could not support this trend. The author suggested that this might be the profound effect of mandatory use of shin guards in the rules of amateur boxing. However, we cannot deny that minor abrasion and contusion are an accepted "norm" in Muay Thai and the boxers might not perceive as an injury.

Injuries in other regions: Other injuries like fractures of nose, carpal bones, metacarpals, digits and ribs were reported in literature [7,16,17,21]. As these injury sites are often given little or no protection, they are subject to high impact, especially facing the strong elbow and knee attacks in Muay Thai. On the other hand, although the rib cage is subject to repeated high impact, Saengsirisuwan et al. (1998) suggested that there was no immediate deleterious effect on liver and renal function [22]. Although it was suggested that muscle imbalance are common in boxers, in which they tend to use the anterior musculature more than the posterior, there is no study on chronic or overuse soft tissue injury in Muay Thai players [23].

Protective equipment

Under traditional rules, boxers bound their hands with cotton cloth, dipped them with glue, and sprinkled them with ground glass. This showed how aggressive of this sport was. In contemporary Muay Thai bouts, the international boxing gloves that are used for European boxing are standard protection. The fighters only wear trunks with or without T-shirts, mouthpieces, and groin protectors. The anklets are optional for protection of ankle injury. The use of shin guard & headgear sometimes is mandatory in some tournaments, but most of them were used in beginner or amateur's level combat, not in professional bouts [1,2,8].

Health benefits of Muay Thai

Although Muay Thai have been practiced for decades, research study on the benefit of Muay Thai training remained scarce.

Crisafulli et al. (2009) studied the physiological capacities underlying Muay Thai performance. The aerobic expenditure and the recruitment of anaerobic metabolism were assessed in ten males during a simulation match using the portable gas analyzer and heart rate monitor. During the match, group energy expenditure was on average, 10.75 ± 1.58 $kcal^{-1}min^{-1}$, corresponding to 9.39 ± 1.38 metabolic equivalents. Oxygen uptake and heart rates were always above the level of the anaerobic threshold assessed in the preliminary increment test. The excess of CO_2 production showed an abrupt increase in the first round, and then gradually decreased throughout the simulation match. This study suggested that Muay Thai provide challenge on both aerobic metabolism and anaerobic glycolysis. In particular, after an initial burst of anaerobic glycolysis, there was a progressive increase in the aerobic demand [24].

Machado et al. (2010) analyzed the performance of knee extension and flexion of kick-boxers and Taekwondo athletes. They found that the muscular recruitment performance were better in more experienced athletes. This implied that the training in kickboxing, like Muay Thai, might promote the development of motor coordination [25].

Regarding mental health, Devonport (2006) reported a semi-structured interview to explore the high performance kick boxers regarding the contribution of psychology to the development and maintenance of expert performance within kickboxing. Mental skills including high self-efficacy, high motivation and mental toughness were identified as the major three contributing factors for success. However, we cannot prove that the kick boxing training, like Muay Thai, can facilitate the promotion of these psychological attributes. Indeed, integration of mental skill training within physical training may help to improve the quality of practice [26].

Conditioning and Training of Muay Thai

Boxing camp

Despite the recreational fitness class in studios, most professional Muay Thai boxers train in boxing camps. Trainers hold practice everyday and fighters compete at least monthly, no matter it is internal or regional [1,27].

Routine training regimen

A boxer's training regimen includes stretching; warm-up exercises that included in the ritual dance; weight lifting; rope skipping; running; swimming; shadowboxing; equipment drills with focus mitts, kick pads, and heavy bags; and sparring. During the drills, hissing sound of exhaling air is usually heard as the boxer practice their breath control.

To prevent unnecessary injury, dangerous strikes are not permitted during sparring. Training session may last for about two hours, but are held throughout each day in professional boxers [1].

Basic steps and attacks

Muay Thai boxers employ combinations of punches, elbow and knee strikes, kicks, blocks, and grappling during fights.

The boxers use the fists in the fashion very similar to that of western-style boxing, including straight punch, reserve punch, swing, job, hook, and uppercut.

The elbow strike is a very typical short-range weapon; it is also employed at longer distances when used with jump technique. Roundhouse elbow strike, rising strike and downward strike are commonly used.

The knee strike is a very powerful weapon for boxers. Roundhouse knee strike, rising strike and side strike are commonly used in short-range attacks, or in long-range attacks when combined with jumps.

Roundhouse kick is the well known Muay Thai trademark, delivered with the lower shin or instep, two rather sensitive parts of the leg that have been toughened to an unbelievable degree in professional boxers. It is directed to any part of the opponent's body and has been accounted for a great number of first-round knockouts. Other techniques like front kick, side kick, back kick, hook kick and spinning hook kick are commonly used as well.

Blocks are essential for active defense. Rear hand, front hand, forearm, front leg shin are commonly used during blocks. Boxers may also perform leg catch to hold the opponent's attacking leg so that short-range techniques can be utilized for further attack.

Grappling side of Muay Thai refers to clinch work, and sometimes followed by throwing. The boxers pull tightly and trying to control against each other. They usually deliver knee strikes during the clinch to gain the advantage [2].

Condition the shins, focus and control training

In professional Muay Thai, no protection gear is allowed on the shin. Fighters condition their shins to withstand the impact of their opponents' kicks by striking them with sticks or by kicking banana trees. This training may develop high pain and stress threshold on the bone and skin on the lower leg.

As the fighters have strong desire to target on the head region to attack, they practice kicking at lemon or small target hanging from rope in order to improve the focus and control of the lower body [1].

Recovery after training

In professional training regimen, fighters believe that therapeutic massage with ointment can help for better recovery. Also, proper nutrition is encouraged for stamina [1]. Unfortunately, no literature supporting these recovery maneuvers could enhance the performance in Muay Thai so far.

Recommendations of Conditioning Training in Muay Thai

Textbooks were available in detailed illustration of Muay Thai training [2,5]. However, most of the content focus on the boxing techniques, while only limited discussions were on the conditioning training.

Turner (2009) reviewed the use of strength and conditioning exercises within Muay Thai in detail [27]. There are some points worth to address here, so that the training can enhance sports performance, or even prevent injuries.

Control of body weight

Fighters often aim to compete at their lowest possible weight to fight opponents of lower mass. Therefore, most of them are reluctant to undergo strength training because of fear of gain in body mass. Even worse, fighters may try to make a rapid weight loss before the competition. In fact, rapid weight loss is associated with concurrent decrements in performance in combat sports such as wrestling [28-31] and boxing [32] due to dehydration, depleted glycogen stores, reduced lean muscle mass and negative mood. Therefore, strength and conditioning training should aim to increase muscle strength without concomitant increases in muscle cross-sectional area. Buildup of lactate and hydrogen ions should be avoided, as these are contributing factors to the release of anabolic hormones and subsequent muscle hypertrophy [33]. Alternation of exercises in different muscle groups (upper and lower limbs; agonist and antagonist) can provide longer rest period on individual muscle to achieve this purpose.

Carry-over training

Carry-over training focuses on the transfer of neuromuscular stimulus and firing sequence of specific groups of muscle after a set of strengthening exercise to a real sports-specific action [27]. For example, a boxer may perform a set of power snatches followed by performing a few straight punches to the bag. It is hypothesized that this will assist in neural development and carryover, ultimately facilitating an increase in force production when striking.

Plyometric exercises are suggested to be included in the conditioning program. Almost all of the stance position and shuffle steps in Muay Thai are in heel-raised position, and so the reactive strength of the lower legs is very important. It was suggested that efficient stretch-shortening cycle mechanics could result in enhanced propulsive forces, [34] and conservation of energy [35]. Therefore, plyometric exercises like drop lands and drop jumps might enhance the power and power endurance of striking in Muay Thai. Again, immediately after drop jump exercise, boxers are encouraged to perform some real shuffle steps or strikes for enhancing the carry-over effect.

Sports specificity

During punches, the ankle, knee and hip extend on the hind foot to generate force from the ground. Using the links of the kinetic chain, the trunk, shoulder, and arm, force could be transferred to the opponent originate from the ground. Literature suggested that boxers in elite level predominately generate force from the leg, while the boxers in lower level generate the majority of force from the trunk and arms [36]. Therefore, specific motor pattern of force generation should be trained in the conditioning program. As the rate of force development during punches and kicking is very high, conditioning should focus on development of power, apart from strength. Snatch, clean and jerk exercise exhibit much greater power outputs compared with the squat and deadlift [37]. As discussed before, Crisafulli et al. (2009) suggested that Muay Thai is a physically demanding activity with great involvement of both the aerobic metabolism and anaerobic glycolysis. Therefore, apart from speed and explosive training, interval training like sparring may be a good training for both energetic pathways. The pad man can lead the boxer to perform a few seconds of fast rhythmic attacks, and then a few seconds of free shuffle steps. This "combat interval" training may mimic the time period of a real competition, i.e. Five rounds of three minutes. In a recent literature, it was found that sparring and pad work required similar VO_2 (43 and 41 ml $kg^{-1}min^{-1}$, respectively), which corresponds to around 70% VO_2 peak [24].

