RESEARCH INTO THE EFFECTS OF TAI CHI
Compiled for the Department of Health and Ageing

Introduction

This submission starts with an introduction to tai chi, follow by the evidence of tai chi's effect on health and how it works. There is robust evidence of tai chi's benefits to health. It is safe especially when modern knowledge of sport medicine for exercising safely is incorporated. It is very cost effective, in a large study by ANU and the former Greater Southern Area Health Service (GSHAS) as attached, the cost is estimated to be $76 per person per year! We believe this is a strong case for financial support by the private funds, indeed, by all level of health planning in the future.

Introduction of Tai Chi

Tai Chi, also known as Tai Chi Chuan, taiji, or taijiquan, is a moderately intense aerobic exercise characterized by continuous movements that embrace the mind, body, and spirit. The unique feature of Tai Chi is that it builds inner strength from within by building strength of mind and serenity. It strengthens internal structures such as the internal organs and deep stabilizer muscles. Tai Chi emphasizes the cultivation of Qi, the life energy. By combining training of mind, joints and internal and external muscles, Tai Chi represents a powerful holistic approach to health and wellness.

Tai Chi stresses the integration and balance of mind and body using fundamental principles that are common to all of its styles and forms. Tai Chi practitioners use visualization such as imagining moving against a gentle resistance. The slow, smooth, and continuous Tai Chi movements require complex motor control. Tai Chi practitioners are mindful of transferring weight with each step while maintaining an upright and supple posture and coordinating their breathing with their movement while focusing and calming their minds as they loosen and relax their joints and ligaments.

There are many styles and forms of Tai Chi, but the four major styles (in the order of the time of origin) are Chen, Yang, Wu, and Sun. Although each style has its own features, they all share the same essential principles. Any style of Tai Chi will bring health benefits as long as the essential principles are incorporated and safety precaution based on modern medicine is incorporated.

In the 1670s, Chen Wangting developed the Chen style based on martial arts, the ancient Taoist philosophical understanding of nature, and Chinese traditional medicine. Chen is characterized by slow and soft movements intermixed with fast and hard ones. It involves explosive power and low stances. The Chen style is rich with combat techniques and has more vigorous movements with a higher risk of injury than other styles. Chen is therefore more suitable for younger and fitter participants. Yang Lu-chan (1799–1872) created Yang style in the early 19th century. This style is characterized by gentle, graceful, and slow movements, which are easier to learn than Chen style. The Yang style has become the most popular in modern times. Wu Quan-you (1834–1902) and his son Wu Jian-quan (1870–1942) created the Wu style. Its movements are gentle and soft, with emphasis on redirecting incoming forces. Many Wu stylists use a forward leaning posture, while upright posture—whereby the body is vertically aligned relative to the ground—is considered to be the best for most other styles. In Wu style, the body is aligned along a straight line from the head to the back foot, which produces a forward leaning posture. The most recent style is the Sun style, created by Sun Lu-tang (1861–1932). It is characterized by agile steps, unique Qigong (method of generating life energy), and a higher stance than other styles. Qigong cultivates strong internal power, which is especially effective

for healing and relaxation. The higher stance minimizes the risk of injury and makes it easier for older people to learn. The great depth of Sun style holds learners' interest as they progress.

Scientific evidence is accumulating that Tai Chi is one of the most effective forms of exercise for health and wellness. The many health benefits of Tai Chi have spurred an exponential increase in the number of published reports of studies on the subject over recent years. A PubMed search of articles published between 2000 and April 2012 yielded 544 research articles with keywords Tai Chi, T'ai Chi, or Taiji. One hundred thirty-three randomized trials and 51 meta-analyses or systematic reviews were published during this time period. In contrast, only 48 articles were published between 1990 and 1999, and included only 10 randomized trials and one systematic review.

Studies of the Effects of Tai Chi

The following sections describe selected Tai Chi studies that are randomized clinical trials or meta-analyses. Health outcomes were selected to highlight consistent and emerging effects of Tai Chi. In those instances when the styles of Tai Chi are identified, the style name is only used.

Pain

Tai Chi for pain management has been studied primarily in arthritic conditions using visual analog scales and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). In a meta-analysis of randomized controlled trials of pain (Hall et al., 2009), Tai Chi was associated with significant pooled effect sizes (ES) of 10.1 (range 0–100) for persons with osteoarthritis (Abbott et al., 2007; Adler, Roberts, Good & Synder, 2000; Brismee et al., 2007; Fransen et al., 2007; Hartman et al., 2000; Song, Lee, Lam & Bae, 2007) and rheumatoid arthritis (Lee & Jeong, 2006). The pain reduction effects of 12 weeks of Tai Chi persisted during 36 weeks of home practice (Wang et al., 2009). Similar improvements in back pain and associated bother have been found for ten weeks of Sun style (Hall, Maher, Latimer, & Ferreira, 2011).

