A systematic review of the health benefits of Tai Chi for students in higher education

Craig S. Webster a,⁎, Anna Y. Luo b, Chris Krägeloh c, Fiona Moir d, Marcus Henning b

a Centre for Medical and Health Sciences Education and Department of Anaesthesiology, University of Auckland, Private Bag 92-019, Auckland 1142, New Zealand
b Centre for Medical and Health Sciences Education, University of Auckland, Auckland, New Zealand
c Department of Psychology, Auckland University of Technology, Auckland, New Zealand
d Medical Programme Directorate, University of Auckland, Auckland, New Zealand

ABSTRACT

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Background. The poor health consequences of stress are well recognized, and students in higher education may be at particular risk. Tai Chi integrates physical exercise with mindfulness techniques and seems well suited to relieve stress and related conditions.

Methods. We conducted a systematic review of the health benefits of Tai Chi for students in higher education reported in the English and Chinese literature, using an evidence hierarchy approach, allowing the inclusion of studies additional to randomized controlled trials.

Results. Sixty eight reports in Chinese and 8 in English were included — a combined study sample of 9263 participants. Eighty one health outcomes were extracted from reports, and assigned evidence scores according to the evidence hierarchy. Four primary and eight secondary outcomes were found. Tai Chi is likely to benefit participants by increasing flexibility, reducing symptoms of depression, decreasing anxiety, and improving interpersonal sensitivity (primary outcomes). Secondary outcomes include improved lung capacity, balance, 800/1000m run time, quality of sleep, symptoms of compulsion, somatization and phobia, and decreased hostility.

Conclusions. Our results show Tai Chi yields psychological and physical benefits, and should be considered by higher education institutions as a possible means to promote the physical and psychological well-being of their students.

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Contents

I n t r o d u c t i o n ................................................................ 104
M e t h o d s.................................................................. 105
T y p e o f p a r t i c i p a n t s .......................................................... 105
T y p e s o f i n t e r v e n t i o n s ......................................................... 105
T y p e s o f o u t c o m e m e a s u r e s ....................................................... 109
R e s u l t s ................................................................... 109
S e a r c h r e s u l t s............................................................. 109
Health beneﬁts ............................................................ 109
P h y s i c a l d o m a i n............................................................ 110
P s y c h o l o g i c a l a n d p s y c h o s o c i a l d o m a i n ................................................. 110
D i s c u s s i o n ................................................................. 110
S t r e n g t h s a n d l i m i t a t i o n s........................................................ 110
C o n c l u s i o n................................................................. 110
C o n f l i c t s o f i n t e r e s t s t a t e m e n t ........................................................ 111
A c k n o w l e d g m e n t s ............................................................. 111
R e f e r e n c e s................................................................. 111

⁎ Corresponding author.
E-mail addresses: c.webster@auckland.ac.nz (C.S. Webster), yluo027@aucklanduni.ac.nz (A.Y. Luo), chris.krageloh@aut.ac.nz (C. Krägeloh), f.moir@auckland.ac.nz (F. Moir), m.henning@auckland.ac.nz (M. Henning).

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Introduction

Excess stress is widely recognized as a major health problem worldwide (Thoits, 2010). Chronic stress has been linked repeatedly to increased mortality, morbidity and decreased functioning of the immune system, as well as diminished cognitive function and poorer mental health (Juster et al., 2010). Students in higher education who face the pressures of a heavy workload, examinations and entrance restrictions on favored courses, such as those used in medical schools, are particularly at risk of long-term stress and the resulting higher likelihood of burnout (Dyrbye et al., 2010, 2006; McManus et al., 2002). The prevalence and severity of many psychological conditions in students have increased over recent years, with consequences such as poor concentration and compromised productivity, which can be devastating for their productive involvement in future careers (Hunt and Eisenberg, 2010; Knight, 2013). It has also been shown that students’ physical health may deteriorate, with some students exercising and sleeping less once they begin studying (Wolf and Kissling, 1984).

A large body of research has investigated how students may react to stressors (Alzahem et al., 2011; Zhang and Goodson, 2011). Maladaptive ways of coping with stress include excessive alcohol use (Park and Levenson, 2002) and unhealthy eating habits (Wichianson et al., 2009), as well as denial and avoidance (Maclean et al., 2007), — these may provide temporary relief but exacerbate stress in the long term. In contrast, adaptive coping strategies are generally associated with...
positive outcomes, and include problem-focused coping and planning (Penley et al., 2002), spirituality (Kim and Seidlitz, 2002), and seeking social support (Lee et al., 2004). Various self-care strategies also play an important role, both in coping during times of stress as well as in avoiding its consequences. The teaching of skills, such as problem solving, relaxation techniques, self-management, and interpersonal skills has been frequently applied in stress-management interventions for students (Jones and Johnston, 2000; Shiralkar et al., 2013). Regular physical exercise has also been associated with psychological wellbeing (Teychenne et al., 2008), and meditation and mindfulness practices are increasingly used to promote resilience and psychological wellbeing in students (Hassed et al., 2009).