Injury prevention

During Muay Thai, boxers tend to use the anterior musculature more than the posterior [23]. Therefore, conditioning program can address the potential risk of musculoskeletal problem that predisposed by the weakness of the posterior musculature. For example, the strength ratio between the shoulder anterior and posterior rotator cuff muscle may predispose to the shoulder impingement syndrome [38]. Specific conditioning on the posterior rotator cuff might help to prevent the problem. Muay Thai players also perform exercises specifically for the neck. The enhanced eccentric strength on the neck might have defensive benefit through absorbing blows. It was suggested that knockouts resulting from blows to the thorax or abdomen might be less likely, with strength training on the spinal muscles [39]. During the conditioning training, coach or the boxer himself may also be able to detect any weakness on the linkage of the kinetic chain for a specific sport-specific movement. For example, the weakness of the hip abductor might affect the transfer of force from the ground to the trunk during shuffle steps or even strikes [40,41].

Conclusion

Muay Thai is a martial art sports with high aggressiveness during attack. Because of its high impact, sports injuries are common in professional fighter. With the potential benefit from its high intensity training, it has also been generalized to public for fitness in gym studio. With proper guidance from professional coaches, conditioning training might help the fighters to control their body weight, to better utilize the effect of training in real combat, and even to get rid of sports injury. Although popularity is growing on this Thai martial art, limited research study can be retrieved regarding to health issues of Muay Thai. Therefore, further research is vital in this area.

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Western Boxing and Health

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Abstract

Western boxing is a world-renowned combative spectator sport. Despite its popularity, debates persist over its safety and ethics due to its aggressive nature. There are three streams of research related to boxing and health. The first stream focuses on the physiological profiles of boxers, and suggests that a boxer's performance is associated with the interplay between aerobic and anaerobic energy systems. Highly intensive and lengthy training intervals are recommended for boxers to meet the aerobic and anaerobic demands that arise during matches. The second stream of research investigates boxing-related injuries. The most common injuries are head, face and hand traumas. These injuries may have life-threatening or career-ending consequences for boxers. Therefore, ringside physicians are necessary and should pay considerable attention to potentially catastrophic emergencies during matches. The third stream of research suggests that boxing is both physically and psychologically beneficial to young people. However, no solid evidence has been reported to substantiate this proposition, and further research is required.

Keywords

Boxing; Injury; Physical benefits; Physiological profile; Psychological benefits

Introduction

Boxing, also known as pugilism, is a combat sport characterized by two people engaging in short, highly intensive bursts of activity [1]. It is a contest of strength, speed, reflex and endurance. Its origins can be traced back to ancient Ethiopia around 1500 BC, before it spread to ancient Egypt [2]. It was first introduced at the Olympic Games in 688 BC. Around 400 BC, boxing become more competitive and took on a more violent nature due to societal demand [3]. Due to its severe brutality, it was eventually banned in 30 BC [4] until it re-emerged as prizefighting in England in the seventeenth century. Prizefighters set up boxing "schools" and "academies" to provide the middle and upper classes with opportunities to learn boxing skills and techniques [3]. Therefore, modern boxing arose from a desire for recreational and physical activity [4]. In 1742, the first boxing rules were introduced by Jack Broughton, who is known as the "father of English boxing" [5]. In 1867, when boxing was reviewed as a gentlemanly sport, the ninth Marquess of Queensbury further refined a set of rules [5], including the major rule change that required fighters to wear gloves [3]. The modern version of boxing debuted at the 1904 Olympic Games, and debates over its safety and ethics continue to this day [4,6].

Contest format and scoring

Weight classification systems have been applied to boxing matches since 1867 to minimize the influence of different body weights between opponents and make competition fairer [5]. There are currently 11 accepted weight categories in senior international amateur boxing, ranging from light flyweight (48 kg) to super heavyweight (91+ kg) [5]. Prior to the 2000 Olympic Games, the Association Internationale de Boxe Amateur (AIBA) instituted a four-round stipulation and round durations of 2 minutes with 1 minute recovery periods between them [3,5]. After the 1988 Olympic Games, the AIBA introduced a computerized scoring method, which put more emphasis on punching force than on flair [7]. If a boxer's punch hit his opponent's targeted area with sufficient force, five independent judges pressed a colored button matching the color of the boxer's corner [5].

Physiological profile of amateur boxers

Although boxing has amassed worldwide popularity and high levels of participation, few investigations have examined its physiological demands [5]. A group of researchers from Canada developed a quantitative method of simulating boxing exercises in a laboratory to measure the oxygen consumption (VO_2) requirements of various boxing exercises such as sparring, pad work and punching bags [8]. Their results showed that simulated lab sparring and pad work required similar levels of VO_2, corresponding to a peak of about 70%. Due to the higher intensity of real competition, the results of this study, and even those based on more demanding boxing exercises such as sparring and pad work, suggest a VO_2 peak of 62.2 ± 4.1 $mlkg^{-1}$ min^{-1} as the minimal level at which training loads are set for aerobic training, and that boxers should use this amount as a reference [8].

In addition to aerobic capacity, which is normally represented by maximal oxygen consumption (VO_{2max}), the anaerobic adaptability of amateur competitive boxing has been investigated by testing heart rate and blood lactate response. Ghosh et al. [9] measured heart rate and blood lactate concentrations in boxers from three different weight categories. Their results showed that the anaerobic adaptability of the boxers was the same irrespective of their weight categories and aerobic capacities. The findings also indicated that the training required boxers to tolerate a high blood lactate level and a high heart rate during one match.

Examinations based on middleweight-class amateur boxers revealed that the VO_2 level at an individual's anaerobic threshold and hand grip strength were highly correlated with amateur boxers' competition rankings, and that VO_{2max} and wrist girth were moderately related to boxers' competition performance rankings [10]. In other words, these findings suggest that a boxer's performance is correlated with his/her physical fitness level, as indicated by his/her individual anaerobic threshold, maximal oxygen consumption and upper

body muscular strength.

A recent study focused on the effects of aerobic and anaerobic energy systems on amateur boxing performance [5]. The results indicated that both senior and junior England international amateur boxers experienced high blood lactate and VO_{2max} levels after competition, suggesting that boxing performance is dependent on the interplay between aerobic and anaerobic energy systems [5]. The effect of a normally observed pre-contest weight loss pattern has also been investigated. To gain a physiological and psychological advantage in the same weight category [11,12], England international amateur boxers were found to achieve gradual and rapid weight loss over a 21-day period prior to weigh-in via active or passive methods. The boxers' hydration status was reflected in their high urine osmolality values. The author suggested that when boxers cannot use the recovery period between the weigh-in and start of the competition to repair fluid or energy deficiencies, their performance and health are affected if they begin the competition in a dehydrated or glycogen-depleted state [5].

Different age groups and training levels have also been reported to have significant effects on aerobic and anaerobic systems [1]. Based on morphological, physiological and biochemical measurements, senior boxers aged 20 and older had higher statures, body mass, body fat, back strength and hand grip strength compared with juniors aged 19 and under. In addition to lower aerobic capacity and anaerobic power, lower maximum and recovery heart rates were observed in junior boxers compared with seniors. Graded exercises and actual boxing rounds were included in the tests to assess cardiovascular adaptation, and the boxers' blood lactate concentrations increased in both situations when their workloads increased. The results from this study suggested that to meet aerobic and anaerobic demands during matches, boxers must engage in highly intensive training at lengthy intervals [1]. Figure 1 summarizes the aforementioned studies in terms of how the aerobic and anaerobic systems and their interaction affect boxing performance.

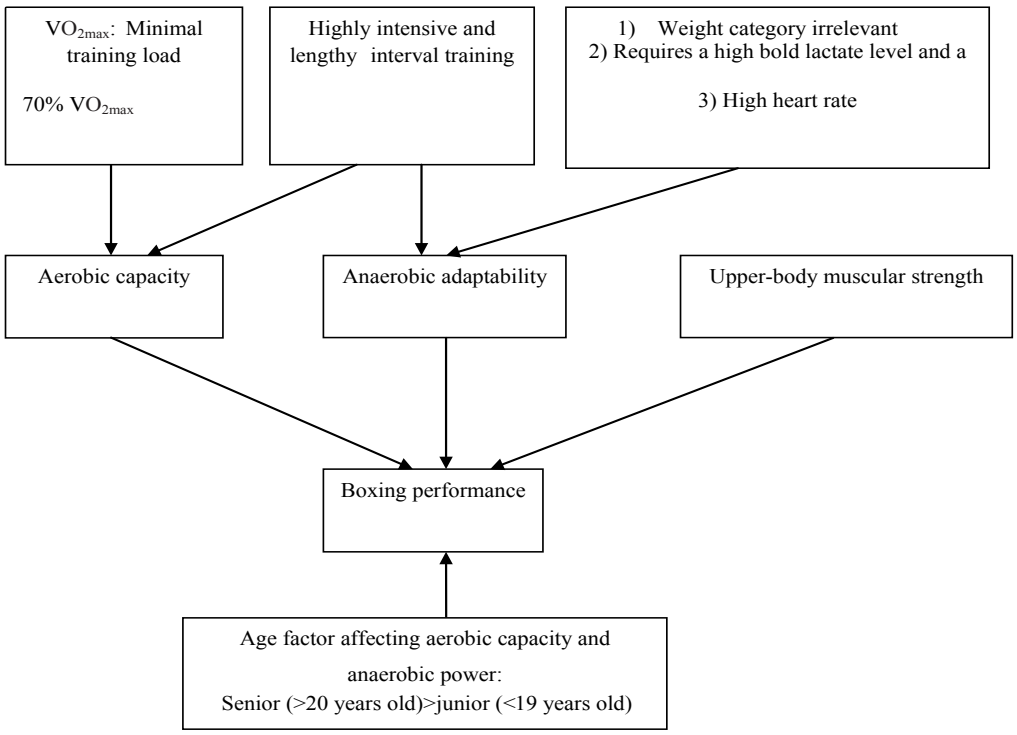

Figure 1: Key points of the physiological demands of boxing performance.