Postural Stability

Each of the major types of Tai Chi (Chen, Sun, and Yang) has been consistently found to increase postural control (Rogers et al., 2009; Wong & Lan, 2008). Participants in Tai Chi were able to stand on one leg for significantly longer (Audette et al., 2006; Choi, Moon & Song 2005; Gatts & Woollacott, 2006; Li et al., 2005; Li, Xu & Hong, 2008; Song et al., 2003; Wong & Lan, 2008; Zhang, Ishikawa-Tkata, Yamazaki, Morita & Ohta, 2006), and displayed greater functional reach than were a control group (Li et al., 2012; Wolf et al., 2006). Using the movements of the center of pressure (COP) from a force plate, those performing Tai Chi had greater stability (Tsang & Hui-Chan, 2003), directional control of weight shifts (Li et al., 2012; Tsang & Hui-Chan, 2004), and smaller area of movement for the COP (Wu, Zhao, Zhou & Wei 2002). Similar differences were found under various challenging sensory conditions (Au-Yeung et al., 2009; Lin, et al. 2000; Wong, Lin, Chou, Tang & Wong, 2001). The inconsistent findings of some subsequent studies may be attributable to the use of samples of older adults at high risk of falls and disability rather than the healthy older adults used in other studies (Day et al., 2012; Logghe et al., 2009), the small number of Tai Chi movements used in the intervention (Tsang, Orr, Lam, Comino & Singh, 2007), and a concurrent government campaign to increase exercise (Woo, Hong, Lau & Lynn, 2007).

Muscle Strength

While Tai Chi involves the muscles of the trunk and arms, those most involved are in the lower

extremities. Not surprisingly, the dorsal flexors and knee extensors of Tai Chi practitioners have greater isokinetic strength (Tsang & Hui-Chan, 2005; Wu et al., 2002; Xu, Li & Hong, 2006; Xu, Hong & Li, 2008) and endurance (Lan, Lai, Chen & Wong, 2000) than non-practitioners. Long-term practitioners also have greater strength in ankle dorsal flexors but not plantar flexors relative to regular joggers and sedentary adults (Xu et al., 2008). Compared with a control group, Tai Chi significantly increased knee extensor strength in some studies (Cheung et al., 2007; Choi et al., 2005; Day et al., 2012; Lan et al., 2000) but not others (Song, Roberts, Lee, Lam & Bae, 2010). Strength was greater for those after Tai Chi when compared to brisk walking (Audette et al., 2006), health education (Li et al., 2009), physical activity (Mustian, Katula & Zhao, 2006), or psychosocial therapy (Mustian, Palesh & Flecksteiner, 2008). Those in a Tai Chi group did not have significantly greater knee flexor strength relative to a control group (Li et al., 2009) or jogging and sedentary older adult groups (Xu et al., 2008).

Disability

Many older adults suffer pain and disability from arthritis that contribute to disability. Several studies assessed disability with the WOMAC. In a pilot study (*N*=20), subjects in a 12-week Tai Chi program twice a week had significantly lower disability compared with the control group (Wang, 2008). Similar findings were found among older adults (*N*=41) in a 6-week Tai Chi program followed by 6 weeks of in-home training (Brismee et al., 2007).

In contrast, older adults enrolled in 12 weeks of Tai Chi exhibited similar improvements in disability relative to those in hydrotherapy, but disability was significantly lower in the control group than the two experimental groups (Fransen et al., 2007). Using the 12-item Short Form health questionnaire (SF-12), greater improvements in disability were found for Tai Chi than wait-listed control (Li et al., 2001) low-impact exercise (Li et al., 2004) and stretching (Li et al., 2005).

Unlike studies of disability in persons with musculoskeletal disease, Day and associates (2012) selected people (*N*=503) with preclinical disability. They used the Late Life Disability and Function Index, which is a more comprehensive measure of disability than the WOMAC and SF-12. Attrition was 32% in the Tai Chi group and 25% in the flexibility group, and only 53% completed at least 75% of the intervention sessions. Disability was not significantly different after 12 weeks of either intervention. The investigators attributed findings to attrition bias, possible similar effects of flexibility exercise on disability, and inadequate intervention dose. The disabilities of the participants also may not have been severe enough to benefit from either intervention because they were selected for preclinical disability that would precede the onset of disability. Day's study also demonstrates the cost effectiveness of tai chi.

