

The Role of Taijiquan in Supporting Adaptive Development in Adulthood

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ABSTRACT

Purpose: Working from lifespan development theory and the theory of Selective Optimization with Compensation (SOC), I provide theoretical analyses to inform and direct research on Taijiquan where research questions involve issues of adaptive development (optimization of gains, maintenance of function, and prevention of lost resources). I also used these frameworks to construct a biopsychosocial mind-body practices model that seeks to explain and predict the role of key aspects (curriculum, practice, context) in Taiji-related development. The above frameworks are further substantiated through a comparative analysis of health status between Taijiquan practitioners ($N=120$; age range = 24-83, $M = 54.77$) and a nationally representative sample ($N = 414,629$; age range = 18-99, $M = 54.86$) collected by the Centers for Disease Control and Prevention (CDC). The model's predictive potential is explored through an analysis of health status within a subset of experienced Taiji practitioners ($N = 94$; age range = 24-83, $M = 55.82$).

Design: Theoretical and cross-sectional; between- and within-group comparisons.

Methods: Responses from a convenience sample of Taiji practitioners were collected using an online survey. The instrument was designed to collect data on health-related quality of life (HRQoL), lifestyle variables, and Taiji practice regimens. Data from Taiji practitioners were merged with the CDC's 2008 Behavioral Risk Factor Surveillance System (BRFSS) dataset, forming three groups: *no exercise*, *some exercise*, and *Taiji exercise*. Health status was regressed on exercise group while controlling for age, income, and education, as well as the interaction between age and exercise group. Further analyses were also conducted on a subset of the Taiji data ($N=94$). These analyses examined the relationships among self-reported health, practice regimens, and diet while controlling for age and experience.

Results: In the first set of analyses (see paper one), I controlled for the effects of age, income, education, and the differential effects of age on exercise group, while determining associations between health and group membership. A significant interaction effect ($p < 0.001$) occurred between age and exercise group membership. This interaction showed little difference between exercise groups in the young adult age range, but among older adults, Taijiquan practitioners displayed the best HRQoL. In the second set of analyses (see paper 2), I found significant

interaction effects between (a) curricular complexity and out-of-class practice ($p < 0.05$) and (b) curricular complexity and diet ($p < 0.05$).

Conclusions: The extraordinary health status trajectory among Taiji practitioners may be attributable to several conditions including: (a) the implied presence of SOC-related strategies, (b) the general benefits of psychophysical expertise, and (c) concomitant structures shared between Taiji-related goals and health behaviors which contribute to optimal aging. Specifically, these findings suggest that intervention designers, Taiji teachers, and practitioners should consider the potential benefits of well rounded Taiji curricula, regular practice, and a healthy diet for optimizing health-related gains and minimizing losses typically associated with aging.

Dedication

To my family

Acknowledgments

This work is the culmination of the time and effort that many have given me over years in both the academic and traditional mind-body practices communities.

The following masters were all deeply influential in helping a young Marine to see that the greatest values in martial arts were their paradoxical capacities to contribute to the cultivation of harmonious and resilient individuals and societies. My deepest gratitude to (in chronological order): Master Tim Holmes, Master James Ennis, Enomoto Sensei, Kwong Sifu, Higashi Sensei, Leong Laoshi, Matsumoto Sensei, Zhang and Hu Laoshi, and Yang Laoshi. I would like to extend my thanks also to their teachers and to the grandmasters who have left records of practice and guidance for us to learn from.

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Table of Contents

<u>Section</u>	<u>Page</u>
I. Introduction and Purpose.....	1
II. The Role of Taiji in Supporting Adaptive Development in Adulthood.....	2
Abstract.....	2
Introduction.....	3
Theoretical Framework: Lifespan Development Paradigm and Taijiquan.....	4
Table 1. Summary of Lifespan Tenets and Principles Relevant to Taiji Research.....	5
Methods.....	8
Table 2. Variable Roles, Names, Descriptions, and Codes for Between Group Analyses of Merged Data.....	10
Table 3. Characteristics of the Study Samples by Sex.....	11
Results.....	12
Table 4. Characteristics of Samples by Exercise Group.....	12
Table 5. ANOVA Source Table and Regression Summary of Health Status and Exercise Group.....	13
Figure 1. Relationship of Health Status and Age for Three Exercise Groups.....	13
Discussion.....	14
References.....	16
III. Predicting Optimal HRQoL in Adult US Taijiquan Practitioners.....	20
Abstract.....	20
Introduction.....	21
Theoretical Framework: The Role of SOC in Taijiquan.....	22
Table 1. General and Taiji-Related Examples of SOC Processes.....	23
Figure 1. Biopsychosocial Mind-body Practices Model.....	31
Methods.....	31
Table 2. Variable Roles, Names, Descriptions, and Codes for Curricular Analyses of TSRS Data.....	32
Table 3. Characteristics of TSRS Sub-Sample by Curriculum.....	33
Table 4. Bivariate Correlations among Study Variables (N = 94).....	34
Results.....	35
Table 5. ANOVA Source Table and Regression Summary of Health Status, Diet, and Curriculum.....	35
Figure 2. Health and Curricular Complexity at Frequencies of Self- or Peer Practice.....	36
Figure 3. Health and Curricular Complexity for Varying Dietary Quality.....	37
Discussion.....	37
References.....	40
IV. Conclusions.....	45
V. Appendices.....	46
A: IRB Approval Letter.....	46
B: Review of SOC-related Findings.....	47
References.....	48
C: Review of Traditional Goals in the Taiji Practice Literature.....	49
References.....	54
D: Taiji Symposium Research Survey (TSRS).....	57

I. Introduction and Purpose

The two papers contained within this dissertation contribute to an emerging interdisciplinary subfield of study that has important implications for aging. This subspecialty is so new that its name has not even been established. Some refer to it as mind-body or psychophysical practices; others refer to it as complementary or integrative practices. Regardless of the name that is eventually agreed on, the time honored practices of meditation, yoga, qigong, Taijiquan, and others will continue to be the focus of its research. In their native lands these arts have long been associated with healthy longevity, and now in the West, investigations into the value of these practices for health promotion, disease prevention, and quality of life are well underway.

Despite the tremendous diversity in the methods of practice within any one of these traditions, and the complex multidimensional mechanisms of effect, the goals and outcomes of these arts are inherently developmental. For this reason, I believe that the lifespan development metatheoretical framework has much to offer researchers investigating these practices. These papers apply this framework, along with a theoretical extension of this paradigm known as Selective Optimization with Compensation, to theoretical and empirical analyses of Taijiquan practitioner data. My intention is to show that lifespan development theory provides a useful scaffolding for accommodating the complexity of Taiji while organizing functional frameworks and testable models to examine the practice benefits of this art.

II. The Role of Taijiquan (T'ai Chi) in Supporting Adaptive Development in Adulthood

ABSTRACT

Purpose: Working from lifespan development theory and the theory of Selective Optimization with Compensation (SOC), I provide a theoretical analysis that demonstrates the potential of these frameworks to inform and direct research on Taijiquan, especially where research questions involve issues of adaptive development (optimization of gains, maintenance of function, and loss prevention). This framework is empirically substantiated through a comparative analysis of health status between Taijiquan practitioners ($N=120$; age range = 24-83, $M = 54.77$) and a nationally representative sample ($N = 414,629$; age range = 18-99, $M = 54.86$) collected by the Centers for Disease Control and Prevention (CDC).

Design: Theoretical and cross-sectional; between-group comparisons.

Methods: Responses from a volunteer sample of Taiji practitioners were collected using an online survey. The link was emailed to registrants of the International Taiji Symposium who further forwarded (snowballed) the link to other practitioners across the country. The instrument was designed to collect data on health-related quality of life (HRQoL), lifestyle variables, and Taiji practice regimens. The HRQoL and demographic sections of the survey were adapted from the CDC's Behavioral Risk Factor Surveillance System (BRFSS). Data from Taiji practitioners and the CDC subsample were merged for analysis. Exercise groups represented *no exercise*, *some exercise*, or *Taiji exercise*. Health status was regressed on exercise group while controlling for age, income, and education, as well as the interaction between age and exercise group.

Findings: After controlling for the effects of age, income, education, and the differential effects of age on exercise group where health was concerned, a significant interaction effect ($p < 0.001$) was detected between age and group membership. This effect suggested that exercise group membership was not a substantial predictor of health among younger individuals, but among older adults, substantive and significant between-group differences appeared, with the Taiji group evincing the best average health trajectory across age.

Conclusions: The extraordinary trajectory of health status among Taiji practitioners may be attributable to several conditions related to the theory guiding this research, including (a) the implied presence of SOC life management strategies, (b) the general benefits of psychophysical expertise, and (c) concomitant goal structures between Taiji-related goals and other individual health-related goals contributing to optimal aging.

The Role of Taijiquan (T'ai Chi) in Supporting Adaptive Development in Adulthood

Introduction

The purpose of this research was to explore the role of Taiji and similar mind-body or psychophysical practices in supporting optimal aging and adaptive development across the life course. This research focused on the art of Taiji because (a) many traditional aims of this practice are aligned with the goals of gerontology, especially its focus on healthy longevity, (b) experienced practitioners of Taiji maintain levels of physical, cognitive, and sensorimotor function above those typically expected for their age, (c) the complexity of Taiji offers a number of research challenges related to confirming its benefits through rigorous testing, and (d) lifespan development theory provides a scaffolding that can accommodate the complexity of Taiji while organizing functional frameworks and testable models to examine its benefits.

The origins of Taiji are still much debated. Its antecedent martial art and meditative practices may date back a thousand years or more, but it has evolved greatly over the course of the last century and continues to do so today (Yang, Grubisich, & Feng, 2005). Despite popular cultural associations of the martial arts with violence and destruction, the achievement of healthy longevity is, paradoxically, among the top goals of this art as identified by its contemporary proponents (Da, 1986; Frantzis, 2006; Yang et al., 2005). A recent cross-sectional analysis of the National Health Information Survey confirmed that Taiji and qigong users had significantly higher health status than the general population (Birdee, Wayne, Davis, Phillips, & Yeh, 2009). Of greater interest to gerontologists are a number of cross-sectional and comparative studies that have investigated differences between Taiji practitioners and controls across age groups (Chan et al., 2005; Hong, 2008; Lan, Lai, Wong, & Yu, 1996; Xu, Li, & Hong, 2006; Yau, 2008). These studies have shown that experienced Taijiquan practitioners evince a wide range of sensorimotor, physical, emotional, and cognitive benefits. Furthermore, levels of performance, or assessed status, among participants in later adulthood are often significantly better than expected.