Boxing-related health hazards

Although boxing is popular worldwide and watched by millions of people on television, it consistently evokes contrasting moral opinions and fierce debate due to the physical damage it can cause to competitors [4,13,14]. Most injuries are inflicted on the head, neck, face and hands [4,15]. Non-neurological injuries, including cardiovascular incidents, orthopedic trauma, blunt chest or abdominal trauma, acute psychotic emergencies and airborne infections, are not unusual in boxing [16-18]. Table 1 summarizes the different locations and possible results of injuries sustained in boxing matches.

Location	Type of injury	Hazardous results
Brain	Acute traumatic brain injury	Cerebral concussion; cognitive, behavioral or neurophysical impairment
	Chronic traumatic brain injury	"Punch drunk" syndrome; dementia pugilistica
Eye	Corneal abrasion	Corneal ulcer; blindness
	Hyphema	Acute ocular hypertension; optic nerve atrophy
	Retinal lesions	Vision loss
Hand	Boxer's knuckle and traumatic carpal boss	Pain and dysfunction of the hands
Non-neurologic emergencies	Blunt chest trauma; cardiac arrest; blunt abdominal trauma; orthopedic trauma	Life-threatening or career-ending injuries

Table 1: Summary of different locations and possible injuries resulting from boxing.

Brain injury in boxing

The most commonly reported and widely discussed injury associated with boxing is traumatic brain injury, including acute and chronic injury [13,19,20] and the most common acute brain injury encountered in boxing is cerebral concussion [19]. In amateur boxing, 5.7–8.7% of matches are stopped due to knockout or blows to the head [21,22]. The incidence among professional boxers is

reportedly higher. In a survey that reviewed boxing injuries in Victoria, Australia from 1985 to 2001, 15.9% of the injuries sustained were concussions [23]. Graham and colleagues recently provided evidence to further confirm that punches to the head following five two-minute boxing rounds caused acute brain trauma [24]. Punches to the head resulted in elevated levels of neurochemical markers compared with punches to the body, indicating the presence of brain tissue damage such as neuron-specific enolase and cortisol. This kind of biochemically discernible brain tissue damage may cause intra-cerebral hemorrhage in up to 38% of boxers, with 7% requiring neurosurgical intervention [25].

The clinical presentation of acute brain injury includes cognitive, behavioral, neurological and physical impairment. Boxers suffering acute brain injuries may experience problems with attention, planning and memory [26]. Various other neurologic symptoms are also encountered in boxing, such as derangement of muscular tone, cerebellar and vestibular signs, pyramidal symptoms, unconsciousness, extrapyramidal signs and general muscular weakness [27].

Comprehensive neurologic examination, neuropsychological testing and neuroimaging are used to diagnose the acute brain injuries associated with boxing [19]. The Glasgow Coma Scale is used to assess boxers suffering moderate or severe brain injuries and offers guidelines on the categorization of emergencies. Observation is useful in the treatment of acute brain injury, as the types and severities of such injuries vary due to their self-limited characteristics [19]. However, any boxer suspected of suffering an acute brain injury during competition should be immediately sent to a hospital with proper neuroradiological and neurosurgical services to minimize/eliminate the potential dangers presented to the central nervous system [19]. A qualified ringside physician who can identify a concussion during a match and be responsible for the pre- and post-fight evaluations is essential. With such a physician in place, a match can be terminated before additional neurological injuries occur [6,15,19].

Chronic traumatic brain injury is considered the most serious health concern in modern-day boxing [4,19]. It is known by a number of names, including dementia pugilistica, chronic traumatic encephalopathy, chronic neurologic injury and "punch drunk" syndrome. As early as 1984, Casson and colleagues observed definite evidence of chronic brain damage in 87% of the professional boxers they subjected to neurological examination, Electroencephalograms (EEG), Computer Tomographic (CT) scans of the brain and neuropsychological testing [20]. Their neuropsychological test results were highly correlated with abnormal CT scans and/or EEG findings. Such tests could be used as highly sensitive and accurate predictors of brain damage, and detect early signs of brain damage if applied periodically [20].

Later studies of amateur boxers concluded that there was no evidence of neurological abnormalities according to CT or EEG in current or former amateur boxers [13,28], perhaps because professional boxers are subjected to stronger and more damaging blows [13]. Previous studies have also documented the risk factors for chronic brain injury among boxers, such as later retirement, increased career duration, a greater number of bouts and examination after the age of 50 [29]. Increased/prolonged exposure to boxing could account for the most important risk factor of cumulative boxing-related brain trauma [19].

In addition, research has suggested that chronic traumatic brain injury in boxers may be related to the Apolipo Protein E (APOE) ε4 gene, and that together they can increase an individual's risk of Alzheimer's disease by 10 times or more [30]. After analyzing 30 professional boxers aged 23–76, Jordan and colleagues found APOE ε4 to be associated with an increased severity of chronic neurologic deficits in highly exposed boxers, suggesting that chronic traumatic brain injury is associated with a genetic predisposition [31].

The symptoms of chronic traumatic brain injury affect an individual's motor, cognitive and psychiatric conditions [32]. The initial manifestations are mainly presented as behavioral and personality disturbances such as dysarthria, and mild deficits in coordination and attention. These symptoms are usually difficult to detect and assess, especially when the examiner lacks knowledge of the boxer's premorbid personality [19]. Progressions of motor, cognitive and behavioral symptoms indicate the second stage of chronic traumatic brain injury [32]. Boxers may present signs of Parkinsonism or a progressive difficulty with coordination and ambulation [19]. The severe stage is characterized by dementia pugilistica, which is characterized by significant motor dysfunction such as prominent pyramidal, extrapyramidal or cerebellar symptoms [19,32].

Detailed neurological examination, neurodiagnostic tests, computed tomography and magnetic resonance imaging are used in the diagnosis of boxers suspected of suffering from chronic traumatic brain injuries [19,33]. Electroencephalograms (EEGs) are also helpful in evaluating boxers suffering from these injuries [34]. In terms of management, great efforts have been made to decrease the focus on head blows and protect boxers with mandatory headgear, mouthpieces and larger gloves with more padding [4]. However, no definitive treatment has yet been established. As chronic traumatic brain injuries share similar pathologies with Alzheimer's disease, the methods used to manage cognitive and behavioral symptoms in patients with Alzheimer's disease may be applied to boxers suffering from chronic traumatic brain injuries. For those showing signs and symptoms of Parkinson's disease, dopaminergic agents can be used to relieve their condition [19].

Concussions are less frequent in modern-day boxing due to the greater public awareness of their seriousness and enhanced prevention efforts. However, identifying boxers who are at high risk of receiving concussions via careful pre- and post-bout medical evaluations would help to reduce the prevalence of chronic traumatic brain injury. Whether genetic testing (e.g., APOE genotyping) is recommended in the prevention of chronic traumatic brain injury remains undetermined.

Eye trauma in boxing

Boxing is considered a high-risk sport for ocular injuries due to its inherent traumatic nature and the high incidence of ocular trauma among boxers [35]. About 21–58% of boxers suffer obvious and significant vision-threatening ocular injuries, and more than half of all asymptomatic boxers' exhibit signs of ocular trauma [36,37]. This implies that many boxers risk permanent vision loss due to retinal tears/detachments, macular lesions, cataracts, angle injuries and even ruptured globes [35]. The following paragraphs describe several common types of eye trauma, including corneal abrasion, hyphema and retinal lesion.

Corneal abrasion probably goes undiagnosed in boxing due to its low morbidity, and usually heals within 24–72 hours without other complications [35]. However, if the cornea becomes infected due to epithelium denudation, a corneal ulcer can develop, penetrating into the eye and leading to irreversible blindness and even loss of the eye if proper and prompt treatment such as surgery is not administered. A loose epithelium may predispose the eye to recurrent corneal abrasions, and cause secondary sudden and unpredictable blurred vision and eye pain [35]. In addition to eye ointment and artificial tears, conservative treatment such as microstromal puncture or phototherapeutic keratectomy may be required [38].