Tai Chi is an exercise system that integrates physical strengthening and self-defense with mindfulness techniques including relaxation of the mind (Tsang et al., 2008), and so may be particularly fruitful for reducing or preventing stress. It is widely accepted that the practice of Tai Chi dates back to 13th century China and has traditionally been used in various forms for the promotion and maintenance of health and longevity (Zhuo, 1982; Koh, 1981). A number of systematic reviews have attempted to investigate the often-claimed positive effects of Tai Chi on a variety of health dimensions (Adams, 2004; Kuramoto, 2006), including decreased blood pressure (Yeh et al., 2008), aerobic capacity (Lee et al., 2009), psychosocial wellbeing (Wang et al., 2009), and psychological wellbeing (Wang et al., 2010). The general findings of these reviews point toward potential health benefits, although a lack of sufficient high-quality studies often prevents strong conclusions.

The purpose of the present systematic review was to survey the academic literature on the health benefits of Tai Chi in relation to students in higher education. Purposely selecting a potentially at-risk population may reveal evidence of health benefits more clearly than a general-purpose search. In addition, given the cultural origins of Tai Chi, we deemed it appropriate to include Chinese-language studies in our review as well as English-language studies, thus substantially increasing the pool of evidence to be analyzed, which is a significant extension of previous reviews. Furthermore, evidence-based medicine involves making use of the best available evidence with which to answer our clinical questions, and this may constitute considering evidence other than that present in randomized controlled trials (Sackett et al., 1996; Mays et al., 2005). We therefore used an evidence hierarchy approach, which ranks and weights all evidence identified during our search (Jensen et al., 2004). Our aim was to identify evidence for the benefits of Tai Chi in improving the mental and physical health of students in higher education.

Methods

Two separate literature searches were conducted on 18 February 2013 to identify as many relevant publications as possible. The first of these aimed to identify material published in, or translated into, English. Online electronic searches were conducted using the seven most common databases (Google Scholar, Pubmed, CINAHL Plus, Embase, PsychInfo, Scopus, and Cochrane Library) and three library catalogues (Te Puna, World Catalogue, and University of Auckland catalogue). During this process, the researchers met as a team and search terms were extensively discussed and iteratively refined. The final search terms are shown in Table 1. The second literature search focused on articles in Chinese using four online electronic databases (Google Scholar, WangFang Data, the National Central Library of Taiwan, and China Academic Journals). This was conducted with the assistance of a fluent Chinese speaker using a subset of the search terms in Table 1 in their Chinese character forms. HanYu pinyin forms of characters were used initially in developing the search, but were not included in the final search as their use resulted in large numbers of irrelevant hits. Our review and reporting method was guided by the Cochrane Handbook of Systematic Reviews and the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to the extent that this was possible given our evidence hierarchy approach (Anonymous, 2015; Higgins and Green, 2011).

Type of participants

Our participants were defined as students undertaking tertiary or higher education (Set one, Table 1). We searched the Chinese databases with the keyword 大学生 (university student), as well as in the traditional character forms.

Types of interventions

Our intervention was defined as any form of Tai Chi (Set two, Table 1). Papers concerning “Qi Gong,” “mindfulness” and other activities related to, but not constituting Tai Chi, were excluded. In the Chinese

| Level of evidence | Combined number of participants in included studies (n = 9263) | No. of studies (n = 76)* | Scoring regime for each publication** |
|-------------------|-------------------------------------------------------------|-------------------------|--------------------------------------|
| Ia — evidence from meta-analysis of randomized controlled trials | 0 | E = 0  
C = 0 | Evidence levels Ia-III  
X = 8; Y = 4; Z = 2 |
| Ib — evidence from at least one randomized control trial | 866 | E = 2  
C = 10 | Case or case series reports  
X = 6; Y = 3; Z = 1 |
| Ila— evidence from at least one controlled study without randomization | 1718 | E = 1  
C = 17  
Total = 12 | Opinion reports of experts  
X = 4; Y = 2; Z = 0 |
| Iib— evidence from at least one other type of quasi-experimental study (for example one-group, pretest, posttest studies) | 2106 | E = 2  
C = 17  
Total = 18 | |
| III— evidence from non-experimental descriptive studies, such as comparative studies, correlation studies and case-control studies | 4570 | E = 3  
C = 21  
Total = 24 | |
| IV— evidence from expert committee reports or opinions and/or clinical experience of respected authorities | 3† | E = 0  
C = 3  
Total = 3 | |