These studies have documented the general suitability of Taijiquan for aging adults and suggest that that Taijiquan may have an important role to play in promoting optimal physical and psychological aging. Yet, findings remain inconclusive, and largely disorganized, except where organized in reviews by authors interested in effects of interventions, such as biomechanical effects of Taiji (Hong & Li, 2007), therapeutic effects of Taiji (Klein & Adams, 2004), and the effects of Taiji on individuals with chronic conditions (Wang, Collet, & Lau, 2004). Still, many unanswered questions remain about whether and how Taiji might be responsible for generating enduring gains in health, cognition, and sensorimotor abilities. Furthermore, a number of recent reviews and meta-analyses have questioned the evidence on Taiji as well as the quality of studies

completed to date (Lee, Lee, & Ernst, 2009; Lee, Pittler, & Ernst, 2008; Lee, Pittler, Shin, & Ernst, 2008; Lee, Pittler, Taylor-Piliae, & Ernst, 2007). Many of the challenges to improving the validity, reliability, and overall quality of Taiji research were recently elaborated by Wayne and Kaptchuk (2008). Chief among these are the lack of standardized intervention protocols and the complex (biopsychosocial and ecological) means by which Taiji is expected create benefits.

The establishment of Taiji protocols is an important step in improving the validity, reliability, and quality of Taiji research (Wayne & Kaptchuk, 2008; Yang, Verkuilen, Rosengren, Grubisich et al., 2007), and the suggested approach for initiating this endeavor includes the use of observational and cross-sectional research to evaluate practice outcomes among regular practitioners. Given the complexity and plurality of Taiji, determining which of dozens of practices and curricula are most effective for overall health, or most therapeutic for specific conditions, could prove to be a daunting task. Some of the difficulty faced by researchers may be alleviated if research can be organized and guided by effective theory on the front end of this endeavor. Since both Taiji intervention protocols and the Taiji of regular practitioners have inherently developmental aims, the lifespan developmental metatheoretical perspective (Aldwin et al., 2006, Baltes, 1987) should prove especially useful for organizing, explaining, and predicting the outcomes in Taiji research.

Lifespan Development Paradigm and Taijiquan

Lifespan development is the study of change and consistency across the human life course, emphasizing the discovery and organization of principles that govern change, including the conditions that lead to gains, losses, and maintenance of physical and psychological function. These key principles of development, which have been supported through empirical research, form the lifespan development paradigm or metatheory (Baltes, 1987) (see Table 1). This paradigm holds promise for improving understanding of how complex arts such as Taijiquan affect development (growth, maintenance, adaptation, and recovery).

The basic propositions of lifespan development (1-3) suggest that starting Taiji at any age is likely to have some effect on development and that prolonged practice will yield cumulative effects. Since Taiji has been identified as a practice with complex benefits (Wayne & Kaptchuk, 2008b), an intervention based on it has the potential to affect participants physically, psychologically, socially, and spiritually. These factors should be considered in designing measures for cross-sectional investigations or pre- and post-test measures in interventions.

Table 1

Summary of Lifespan Tenets and Principles Relevant to Taiji Research

Theoretical Tenets	Developmental Principles
Lifespan Development	<ol style="list-style-type: none"> 1. Development (change) is continuous across the life course and equally important at all ages and stages of life. 2. Development may be cumulative and/or sudden and discontinuous. 3. Development is multidimensional: Psychological, physical, social, and spiritual.
Multidirectionality	<ol style="list-style-type: none"> 4. No period of life should be characterized as all growth or all decline. 5. Directions and rates of change typically vary across and even within aspects of development. 6. Through encapsulation or crystallization, growth in areas of expertise or mastery may continue across the lifespan, even as decline occurs in seemingly parallel functions.
Dynamics of gains and losses	<ol style="list-style-type: none"> 7. Development occurs through the interplay of gains and losses within and across dimensions. 8. Individual losses may lead to innovative or adaptive growth within or across dimensions. 9. Growth, innovation, and adaptation are driven by the processes of selection and compensation and always come at some cost (loss). 10. The balance between gains and losses, on average, becomes increasingly negative, especially in the last decades of life. 11. Investments in mastery, expertise, and wisdom may contribute to optimal (successful) development across the life course: The maximization and maintenance of desired gains and the minimization of undesirable losses.
Plasticity (reserve capacity)	<ol style="list-style-type: none"> 12. Individuals have capacities to maintain and optimize function through reserve (untapped) capacities and compensatory processes. 13. The degree of plasticity may vary by dimension or subsystem (i.e., organ reserve, cognitive reserve) 14. Plasticity, on average, shows general rates of decline across the lifespan. 15. Plasticity shows less age-related decline in areas of expertise-related task performance than in areas where expertise is not maintained.
Historicity and Context (multicausality)	<ol style="list-style-type: none"> 16. Individual development occurs through a dialectic between aging (genetic/biological), historical (environmental, social, cultural), and nonnormative (unpredictable, unexpected) forces. 17. Individuals and entire cohorts can be substantially affected by culture and historical circumstances in ways that persist, even after those circumstances are no longer apparent.
Multidisciplinary	<ol style="list-style-type: none"> 18. No single discipline has all the tools necessary to measure, explain, or predict all aspects of development across the lifecourse. 19. Any field engaged in the study of growth, maintenance, and decline may benefit from (or contribute to) the lifespan metatheoretical paradigm.

Note. Adapted from Baltes (1987) and revised with consideration to Baltes & Smith (1999, 2008), Ericsson (2000), and Hoyer & Rybash (1994).

Multidirectionality (4-6) suggests that rates and directions of gains and loss may vary substantively based on individual differences in participants such as fitness level and biological age, or personality traits such as openness to new experiences. Rates and directions of change

may also be influenced by individual differences in crystallized or expert capacities such as prior experience with dance or other mind-body modalities such as yoga or qigong. Again, such factors can be considered in initial measures when implementing research or intervention protocol.

The cumulative effects of thousands of hours of psychophysical training should also inform an understanding of why experienced Taiji practitioners tend to show outstanding profiles across dimensions of physical and psychological functioning (Chan et al., 2005; Hong, 2008; Lan et al., 1996; Xu et al., 2006; Yau, 2008). However, well planned interventions have also shown measureable benefits with even a few weeks of intensive Taiji training (Gatts & Woollacott, 2006; Yang, Verkuilen, Rosengren, Mariani et al., 2007; Yang, Verkuilen, Rosengren, Grubisich et al., 2007).

While many of the propositions discussed in this analysis relate to the complex individual and environmental factors that can influence change, the dynamics of gains and losses (7-11) are of particular importance to understanding the mechanisms that drive development through Taiji practices such as meditation, silk reeling, choreography, and partner training (described in more detail in the next section).

Developmental gains and losses occur throughout the life span. Lifespan developmental theory posits that all gains are concomitant with costs, or loss, and that all losses include the potential for gain. Although early stages of development are typically characterized more by gains than by losses, the balance between gains and losses is typically considered to grow increasingly negative across the lifespan. Among the oldest adults, where resources may be scarcest, each investment of time and energy needs to yield substantial objective and subjective rewards to justify the costs. These propositions highlight an important consideration about the design and implementation of Taiji curricula, especially where older adults are concerned. Interventions need to be low cost (time, money, cognitive resources) and high yield (physical, cognitive, and emotional).

The long-term value of any Taiji curricula, when practiced regularly, will be apparent in its potential to promote optimal aging—the maximization of desired gains and the minimization of undesired losses across the lifespan. One way that Taiji may be supporting optimal aging is through the formation of expertise. The intentional and frequent nature of Taiji practice among experienced practitioners is likely to contribute to the development of expertise (Ericsson, Krampe, & Tesch-Römer, 1993). Expertise, in a particular area, is associated with above-average physical and cognitive function, in that same area, across the lifespan (Hoyer & Rybash, 1994; Johansson, 2002). Given the inherently psychophysical nature of Taijiquan, expertise in this discipline may support above-average performance in a range of sensorimotor and cognitive

abilities. The presence of expertise may be an important proposition for explaining the many ways experienced Taiji practitioners tend to differ from controls. Since expertise is considered to be a resilient crystallized feature of cognition, differences in brain structure and function may be detectable in expert practitioners through neuroimaging.

Principles related to plasticity (12-15) suggest that typical age-related declines in physical and psychological abilities need to be accounted for in intervention planning and outcome interpretation. For instance, the general decline of fluid processing abilities throughout adulthood can present substantial challenges to adults trying to learn highly novel material, such as Taiji choreography. Attempting to teach choreography too soon, or too quickly, may inhibit learning because of frustration and attrition (Yau, 2008). Working with older adults who have pain caused by chronic conditions can also complicate learning. Such problems can be addressed by carefully planning interventions to reduce excessive physical strain and cognitive overload while maximizing other benefits. In any case, such issues are likely to affect outcomes and should be accounted for during data collection.

An understanding of the interaction between expertise and plasticity suggests that, on average, more enduring benefits should be expected among Taiji practitioners who have completed several thousand practice hours and continue to practice regularly. How much earlier in life practice should begin and how much regular practice is needed are both questions in need of empirical answers. Traditional Taiji families begin training their members as children. But several studies have shown that frequent practice (four to seven days per week) among older adults offers substantial benefits (Gatts & Woollacott, 2006; Lee, Lee, & Woo, 2009; Yang, Verkuilen, Rosengren, Grubisich et al., 2007), especially among those who enjoy their practice (Yau, 2008).

A consideration of historicity and context (16-17) raises questions about potential differences in developmental effects that might be partially attributable to cohort or culture. For instance, do Chinese practitioners of Taiji have a cultural understanding of the philosophy and methods of Taiji practice that substantively affects outcomes? Can US practitioners achieve similar benefits as Taiji evolves here? These possibilities have not been explored empirically, but the principles of historicity and context suggest that they should be examined before assuming that cross-sectional findings in one cultural milieu are generalizable to another.

Historicity and context are also known to be highly influential in determining individual health (Aldwin, Spiro, & Park, 2006). For instance, poverty and lack of education have remained strong predictors of health risk in the US (Zahran, Zack, Vernon-Smiley, & Hertz, 2007; Zahran et al., 2005). Results from cross-sectional studies of mainland Chinese Taiji practitioners are all

the more remarkable when one considers the turmoil and poverty that many older Chinese persons faced as children and young adults. In the same way that decades of Taiji practice can lead to extraordinary results, decades of disadvantage may be very difficult to ameliorate in a brief intervention. If possible, outcome-relevant demographic predictors of advantage and disadvantage should always be assessed, as well as the degree to which these have changed in members of a sample over time.