Hyphema refers to the bleeding inside the anterior chamber due to trauma caused to the highly vascularized iris and angle structures.

Given the amount of blood in the anterior chamber, the most common consequence of hyphema is acute ocular hypertension [39]. Within 7 days after the initial bleeding, 38% of cases may experience re-bleeding, which usually indicates a poor visual prognosis [35]. In patients who are susceptible to re-bleeding, antifibrinolytic agents have been observed as an effective prevention method [40]. Moreover, both corneal blood staining and irreversible optic nerve damage with atrophy may occur along with hyphema [39,40]. In particular, a corneal transplant may be required for visual rehabilitation in corneal blood staining cases [39]. Treatments for hyphema include oral and topical steroids, aqueous suppressants, eye shields and mandatory rest. Surgical evacuation is essential to save the sight of patients who experience difficulty controlling the intraocular pressure [35].

Retinal lesions, specifically retinal detachment and dialysis, has been reported as one of the most frequent and sight-threatening injuries among boxers [37,41]. A correlation between the number of fight losses and incidence of retinal tears has been reported based on a series of 74 boxers [37]. Furthermore, the chances of a retinal tear occurring have been found to increase steadily with the number of matches in which a boxer participates. For example, after 75 matches, a boxer has a 90% chance of suffering a retinal tear [37]. Studies have reported that even after retinal surgery, only half of all boxers with retina injuries can drive legally [42]. To minimize the possibility and effects of eye injuries for boxers, the American Academy of Ophthalmology recommended a revision of the policy statements [43]. For instance, they instituted a mandatory temporary suspension from boxing for specific ocular pathology, and thumb less boxing gloves to minimize ocular injuries.

Hand injuries in boxing

Due to the continual exposure of the hands to trauma in boxing, no other sport presents a greater risk of hand injury [44]. Previous studies have shown evidence of a high prevalence of hand injuries in both amateur and professional fighters [45,46]. Boxer's knuckle and traumatic carpal boss are the two most common hand-related injuries in the sport [46,47]. Boxer's knuckle refers to injuries that disrupt the Metacarpophalangeal (MP) joints of fingers. The enormous force of a punch predisposes the MP joints or knuckles to damage, particularly with a clenched-fist posture [44]. Extensor hood disruption is the most frequent and severe type of Boxer's knuckle due to its disturbance of the longitudinal central tendon and transversely oriented sagittal fibers [47].

Traumatic carpal boss is another common hand injury that causes major disability. The rigid Carpometacarpal (CMC) joints can become unstable due to the repeated excessive trauma transmitted from the MP joint to the base of the metacarpals [44]. Chronic or recurrent injuries may lead to painful periarticular bony atrophy, joint subluxation and articular degeneration [48].

Although most hand injuries in boxing can be successfully treated using conservative methods, surgery is the best option for the management of both boxer's knuckle and traumatic carpal boss [44]. Direct repair of the disrupted extensor hood for boxer's knuckle and arthrodesis of the destabilized CMC joint are the preferred methods. Follow-up evaluations conducted after operations indicated that boxers were highly satisfied in terms of pain relief, digital mobility recovery and hand strength restoration [44].

As hand injuries are inevitable due to the inherent traumatic nature of boxing, preventive methods are essential to decrease their incidence. For instance, boxers should master punching techniques with efficient and potentially less injurious mechanics, and avoid excessive punching; correct taping and wrapping methods should be precisely applied to absorb, diffuse and diminish detrimental forces. Medical personnel should constantly examine and monitor boxers' hands to discover potential trauma or injury at an early stage and thus prevent severe consequences [44].

Non-neurological emergencies in boxing

In addition to the basic noncritical injuries suffered in the ring, there is a wide variety of less common but serious medical and traumatic emergencies that may threaten the lives or end the careers of boxers. Ringside physicians must pay special attention to these conditions and manage them immediately [49].

Blunt chest trauma, for example, does not normally present a life-threatening emergency for a boxer due to the strong muscular coverage of the thoracic cage and the protection offered to the chest wall by the upper limbs [49]. However, when a fractured rib resulting from a hard punch administered directly to the thorax causes a laceration to the spleen or the development of a tension pneumothorax, the blunt thoracic trauma could result in death [50]. Cardiac arrest caused by a direct blow to the peristernal area is also a catastrophic condition. Immediate defibrillation is critical to saving lives in ventricular defibrillation cases [49,51].

Trauma to other systems incurred during boxing matches can also have devastating consequences. Blunt abdominal trauma can cause spleen and liver injuries. Although rare, orthopedic trauma can lead to cervical spine fracture and threaten a boxer's life. Cardiac emergencies such as sudden cardiac death, which mostly affects seemingly healthy athletes, occur due to either structural abnormalities of the heart or inherited arrhythmia conditions [49].

It is equally important to recognize and diagnose both obvious injuries and noncritical abnormalities before and during a boxing match. As the mainstays in boxing, the ringside physician and other health professionals should be proficient at managing life-threatening emergencies and be prepared to deal with them at all times [49].

Medical safety in boxing and the role of the ringside physician

Due to the absence of a national commission for the surveillance of boxing, the ringside physician plays a multifaceted role. He/she is responsible not only for the safety of boxers and making recommendations related to match termination, but also for executing pre- and post-fight evaluations and medical care [6,15]. In a pre-fight evaluation, ringside physicians review each fighter's medical records. This evaluation is the most vital screening for any medical conditions that may endanger the fitness of the participants, thereby minimizing the risk of injury and death [6]. In most states, the pre-fight evaluation includes a comprehensive medical history form, periodic blood tests, physical examinations, electrocardiograms, dilated eye exams and brain scans [15]. Physical examinations must be conducted by a ringside physician no more than 24 hours before a match [6,15]. Ringside physicians identify issues that could increase a fighter's risk of serious injury in the ring, such as unhealed lacerations, active skin infections, cardiac abnormalities, pulmonary abnormalities, orthopedic injuries and neurological abnormalities [6].

During a match, in addition to obvious injuries, ringside physicians monitor the fighters' coordination, agility and aggressiveness to make prompt and accurate recommendations related to terminating the match if a risk of serious injury arises [15]. After the match, each fighter undergoes a post-fight evaluation to assess his/her need for urgent medical attention and to determine any appropriate follow-up

tests and medical consultations [15]. The mental status of the fighters and a review of every physical injury are also included in a post-fight evaluation [6]. To conclude, the continuous evolvement of medical safety and the legislative and legal aspects of ringside medicine will ensure more adequate protection of boxers' interests [6].

The positive side of boxing

Although there are a number of health hazards associated with boxing, the sport does have some benefits [52,53]. For example, Blonstein [52] and Morrison [53] both suggested that boxing develops young people's self-control, determination, discipline and good sportsmanship on top of their physical conditioning. Boys may also derive psychological benefits (e.g., develop confidence and become more extroverted) due to boxing training [52]. A group of researchers recently exposed patients with Parkinson's disease to boxing training [54]. The authors reported short- and long-term improvements in their balance, gait, daily activities and quality of life after 12-24 weeks [54].

Summary

Although the majority of the evidence suggests that boxing is a dangerous sport, it does have some physical and psychological benefits, particularly for young people. More research is required to substantiate this proposition.

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Wrestling and Health

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Abstract

Wrestling is one of the oldest sports in the world and appeared in the first Olympic Games since 776 B.C. It has been developed into a wide range of styles based on different cultures, including Greco-Roman, Freestyle wrestling, Grappling, Mixed Martial Arts, Chinese Shuai jiao, Mongolian wrestling and Sumo. In this chapter, different styles of wrestling are presented with the focus on Greco-Roman and Freestyle wrestling, and the benefits of wrestling, known as the whole person development, muscular strength and endurance, cardiovascular capacity, body composition and bone mineral density, are discussed. The nutritional status, metabolic system and common injuries of wrestlers, are also presented in this chapter.

Keywords

Freestyle; Greco-Roman; Injury; Nutrition; Physical benefits; Wrestling

Introduction

Wrestling, involving grappling type techniques such as clinch fighting, throws and takedowns, joint locks, pins and other grappling holds, which demands athletes using strength to subdue an opponent without weapon and is one of the oldest combat sports in the world. It appeared in the first Olympic Games in 776 B.C. [1] and was a focal sport in ancient Greece. To date, the presentation of muscles, power, techniques and athlete's spirit make wrestling popular over the world. Based on different cultures, wrestling has been developed into a wide range of styles, including Greco-Roman, Freestyle wrestling, Grappling, Mixed Martial Arts (MMA), Chinese Shuai jiao, Mongolian wrestling and Sumo. This article focuses on the Freestyle Wrestling and Gerco-Roman Wrestling which are the official Olympic events. In the modern Olympic Games, Freestyle and Greco-Roman wrestling made their first appearance in 1904 and 1908, respectively, while the women's freestyle competition was introduced in 2004.