*Number of reports: E = English, C = Chinese. **Highest ranking publication from each authority = X points; second highest ranking publication from that authority = Y points; each additional publication from that authority = Z points. An authority is defined as the first author of each publication or report. †Two reports at this evidence level comprise expert narration on the benefits of Tai Chi and do not include study participants.
| Outcomes | Support findings | Uncertain findings | Dissent findings | Support score | Uncertain dissent score | Net evidence score |
|----------|------------------|--------------------|------------------|---------------|-------------------------|-------------------|
| **General wellbeing** | | | | | | |
| 1. Improved quality of sleep | | | | | | |
| 2. Improved energy/vitality | | | | | | |
| 3. Improved appetite | | | | | | |
| 4. Increased ability to relax | | | | | | |
| 5. Increased satisfaction with life | | | | | | |
| 6. Improved self-rated overall health | | | | | | |
| 7. Improved overall physical health | | | | | | |
| **Body composition** | | | | | | |
| 8. Reduced body circumference | | | | | | |
| 9. Reduced body fat | | | | | | |
| **Body fitness** | | | | | | |
| 10. Reduced body weight | | | | | | |
| 11. Increased lean body mass | | | | | | |
| 12. Reduced body mass index (BMI) | | | | | | |
| 13. Increased height | | | | | | |
| **Physiology** | | | | | | |
| 14. Increased flexibility | | | | | | |
| 15. Improved balance | | | | | | |
| 16. Improved 800/1000 m run time | | | | | | |
| 17. Improved general body strength | | | | | | |
| 18. Overall improved fitness | | | | | | |
| 19. Increased standing long jump distance | | | | | | |
| 20. Increased number of sit-ups in one minute | | | | | | |
| 21. Increased grip strength | | | | | | |
| 22. Improved step-test score | | | | | | |
| 23. Enhanced sports performance | | | | | | |
| 24. Improved jump-rope test score | | | | | | |
| 25. Improved agility | | | | | | |
| 26. Improved shot put performance | | | | | | |
| 27. Improved 50/100 m sprint time | | | | | | |
| **Additional Measures** | | | | | | |
| 28. Increased lung capacity | | | | | | |
| 29. Decreased blood pressure | | | | | | |
30. Faster heart rate recovery after exercise  
31. Decreased resting heart rate  
32. Improved cardiovascular function  
33. Increased maximal aerobic capacity (VO2)  
34. Improved bone density  
35. Decreased blood viscosity  
36. Reduced blood lipids  
37. Increased high density lipoprotein (HDL) cholesterol  
38. Stimulated nervous system  
39. Reduced blood glucose  
40. Decreased salivary cortisol  
41. Decreased insulin  
42. Decreased leptin  
43. Decreased oxidative stress and improved oxidative capacity  
44. Increased baseline vagus nerve activity  
45. Decreased serum Monoamine oxidase (MAO)  
46. Decreased B-endorphin levels  
47. Improved immune function  
48. Increased blood cell counts  
49. Reduced self-rated symptoms of dysmenorrhea  
50. Reduced self-rated hair loss  

Psychological health  
51. Reduced symptoms of depression**  
52. Decreased anxiety**  
53. Reduced symptoms of compulsion**  
54. Decreased somatization symptoms**  
55. Decreased hostility**  
56. Decreased symptoms of phobia**  
57. Increased self-esteem and self-confidence  
58. Improved mood  

Biochemistry  

Total cholesterol:  
Triglycerides:  
Low density lipoprotein (LDL):  
Apolipoprotein A and B (ApoA and ApoB):  

(continued on next page)
Table 3 (continued)