Another crucial aspect of context is access to a knowledgeable teacher. It may be difficult to understand the traditional goals and methods of Taiji without close mentorship. As the difficulty level of training increases, so does the need for integration of mental and physical skills to accomplish learning objectives. The process by which this is achieved may be difficult to perceive without guidance, so student achievement is likely to be influenced by the teacher.

Finally, the multicausal aspect of contextualism suggests that pure training effects do not exist. All development is multicausal, and researchers are tasked with piecing together the most salient models to explain change and stability. Investigators conducting intervention studies must take responsibility for detailing the specific components of their interventions, hypothesizing the potential mechanisms of effect with consideration to the complexity of context, and reporting the findings of their *own* intervention without conflating these with Taiji as whole. With an increasing awareness of the complexity that Taiji training entails, concluding studies with simple statements such as, “Taiji was effective at X”, or “Taiji failed to produce Y”, can no longer be considered sound science.

Given the wide range of potential measures and instruments that might be employed in studying Taiji, it makes sense that development of Taiji research should incorporate multidisciplinary teams. Although Taiji research has never been identified with a particular theoretical framework, it fits well within the lifespan developmental model. Regardless of disciplinary perspective (biomechanical, rehabilitative, or social science), the goals of Taiji research are implicitly developmental in nature, questioning whether and how Taiji plays a role in growth, maintenance, and recovery of health and well being.

Methods

The purpose of this research is to evaluate and discuss potential differences in health status between experienced US Taiji practitioners ($N=120$; age range = 24-83, $M = 54.77$) and a representative sample of the US population ($N = 414,629$; age range = 18-99, $M = 54.86$). The primary dependent variable, GENHLTH, (see Table 2), is self-reported health status. This measure was chosen because health is a multidimensional construct (physical, psychological, and

social), which has strong associations with many indicators of successful aging (Aldwin et al., 2006; Freund & Baltes, 1998).

Data Collection Procedures and Instruments

Taiji Symposium Research Survey (TSRS). The TSRS was designed to collect data on regular Taiji practitioners related to their health, lifestyle, practice routines, and demographic characteristics. Administrators of the International Tai Chi Symposium supported the collection of the TSRS data by sending out recruitment email messages to symposium attendees. The messages contained information about informed consent and the purpose of the survey as well as links to the survey. These email messages also contained a request to forward the survey to other practitioners. Data were collected online through the Virginia Tech Survey System after obtaining approval from the university's Institutional Review Board (see Appendix A). Both the email summary and the survey disclosed the purposes of the research and its voluntary and confidential nature. Since the TSRS was released June 18, 2009, the survey has received 300 responses. US practitioners comprise 120 of the 300 cases. These 120 US cases comprise the subset of data used for the present analyses.

The TSRS contained 40 items, 20 of which were adopted from the Centers for Disease Control and Prevention's (CDC's) 2009 Behavioral Risk Factor Surveillance System (BRFSS) (CDC, 2009a). These measures were included in the TSRS because they have good validity, reliability, and risk prediction (CDC, 2008; Moriarty, Zack, & Kobau, 2003). Furthermore, they allow for comparisons between the TSRS sample and the CDC's BRFSS sample. The demographic items on the TSRS were also modeled after the BRFSS so as to provide data on health status predictors such as income and education level (Zahran et al., 2005). The remaining items on the TSRS survey were designed to document the complexity of Taiji curricula, including frequency, content, and duration of practice, and assess lifestyle factors relevant to Taiji practitioners' health and well being such as diet, exercise, and the use of other mind-body practices (see Appendix D).

Behavioral Risk Factor Surveillance System (BRFSS). Comparison group data for the analyses came from the BRFSS telephone survey for 2008, the most recent data available. With the assistance of the CDC, US states and territories collect data annually from a nationally representative sample of noninstitutionalized adults for the purposes of understanding and predicting trends in health and disease. Adults, ages 18 and older, are randomly selected from among adult members of households phoned in the survey. The 2008 BRFSS data set includes 414,509 cases. The 2008 BRFSS dataset was downloaded from the CDC's website (CDC, 2009b). Use of these public access, anonymous data requires no special permission. Table 2

describes the variables of interest for the current analysis. These variables are present in both datasets, so the BFRSS and TSRS data were merged (see Table 3) to allow for between-group comparisons.

Table 2

Variable Roles, Names, Descriptions, and Codes for Between Group Analyses of Merged Data

Variable	Description	Code
GENHLTH	Continuous variable indicating self-reported health	0= Poor 1= Fair 2= Good 3=Very good 4=Excellent
EXGROUP	Nominal variable indicating group membership in the combined BRFSS/TSRS dataset. 1 & 2 were determined through questions in the BRFSS. 3 is equivalent to the entire TSRS sample.	1=No Exercise 2=Some Exercise 3=Taiji Exercise
AGE	Continuous variable indicating years since birth	18-99
INC_LEVEL	Continuous variable indicating approximate annual household income	0 = < \$10,000 1 = \$10,000 - \$15,000 2 = \$15,000-\$20,000 3 = \$20,000-\$25,000 4 = \$25,000-\$35,000 5 = \$35,000-\$50,000 6 = \$50,000-\$75,000 7 = > \$75,000
EDU_LEVEL	Continuous variable indicating approximate level of education.	0 = No School 1 = Grades 1-8 2 = Grades 9-11 3 = HS Grad/GED 4 = Some College 5 = BA/BS or Higher

Sample Characteristics in the Combined Dataset

Tables 3 and 4 provide demographic characteristics and health data for the BRFSS and TSRS samples, including age, income, years of education, self-reported health. Race is not reported because only 18,281 cases out of a total of 414,509 indicated race in the BRFSS dataset; the majority of respondents do not appear to have been asked this question. Although most of the TSRS respondents did indicate race, due to the small sample size ($N=120$) only the White racial category contained more than 10 cases.

Table 3

Characteristics of the Study Samples by Sex

Characteristics		Samples						Total
		BRFSS		TSRS		BRFSS	TSRS	
		Male	Female	Male	Female	Overall	Overall	
Total		155703	258806	57	62	414509	120	414629
%		37.56%	62.44%	47.50%	51.66%	99.97%	0.03%	100%
Age	N	154810	256046	56	61	410856	117	410973
	M (SD)	54.11(16.38)	55.31(16.93)	54.29(10.81)	55.23(10.73)	54.86(16.74)	54.77(10.73)	54.86(15.73)
	Range	18-99	18-99	24-83	29-77	18-99	24-83	18-99
Income	N	140720	220115	54	54	360835	109	360944
	M (SD)	4.97(2.02)	4.45(2.19)	5.93(1.70)	5.93(1.77)	4.65(2.14)	5.90(1.74)	4.65(2.14)
	Range	0-7	0-7	0-7	0-7	0-7	0-7	0-7
Education	N	155215	258013	56	62	413228	119	413347
	M	3.83(1.11)	3.77(1.08)	4.71(0.62)	4.81(0.51)	3.79(1.09)	4.76(0.56)	3.79(1.09)
	Range	0-5	0-5	0-5	0-5	0-5	0-5	0-5
Self-rated Health	N	154992	257647	57	62	412639	120	412759
	M	2.45(1.09)	2.42(1.11)	3.19(0.83)	3.02(0.86)	2.43(1.11)	3.09(0.85)	2.43(1.11)
	Range	0-4	0-4	0-4	0-4	0-4	0-4	0-4

Because the BRFSS included an item related to exercise participation it was possible to further divide that sample into groups based on that characteristic. Table 4 displays demographic and health data for the same merged dataset, here broken into three comparison groups, no exercise (BRFSS sample), some exercise (BRFSS sample), and Taiji exercise (TSRS sample).

Table 4

Characteristics of Samples by Exercise Group

Characteristics		No Exercise	Some Exercise	Taiji Exercise	Total
Total		114844	299159	120	414629
%		27.73%	72.24%	0.03%	100%
Age	N	113883	296485	117	410973
	M(SD)	57.70(16.94)	53.76(16.52)	54.77(10.73)	54.86(15.73)
	Range	18-99	18-99	24-83	18-99
Income	N	97796	262704	109	360944
	M(SD)	3.85(2.20)	4.95(2.04)	5.90(1.74)	4.65(2.14)
	Range	0-7	0-7	0-7	0-7
Education	N	114403	298331	119	413347
	M(SD)	3.40(1.11)	3.94(1.04)	4.76(0.56)	3.79(1.09)
	Range	0-5	0-5	0-5	0-5
Self-reported Health	N	114123	298025	120	412759
	M(SD)	1.94(1.14)	2.62(1.03)	3.09(0.85)	2.43(1.11)
	Range	0-4	0-4	0-4	0-4

Analysis Plan

Based on the theoretical underpinnings of this research and the traditional goals of Taiji, I hypothesized that Taiji exercise group membership would be a significant predictor of best health and that the membership in the Taiji exercise group would also be associated with the best average health trajectory across age even when controlling for differences in income and education. The analysis regressed health on the exercise groups, age, and the interaction between exercise groups and age, while controlling for the effects of income and education levels. The no exercise group was set as the reference group for between-group comparisons in the general linear model. This analysis was designed to determine (a) If membership in the Taiji exercise group is, on average, associated with better health outcomes than membership in the other two groups, some exercise and no exercise, and (b) whether the expected and usual pattern of deteriorating health status across age would be alleviated in the Taiji exercise group.

Results

Table 5 shows the results of the regression analysis. The ANOVA source table is at the top followed by the parameter estimates, with NO EXERCISE set as the reference group. The R^2 value was 0.219, indicating that 22% of the variance in health status was explained by the fitted model. Figure 1 represents the relationship between health statuses for the three groups based on

the parameter estimates.

As expected, exercise group membership was a significant predictor of health status across age, even after controlling for differences of income and education (see Table 5 and Figure 1). A significant interaction effect between exercise group membership and age ($F = 241.571, p < 0.001$) showed that the average health of each group was similar for younger members, but among older members, the disparities among the exercise groups were large (see Figure 1). Both the no exercise and the some exercise groups showed lower health status at older ages. Although the average health status for exercisers was better than that of nonexercisers, the Taiji exercise group showed no age differences in health status.