Wrestling is a one-versus-one game and a physically demanding sport which requires wrestlers' whole body muscle involvement and thus high energy consumption. Techniques of wrestling include 'throws', 'takedown', 'pins' and 'grappling holds'. Since June 2013, International Federation of Associated Wrestling Styles adopts new competition rules that the game contains two sessions of three-minute periods, with 30 seconds break in between [2]. As wrestling does not require any weapons, wrestling techniques are not only widely applied at other material art in form of combat sports, but also applied in daily practical use, especially at military hand-to-hand combat systems and self- defense techniques.

Greco-Roman vs. Freestyle Wrestling

Rajabi, Doherty, Goodarzi and Hemayattalab (2008) described the development of two styles of wrestling that "freestyle wrestling is directly descended from ancient forms of wrestling as depicted in Greek and Egyptian art. On the other hand, Greco-Roman wrestling is a more modern form developed in Europe in the late 19th century. Both styles emphasize takedowns and pinning with very little mat wrestling, but there are clear differences in body position" [3].

The major difference between Greco-Roman and freestyle wrestling is that, Greco-Roman wrestling only allows holds above the waist and forbids the use of legs to gain advantage over the opponents, while the use of legs is permitted at freestyle wrestling [1,3,4]. Apart from the above, the point calculation and the forbidden of dangerous actions are also different.

Benefits of Wrestling

Health can be interpreted as physical, mental and social well-being which is associated with the engagement of wrestling. In the following paragraphs, the whole person development, muscular strength and endurance, cardiovascular capacity, body composition and bone mineral density associated with wrestling are discussed.

Benefit for whole person development

Although wrestling appears to be a rude and violent game, it involves different strategies and techniques hence require wrestlers' significant psychological and emotional preparation [5]. In addition, wrestling not only improves participant's physical fitness including speed, agility, muscular endurance, strength stamina and flexibility, but also mental development, affective domain including courage, perseverance, self-control and sportsmanship [6].

Benefit for physical health

Muscle strength and endurance: Muscle strength and power is the key to success in wrestling. When two wrestlers twist and lie on the ground, or wrestlers attempt to throw or pin the opponent on the ground, high anaerobic power (to subdue the opponents or escape from opponent's catch) and strong muscle endurance (lasting for over 6 minutes competition) are required.

Despite the absolute strength, relative strength (muscular strength relative to body weight) seems to be more crucial as the wrestlers are weighted and match up with the opponent in the same weight group; therefore higher relative muscular strength and lower body weight are advantageous. Yoon (2002) reported that absolute strength was greater in heavier wrestlers than in lighter wrestlers, but the reverse was true for relative strength.

It was found that long term wrestling training enhanced the anaerobic performance of wrestlers' upper body muscles, by which senior athletes had longer sustenance than juniors [7]. The same experiment also discovered that wrestlers having longer training experience had higher muscle endurance performance which displayed higher tolerance to muscle acidosis.

Yoon (2002) explained that successful wrestlers were more tolerant of lactate, because extremely higher intensity-trained athletes were less sensitive to lactic acid and they might even withstand and ignore the pain threshold.

Unlike other ball games or racquet games, neck muscle strength is an important issue for wrestlers due to the high impact of body contact. Strong cervical muscle can support wrestlers to prevent injury both in competition and practice. It was found that wrestlers had stronger cervical muscle strength than non-athletes in term of cervical muscle strength to weight; especially Greco-Roman wrestlers appeared to be stronger than free style wrestlers [8]. As Greco-Roman wrestling mostly emphasizes on upper parts of the body, comparatively strong cervical muscle groups are the result of specific training in accordance with the nature of the sports.

Cardiovascular/aerobic fitness: High demand of both aerobic and anaerobic has been identified as a crucial winning factor in competitive wrestling [4]. Grindstaff and Potach (2006) described wrestling as a highly anaerobic sport which required wrestler's maximal power and strength for explosive attacks, and it also required aerobic capacity due to prolong anaerobic efforts. Indeed, Hübner-Woźniak, Lutosławska, Kosmol and Zuziak (2006) defined wrestling as an intense intermittent exercise in which the ability to restore phosphocreatine and remove lactate at rest may determine the winners, and concluded that long-term wrestling training contributed to an increase in aerobic capacity.

It was found that wrestling athletes' aerobic capacity did not meet the level of elite endurance runners, but was significantly higher than the lay active males [5]. Apart from aerobic and anaerobic capability, other components of physical fitness also play key roles in wrestling. It was found that successful wrestlers had higher muscular strength and endurance, and higher flexibility of the low back and hamstrings, than less successful wrestlers [9]. Moreover, Yoon (2002) indicated that "pulmonary volumes and functions of wrestlers were greater than those of non-athletes but were average compared with other well-trained athletes".

Body composition: Body composition reflects the percentage of fat, bone and muscle in human body which determines the metabolism for body grow and is influenced by different dietary intake during preseason, in-season and postseason of wrestling competition. Studies have shown that body composition of young elite wrestlers altered after participating in wrestlers training. It was found that Fat Free Mass (FFM) was larger in male than female wrestlers [10]. In contrast, percentage of Fat Mass (FM) was lower in male than female wrestlers. In addition, it was found that mean power of the wrestlers was significantly correlated with FFM in both genders. In general, most wrestlers had a preference on small percentage of Body Fat (BF %) as they were allocated to different categories of competition determined by their body weight. The study suggested that wrestlers and coaches should control the percentage of FM as well as FFM which determined anaerobic performance. Moreover, insufficient dietary intake reduced protein which caused impairs on muscular performance and decreased FFM levels. FFM changes were also associated with strength and power during the sport seasons. Power was significantly associated with FFM in young wrestlers while evidences were still unclear in adult group [11].

Lingor and Olson examined the methods used to meet certification weight for wrestling and to measure the changes in body composition during one season for college wrestlers. They reported that subjects' Fat-Free Mass (FFM) increased an average of 1.8 kg, whereas Fat Mass (FM) decreased 2.2 kg from the beginning to the end of the season [12].

In the study conducted by St. Cloud State University in 1978 [13], the test results of body composition had shown that there were over half of the wrestlers in the past study made weight by losing several pounds (up to 11 pounds). Weight losing appeared in the last few days just before their matches throughout the regular season. In fact, four of the national wrestling qualifiers lost more than 9.5 pounds (one lost 20 pounds) within a few days preceding the national championships. Two of them made it to the finals and advanced to a higher Division while in another received AII American honors. All four athletes wrestled in a weight category that was equal to or below their lean body weights. None of these wrestlers were below 6.2% fat at the time. Among all different body composition measurements, skinfold measurement tended to make the athletes appeared to be less fat than what was actually the case. Dehydration appeared to be the preferred method of rapid weight reduction among wrestlers and a result of the rules governing the sport [13].

Bone mineral density: Mechanical loads have strong effects on bone adaptation, as reflected by the fact that males' Bone Mineral Density (BMD) increased after athletic training, particularly in the highly stressed part of skeleton [14]. Wrestling is a high impact body contact activity causing short, high, and multidimensional loads on skeleton. It was found that wrestling athletes not only needed high accelerations and in multidimensional, but also moved with high power in a dynamic way, which resulted high strain on bones and high positive osteogenic effect [14].

Platen et al. also found out that weight athletes (judo and wrestling) had the highest bone mineral density values, among team sports athletes, sport students, athletes (runner, cyclist and triathletes) and untrained controls, supporting that wrestling facilitated skeleton growth and development.

Nutrition

Nutrition is another important element affecting wrestler's body composition and their performance. Roemmich and Sinning (1997) found that dietary restriction reduced protein nutrition and muscular performance, but had little effect on linear growth and maturation in the young individuals. The changes in lean tissue were associated with strength and power. Weight loss through dietary restriction has been proposed to hinder the somatic growth of adolescent wrestlers, but no reported adverse effects on body height. Previous studies of

pubescent wrestlers have presented that incremental growth in skeletal breadths and body girths have decreased during the season and increased during the postseason. In addition, several longitudinal investigations on body composition have shown that FFM decreased or unchanged across a wrestling season. One study reported that the incremental growth in FFM of young wrestlers was significantly slower than other active youth during the wrestling season. Nevertheless, several studies have reported accelerated growth in FFM of young wrestlers during the postseason [11].

The reduction in the protein nutrition status of adolescent wrestlers due to dietary restriction contributed to the significant reduction in skin fold estimates of FFM [15]. However, no study established a criterion for body composition assessment in an attempt to investigate the relationship between changes in the protein nutrition, FFM of wrestlers and other weight-control athletes. In general, body composition was measured by underwater weighting with the use of the procedures previously described [16]. In brief, lung Residual Volume (RV) was measured on land first by nitrogen washout with the subject seated in the same position during the underwater weighing. The RV measurements were repeated until the two trials were within ± 50 ml. The equation which accounts for maturation-related changes in the density of the FFM, were used to compute percentage of Body Fat (BF %) [17]. Results revealed that control subjects increased their weight and FFM from pre-to post-season but their BF% or FM did not change. The in-season decreased in FFM by 1.1 kg which was not significant, but the postseason increased by 3.0 kg significantly. The pre-to-post-season increased in FFM (1.9 vs. 2.1 kg) was similar for both groups.