| Outcomes | Support findings | Uncertain findings | Dissent findings | Support score | Uncertain dissent score | Net evidence score |
|----------|------------------|--------------------|------------------|---------------|-------------------------|-------------------|
| **Psychological health** | | | | | | |
| 59. Decreased symptoms of psychosis** | (宋志刚, 2010; 林友标, 章耀强, 2010; 王正良, 2012; 李凌云, 2007; 王克涛, 2010; 杨祥全, 2003; 张晓辉, 王力, 郭义军, 刘晓军, 黄克海, 宇文展, 2010; 李云清, 杜新, 2006) | (罗立平, 2008; 周春太, 2010; 魏晓红, 梁蓉, 2012; 李阿特, 孙福成, 2006) | 64 | 32 | 32 |
| 60. Increased resilience | (王超, 申忠华, 卢华, 2008; 刘永祥, 2006; 王超, 申忠华, 2008; 吴永存, 乔秀玲, 2006) | | | | | |
| 61. Decreased self-rated stress | (Caldwell et al., 2010, 2011; Esch et al., 2007) | | | | | |
| 62. Improved emotional stability | (吴雅彬, 张明明, 2008; 魏晓红, 宇文展, 2011) | (吴永存, 2006) | 24 | 0 | 24 |
| 63. Decreased symptoms of paranoia** | (宋志刚, 2010; 陈薇, 2009) | (林友标, 章耀强, 2010; 罗立平, 2008) | | 16 | 16 | 0 |
| 64. Improved overall mental health | (Wang et al., 2004; 吴永存, 2010; 乔秀玲, 2005) | | | | | |
| 65. Decreased self-rated stress | Caldwell et al., 2010, 2011; Esch et al., 2007 | In Tai Chi novices: (张晓辉, 吴永存, 2006) | | 24 | 16 | (†) |
| 66. Improved trust | (林友标, 章耀强, 2010; 罗立平, 2008) | | | | | |
| 67. Improved trust | (林友标, 章耀强, 2010; 罗立平, 2008) | | | | | |
| 68. Improved trust | (林友标, 章耀强, 2010; 罗立平, 2008) | | | | | |
| 69. Improved trust | (林友标, 章耀强, 2010; 罗立平, 2008) | | | | | |
| 70. Improved trust | (林友标, 2010) | | | | | |
| 71. Increased obedience | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 0 | 8 | −8 |
| 72. Improved trust | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 0 | 8 | −8 |
| 73. Improved trust | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 0 | 8 | −8 |
| 74. Decreased symptoms of anger | (孙耀, 2003) | | | | | |
| **Personality** | | | | | | |
| 65. Increased motivation | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 24 | 0 | 24 |
| 66. Reduced type-A behavior† | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 16 | 0 | 16 |
| 67. Decreased stubbornness | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 24 | 16 | 8 |
| 68. Increased motivation | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 8 | 0 | 8 |
| 69. Increased motivation | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 8 | 0 | 8 |
| 70. Increased motivation | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 8 | 0 | 8 |
| 71. Increased motivation | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 8 | 0 | 8 |
| 72. Increased motivation | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 8 | 0 | 8 |
| 73. Increased motivation | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 8 | 0 | 8 |
| 74. Increased motivation | (吴雅彬, 张明明, 2008; 吴永存, 2006) | | | 8 | 0 | 8 |

** Evidence scores attached to each outcome relate to the paper from which the outcome is drawn as defined by the scheme in Table 2.

* This outcome is included in The Symptom Checklist-90 (SCL-90) questionnaire, a self-reported psychometric instrument designed to evaluate a broad range of psychological problems and symptoms.

† Type-A behavior is characterized by ambition, rigidity of organization, status consciousness, impatience, anxiousness and a propensity for workaholism.

†† Interpersonal sensitivity refers to the accuracy and/or appropriateness of perceptions, judgments, and responses we have with respect to one another.
database searches we used the keyword 太极拳 (taijiquan), as well as in the traditional character forms.

**Types of outcome measures**

Our outcome measures were defined as any reported physical or mental health effects of Tai Chi practice, both beneficial and potentially deleterious (Set three, Table 1). The keyword 健康 (health), as well as the traditional character forms, were used for the Chinese database search.

For the Cochrane and Psychinfo databases, only keywords from the first two sets were used due to the smaller number of articles returned (Table 1). Truncation, word variants and MESH terms were also used in searches, which increased the number of relevant papers found.

Published theses from the grey literature were also searched and included, but unpublished literature was not sourced. Reference lists of publications were not screened for further possible studies. All search results were imported into a reference management program (Refworks, Bethesda, USA) to form a single library of references. Duplicates were then removed. The titles and abstracts of remaining articles were screened, and the full texts were retrieved for those papers that the authors agreed were relevant to the research aim. The final set of papers included in our review was determined based on their full texts and the following inclusion criteria (see Fig. 1 for a flow diagram of the full screening process):

1. The paper or report must have been published in the 10 years, 2003–2012 inclusive (a period coinciding with an increased number of publications on Tai Chi (Adams, 2004)), and the full texts of papers must be available in English or Chinese.
2. The paper or report must be original: an experimental research paper, review or report published in the peer reviewed literature, or a research thesis. Essays and narrative articles not published in the peer-reviewed literature or that merely mention or discuss the findings of other studies were excluded.
3. There must be a specific discussion of students in higher education at least once in the paper. If a paper is an experimental study, students must form at least one of the intervention groups.
4. The intervention used must be a form of Tai Chi. The use of Tai Chi must not be combined with any other intervention in such a way that the effects of the Tai Chi aspect cannot be isolated.
5. The outcomes included were those of any form of health-related effect reported in the study.