Falls

Tai Chi has been found to reduce falls in older adults in large studies where the inherently low rate of falls in this population could be ascertained. In the first large study of community-living older adults, 15 weeks of Tai Chi reduced the risk of repeat falls by 47% but not on the incidence of new falls (Wolf et al., 1996). Although the relative risk for falls was not significant in a transitionally frail older adults (*N*=291), the fall rate was 47.6% in the Tai Chi group and 60.3% in the wellness education group (Wolf et al., 2003). In persons with Parkinson's disease, the incidence of falls was significantly lower for Tai Chi than resistance exercise (Li et al., 2012). In a larger randomized clinical trial (Voukelatos, Cumming, Lord & Rissel, 2007), older adults (*N*=710) completed a 16 weeks of weekly Tai Chi. Twenty-two Tai Chi instructors from the community provided classes consistent with the styles that they normally taught. Participants

paid a small amount for the sessions. At 16 weeks, the unadjusted and adjusted hazard ratios (HRs) for one or more falls approached significance (p<0.07) but were significant for two or more falls (HR=0.33 and 0.25, respectively). At 24 weeks, the HRs were significant for one or more falls (HR=0.67 and 0.66, respectively) and for two or more falls (HR=0.33 and 0.27, respectively).

Blood Pressure

Systematic reviews support the positive effects of Tai Chi in individuals with hypertension (Dalusung-Angosta, 2011; Jahnke, Larkey, Rogers, Etnier, & Lin, 2010; Yeh, Wang, Wayne, & Phillips, 2009b). Investigators mostly used Yang-style performed 3–5 times weekly for between 12 weeks and 12 months. In randomized clinical trials, Tai Chi had greater clinically significant reductions in blood pressure when compared with no treatment (M. S. Lee, Lee, Kim, & Ernst, 2010) or education (Wolf et al., 2006).

The effects of Tai Chi are similar to the effects of other types of physical exercise. In a randomized clinical trial involving women with type 2 diabetes (Zhang & Fu, 2008), resting blood pressure improved significantly after performing Yang-style five times a week for 14 weeks compared to those in a free activity program. In elderly subjects with chronic heart failure (Caminiti et al., 2011), Yang-style combined with endurance training four times per week for 12 weeks significantly reduced systolic blood pressure relative to cycling or walking.

Cholesterol

Aerobic exercise is known to be effective in managing blood lipids in various populations with cardiovascular disease. In an early randomized trial (Tsai et al., 2003), individuals with dyslipidemia showed significant improvement in cholesterol, triglycerides, those performing Yang-style three times per week for 12 weeks had higher low-density lipoprotein (LDL) cholesterol and lower high-density lipoprotein (HDL) cholesterol compared to a sedentary controls. When compared to usual care, middle-aged adults with dyslipidemia had significant decreases of 26.3% in triglycerides, 7.3% in total cholesterol, and 11.9% in LDL after 12 months of Yang-style three times per week (Lan, Su, Chen, & Lai, 2008). In a randomized study using Chen-style three times per week for 12 weeks (Chen, Ueng, Lee, Sun, & Lee, 2010), obese patients with type 2 diabetes and elevated lipid profiles experienced significantly improved triglycerides and HDL when compared to conventional exercise.

In persons without abnormal lipid profiles, clinically significant changes in lipids would not be possible because of floor effects. For example, after 12 months of Chen-style, no significant differences in lipid profiles were found in healthy adults with borderline or normal lipid profiles at the baseline relative to resistance training or control groups (Thomas et al., 2005).

Glucose Metabolism

Exercise has been found to improve diabetes control. Tai Chi may be a beneficial alternative**,** but research findings have been inconsistent. In randomized clinical trials, no significant changes in glucose control were found after 16 weeks of a combined form of Sun and Yang styles (Tsang & Hui-Chan, 2008), 12 months of Yang-style (Thomas et al., 2005) or Sun style (Song, Ahn, Roberts, Lee, & Ahn, 2009).