It was believed that the most successful wrestlers would reduce their body weight and maintain their strength and power by limiting the loss of FFM. Dietary restriction and the wrestling training had little effect on bone growth and maturation. In contrast, dietary restriction reduced body protein and fat stores, muscular strength and power. All adverse body reactions quickly recovered during the post-season when wrestlers decreased their training volume and increased their energy intake. During the sport season, changes in lean tissue mass were directly associated with protein nutritional status; while loss of lean tissue mass was associated with a reduction in muscular strength and power [11].

Metabolism system

It was found that intense wrestling bout in adolescents caused profound stimulation of the immune system [18]. The role of these common changes in overall immune status and the development of the immune and haemopoietic systems had yet to be confirmed. In contrast, it was known that wrestling caused a significant increase in the number of all circulating white blood cells, including but not limited to granulocytes, monocytes and mixed lymphocytes [18].

Injury

Wrestling is highly comparatively sports with full of body contact. Same as most of the sports, wrestling have the opportunity to get injured during practice and competition. Data from the National Collegiate Athletic Association Injury Surveillance System concluded that collegiate wrestling ranked second high of the injury rates (9.6 injuries per 1000 athlete exposures), in which most of the injury regions included knee, shoulder and ankle [19]. Expectedly, the study also found that competition had a significantly higher injury rate than practice.

Statistics from The National Center for Catastrophic Sports Injury Research (NCCSIR) during the period from September 1981 until June 1999 showed that there were 2.11 direct catastrophic injuries per year or 1 per 100,000 participants during wrestling practicing or competition, which 80% of wrestling catastrophic injuries came from competition and most of them from the low or middle weight classes [20]. Barry, Lin, Young and Mueller (2002) also summarized that most of the catastrophic injuries were related to the cervical fractures or major cervical ligament injuries. Rezasoltani, Ahmadi, Nehzate-Khoshroh, Forohideh and Ylinen (2005) explained that cervical injury mostly occur when the defender tried but failed to keep the head and neck in a fixed position against the opponent's force.

At an elite senior level of wrestling competition (2008 Beijing Olympic), the overall incidence rate was 9.3 per 1000 athletes and 7.88 injuries per 100 matches, and most injury was minor [21]. As elite senior wrestlers should have more experience than youth and their physical condition also at the highest level for the competition, they can minimize the risk of the serious injury.

Conclusions

Wrestling not only can build up stronger body strength, but also enrich the cardiovascular capacity, body composition, bone mineral density and even the metabolism system. Moreover, participants' all rounded development also can be improved through wrestling practice and competition. Although injury may occur, the risk of serious injury can be minimized through different recommendations. Specific muscular training for the wrestlers may help protect the cervical and spinal away from serious injury, especially the isometric contraction of the cervical muscle which withstands massive loads to maintain their acquired position [8]. Proper coaching on wrestling techniques and strictly enforcing penalties for slams from referees can reduce the risk of injury [20], as illegal action accounted for 4.6% of injuries in competition [19].

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Fencing and Health

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Abstract

Fencing has long been considered a martial art and has an extensive history of practice. Competitive fencing is part of the Olympic Games, World Championships and World Combat Championships and it is a popular sporting activity for children and adults. This article presents a literature review of the anthropometrical, physiological, psychological and psychomotor characteristics of fencing, supported by data from published research studies. As competitive fencing is highly physically demanding, metabolic changes in aerobic and anaerobic power and muscular involvement during competition performance are addressed. During fencing practice, it is important to take proper precautions to prevent heat illness and physical injuries. Muscle overuse, muscle strains and ligament sprains are the most commonly reported injuries in fencing. Serious injuries such as penetrating accidents with broken blades are rare but not unknown. Although protective clothing can lower the risks faced by elite fencers during intensive training and highly competitive sporting events, it can also contribute to heat stress, which can be lethal especially when thermal cooling cannot be effectively applied with proper rehydration. In addition, protein requirements are related to muscle mass, which affects an individual's optimal sports capacity. Common myths surrounding protein supplements are examined to ensure proper administration. Thus, this review summarises the broad areas of fencing and health with the objective of ensuring fencing is practiced as a safe and health-promoting sport.

Keywords

Fencing; Metabolic requirement; Muscle strength; Protein catabolism; Thermoregulation

Introduction

Fencing is a historical sport that was first practiced in ancient Egypt as early as 1200 BC [1].Fencing was once considered an art form and was formally admitted as a sport in the first modern Olympic Games in 1896. The approved weapons include the foil, the sabre and the epée. At first, only men competed in foil and sabre fencing, and in epée fencing from 1900. Women first participated in foil fencing at the 1924 Olympic Games, and in sabre fencing at the 1998 World Championships and 2004 Athens Games [2].

Fencing is an open-skilled combat sport involving two athletes fighting with the use of weapons [1]. It is referred to as open-skilled because fencers must constantly adapt to changing situations during the competition through the processes of perception, decision-making and execution. The cognitive decision-making process is a critical strategy to counter the movements and body gestures of the opponent [3]. Different weapons follows different rules: the valid target area in the foil combat includes the torso and the groin while the head, arms and legs are not allowed; the target area for sabre fencers includes the torso above the waist which referring to the inclusion of arms and head, but not the hands; the target area in the epée combat includes the entire body. In a fencing competition, a referee oversees the bout with the assistant of an electrical scoring apparatus connected to the fencers. Competitions are organised into preliminary pool bouts or elimination bouts, with an allowed maximum time stated according to various game rules. The first fencer to reach a designated score is declared the victor of the game. In sabre and foil fencing, a priority system is followed whereby if the two fencers score a touch at the same time, only the fencer having the priority scores the touch. However, there is no such priority system existing in epée fencing and two fencers could score if they touch each other at the same time.

It is common for fencers to cover between 250 and 1000metres in each action [4]. During each bout, fencers will make preparatory movements that last longer and are less intense than the very intensive movements that end with a tentative touch on the opponent and are aimed at scoring. Each round of an international fencing contest lasts for about 15 minutes, and a whole competition lasts 9 to 11 hours in a single day with around 18% of the time spent in bouts [5].

Anthropometrical characteristics

Most fencers are of normal size in terms of Body Mass Index (BMI), but with a variable body fat percentage [6-12]. Similar to the general population, female fencers' have a higher body fat percentage and lower lean mass percentage compared with male fencers. This may affect women's fencing performance because muscle strength and muscle endurance are the key predictors in sports with long competition times. Besides, fencers in different fencing types are different because foil and sabre fencers require vibrant movements for aggressive touching on the opponents, they are usually trained with higher percentage of muscle mass, while the epée fencers are relatively conservative in their combat in order to get a score without a touch by the opponents, they do not have as high percentage muscle mass as other two types for better flexibility.

Somatotype is another indicator of athletic performance and is used to assess athletes' physiques. However, few studies have examined the anthropometry of fencers [12,13]. These studies revealed that competitive fencers were of different types: men were predominantly of the central type, with mean endomorphy, mesomorphy and ectomorphy of 3.1, 2.6 and 3.2, respectively while women were predominantly endo-ectomorphic, with mean endomorphy, mesomorphy and ectomorphy of 3.8, 1.8 and 3.3, respectively [12]. Significant asymmetry has been found in the Cross-Sectional Area (CSA) of the dominant forearm, arm [12-14], thigh [14-16] and calf [17] offencers. Asymmetry was also observed in different technical level or number of years in training [15].The CSA of the medial extensor muscles in both left and right legs of the studied fencers were also found to be larger than the same muscles of control non-fencers [15], suggesting that the bouncing movements exhibited in the on-guard posture with the knee joint angled 20-30°(Figure 1a)

could cause the asymmetry in the limb muscles. As the anthropometrical and somatotype data were observed consistently in the studied fencers over time, their asymmetrical limb characteristics were evidently influenced by their practice.

Figure 1a: On guard pose.

Aerobic and anaerobic power

Fencing though not an endurance activity, it can be classified as a moderately aerobic sports activity [18]. Fencers must control the game by sub-maximal changes in aerobic activity and refuelling the anaerobic movements during the interruptions that occur throughout fencing bouts. Fencing is physically demanding as it emphasises the variability in the physiological response to the adversary. Factors such as age, gender, level of training, technical and tactical models also affect the physical demand.

The relationship between performance and physiological characteristics varies with different styles of fencing. Adrian and Klinger [19] observed that fencers were capable to attack the opponent from a deep on-guard posture point. Their studies showed that fencers' lunge speed (Figure 1b) was inversely related to the vertical impulse generated by the rear leg. They also found a directly proportional relationship between the lunge speed and the horizontal impulse of the rear leg. The drive from the rear leg could be the main factor in promoting the speed and power of the lunge for an attack [20]. The power generated by fencers has also been found to be independent of their level of skill. Some skilled male fencers may present monotonic energy while less skilled ones present maximum energy [21]. Skilled fencers seem to require less power but are faster at hitting the target, suggesting a relationship between coordination and technique.