Individual reports were then given an evidence score based on their methodological strength, while discounting multiple reports from the same first author, according to a hierarchy of evidence developed by Jensen and colleagues (Table 2) (Jensen et al., 2004). This scoring strategy was used because, unlike other systematic reviews, it allows the inclusion and weighting of evidence from studies which are not randomized-controlled trials — this was particularly important in our present study as we wanted to include more traditional forms of knowledge on Tai Chi. Furthermore, Tai Chi is most often reported as an intervention in the literature, and so the evidence hierarchy approach allows the weighing-up of the evidence for the benefit of these various types of interventions. Individual reports were independently scored by two study investigators (AYL and CSW) who conferred to arrive at the final score where discrepancies occurred.

Individual outcomes from each report were extracted and assigned the evidence score of the report from which they were drawn. These outcomes were then tabulated along with the associated reports according to whether evidence in the report supported (i.e. showed a statistically significant benefit, $p < 0.05$), was uncertain (i.e. did not show a significant benefit) or was dissenting of the outcome (i.e. showed a deleterious significant effect, $p < 0.05$). Evidence scores were reported as a total support score and a total uncertain or dissent score for each outcome (Table 3). We took a conservative approach to our analysis by requiring that evidence scores supporting an outcome must exceed the sum of both dissent and uncertain evidence scores before an outcome may be considered a possible or likely benefit of Tai Chi practice — we called this the net evidence score. Outcomes were ranked under each outcome category according to their net evidence scores (Table 3).

**Results**

**Search results**

Substantially more relevant Chinese articles were found than English ones, although the English databases were larger and returned more search results (Fig. 1). The majority of Chinese studies recruited students in compulsory and optional Tai Chi courses at Chinese universities, whereas these courses are far less common outside of China. Seven hundred and thirty-six articles were found in the English search — 330 remained after duplicates were removed, and 300 were excluded after screening the abstracts. After assessing full texts, 8 English-language articles were included in the final analysis. Four hundred and sixty papers were found in the Chinese search, and an additional 109 Chinese articles were included from the English search. Sixty-eight Chinese reports were included in the final analysis after the exclusion process (Fig. 1).

There was a wide range in the quality of the evidence of the final 76 analyzed articles. As there were no meta-analyses of randomized control trials (level Ia), the highest level of evidence included was from Ib (evidence from at least one randomized controlled trial). The lowest level was IV (evidence from the experience of respected authorities — Table 2), and studies with a lower evidence level were excluded. The spread of levels of evidence found in English and Chinese searches were similar, with a predominance of case-control studies in both languages, and similar proportions of one-group, pre- and post-test studies and non-randomized controlled studies.

**Health benefits**

Consistent with the reputation of Tai Chi as a holistic health intervention, a wide range of outcomes were extracted from reports included in our evidence review, comprising 81 outcomes in 10 categories, based on a combined study sample of 9263 participants (Table 3). Only a single study in our review showed any significant deleterious effects of Tai Chi practice (张斌等, 2010). In this study, the overall mental health of Tai Chi novices was found to worsen. However, this evidence of a deleterious effect was in conflict with additional supporting and uncertain evidence, meaning that the net evidence score was zero, and so no conclusion could be reached concerning this outcome (outcome 64, Table 3).

Eleven outcomes showed higher uncertain evidence scores than supporting evidence scores, suggesting that these outcomes were not promoted by Tai Chi practice. For example, with a net evidence score of −32, an increase in the height of the participant seems an unlikely benefit of Tai Chi practice (outcome 13, Table 3). Sixty-five outcomes showed positive net evidence scores, suggesting possible or likely benefit of Tai Chi practice in at least some of these outcomes. Evidence scores appeared to cluster into three strata — we have therefore designated these as low, moderate and high levels of evidence — demonstrating median (range) evidence scores of 8 (−32 to 42), 58 (54 to 80) and 124 (104 to 136) respectively. Sixty-nine outcomes demonstrated low evidence scores and are not discussed further (Table 3).

Four outcomes in our results demonstrated a high level of evidence with scores of over 100 with few, or no, uncertain scores, demonstrating likely benefits of Tai Chi practice — these were designated the primary outcomes of our review. Eight secondary outcomes showed moderate levels of evidence, thus demonstrating possible benefits of Tai Chi...
practice. These primary and secondary outcomes spanned the physical, psychological and psychosocial domains, and are detailed below.