In other randomized studies, glucose control significantly improved with Tai Chi. In a case–control study of 12 weeks Chen-style, HbA1c (a marker of diabetes control) was significantly lower in patients with type 2 diabetes compared to age-matched controls (Yeh et al., 2009a). In women with type 2 diabetes, Yang-style at a moderate aerobic intensity [50–85% maximum

oxygen consumption (VO_2max)] significantly improved glucose control after 14 weeks of five sessions per week (Zhang & Fu, 2008). Hui and associates (2009) found similar changes in blood glucose of sedentary middle-aged men after 12 weeks of Yang-style or walking exercise. In obese patients with type 2 diabetes, beneficial decreases in HbA1c were found after 12 weeks of Chen style five times per week (from 8.9% to 8.3%) and walking (from 8.8% to 8.5%) (Chen et al., 2010).

Stress, Anxiety, and Other Emotions

Several studies have found that Tai Chi increases psychological health. Jin (1992) randomly assigned subjects to four treatment groups: Tai Chi, brisk walking, meditation, and neutral reading. State anxiety was decreased more in the Tai Chi and brisk walking groups than the other two groups. Compared to a stretching and wellness education, depression among community-dwelling adults with rheumatoid arthritis was significantly lower in the group performing Yang-style one hour twice-weekly for 12 weeks (Wang et al., 2005). When people with traumatic brain injury completed 6-weeks of Chen-style, sadness, confusion, anger, tension and fear significantly decreased, and energy and happiness increased (Gemmell & Leathem, 2006). Similarly, in persons with human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS), groups engaged in 8 weeks of either Tai Chi or aerobic exercise had better mood states than in the control group (Galantino et al., 2005). A recent meta-analysis described effect sizes (ES) of one hour to one year Tai Chi on psychological well-being in community-dwelling healthy participants and those with chronic conditions (Wang et al., 2010). Beneficial effects of Tai Chi included reductions in stress (ES=0.66), anxiety (ES=0.66), and depression (ES=0.56), and increased mood (ES=0.45).

Quality of Life

Quality of life (QOL) is derived from the complex process of a person's perceived physical health, psychological state, personal beliefs, social relationships, and relevant features of the external environment. Several randomized studies involving diverse populations of healthy chronically ill adults have consistently found that Tai Chi improves QOL.

Irwin and associates (2003) reported that the role-physical and physical functioning components of QOL [36-item Short Form questionnaire (SF-36)] were better in healthy older adults after completing 15 weeks of Tai Chi compared with the wait-listed control group. In randomized clinical trials in persons with heart failure, QOL was improved after 12 weeks of Yang-style performed for one hour twice a week as compared with those receiving usual care (Yeh et al., 2004, 2008, 2011). Galantino and associates (2005) also reported that health-related QOL of persons with AIDS was significantly greater after 8 weeks of Tai Chi and aerobic exercise than in controls.

Community-dwelling persons with lower-extremity osteoarthritis reported improved QOL (WOMAC) after one hour Yang-style twice weekly for 12 weeks compared to those receiving usual care (Hartman et al., 2000). In persons with rheumatoid arthritis, the vitality components of QOL (SF-36) were significantly higher with 12 weeks of twice weekly Yang-style when compared with wellness education (Wang et al., 2005). Lee and associates (2007) studied residents of a care facility in Hong Kong and reported that health-related QOL improved more after 26 weeks of Tai Chi than the control group who continued their usual daily activities. In a randomized trial involving breast cancer survivors, Mustian and colleagues (2004) also found significant improvements in health-related QOL after 12 weeks of 60 minutes Yang-style Tai Chi and Chi Kung three times a week compared to those who received psychosocial support.

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Sleep

Improved sleep has also been reported following Tai Chi, which could be associated with decreases in stress and anxiety induced by this exercise (Li et al., 2004; Wall, 2005). Using the Pittsburgh Sleep Quality Index, Li and associates (2004) found improvements in sleep quality, sleep efficiency, and sleep disturbances were better for the participants who performed Yang-style three times per week for 24 weeks than for those engaged in low-impact exercise. Older adults with moderate sleep complaints involved in 25 weeks of Tai Chi had greater sleep quality, efficiency, and duration, and less sleep disturbance than those who received health education (Irwin, Olmstead & Motivala, 2008).

Sleep stability was also improved following Tai Chi in patients with heart failure compared with usual care (Yeh, Wayne, & Phillips, 2008). The Tai Chi group had greater high-frequency cardiopulmonary coupling and lower low-frequency coupling on sleep spectrograms.

Immune Function

A few randomized clinical studies reveal Tai-Chi-induced immune-related responses. Combining vaccination with Tai Chi three times a week for 25 weeks was significantly more effective at increasing varicella zoster virus cell-mediated immunity in healthy older adults than was vaccine alone (Irwin, Olmstead & Oxman, 2007).