Figure 1b: A lunge.

Metabolic requirements

Fencing is a mix of aerobic and anaerobic exercise. In a women's epée competition, fencers' heart rates were found to vary with the intensity of the bout, ranging from 167 to 191 beats/min, approximately 70% of the maximal heart rate, during two thirds of the fight [18,22]. Another study found that male epée fencers at the international level required a higher daily energy intake (3868 ± 954 kcal) compared with foil fencers (3176 ± 467 kcal) and sabre fencers (3127 ± 640 kcal) [6].

Heart rates may exceed the anaerobic threshold. During a men's foil completion, it was found that lactate concentrations in blood ranged from 1.4 to 3.9mmol/L (2.5 ± 1.1mmol/L) if measured 5 minutes after the end of the preliminary pool bouts and the lactate concentrations in blood was found higher than 4mmol/L if measured 5 minutes after the end of the direct elimination bouts and in the finals [23]. The highest lactate concentration of 15.3mmol/L was measured in the winner at the end of the competition [23]. Because lactic metabolism is always lower during training than competition, the stimulation of this anaerobic muscular glycolysis was explained as the result of additional adrenaline (epinephrine) [8].

Although muscular involvement is high during fencing competitions, it is submaximal most of the time [8]. In general, the better

the technico-tactical abilities of the fencer, the higher the metabolic involvement. Usually, technico-tactical involvement increases as metabolic and muscular involvement increase. Lactic metabolism plays a critical role in the later stage of a competition [1]. In the Cori cycle, lactic acid from the muscles is transported to the venous system and converted to lactate [24]. Lactate is then transported to the liver and converted to pyruvate, which is synthesised to glucose for delivery back to the muscles. This process is called gluconeogenesis and it helps to maintain carbohydrate reserves during a competition.

Creatine kinase is an enzyme occupying the skeletal muscle fibres. The amount of this enzyme in the plasma increases when physical effort is exerted, causing mechanical injury to the muscle fibres [25]. The degree of efflux of this intracellular protein in the blood is counting on the level of muscle cell destruction, thus it is a good indicator of muscle fibre injury [26]. Plasma creatine kinase activity was found to increase significantly in women's epée fencers one day after competing in a national competition[22], reflecting the high level of muscle fibre damage during epée competitions.

Static strength

Stronger isometric handgrip strength has been reported in the fencers' weapon hands [14]. However, there was no evidence of significant differences in endurance strength: the maximal isometric finger strength was the same in both hands and the maximal isometric strength regarding the knee extensors at angles of 30°, 60° and 90° was the same for both lower limbs [14,15]. These results suggest that muscle strength is affected by holding the weapon in one hand, but the muscular activity of both lower limbs is similar, regardless of the dominant leg in the on-guard position.

Dynamic strength

During fencing activity, the decelerating movement in the lunge requires the forward knee extensor muscles to perform an eccentric action while simultaneously requiring the rear limb muscles to perform a concentric action. Electromyographic (EMG) activity showed that the forward quadriceps are comparatively static and the backward quadriceps work faster [27].

Interesting results from a muscular biopsy specimen taken from the quadriceps of four epée fencers[15]showed that the proportion of type I fibres in their forward legs was higher than in their backward legs (range: -13% and 31% between legs). As type I fibres are characterised by slow contraction speed, resistance to exhaustion and a high capacity to produce adenosine triphosphate (ATP) by oxidative metabolic processes, an increase in the percentage of type I fibres can improve both sports performance and health. However, with only four fencers in the experiment, further studies are required to draw clear conclusions.

Psychological characteristics

During exercise training and intensive competitions, athletes may experience various levels of overtraining syndrome, such as stress, fatigue and other symptoms that cannot be easily diagnosed [28]. To monitor the physiological strain in training, it is useful to measure endogenous hormones such as testosterone and cortisol. However, overtraining syndrome is parasympathicotonic, leading to a decreased level of maximal blood lactate. To facilitate prolonged aerobic training at intensities below the athlete's anaerobic threshold, the levels of plasma adrenaline and noradrenalin can provide additional information in overtraining syndrome [28]. Hoch et al [8] investigated the physical and psychical strain of competitive fencers using the noradrenaline (norepinephrine) to adrenaline ratio. The results showed that the fencers experienced additional strain during the national championships, with a 525% increase in adrenaline. This reflected the physical effort exerted in training sessions where causal training was conducted and can be explained by the higher levels of cortisol and renin corresponding to the active central stimulation and direct peripheral effects of adrenaline.

Psychomotor characteristics

Fencing practice is associated with consistent muscle harmony and coherent patterns of muscle coordination. Elite fencers have more differentiated control in these areas than novice fencers [29]. Before the execution of a lunge, anticipatory postural adjustments temporally progress from the maximal foil velocity to a minimal value. These anticipatory postural adjustments preceding the lunge movement induce a refractory period– the time that elapses between the excitation state, the rest state and the ready state. This refractory period is undesirable because it can affect performance on the pointing task [30]. Therefore the optimal goal is to reduce the amount of time required in a refractory period through intensive training [31].

Thermoregulation

The heat generated by active muscles raises the core temperature of athletes. Thermoregulation is important, especially in hyperthermia (an increase in body temperature), which can result in death from excessive heat stress. The body's core temperature can increase rapidly when heat gain exceeds heat loss during sports competitions. Heat loss occurs through three physical mechanisms: radiation, conduction and convection. In addition to thermal balance, evaporative cooling from the skin provides essential circulatory heat loss of 18 kcal-min^{-1}[24]. The hypothalamus regulates the body temperature at 37°C. Heat-regulating mechanisms are activated when the temperature in the blood circulating the hypothalamus changes or the thermal receptors in the skin detect temperature changes [24].

Heat stress

The effectiveness of heat transfer by the three physical mechanisms is reduced when the environmental temperature is high; consequently, sweat evaporation from the skin and water vaporisation from the respiratory tract are the only ways for the body to dissipate heat. The relative humidity of the ambient air also affects heat transfer. If the percentage of water in the ambient air is higher than the moisture-carrying capacity at a specific temperature, evaporative heat loss becomes inefficient, producing heavy sweat beads on the skin. Such water loss without heat loss causes dehydration and overheating, with potentially lethal consequences. As skin cooling is only effective in environments with low humidity, not sweating, therefore, it is not recommended to remove sweat from the skin with a towel before the sweat evaporates because this does not produce thermal cooling.

The sweat glands secrete a hypotonic saline solution that evaporates from the skin surface in response to heat stress. The reduced plasma volume increases the osmolality of the blood plasma. This cooling effect from the skin then cools the blood flowing from the interior to the surface. Water loss is another problem associated with excess heat. Dehydration occurs when fluid intake is insufficient to replenish water loss. Dehydration is a state of fluid deficit and if this happens, heat dissipation is hindered. The hindered heat dissipation reduces heat tolerance and seriously affects cardiovascular circulation. Fencers must wear a specific 4-layers fencing gown, mask, shoes

and gloves for body protection (Figures 2a-d), which may increase water loss. Heat stress is high during fencing training and competitions as perspiration enhances the loss of water-soluble vitamins, namely B1, B2 and B3 [32]. During heat stress, there are two hormonal adjustment mechanisms for preventing salt and fluid loss through sweating. First, the pituitary gland releases an antidiuretic hormone, which increases water reabsorption from the kidney tubules during hot conditions. Second, the adrenal cortex releases aldosterone to increase the renal tubules' reabsorption of sodium and thus decrease the sodium concentration in the sweat. These two hormonal adjustments facilitate additional electrolyte conservation in thermoregulation [24].

Figure 2(a-d): Four layers of clothing protection (inner protector, under plastron, outer plastron and the electric protector for foil and sabre).

Heat illness

Reports of heat illness and heat exhaustion induced by the fencer's protective mask, gloves and plastrons (Figures e-f) are common [33]. The risk of heat illness greatly increases when the fencer begins in a dehydrated state. When dehydration reaches a state commensurate to a 3% decrease in body weight, the gastric emptying rate slows and epigastric cramps and nausea increase [34]. Maximal exercise performance is not impaired if dehydration is as short as 60 seconds; however, physiological functioning and optimal competitive ability is significantly impaired when dehydration lasts for more than a minute. Heat cramps occur during or after intense exercise in the group of exercised muscles due to an imbalance in the hydration level and electrolyte concentrations. With heat exposure, the electrolytes are not replenished in time and this increases the muscle spasm. Therefore, it is essential to intake plenty of water containing salt and to increase the daily salt intake in the few days before a competition.

Figure 2e: Glove.

Figure 2f: A sabre mask.