Table 5

ANOVA Source Table and Regression Summary of Health Status and Exercise Group

Source	Type III SS	df	M Square	F
Exercise group	11488.740	2	229.313	241.571 **
Age	2844.076	1	2.927	3.083
Exercise group*age	116.652	2	58.326	61.444 **
Education level	5134.848	1	5134.848	5409.337 **
Income level	23295.200	1	23295.200	24540.469 **
Model	95053.628	7	13579.090	14304.97 **
Error	339048.787	357173	0.949	
Total	434102.415	357180		

Independent Variables	General Health Status			
	B	SE B	β	t
Intercept	1.575	0.013		122.326 **
Taiji exercise	-0.031	.495	.000	-.064
Some exercise	0.287	0.013	.116	21.975 **
No exercise	0 ^a	.	.	.
Age	-0.010	0.000	-.154	-54.737 **
Education level	0.129	0.002	.125	73.548 **
Income level	0.139	0.001	.270	156.654 **
Taiji exercise*Age	0.013	.009	.011	1.446
Some exercise*Age	0.002	0.000	.061	11.015 **
No exercise*Age	0 ^a	.	.	.
R ²		0.219	**	

* $p < .05$. ** $p < .01$.

^aThis parameter is set to 0 because it is redundant.

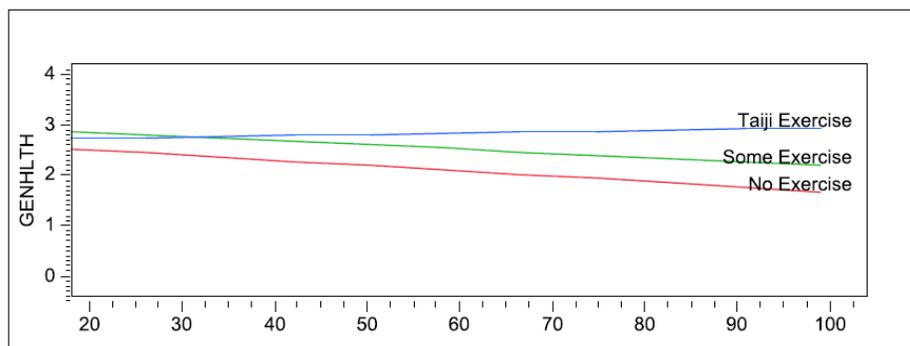


Figure 1. Relationship of Health Status and Age for Three Exercise Groups.

Discussion

The finding that such a positive average health status occurred for the Taiji exercise group must be interpreted with great care. Based on the theoretical analyses guiding this research, it should be clear that these findings should not be simplistically associated with the performance of Taiji choreography or any other single cause. The following discussion illustrates the potential for multicausal explanations based on further consideration of variables in the TSRS data.

Among the basic propositions of lifespan development outlined in Table 1 is the potential for development to be cumulative. Members of the TSRS dataset had been practicing Taiji for an average of 14 years ($SD = 10$) before participating in this survey. On average they practiced with a teacher 1.22 ($SD = 1.26$) days per week, and alone or with a peer for a mean of 4.16 ($SD = 2.60$) days a week. Given that the average practice time for this sample was 51.10 ($SD = 26.40$) minutes per session, members of this group may have averaged 3,000 or more total practice hours before taking this survey. While the exact number of practice hours cannot be determined because the TSRS did not collect data related to change in practice frequencies over time, it is safe to assume that members of this group had ample time to benefit from the cumulative effects of Taiji, including regular light to moderate aerobic activity and meditation. Similar data are not available in the 2008 BRFSS to make group comparisons related to practice history and frequency.

Aerobic activity is well established in the literature as having far-reaching physical and cognitive benefits (Colcombe, Kramer, McAuley, Erickson, & Scalf, 2004), and the benefits of meditation are most commonly tied to the relaxation response and stress reduction which includes benefits for immune and endocrine function (Astin, Shapiro, Eisenberg, & Forsys, 2003; Sternberg, 2000). Aldwin and colleagues' (2006) lifespan health-behavior model of optimal aging discusses the cumulative effects of these activities across the life course (Aldwin et al., 2006).

These practice-related statistics also suggest that many of the Taiji practitioners in this sample have achieved enduring levels of expertise through deliberate practice (Ericsson, Krampe, & Tesch-Römer, 1993). Since expertise is supported by crystallized or pragmatic intelligence, it is among the most age-resilient forms of cognition (Baltes, 1987; Baltes & Smith, 1999) and may play a substantial role in explaining the anomalous health status differences seen in this research. Put another way, many declines in both cognitive and sensorimotor function are correlated with loss of brain mass due to atrophy or lesions (Baltes & Smith, 1999; Guo et al., 2000). It would be fruitful for future research to examine the brain health of expert Taiji practitioners in comparison to other exercisers.

The average dietary score in the TSRS group was 2.15 out of 3 ($SD = 0.67$), indicating that most Taiji practitioners in this sample rarely consumed fast or processed foods and consumed

five or more servings of fruits and vegetables daily. Such lifestyle choices may be related to the social and contextual effects of belonging to certain Taiji communities where diet is emphasized. It may also suggest overlap between Taiji-related and health-related goals at the individual level. That is, practitioners who practice Taiji because health is an important goal may also watch their diet for the same reason, or practitioners who notice that their performance in Taiji is affected by their diet may alter their diet to improve or maintain performance. In either case, such behaviors would strongly resonate with Aldwin and colleagues' (2006) lifespan model of optimal aging, which suggests the importance of avoiding age accelerating behaviors and engaging in age decelerating behaviors.

Lastly, although historicity and context cannot be fully considered in a cross-sectional design, given the length of practice experience reported in the TSRS, it is apparent that the personal life histories of practitioners in the Taiji group have been affected for more than a decade by Taiji-related goals, practices, and compensatory methods, as well as any concomitant adaptive developmental processes. In the present analysis, income and education were used as control variables, but the distinct possibility exists that both of these variables have reciprocal relations with other variables and processes discussed previously (e.g., health, SOC as life management). That is, the many contextual variables surrounding participation in Taiji may contribute not only to healthy longevity, but also to productivity in ways that are too complex to account for with general linear analyses. As discussed by Wayne and Kaptchuk (2008), future longitudinal work should include a mix of qualitative and multivariate methods to determine the contributions of these likely relationships to indicators of optimal aging.

This paper presented a comparative analysis of health between Taiji practitioners and respondents from a nationally representative dataset to demonstrate the utility of the lifespan theoretical framework for avoiding reductionism and recognizing the limitations of findings. I have also suggested that Taiji research, due to its complex and inherently developmental nature, would likely benefit from the use of the lifespan metatheoretical framework because this paradigm is capable of addressing individual and contextual complexity while maintaining a focus on measurable developmental outcomes.

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III. Predicting Optimal HRQoL in Adult US Taijiquan Practitioners

ABSTRACT

Purpose: Working from the adaptive developmental theory of Selective Optimization with Compensation (SOC), I constructed and evaluated a framework for examining the general contributions of Taijiquan (T'ai Chi) to optimal physical and psychological aging. The framework considers the effects of Taiji-related goals and environmental constraints (selection), organizes Taiji practices into domains based on their expected benefits (optimization), and details the importance of loss-based gains, adaptive strategies and Taiji teachers (compensation) in predicting optimal aging among Taiji practitioners.

Design: Theoretical and cross-sectional

Methods: Responses from a volunteer sample of Taiji practitioner were collected using an online survey. The link was emailed to registrants of the International Taiji Symposium who further forwarded (snowballed) the link to other practitioners across the country. The instrument was designed to collect data on health-related quality of life (HRQoL), lifestyle choices, and Taiji practice regimens. Utilizing lifespan and SOC frameworks, I constructed and tested a Taiji practice model to predict optimal health among 94 experienced (≥ 4 years) practitioners across a wide range of ages (24-83, $M = 55.82$). The relationships among self-reported health, diet as an indicator of lifestyle, and aspects of practice regimens were analyzed while controlling for age and experience.

Findings: Significant interaction effects were detected between (a) curricular complexity and additional practice ($p < 0.05$) and (b) curricular complexity and diet ($p < 0.05$). The first interaction supported a hypothesized curricular efficiency effect, where less practice was required to optimize health when curricula were richer. The second interaction can be described as synergistic, where healthy diets and complex curricula worked to predict optimal health.

Conclusions: Intervention designers, Taiji teachers, and practitioners should consider the potential benefits of well-rounded curricula, regular out-of-class practice, and healthy diet for optimizing health-related gains and minimizing losses typically associated with aging.

Predicting Optimal HRQoL in Adult US Taijiquan Practitioners

Introduction

Taiji is a mind-body practice to which millions of people have turned for its purported health and therapeutic benefits (Birdee, Wayne, Davis, Phillips, & Yeh, 2009a). The ultimate aim of this practice is achievement of healthy longevity through mind-body cultivation (Da, 1986; Frantzis, 2006; Yang & Grubisich, 2000). Evidence to support the possibility that regular practitioners are achieving this goal is reflected in a number of cross-sectional and comparative studies that investigated differences between Taiji practitioners and controls (Chan et al., 2005; Hong, 2008; Lan, Lai, Wong, & Yu, 1996; Xu, Li, & Hong, 2006). These studies showed a wide range of health, sensorimotor, physical, and cognitive benefits, especially in experienced practitioners where functioning in later adulthood is often significantly better than expected. However, a number of recent reviews and meta-analyses have questioned the evidence on Taiji as well as the quality of studies to date (Lee, Lee, & Ernst, 2009; Lee, Pittler, & Ernst, 2008; Lee, Pittler, Shin, & Ernst, 2008; Lee, Pittler, Taylor-Piliae, & Ernst, 2007).

Wayne and Kaptchuk (2008) recently discussed many of the challenges to improving the validity, reliability, and quality of Taiji research. These include (a) the complex mechanisms (biopsychosocial and ecological) through which Taiji is likely to provide effects, (b) the plurality and eclecticism of Taiji practices, (c) a lack of understanding of dose and response effects with Taiji practice; including means that can confirm the quality of practice, (d) the inadequacy of preferred or “gold standard” research designs, such as RCTs, to deal with the complexity of the problems, and (e) the need for multimodal (cross-sectional and longitudinal studies; community based and pragmatic-controlled studies), concerted efforts to determine best practices and establish testable intervention protocol.