**Physical domain**

The single primary outcome in the physical domain, with a net evidence score of 104, was increased flexibility (outcome 14, Table 3). Secondary outcomes showing possible benefits of Tai Chi practice in the physical domain comprise increased lung capacity (outcome 28, net evidence of 64), improved balance (outcome 15, net evidence 60), improved 800/1000 m run time (outcome 16, net evidence 56) and improved quality of sleep (outcome 1, net evidence 54). These results would appear to be consistent with improvements in aerobic fitness. However, a relative lack of evidence in other physical activities such as long jump (outcome 19, net evidence 16) or 50/100 m sprint (outcome 27, net evidence — 8) suggest that Tai Chi is less effective in improving anaerobic fitness. This may also be consistent with findings that Tai Chi has little effect on a number of other physiological or body composition outcomes such as reduced body mass index (BMI) (outcome 12, net evidence — 18) or improved overall physical health (outcome 7, net evidence — 24).

**Psychological and psychosocial domain**

All likely and possible outcomes in this domain are defined by the Symptom Checklist 90 (SCL-90), a well validated self-report instrument testing for a broad range of psychological symptoms. Primary outcomes in the psychological and psychosocial domain that show likely benefit of Tai Chi practice comprise reduced symptoms of depression (outcome 51, net evidence 136), decreased anxiety (outcome 52, net evidence 128) and improved interpersonal sensitivity (outcome 80, net evidence 120). Secondary outcomes showing possible benefit of Tai Chi practice are reduced symptoms of compulsion (outcome 53, net evidence 80), decreased somatization symptoms (outcome 54, net evidence 64), decreased hostility (outcome 55, net evidence 56) and decreased symptoms of phobia (outcome 56, net evidence 56).

**Discussion**

Our results suggest that Tai Chi is a genuinely integrated health-promoting practice with some physical benefits but also psychological benefits, giving it an advantage over activities that enhance only physical aspects of health. Our results indicate that Tai Chi has aerobic but not anaerobic physical benefits, and this is consistent with the low impact nature of Tai Chi practice. In addition, the cluster of psychological and psychosocial benefits seen in our findings is consistent with the deliberate mindfulness training of Tai Chi, which aims to improve well-being by focusing emotions and sensations on the events occurring in the present moment (Carmody, 2009).

Students in higher education can be at increased risk of specific stress-related disorders such as depression and anxiety — these are serious and debilitating conditions, and our results show a benefit of Tai Chi practice for these conditions in these at-risk populations (Dyrbye et al., 2010, 2006). Increased flexibility may also benefit students in higher education who spend long periods sitting while studying, taking examinations, or during lectures. It is also possible that the fourth primary outcome identified in our study, that of increased interpersonal sensitivity, could also benefit tertiary students by allowing them to better cope with the competitiveness of restricted and high-stakes entry requirements of certain courses, such as medicine.

**Strengths and limitations**

An important strength of our study is that it is the only systematic review that we are aware of that combines evidence from Chinese and English language reports, including a significant amount of systematically discovered grey literature in the form of Chinese research theses. The inclusion of Chinese-language reports in our study significantly increased the number of sources that were reviewed, which we believed was an important part of gaining a comprehensive view of this holistic health intervention. It also resulted in a complementary set of evidence, allowing a broad comparison of the quality and type of evidence from two quite different cultural contexts. Given the cultural background of Tai Chi, the inclusion of the evidence from Chinese reports is an important part of our review. Our designation of low, moderate and high levels of evidence emerged from the data, but we have reported our results in a transparent way that would allow anyone to designate different thresholds for the levels of evidence if they wished.

Different usage of terminology is an inherent potential bias in a systematic review incorporating reports in two languages. Although there was some supportive evidence of the benefit of Tai Chi in decreasing self-rated stress (outcome 61, net evidence 24), the relative lack of the mention of stress in our findings is likely to reflect the fact this outcome was included specifically only in the English articles. In the Chinese literature this factor was generally included under the term “anxiety” (included as one of the four primary benefits found in our study). In addition, the allocation of studies into a hierarchy of evidence can be difficult when certain details are omitted from the study report. Whenever these difficulties occurred or were suspected in the present study, we assigned the report to the most conservative evidence tier indicated (Table 2).

Our method of ranking and synthesizing the evidence did not allow us to quantify the effect size of outcome measures as is often possible where quantitative measures of like outcomes can be aggregated and standard errors calculated. Other reviews of the benefits of Tai Chi in general populations of participants have excluded data that fails to meet the Level I or Level II evidence criteria (Adams, 2004). However, given the paucity of randomized controlled trials of Tai Chi, particularly involving students in higher education, the inclusion of a large number of reports containing other forms of evidence is a strength of our study, and our method allowed us to do this in a systematic way. Such an approach is also consistent with the principles of evidence-based medicine (Sackett et al., 1996).