Pre-exercise hydration

Hyper hydration before exercising in a hot environment protects against heat stress by delaying dehydration, increasing sweating during exercise and inhibiting the rise in the core temperature. About twenty minutes prior to the competition, consumption of cool water with the volume of 400 to 600 mL is recommended. A systematic regimen of hyper hydration (4.5 L of fluid per day) one week before sports competitions was found to optimise gastric emptying and improve water reserves and temperature regulation [35]. However, plain water absorbed dilutes plasma sodium concentration and decrease plasma osmolality which then stimulates urine production and blunts the normal sodium-dependent stimulation of the thirst mechanism [24]. With 9-11 hours competition, fencers are not easy to leave the competition field for frequent urination. To promote retention of ingested fluids with less urine output, beverage with sufficiently high sodium content (100 mmol-L^{-1}) contributed the greatest fluid retention [36].

Water replacement

Adequate fluid replacement sustains the exceptional potential that acclimatised humans have for evaporative cooling. Inadequate water replenishment not only reduces exercise capacity, it also contributes to lethal consequences in fluid balance and core body temperature. Properly scheduled fluid replacement keeps the plasma volume to ensure optimal circulation and sweating. However, some athletes may not follow an adequate water replacement regime because they believe that water consumption hinders performance. Surveys have discovered that a water loss of less than 500 mL-L^{-1} was voluntarily replaced [37]. Poor water replacement practices were also found, such as applying cold towels to the skin during exercise or taking a cold shower before exercising in hot weather. These methods, however, are not supported by evidence and may result in heat transfer from the body's surface. In order to balance fluid intake and fluid loss in competitive fencers, five steps of rehydration are tips to follow [24]:

1. Drink 400 to 600 mL fluid two or three hours before the competition.

2. Drink 150 to 300 mL of fluid thirty minutes before the competition.

3. Replenish with plain water in every 15-minute during the competition and after the competition, in total not more than 1L per hour.

4. Sports drinks or fluid with a quarter of teaspoon sodium added are effective in electrolytes balance and carbohydrate fuel.

5. No need to restrict salt in the diet before competition.

Dietary recommendations

International fencing competition is a high-intensity sport and fencers with either inadequate or incorrect dietary practices may not match their energy expenditure with their training needs, which may adversely affect their performance. Many athletes believe that protein is the most important part of the diet because resistance training damages the muscle protein structure, which requires additional dietary protein for tissue re-synthesis. Some athletes also think that endurance training increases protein catabolism to sustain energy requirements when glycogen reserves are low. In fact, this concept of body fuelling is incorrect. By the time an athlete has a low carbohydrate reserve, he or she is exercising in a glycogen-depleted state that increases the use of protein as energy [38]. This increased protein catabolism is a result of gluconeogenesis from amino acid-derived carbon skeletons and aims to sustain the liver's glucose output. This chain of protein breakdown reflects the body's reaction to maintain the blood glucose concentration for the functioning of the central nervous system. Therefore, the correct approach to conserve muscle protein during intensive training is to eat a high carbohydrate rather than a high protein diet. Only a non-glycogen-depleting diet can cope with high endurance training and prevent muscle protein breakdown, which affects sports performance.

Injuries

The incidence of reported injuries in fencing is rare and a quarter of the documented injuries are wounds and bruises. A survey by Roi and Fasci [38] reported the injury rate in regional competitions as 3.7% for males and 5.6% for females. A review claimed that the low rate of reporting could be because fencing injuries do not tend to be serious and surgical treatment is uncommon [1]. The most frequently reported injury locations are the lower and upper extremities [1]. The majority of reported injuries relate to ligament sprains and muscle strains [39-41], and ruptures of the tibial are anterior [42] and Achilles tendons [1].

Overuse injuries resulting from repetitive movements are common in fencing, which is an asymmetrical sport. The problems of overuse injuries are reported in the shoulders, back, the menisci of the knee joint and pelvic girdle [39]. Fencers must maintain a balanced posture with their weapon poised in a proper stance while training for long periods. Tissue lesions may result from such repetitive chronic micro trauma [2]. Lower back pain sometimes affects fencers as the lumbar spine is located in hyper lordosis, which must be supported by strong abdominal muscles. According to Janda [43], this muscle imbalance is described as differences in muscle length or strength, thus a balance of muscle length and strength with opposing muscles around a joint is essential to keep the bones centred in the joint during motion. An imbalance between the two opposing muscles could cause excessive stress on the joint and musculoskeletal pain may result. Therefore, the body position can easily become distorted and the lumbosacral spine structures overloaded [2]. Another injury commonly affecting fencers is knee pain, including medial meniscal tears, medial collateral ligament sprains, lateral subluxation of the patella and patella femoral and pesanserinus syndrome. These injuries are caused by frequent explosive movements such as jumping and sudden starts, forward and backward movements and tibial shock in the lunge. These movements cause a strong impact on the musculoskeletal system and the muscles around the knees are not strong enough to attenuate such impact [44].

Most fencing injuries to the muscles and tendons can be handled by rest, ice, compression and elevation (RICE). RICE is a common and effective treatment method for relieving the discomfort of soft tissue injuries and, with proper management can help to shorten the recovery period and minimise pain (Table 1) [45]. For chronic low back pain, functional training and lumbar stabilization showed benefits and improvement to the patients. Functional training programme in general consists of a warm-up exercise, a strengthening exercise, activity simulation training, fitness and endurance training [46]. These could be achieved with the use of stationary bicycle, stepping or trotting exercise. While spinal stabilization programme usually starts with local stabilization on musculature, with progression to global stabilizers. Examples are supine abdominal draw exercise with natural lordosis and the same exercise with simultaneous upper and lower extremity flexion [47].

Treatment	Primary Management
Rest	Rest is important as it prevents further strain on the affected muscles. If the affected muscle is under continual strain it may increase inflammation and pain and result in further injury, thus hindering the healing and repair of soft tissue. Theoretically, the rest period should be long enough for the affected muscle to restore full function and for the pain to disappear.
Ice	Ice is useful for reducing the inflammatory response and the subsequent heat sensation. Guidelines suggest that an ice-padding towel should cover the affected muscle for 20 minutes and a no-ice padding towel for another 20 minutes. This alternate treatment method is recommended for the first 24-48 hours after injury.
Compression	Swelling is a painful symptom in the inflammatory process. Physical damage to the cells and tissues triggers the inflammation. Capillaries at the affected site dilate and slow the blood flow out of the affected area, causing redness, heat and pain. Compression stockings are usually the best choice for graded compression.
Elevation	Elevation involves lifting the injured area above the level of the heart. The increased venous return of blood helps to minimise swelling, which then reduces inflammatory pain.

Table 1: A summary of RICE management in tissue injuries [45].

Severe injuries resulted by the sharp broken blade can occur, particularly in sabre fencing, which uses a weapon with a thinner blade [48]. Fatal penetrating injuries are not impossible, although rare. Such fatal injuries tend to occur in elite fencers, usually due to the force of penetration breaking the blade. Other factors may contribute to fatal injuries, included a right-handed fencer competing with a left-handed fencer, the action used to make a counterattack and the use of orthopaedic grips [1]. During the 1982 World Championship in Rome, Vladimir Smirnov, a Soviet foilist, died because his opponent's blade broke and pierced his mask. Another fatal injury occurred at the Junior Games in 2004 when an opponent's foil broke, penetrating the chest of a 17-year-old fencer and puncturing his lung. Very rare penetrating injuries, such as to the orbital region, are caused by unbroken blades. In one case, in which the fencers were practicing without protective masks, the tip of the foil penetrated the skull, an intracranial haematoma developed and it took two months for the fencer to fully recover [49].

Prevention of injuries

Fencers' protective clothing is manufactured by tough cotton or nylon with Kevlar fibres. The safety standard for fencers' blades, masks and clothing must be certified by the Federation Internationale Excime (FIE). In international competitions, the clothing and plastrons must withstand a force of 800 N, the mask bib must withstand a force of 1600 N and blades must be made from Managing steel. The equipment used in competitions must be controlled and examined by the equipment measure authorized by FIE (www.fie.ch), a stamp from the authorised organization is put on the approved equipment before the competitions commencement (Figure 3). Elite fencers' weapons are regularly checked during training sessions and competitions to lower the chance of blade breakage. Soft or seriously bent blades should be discarded to avoid the risk of serious injury.

Figure 3: Stamps on approved equipment and protective clothing before the commencement of competitions.

According to Zemper et al. [39], around 50% of fencing injuries could be preventable. The contributing factors include inadequate warm-up, dangerous tactics, poor defending skills, overtraining and the overuse of repetitive movements. Recommendations for injury prevention in fencing sports can be found on the British Fencing website [50].

Conclusion

As an asymmetric combat sport, the strength and control of the lunge poise should be adjusted in continuous training sessions to avoid muscle overuse. As fencing involves rapid tactical abilities, fencing practice is likely to be linked with neuro-physiological competences. However, fencing performance is led by the intrinsic judgment of the fencers in the stimulus-response situation, and without psycho-physical support, performance in a long fencing competition may not be sustained. As fencing injuries are uncommon, fencing is considered a safe sport for most of the population.

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