Given the complex nature of Taiji and the fact that so many of its long- and short-term goals are directly related to optimal aging and adaptive development, the general theory of adaptive development known as Selective Optimization with Compensation (SOC) (Baltes, 1987) may prove useful in developing an analytic tool for interpreting and predicting the outcomes experienced by Taiji practitioners. SOC theory has been considered relevant to complex systems research (Riediger, Li, & Lindenberger, 2006), and its framework tightly organizes many of the problems in Taiji research that were identified in the work of Wayne and Kaptchuk (2008).

Working from the lifespan developmental framework and SOC theory, I constructed and evaluated a model for examining the contributions of Taijiquan to optimal aging and adaptive development. The model considers the effects of Taiji-related practice goals and environmental constraints (selection), organizes Taiji practices into domains based on their expected benefits

(optimization), and details the importance of loss-based gains, adaptive strategies, and Taiji teachers (compensation) in predicting optimal aging among Taiji practitioners. The model is tested in a cross-sectional sample of experienced adult practitioners (≥ 4 years, $N = 94$; age range = 24-83, $M = 55.82$) using health status as a key indicator of adaptive development and optimal aging.

The Role of SOC in Taijiquan

The SOC Model was first proposed as a general theory of adaptive development within the overall lifespan metatheoretical framework. SOC theory applies directly to the dynamics of losses and gains, explaining and predicting tendencies toward the simultaneous minimization of losses and maximization of gains that support optimal aging (Aldwin, Spiro, & Park, 2006; Baltes, 1997; Freund & Baltes, 2002; Riediger et al., 2006). This framework specifies that successful adaptive development is achieved through the orchestration of three interdependent processes (a) the *selection* of goals within constraints, (b) the *optimization* of means to achieve and maintain those goals, and (c) *compensatory* efforts to maintain function or achieve goals when other goal-relevant means are lost (Freund & Baltes, 2002). Although each component (selection, optimization, and compensation) can be conceptualized as having distinct attributes, Baltes and colleagues maintained that in terms of life management SOC should be understood as an interdependent ensemble of nested processes (Baltes, 1997). See Appendix B for a review of findings.

Because SOC theory is considered appropriate to complex systems analysis and is predictive of optimal and adaptive development (Riediger et al., 2006), it may prove particularly useful in organizing complex goal/practice/outcome oriented frameworks and models explicating the general benefits of Taijiquan. Table 1 displays my integration of Taiji elements with the SOC Model. This framework considers the effects of Taiji-related practice goals and environmental constraints (selection), organizes Taiji practices into domains based on their expected benefits (optimization), and details the importance of loss-based gains, adaptive strategies, and Taiji teachers (compensation) in predicting optimal aging among Taiji practitioners.

The Role of Selection in Taijiquan

The primary attributes of *selection* are goal setting, resetting, and goal adaptation; this also includes the cognitive processes involved in planning and elaboration of goals, as well as a consideration of the constraints (individual and environmental) that limit this process. Goals, as discussed here, refer to desired states that people attempt to obtain, maintain, or avoid (Freund & Baltes, 2002), such as health and equanimity or disease and anxiety. According to SOC theory, when goals are set and attributed with some degree of importance then resources needed to

achieve those goals will be allocated. Thus intentionality, goal setting, and goal hierarchies are important factors to be considered in the study of Taiji practitioners as these cognitive precursors play a role in resource allocation and other behaviors relevant to success in Taiji.

Table 1

General and Taiji-Related Examples of SOC Processes

<u>General Examples</u>		
Selection	Optimization	Compensation
Elective selection	Attentional focus	Increased attentional focus
Detailed goals	Effort/energy	Increased effort/energy
Goal systems (hierarchy)	Time allocation	Increased time allocation
Contextualization of Goals	Practice of skills	Activation of unused skills/resources
Goal commitment	Acquiring new skills/resources	Acquiring new skills/resources
Loss-based selection	Motivation for self-development	Modeling others who compensate
Goal focus	Modeling others	Use of external aids/seek help of others
Finding new goals		
Adaptation of standards		
Reconstruction of goal hierarchy		
<u>Taiji Related Examples</u>		
Intentional/Speculative Goal Processes	Behavioral/Performative Processes	Corrective/Constructive Processes
Knowledge of training methods/priorities	Mindset	Mindset
Goal hierarchy/context	Mindfulness	Mindfulness
Healthy Longevity	Visualization	Humility
Moderation	Equanimity	Refocus
Discipline/Dedication	Focus/intentionality of practice	Repose/recharge
Psychophysical Expertise	Flow	Persistence
Equanimity	Practices	Discovery of new psychophysical methods
Flow	Meditation	Innovation of learning style
Repose & Transcendence	Iteration	Integration of mental and physical skills
	Choreography	Relationships with teacher & peers
	Partner Training	Seeking help from teachers & peers
	Frequency of practice	Research of concepts and skills
	Learning strategies	
	Concomitant Behaviors	
	Avoid age accelerators	
	Engage age decelerators	

Note. General examples adapted and revised from Freund and Baltes (1998).

Since there are no published empirical studies relating to the goal structures of US Taijiquan practitioners, this analysis is based on inferences from written sources where the goals of Taiji have been discussed. Traditional proponents of Taijiquan who have described Taiji's ultimate goals as relating to healthy longevity, peace, and equanimity through the integration of mind and body (Da, 1986; Frantzis, 2006; Ni, 1993; Yang, Grubisich, & Feng, 2005). Other goals may include self-defense, self-discovery, mastery, equilibrium, flow, relaxed awareness, and success in performance or competition (Kiehne, 2003; Wayne & Kaptchuk, 2008a; Yang et al., 2005).

While some of the above goals may resonate well with each other, others, when placed in the same hierarchy, may lead to dissonance. For instance, competition and other types of extrinsic

performance goals may physically damage the body in ways that make aging less optimal. Although taking such goals to the extreme is cautioned against in the practice literature of Taiji (Kauz, 1997; Yang et al., 2005), some practitioners and even teachers may value competitive victory or performance over health and safety. Establishing a clear picture of individuals' Taiji-related goals will likely prove useful in constructing a thorough predictive model. For instance, frequency of sprains and other practice related injuries (Birdee, Wayne, Davis, Phillips, & Yeh, 2009) could be related to competitive goal structures. Another distinct possibility is that Taiji-related goals (e.g., healthy longevity) and other general life goals share a common structure and work interdependently to promote health.

The goals, expectations, and motivations of newcomers to Taiji may be influenced set by the media or their first encounters with practice. However, long-term practitioners will have had more opportunity to learn from first-hand experience, peer experience, and the guidance of teachers, as well as other sources of insider culture such as books, newsletters, websites and blogs. Therefore experience may influence many aspects of goal setting including long-range goals, details of practice curriculum, motivation, and confidence. Thus more attention to direct measurement of Taiji practitioners' goals, beliefs, and motivation should provide researchers with more informed intervention designs and more accurate models of outcomes.

SOC theory places emphasis not only on selection (goal setting, planning, commitment, ect.) but also on optimizing and compensatory behaviors. Next I move to an analysis of the behavioral correlates of selection (optimization and compensation) as they apply to the practice of Taiji and optimal aging.

The Role of Optimization in Taijiquan:

Practices, Curriculum, and Concomitant Behaviors

The individual practices of Taiji are important means through which Taijiquan artists work towards optimization and maintenance of the kinds of goals discussed in the previous section. Also, certain goal states (equanimity, flow, mindfulness, health), when achieved and maintained through practice, can also function reciprocally as optimizing resources. Thus, experienced Taiji practitioners with well integrated SOC ensembles (see Table 1) might evince synergistic or multiplicative effects that exceed the acute training value of any one Taiji practice. Readers should keep this holistic effect in mind through the following sections which focus more narrowly on a categorization of practices based on specific characteristics and expected benefits.

According to traditional proponents of Taijiquan, a well rounded curriculum is necessary to receive the full range of mental and physical health benefits attributed to Taiji. Of particular importance is the combination or alternation of moving practices with stillness and meditation

(Da, 1986; Ni, 1993; Yang et al., 2005). However, great plurality exists in the world of Taiji practices (Wayne & Kaptchuk, 2008b), and caution must be exercised in not assuming that the name Taiji refers to a single curriculum, or that all types of Taiji will produce the same results at the same rate. Differences between curricula are hypothesized to affect the overall benefits of practice, as well as the amount of time and energy it takes to receive benefits (Yang et al., 2005; Yang et al., 2007).

In spite of the complexity and plurality of Taiji (Wayne & Kaptchuk, 2008), I argue that, for research purposes, the practices of any individual's curriculum can be meaningfully categorized into four general domains based on practice characteristics, benefits, and synergistic potential. These domains are *Still Meditation*, *Iterative Movement*, *Choreography*, and *Partner Training*. The characteristics of each domain are discussed briefly below.

The domain of still meditation. Overall optimization within Taijiquan depends on the quality of the mind-body relationship. Meditation practices are essential to enhancing this relationship (Da, 1986). Common categories of meditative practices include recumbent meditation, seated meditation, and standing practices (Yang et al., 2005); each includes numerous subcategories (Wong, 1997). Regardless of the specific form, the goal is to enhance or balance the movement aspects of Taiji in some way. Reciprocally, movement both improves the physical condition of the body and supports meditative gains (Da, 1986). Psychophysical skills such as mindfulness, visualization, awareness of breath and body, and relaxation demonstrate how meditation can strengthen the mind-body relationship (Liao, 1995). These fundamental skills are important building blocks for achieving other more refined goal states such as *xiulian*, *gong*, *zhongding*, and *xujing*.

The domain of iterative practices. The defining feature of this domain is focused repetitive movement in which a particular pattern is executed many times. Practices of this nature are particularly important to the efficient development of *gong* (Yang & Grubisich, 2000). Common iterative practices include silk reeling, nonsequential qigong, power release or *fali* exercises, and various kinds of walking, shuffling, and bouncing. Iterative movement in Taiji provides opportunity to integrate mental skills into physical action. For instance, iterative movement typically involves the matching of movement to breath; each movement is performed synchronously with a breathing cycle. Like a mantra of the body, through deep concentration, visualization, and relaxed awareness, lengthy periods of iteration can be accomplished without fatigue (Wang, Liu, Mimura, & Fujimoto, 2007). This is due to reduced tension and improved modulation of co-contraction (Christou, Yang, & Rosengren, 2003), which is likely an effect of the combination of relaxation and movement.