Although our results are not inconsistent with the findings of systematic reviews of level I and Level II studies in general participant populations, they show differences that may be expected due to the fact that the students in our results are a predominately younger population (Adams, 2004; Kuramoto, 2006). For example, others have evaluated Tai Chi for its therapeutic application in specific populations of participants suffering various conditions, and found benefits in terms of improved cardiovascular function, pain management, and reduced risk of falls (Adams, 2004). These benefits would not be expected to be seen in young individuals who are generally physically fit. As suggested by our findings, such youthful populations may benefit from Tai Chi quite differently when compared to older populations. However, the evidence for Tai Chi in tertiary students might also be applicable to other youthful cohorts.

The range of outcome measures included in our study and the evidence for both physical and mental benefits of Tai Chi seen in our results indicate the need to carefully consider the key outcome measures in any future study. There is also scope for a wider range of methods to be considered in exploring the benefits of Tai Chi — for instance, interviews, multiple-baseline studies and focus groups were seldom used in the studies we reviewed. Furthermore, new understanding of the neurophysiological processes underlying meditation and other mind-body integrative activities may suggest that new quantitative measures of brain activity during the practice of Tai Chi may be possible and insightful (Reis et al., 2014; Ricard et al., 2014).

**Conclusion**

Students in higher education practicing Tai Chi benefit significantly in terms of reduced symptoms of depression and anxiety, improved interpersonal sensitivity, and increased flexibility. There remains scope
for more research to determine how long and how often students need to practice Tai Chi to achieve the most benefit, and the extent to which Tai Chi may benefit other youthful participant cohorts. The potential of Tai Chi as an effective intervention to reduce health risks for students, with few or no side effects, should be considered alongside with other well-engineered strategies taken by education authorities to ensure the well-being of their students.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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References