Based on a psychoneuroimmunology paradigm, McCain and associates (2008) explored 10 weeks of alternative stress-management interventions on immune function in subjects with HIV. The weekly 90-minute sessions of Tai Chi and psychosocial interventions (spiritual and cognitive-behavioral relaxation) significantly enhanced immune function (lymphocyte proliferation counts). Because other indicators for stress management including salivary cortisol were not significantly changed by the interventions, the mechanism underlying this enhanced immune function has yet to be established (McCain et al., 2008).

Immune function and inflammation are closely related and are often assessed using biomarkers, such as interleukin-6 (IL-6) or C-reactive protein (Jahnke et al., 2010). Irwin and Olmstead (2011) found that older adults performing Tai Chi for 16 weeks had reduced IL-6, while it remained high among those who had received health education. A psychoneuroimmunological mechanism potentially underlies the effects of Tai Chi because changes in depression and IL-6, were significantly correlated. In a randomized clinical trial, obese patients with type 2 diabetes engaged in Chen-style three times per week for 12 weeks experienced significantly decreased inflammation (high-sensitivity C-reactive protein) compared to the conventional-exercise group (Chen et al., 2010).

Mechanisms Underlying the Effects of Tai Chi

Physical Function

Tai Chi is more challenging to postural control than normal walking. Compared to normal gait, Tai Chi movements involve a longer-duration single-leg stance (Wu et al., 2004) but a greater proportion of time in double-stance support (Hong, Mao & Li, 2008; Wu et al., 2002). The duration of the transition from one stance to another is also longer for Tai Chi movements. The greater postural control and shorter transitions required for Tai Chi may account for the improvement in postural stability found in many studies.

The characteristics of Tai Chi may also explain its muscle-strengthening effects. During Tai Chi, the muscles responsible for knee flexion and extension, ankle dorsal and plantar flexion, and hip flexors and abductors are coactivated longer than during normal walking and involve greater

proportions of alternating concentric and eccentric contractions (Wu, Liu, Hitt & Millon, 2004). Moderate-to-large correlations between the strength of the knee extensors and duration of muscle activation of the knee extensors and ankle dorsal flexors were found during Tai Chi gait (Wu et al., 2004) and movements (Chan et al., 2003; Wu, 2008) but not normal walking. In summary, Tai Chi movements are more challenging than normal walking and require sustained motor control of the muscles of the lower extremities (Wu et al., 2004; Wu, 2008). The cumulative effects of performing Tai Chi may thus increase the strength of these muscles.

Although Tai Chi does not involve training for the specific skills required for activities of daily living, the characteristics of this exercise appear to mimic neurological adaptations that are transferable to the performance of these activities (Hong & Li, 2007). The motor patterns required for Tai Chi are also essential for mobility and many instrumental activities of daily living (Fontana, Colella, Wilson & Baas, 2000; Schneider & Leung, 1991). Overall, people who learn Tai Chi ultimately develop a larger repertoire of postural and motor responses that are required for a wide variety of the activities of daily living and challenging environmental conditions.

Cardiovascular Functioning

The potential mediating mechanism underlying the blood-pressure-lowering effect of Tai Chi could be increased vagal stimulation from abdominal (Dantian) breathing (Thornton, 2008). Further studies are required to confirm other potential physiological mediators of Tai Chi on hypertension.

Tai Chi consists of moderate intensity endurance and resistance exercise, which is equivalent to the intensity of aerobic exercise recommended for patients with type 2 diabetes (Colberg et al., 2010). The more vigorous, moderate-intensity forms of Tai Chi, such as the Yang and Chen, require more than 4 metabolic equivalents (METs corresponding to 58% of $\dot{V}O_2$max) that may be more beneficial for cardiovascular functioning (Zhuo, Shephard, Plyley, & Davis, 1984) than would the 2.7–3.0 METs for Sun style or a combination of Sun and Yang styles (K. Y. Lee, Jones, Hui-Chan, & Tsang, 2011).

Psychological Functioning

The psychological benefits of Tai Chi may be attributed to its capacity to endow periods of great calm and mental tranquility, which are based mainly on the mind–body connection through relaxation and meditation components of the exercise (Jimenez, Melendez, & Albers, 2012). Further studies are required to examine whether the psychological benefits of Tai Chi are related to its Qigong component.

Immune Function

The mechanisms underlying the association between Tai Chi and immune function are unclear. Based on a psychoneuroimmunology paradigm, the psychological health effects due to the meditation or Qigong components of Tai Chi as a mind–body exercise may explain the improvement in immune function (Jahnke et al., 2010).

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