In terms of general exercise benefits, some iterative practices in Taiji have been evaluated as low intensity aerobic activities in the 50% to 60% range of maximum oxygen uptake (Chao, Chen, Lan, & Lai, 2002). Many others have not been evaluated. Some iterative practices involve quick releases of power or *fali*, and may enter a high range of aerobic or anaerobic demand. More work is needed to evaluate the exercise contributions of these practices independently.

The domain of choreography. Practices in this domain are commonly known as forms or *quan*, and their defining feature is sequential movement executed in a variety of directions. As the preceding two sections have pointed out, nonchoreographed practices (meditation and iteration) play an important role in developing mental skills, motor control, strength, balance, and sensorimotor organization. Introduction of choreography at the appropriate time is likely to continue supporting the optimization of mental skills, motor control, strength, balance, and sensorimotor organization. The characteristic aspects of choreography such as arrangement of sequence, stance depth and width, speed of movement, and length of sequence all vary greatly from routine to routine, often following elements of clan or guild style. The length of sequences may range from 4 movements to 108 or more. In general, basic forms are slower, higher, and shorter in length than the more traditional routines. Many routines also involve the use of traditional weapons such as swords or pole arms.

Choreography is also likely to enhance the optimization of executive function, semantic and procedural memory, proprioception, spatial orientation, and motor planning for dynamic stability through diversity and complexity of movement (Yang et al., 2005). Complex choreography allows practitioners to challenge and optimize *zhongding*, or central equilibrium. For experienced practitioners, choreography is an autotelic flow experience, the nature of which becomes a natural driver for further optimization (Csikszentmihalyi, 1990; Kiehne, 2003, Yang et al., 2005).

At higher levels of practice, choreography may also become a creative endeavor. While the essential movements of Taiji have been passed down for centuries through clan structures, most of the actual sequences practiced today have been arranged or modified over the course of the last century. It is not unusual for experienced practitioners and especially teachers to modify, combine, or create new sequences. At high levels of expertise and encapsulation, Taiji practitioners become poets of the body and choreography becomes their genre.

The domain of partner training. This domain is typically part of the most complex curricula. Many of the practices in this domain have been guarded family secrets that are now slowly becoming open knowledge (Frantzis, 1998). This may be one of the reasons why they have been the least studied empirically, but may be among the most beneficial for promoting

multidimensional adaptive development through Taiji (Kauz, 1997). Practices in this domain can take on the characteristics of any of the previous three domains; they can be executed in stillness, iteratively, or through choreography. Partner training practices introduce the additional challenge of optimizing performance in the presence of external and sometimes unpredictable forces, other people.

Aside from the general physical requirements of partner training which are similar to those in other domains, important features of partner training are the dynamic stability and reactive recovery stepping ability of Taiji players who regularly engage in them. For instance, push-hands training, a common form of partner training, involves constant modulation and perturbation of balance which is likely to lead to the formation of reactive recovery motor plans in a variety of directions. On a psychosocial level, optimization in this domain requires the presence or formation of a community of practitioners who can extend a degree of mutual trust and care for each others' development.

The categorization of Taiji features outlined above provides a general model through which curricula can be assessed. This model predicts better overall adaptive development and greater range of benefits based on the total number of domains in a practitioner's curriculum.

Concomitant behaviors. Taiji-related goals, such as healthy longevity, are likely to be concomitant with other life goals among experienced practitioners. When this happens, a synergistic effect may occur, where Taiji practice, general behavior, and lifestyle work in tandem to provide support for optimal aging. For instance, Taiji practitioners who seek healthy longevity may be more conscientious about avoiding heavy consumption of alcohol or drugs that are perceived as damaging to organ systems. They may also pay more attention to diet, which is widely understood to affect health and has traditionally been an important consideration in the Taoist view of healthy development. Such positive synergy will not be present in every case, and in some cases the exact opposite may even be true. That is, some may use the efficacy of Taiji practice to mask the negative effects of poor health behaviors. But on average, US Taiji practitioners may be more health conscious than not (Birdee et al., 2009).

Another area of transfer between Taiji goals and optimal aging can be seen in traditional goal states, such as *xiulian*, *xujing*, and *zhongding* (see Appendix C). Each of these relates to psychological skills and attitudes that may be important to coping, stress relief, equanimity, and recovery or healing not only in Taiji, but in other life endeavors as well.

Taiji practitioners are likely to exhibit variation in selection and prioritization of goals. However, to the extent that the above goals are important constituents in their overall goal hierarchies, and detectable in their behaviors as means of optimization, they are in line with the

lifespan development model of optimal aging proposed by Aldwin, Spiro, and Park (2006). This model predicts that individuals who avoid age accelerators such as hostility, depression, and substance abuse, and participate in age decelerating activities such as exercise, mindfulness, and healthy diets, are more likely to see the maximization of gains and minimization of losses across the life course.

The Role of Compensation in Taijiquan

In the SOC literature, compensation is described as the process of altering or adapting means, in the face of loss or decline, for the purpose of achieving or maintaining desired states (Freund & Baltes, 2002). This process includes the tendency for deficits or losses to lead to advances through innovation or anagenesis (Baltes, 1997), and lies at the heart of new growth in Taijiquan. This process is reflected in the underlying developmental philosophy of Taiji, which considers development to be driven by the interaction of opposing yet interdependent forces modeled as Yin and Yang (Da, 1986). Due to the challenging nature of Taiji practices; compensation often precedes optimization, as almost every new practice will initially reveal deficits in artists' abilities. Through compensation and innovation, these inadequacies can be addressed so that optimization is possible.

For instance, when beginners first engage in standing or sitting meditation, they often assume it is as easy as it looks because experienced meditators make the act of maintaining a position look effortless. But experienced meditators who have acquired many practice-relevant resources through compensation, such as discipline, expertise, and mental skills, may maintain a posture for 20 minutes or longer without discomfort or distress (Kawano, 1998). Novices' initial attempts to engage in standing meditation for more than a few minutes typically result in pain and fatigue; psychological and emotional distress may follow shortly after (Lam, 1991).

While difficult to see by visual inspection, self-reports and EEG activity show that beginners and experienced practitioners are engaged in qualitatively different activities (Kawano, 1998). Improvement is not simply a matter of more practice. Standing practices cannot be efficiently maintained through simple physical imitation alone. Compensatory mechanisms are needed, and a failed attempt allows the novice to learn a more integrated mind-body approach. Instead of simple imitation, the use of regulated breath, visualization, and relaxation strategies to prevent fatigue typically prove more effective (Lam, 1991).

Compensation in Taijiquan often involves learning to compensate through such psychophysical coordination. However the initial process of compensation is anything but intuitive. While the modeling of others' compensatory strategies is a general consideration discussed in SOC theory (Freund & Baltes, 1998), unlike external forms of compensation, such as

use of a cane, internal forms of compensation are not obvious and cannot be easily modeled without guidance.

Traditionally Taiji teachers have been the gatekeepers and cultivators of each of the Taiji-related process discussed above. Teachers may affect students through direct instruction or instructional materials. Knowledgeable and exemplary teachers may (a) support selection through goal elaboration and role modeling, (b) support compensation through skill instruction and demonstration, and (c) aid students in the development of compensatory strategies and the discovery of untapped resources (Yang et al., 2005). Thus the presence or absence of a knowledgeable teacher should be considered an explicit overarching constraint when the SOC framework is applied to Taiji.

Towards a Predictive Model of Psychophysical Practices

The following model is derived from the previous SOC-related theoretical analyses, and like SOC should be understood as operating within the constraints and propositions of the lifespan metatheoretical framework (Baltes, 1987). The purpose of this model is to account for the influence of SOC-related factors on developmental outcomes experienced by Taiji practitioners. While the current model focuses mainly on the behavioral aspects of optimization (frequency of practice, curricular complexity), I maintain that both selection and compensation are implicitly present in supporting these complex behaviors. This model also assumes that on average the goal structures of Taiji practitioners support adaptive development. The presence of compensation strategies is also assumed in relation to the complexity of curriculum. Future models will likely improve on this model's explanatory power through direct measurement and incorporation of selection and compensation processes.

In agreement with Yang and associates (2005), the following model (see Figure 1) suggests that curriculum, along with regular practice, has the potential to influence (a) effect strengths, (b) range of benefits, and (c) resilience of benefits across the lifespan. In the following model, curricular complexity is not a measure of total number of practices, but rather total number of practice domains. Thus complexity is expressed by the number of unique yet potentially synergistic practices. Since I have categorized practices with common characteristics by domains, a curricular complexity score is equal to the total number of domains in a given curriculum. Each of the four domains is represented by a sphere in Figure 1, but it should be understood that in some curricula, only one or two domains will be present.

While each domain is constituted by similar practices, it can also be said that within any domain, n levels of difficulty or expertise are also present. While the current dataset and model

do not provide a means to test this assumption, I expect that quantifying levels of expertise within each domain will improve the reliability of model.

Another equally important, yet presently untestable aspect of this model is the interactions that may occur at the confluence of domains. This zone of overlap among domains represents the potential for a qualitatively different practice state to arise through the interaction of distinct forms of practice. The combination of all four domains suggests the potential for an optimal (interdependent and synergistic) zone within which adaptive development of mind-body practitioners is likely to occur. Simplistically, this would suggest that the presence or absence of domains should be a general predictor of the variance in health-related quality of life, and that among expert practitioners this influence should be detectable across a wide range of ages.

Two other key concepts illustrated in this model are experience and frequency of practice. Experience is illustrated by area of overlap in the model. Increased experience can be indicated by increasing the overlap, which implies the integration of information and performance between domains. Frequency of practice is represented by the opacity of the domain. The increasing opacity in areas of overlap indicates the hypothetical interaction between domains, which is traditionally believed to support range of benefit and efficiency of practice (Yang et al., 2005). Put another way, a well rounded curriculum yields the best results in shortest amount of time, thus the term *complexity*, as used in this paper, should not be understood as referring to difficulty, but rather connotes a sense of richness and necessary diversity.

As this model is situated within considerations of lifespan development paradigm, cultural, environmental and contextual factors must also be considered where data are available.

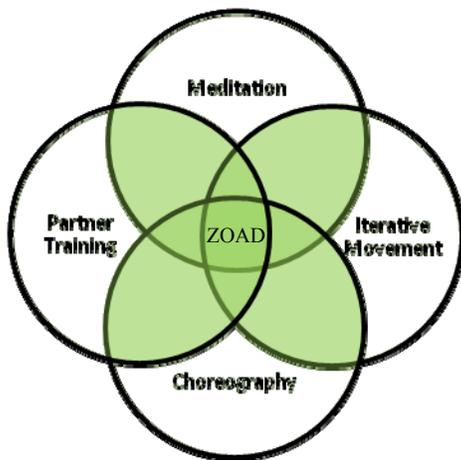


Figure 1. Biopsychosocial mind-body practices model. ZOAD = Zone of optimal adaptive development.