Adams, K.P.J., 2004. Comprehensive therapeutic benefits of Taiji. Am. J. Phys. Med. Rehabil. 83, 735–745.
Alzheim, A.M., van der Molen, H.T., Alaujan, A., Schmidt, H.G., Zemakhshary, M.H., 2011. Stress amongst dental students: a systematic review. Eur. J. Dent. Educ. 15, 4–11.
Anonymous, 2015. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)Available from http://www.prisma-statement.org (Accessed 8 December).
Badr, G.A., 2010. The impact of interactive exercises for Taiji and ballistic on some physical fitness tests. J. Phys. Med. Rehabil. 41, 1128–1132.
Caldwell, K., Emery, L., Harrison, M., Greeson, J., 2011. Changes in mindfulness, well-being, and stress in college students receiving Tai Chi instruction. J. Alternative. Complement. Med. 17, 931–934.
Carmoni, J., 2009. Evolving conceptions of mindfulness in clinical settings. J. Cogn. Psychotherapy. 23, 270–280.
Chang, T., Chang, S., 2010. Assessing the Effect of Antioxidative with Yoga and Tai-Chi Training, Ergonomic Trends from the East: Proceedings of Ergonomic Trends from the East, Japan: 12–14 November 2008, pp. 263–267.
Dyhrb, L.N., Thomas, M.R., Shanafelt, T.D., 2006. Systematic review of depression, anxiety, and other indicators of psychological distress among U.S. and Canadian medical students. Acad. Med. 81, 354–373.
Dyhrb, L.N., Thomas, M.R., Power, D.V., et al., 2010. Burnout and serious thoughts of dropping out of medical school: a multi-institutional study. Acad. Med. 85, 94–102.
Esh, T., Duckstein, J., Welke, J., Braun, V., 2007. Mind/body techniques for physiological and psychological stress reduction: stress management via Tai Chi training – a pilot study. Med. Sci. Monit. 13, CR488–CR497.
Hased, C., Iisle, S.D., Sullivan, G., Pier, C., 2009. Enhancing the health of medical students: outcomes of an integrated mindfulness and lifestyle program. Adv. Health Sci. Educ. 14, 391–399.
Higgins, J.T.P., Green, S., 2011. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0. The Cochrane Collaboration Available from www.cochrane-handbook.org (Accessed 8 December 2015).
Hunt, J., Eisenberg, D., 2010. Mental health problems and help-seeking behavior among college students. J. Adolesc. Health. 46, 3–10.
Jensen, L.S., Merry, A.F., Webster, C.S., Weller, J., Larsson, L., 2004. Evidence-based strategies for preventing drug administration errors during anesthesia. Anaesthesia. 59, 543–560.
Jones, M., Johnston, D.W., 2000. Reducing distress in first level and student nurses: a review of the applied stress management literature. J. Adv. Nurs. 32, 66–74.
Juster, R.-P., McEwen, B.S., Lupien, S.J., 2010. Allostatic load biomarkers of chronic stress and impact on health and cognition. Neurosci. Biobehav. Rev. 35, 2–18.
Kim, Y., Sedlitz, L., 2002. Spirituality moderates the effect of stress on emotional and psychological aspects of life in college students. J. Appl. Nurs. Educ. 1, 1–18.http://dx.doi.org/10.3109/074301502900171150.
Lee, J.-S., Koeste, G.F., Sales, E., 2004. Social support buffering of acculturative stress: a study of mental health symptoms among Korean international students. Int. J. Intercult. Relat. 28, 359–370.
Lee, M.S., Lee, E.-N., Ernst, E., 2009. Is tai chi beneficial for improving aerobic capacity? A systematic review. Br. J. Sports Med. 43, 569–573.
Maclean, J.A., Strongman, K.T., Neha, T.N., 2007. Psychological distress, causal attributions, and physical fitness. N. Z. J. Physiol. 36, 85–92.
Mays, N., Pope, C., Popay, J., 2005. Systematically reviewing qualitative and quantitative evidence to inform management and policy-making in the health field. J. Health Serv. Res. Policy 10 (Suppl. 1), 6–20.
McManus, I.G., Winder, R.C., Gordon, D., 2002. The causal links between stress and burnout in a longitudinal study of UK doctors. Lancet. 359, 2089–2090.
Park, C.L., Levenson, M.R., 2002. Drinking to cope among college students: prevalence, problems and coping processes. J. Stud. Alcohol Drugs 63, 486–497.
Penley, J.A., Tomaka, J., Werbe, J.S., 2002. The association between physical and psychological health outcomes: A meta-analytic review. J. Behav. Med. 25, 551–603.
Reis, P.M.R., Hedenst, F., Gabstreiber, F., von Tscharn, V., Lochmann, M., 2014. Method-ological aspects of EEG and body dynamics measurements during motion. Front. Psychiatry. Neurosci. 8, 375–399.http://dx.doi.org/10.3389/fnsys.2014.00156.
Ricard, M., Lutz, A., Davidson, R.J., 2014. Mind of the meditator. Sci. Am. 311, 22–29.
Sackett, D.L., Rosenberg, W.M., Gray, J.A., Haynes, R.B., Richardson, W.S., 1996. Evidence based medicine: what it is and what it isn’t. BMJ 312, 71–72.
Shi, T., T., Harris, T.B., Eddins-Folensbee, F.F., Coverdale, J.H., 2013. A systematic review of stress-management programs for medical students. Acad. Psychiatry. 37, 158–164.
Teychenne, M., Ball, K., Salmon, J., 2008. Physical activity and likelihood of depression in adolescents: a review. Prev. Med. 46, 397–411.
Theo, P.A., 2010. Stress and health: major findings and policy implications. J. Health Soci. Behav. 51, 541–553.
Tsang, H.W.H., Chia, E.P., Cheung, W.M., 2008. Effects of mindful and non-mindful exercise training on people with depression: a systematic review. Br. J. Clin. Psychol. 47, 303–322.
Wang, M.Y., An, L.G., 2011. Effects of 12 weeks’ tai chi chuan practice on the immune function of female college students who lack physical exercise. Biol Sport. 28, 45–49.
Wang, Y.T., Taylor, L., Pearl, M., Chang, L.S., 2004. Effects of tai chi exercise on physical and mental health of college students. Am. J. Chin. Med. 32, 453–459.
Wang, W.C., Zhang, A.L., Rasmussen, B., et al., 2009. The effect of Tai Chi on psychosocial well-being: a systematic review of randomized controlled trials. J. Acupunct. Meridi-an Stud. 2, 171–181.
Wang, C., Bannuru, R., Jamel, K., Kupelnick, B., Scott, T., Schmid, C.H., 2010. Tai Chi on psych-ological well-being: systematic review and meta-analyis. BMC Complement. Med. Altern. Ther. 10, 23.
Wichian, J.R., Bughi, S.A., Unger, J.B., Spruijt-Metz, D., Nguyen-Rodriguez, S., 2009. Perceived stress, coping and night eating in college students. Stress Health. 25, 235–240.
Wolf, T.M., Kissling, G.E., 1984. Changes in life-style characteristics, health, and mood of freshman medical students. J. Health Psychol. 111, 508–514.
Yeh, G.Y., Wang, C., Wayne, M.P., Phillips, R.S., 2008. The effect of Tai Chi exercise on blood pressure: a systematic review. Prev. Cardiol. 11, 82–89.
Zhang, J., Goodison, P., 2011. Predictors of international students’ psychosocial adjustment to life in the United States: a systematic review. Int. J. Intercult. Relat. 35, 139–162.
Zhou, D.-H., 1982. Preventive geriatrics: an overview from traditional Chinese medicine. Am. J. Chin. Med. 10, 32–49.
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