These are represented in the model by color. Examples of potentially important factors in this regard might include access to healthy food, air, and water, as well as green spaces and adequate sunlight. These factors need to be considered on an individual basis. The model is colored green where they are assumed to be, on average, supportive of adaptive development. This model suggests that, on average, Taiji practitioners will evince gains in relation to curricular integrity, frequency of practice, and experience with consideration of contextual constraints which could potentially suppress or synergize developmental outcomes.

Methods

Taiji Symposium Research Survey (TSRS)

The Taiji Symposium Research Survey (TSRS) was designed to collect data on regular Taiji practitioners. Its aims were to yield data about practitioners' health, lifestyle, practice routines, and demographic characteristics. The TSRS contained 40 items, 20 of which were adopted from the Center for Disease Control's 2009 Behavioral Risk Factor Surveillance System (BRFSS) (CDC, 2009). These measures were included in the TSRS because they have good validity, reliability, and risk prediction (CDC, 2008; Moriarty, Zack, & Kobau, 2003). The remaining items on the TSRS survey were designed to document the complexity of Taiji curricula, including type, duration, and frequencies of practice and record other lifestyle choices relevant to Taiji practitioners' health and well being such as diet and additional health-promoting activities (see Appendix D).

Data Collection Procedure

Administrators of the International Tai Chi Symposium supported the collection of the TSRS data by sending out recruitment email messages to symposium attendees. The messages contained information about informed consent and the purpose of the survey as well as links to the survey. These email messages included a request to forward the survey to other practitioners. Data were collected online through the Virginia Tech Survey System. Both the email and the survey disclosed the purposes of the research and its voluntary and confidential nature. The

Virginia Tech Institutional Review Board provided approval for conducting the survey (see Appendix A).

Variables

Table 2 provides details about the key variables in this analysis. The primary dependent variable, HRQoL, is represented by self-reported health status (GENHLTH) because health is considered a multidimensional construct encompassing physical, psychological, and social dimensions and it has strong associations with many indicators of successful aging (Aldwin et al., 2006; Freund & Baltes, 1998).

The variable CURRICULUM represents the influence of domain effects through a total score (range 1-4). PWSorP (out-of-class practice) is the average number of times per week that Taiji artists practice without a teacher, either alone or with a peer. Lifestyle choices are represented by the variable DIET, a relevant concomitant and contextual factor.

Table 2

Variable Roles, Names, Descriptions, and Codes for Curricular Analyses of TSRS Data

Variable	Description	Code
GENHLTH	Continuous variable indicating self-reported health	0= Poor 1= Fair 2= Good 3= Very Good 4=Excellent
CURRICULUM	Continuous variable created by totaling all domains in which practitioners indicated “regularly practicing.” This total score is referred to as curricular complexity. Domains include: Still Meditation, Iterative Movement, Choreography, and Partner Training.	1= One domain 2= Two domains 3= Three domains 4= Four domains
PWS or P	Continuous variable indicating average number of weekly practices by oneself or with a peer.	0-17.5 sessions/wk ^a
DIET	Continuous variable indicating health of diet. 0= Daily intake of fast foods, junk foods, & overeating 3= Several servings of fresh fruits and vegetables daily, healthy sources of protein and calcium, whole grains, no regular intake of fast or junk foods.	0=Very Unhealthy 1=Somewhat Unhealthy 2=Healthy 3=Very Healthy
EXPERIENCE	Continuous variable indicating years of experience at time of data collection (2009).	4-42 years
AGE	Continuous variable indicating years since birth.	24-83years

^aAverage practice duration for all practice types = 54 minutes (*SD* = 27min)

Sample

Since the TSRS was released June 18, 2009, the survey has received 300 responses. US practitioners comprise 120 of the 300 cases. Because the current analysis seeks to evaluate and predict the effects of curriculum and additional practice, selection criteria were used to avoid error related to lack of practice, lack of experience, and differential rates of learning. I expected,

based on my based on my experience as a Taiji practitioner and teacher, that effects of curriculum should be clearly present by the end of the fourth year of training among regular practitioners. Thus the selected subsample ($N = 94$) comprises all individuals who indicated practicing three or more days a week with at least four years of practice experience.

Table 3

Characteristics of TSRS Sub-Sample by Curriculum

Characteristics	Practice Domains (CURRICULUM)				Total	
	1	2	3	4		
Total	7	22	33	32	94	
%	7.45%	23.40%	35.11%	34.04%	100%	
Age (years)	N	6	20	33	32	91
(AGE)	M (SD)	56.83(4.79)	55.65(10.03)	57.88(9.68)	53.63(11.53)	55.82(10.24)
	Range	49-62	31-74	36-83	24-72	24-83
Self-reported Health	N	7	22	33	32	94
(GENHLTH)	M (SD)	2.71(0.95)	3.09(0.68)	3.09(0.80)	3.50(0.72)	3.20(0.78)
	Range	1-4	2-4	1-4	2-4	1-4
Diet	N	7	22	33	32	94
(DIET)	M (SD)	2.14(0.69)	2.14(0.64)	2.21(0.60)	2.34(0.70)	2.23(0.65)
	Range	1-3	1-3	1-3	1-3	1-3
Practice alone or with a peer (PWSorP)	N	7	22	33	32	94
	M (SD)	3.21(1.63)	4.48(2.16)	4.41(2.13)	5.05(3.12)	4.55(2.50)
	Range	2-6	1-9	0-10	0-17.5	0-17.5
Experience (years)	N	7	22	33	32	94
(EXPERIENCE)	M (SD)	10.71(4.75)	13.50(7.21)	16.61(10.93)	18.69(11.45)	16.15 (10.21)
	Range	5-20	5-34	4-41	4-42	4-42

The majority of practitioners (69.15 %) integrate three or more domains in their regular practice (see Table 3), with seven or more years of experience, averaging 16.15 years ($SD = 10.21$). Along with this, their average practice frequency is 8.78 sessions/week ($SD = 5.06$). These data suggest that members of the TSRS sample have a history of consciously selecting and optimizing goals related to health and mobility. This assumption is also supported by the average diet score of 3.23 ($SD = 0.65$), which indicates that most individuals in this sample rarely choose to eat fast food, and that they usually consume five or more servings of fresh fruits and vegetables daily.

The correlations in Table 4 provide initial confirmation of relationships among the variables in this investigation. Neither age nor experience is correlated with health status. Experience is related to curricular complexity. Age is known to be a significant predictor of health risk or below average health status in the general population (Baltes & Smith, 1999; Haber, 2010), although such associations do not appear to be characteristic of this sample.

Table 4

Bivariate Correlations among Study Variables (N = 94)

	1	2	3	4	5	6
1 Health	—					
2 Curriculum	.275**	—				
3 Practice	.203*	.166	—			
4 Diet	.330**	.123	.249*	—		
5 Age ^a	.119	-.093	.061	.120	—	
6 Experience	.184	.242*	.165	.031	.253*	—

^a*n* = 91 cases due to missing data.

p* < 0.05. *p* < 0.01.

Analysis Plan

The purpose of the analyses was to evaluate the utility of the above mind-body practices model for predicting optimal aging among Taiji practitioners. Based on traditional Taijiquan theory of practice and the lifespan developmental framework, including SOC theory, I hypothesized that, on average, health-related quality of life should be significantly influenced by the complexity of curriculum, amount of self or peer practice, and relevant cultural and contextual factors. In this case diet was an available in the TSRS data and is known to affect health, and so it was included in the analyses. I regressed GENHLTH on AGE, EXPERIENCE, CURRICULUM, PWSorP, and DIET as well as the interactions, CURRICULUM*PWSorP and CURRICULUM*DIET.

This analysis was conducted to determine whether a clear association could be established among curricular complexity, practice, diet, and health while controlling for age and years of experience. Based on the theoretical framework guiding this research, I hypothesized that curricular complexity (CURRICULUM), out-of-class practice (PWSorP), and healthy choices (DIET) should have a substantive and significant affect on health status (GENHLTH). Curricular complexity is represented in the analysis through the use of a total score where the presence each domain contributes a single point.

The underlying theory also suggests the possibility of the hypothesized interaction effects. Where curriculum and practice frequency are concerned, the potential exists for efficiency effects to appear (Yang, 2005, 2007). The potential for multiplicative or synergistic effects between Taiji-related goals and behaviors concomitant to lifestyle choices is also a distinct possibility. This may be represented in an interaction between curricular complexity and diet.

Results

Table 5 shows the results of the regression analysis for the model. The ANOVA source table is at the top followed by the parameter estimates. The R^2 value was 0.270 indicating that 27% of the variance in health status was explained by the fitted model. Figures 2 and 3 represent the relationships between health status and curricular complexity or diet, respectively, for the three groups based on the parameter estimates.

Table 5

ANOVA Source Table and Regression Summary of Health Status, Diet, and Curriculum

Source	Type III SS	df	M Square	F
Age	0.090	1	0.090	0.184
Experience	0.186	1	0.186	0.381
Curriculum	0.072	1	0.072	0.146
Practice with Self or Peer (PWSorP)	2.800	1	2.800	5.726 *
Diet	0.694	1	0.694	1.419
PWSorP*Curriculum	2.574	1	2.574	5.262 *
Diet*Curriculum	2.146	1	2.146	4.389 *
Model	15.014	7	2.145	4.386 **
Error	40.591	83	0.489	
Total	55.604	90		

Independent Variables	General Health Status			
	B	SE B	β	t
Intercept	2.415	1.209		1.998 *
Age	0.003	0.008	0.043	0.429
Experience	0.004	0.008	0.063	0.617
Curriculum	-0.130	0.340	-0.152	-0.383
Practice with Self or Peer	0.274	0.115	0.877	2.393 *
Diet	-0.519	0.436	-0.422	-1.191
PWSorP*Curriculum	-0.076	0.034	-0.970	-2.294 *
Curriculum*Diet	0.283	0.135	1.105	2.095 *
R^2			0.270 **	

* $p < .05$. ** $p < .01$.

As hypothesized, curricular complexity, self-practice, and diet were all significant predictors of health, but each was also involved in significant interactions, such their individual effects can only be interpreted across levels of the other variables. These statistically significant interaction effects occurring between curricular complexity and diet quality ($F = 4.389$, $t = 2.095$, $p = 0.039$), as well as between curricular complexity and practice frequency ($F = 5.262$, $t =$

2.294), $p = 0.024$) were also expected, for reasons discussed above. These findings provide provisional support for the hypothesis that complex curricula demonstrate efficiency in producing positive health outcomes (see Figure 2), and that curricular complexity and diet quality demonstrate synergistic benefits. The best curricula and diets combined to produce the most outstanding average health status regardless of age or amount of Taiji experience (see Figure 3); furthermore, complex curricula appear to be of less value when associated with poor diets, where health is concerned.

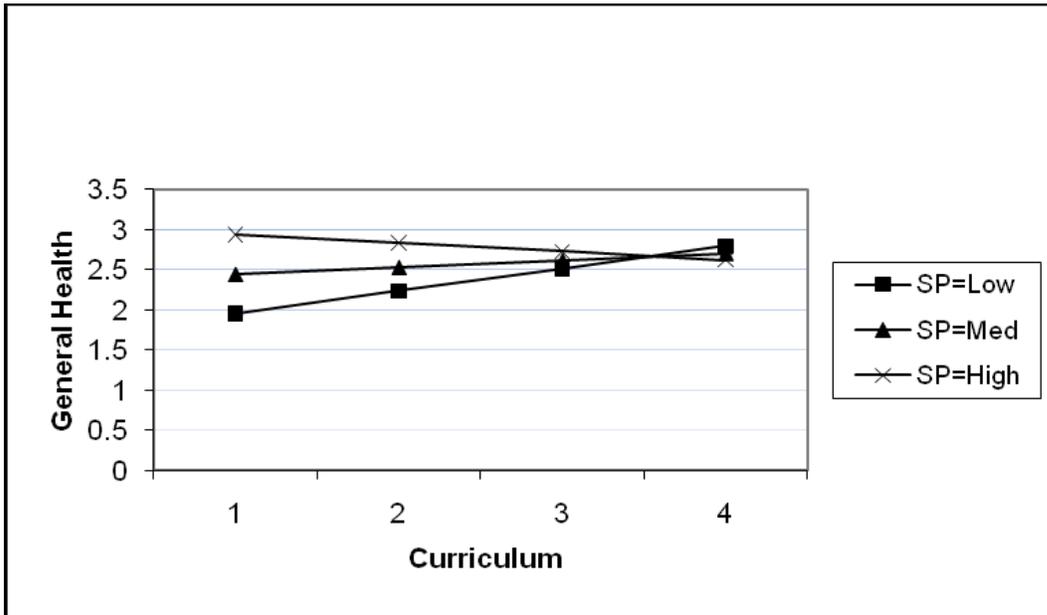


Figure 2. Health and curricular complexity at frequencies of self-or peer practice (SP). Curricular complexity ranges from 1 domain to 4 domains. Low SP = 2.05 self practices per week (1 *SD* below the mean). Medium SP = mean of 4.55 self practices per week. High SP = 7.05 self practices per week (1 *SD* above the mean).

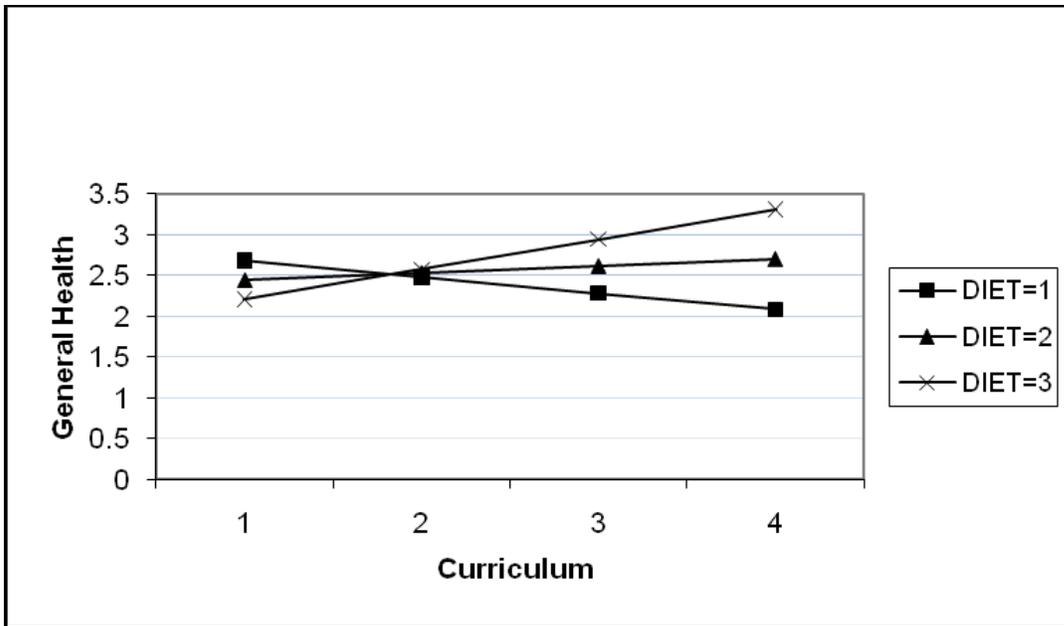


Figure 3. Health and curricular complexity for varying dietary quality. Curricular complexity ranges from 1 domain to 4 domains. Diet 1 = somewhat unhealthy, Diet 2 = healthy, Diet 3 = very healthy. See Table 3 for more information about Diet.

Discussion

In this study I sought to introduce practical theoretical frameworks (lifespan development and SOC) for predicting optimal health among practitioners of Taijiquan across a range of ages. I expect that these same theoretical frameworks could be used to inform research designs and improve intervention outcomes, not just for Taijiquan, but for other mind-body practices as well. Using these frameworks I was able to construct testable models of curricular effects while avoiding reductionism by including known developmentally-relevant variables, including age, experience, practice, and diet. Although the findings were generally consistent with the proposed framework, it is important to recognize some limitations of the research and to point out directions for future study.

The cross-sectional nature of these data means that direction of causal inference cannot be clearly confirmed, but reason can still inform interpretation of the findings. For instance, Does the relationship between complex curriculum and high health indicate healthy individuals tend to practice more complex curricula? Or does it suggest that more complex curricula lead to better health? This cannot be determined for certain without time series data. However, reason would suggest that curricular complexity is more a matter of finding the right teacher than being in optimal health before one begins practice. Likewise, the significant interaction between

curriculum and out-of-class practice (PWSorP) provisionally supports the traditional belief that well rounded curricula are more efficient at producing benefits than simplistic curricula.

In planning future studies, more emphasis needs to be placed on selection processes, perhaps through in-depth interviews. For instance, participants could be asked how they came to engage in their current practice regimen. For beginners this is likely to be a matter of school affiliation, but among more advance practitioners a more complex picture is likely to emerge. The wide range in frequency of practice also suggests that selection processes and constraints relating to goal setting and resource availability are issues that need to be accounted for among practitioners. Such data were not available in the TSRS, but I expect that the predictive power of this model could be further improved through clarifying the relationships among selection, optimization, and compensation among Taiji practitioners.

While diet quality has not been considered in the empirical literature on Taiji, dietary considerations have been addressed by several proponents of Taiji and qigong and have long been understood in the Taoist roots of these traditions to be important to healthy longevity (Cohen, 1997; Ni, 1993; Wong, 1997). Diet is also recognized in lifespan developmental sciences as a key factor in disease and aging processes (Aldwin et al., 2006). The lack of a significant association between diet and experience in this sample (see Table 4) may indicate that the issue of diet, despite its historical importance to the Taoism, is not as explicitly discussed in the Taiji community as one might expect. Nevertheless, quality of diet does seem to be relevant to many practitioners in this sample as shown by the average dietary score of 2.23 out of 3, indicating infrequent consumption of fast foods and daily consumption of 5 or more fresh fruits and vegetables.

Again, further inquiry into the goal structures and concomitant behaviors of practitioners may be fruitful in determining any intentional links between a healthy diet and Taiji effectiveness for sustaining functioning throughout the aging process. In any case, the synergistic connections between diet and curriculum are clear, especially where complex curricula intersect with healthy and unhealthy diets (Figure 3). This finding should be of relevance to Taiji teachers and practitioners truly interested in healthy longevity. It also indicates a point of caution and consideration in intervention research, as poor diet is likely to place serious constraints on the effectiveness of even the best intervention protocol.

Another area for future research involves testing curricular complexity and domain synergies with a more detailed model. Given the small sample size, in the present analysis I used a total score to test the effects of curricular complexity with each domain contributing one point. The findings suggested a general tendency in the benefits of complex curricula where health is

concerned. However, intervention designs could be better informed by studies with larger sample sizes in which subgroups are formed and evaluated based on specific domain combinations. This approach would allow for evaluation of various curricula where fewer than four domains are present. Also, measures more sensitive than general health status will likely be necessary to detect the developmental contributions that the various domain combinations can make. Future studies would do well to incorporate objective biological or biomechanical measures along with complex psychometric assessments.

Lastly, the selection criterion across such a wide age range should have provided ample opportunity to test the limits of Taiji's health related benefits. However, age was neither significantly, nor substantively, correlated with health in this sample. Furthermore, it remained nonsignificant in the regression analysis, despite the typical declines in health associated with age and the conjecture that even everyday activities may be testing the limits of the oldest adults (Baltes & Smith, 1999). The combination of expertise and regular practice characteristic of this sample may have provided robust benefits mitigating the typical age-related declines in functional health observed in the general population.

This important possibility could be better investigated through longitudinal research employing a combination of biomarker and self-report data on an even wider age range of experienced Taiji practitioners. The planning and interpretation of future studies can be well informed by the lifespan developmental framework.

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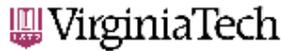
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IV. Conclusions

These papers have shown how Taiji research, due to its complex and inherently developmental nature, can benefit from the use of the lifespan metatheoretical framework. This paradigm is effective at considering issues of individual and cohort complexity while remaining focused on developmental outcomes. The related frameworks and models applied in these papers should prove valuable to planning interventions, modeling and hypothesizing outcomes, and interpreting findings. As demonstrated in the accompanying papers, the lifespan development paradigm contributed to avoiding descriptive reductionism by contextualizing empirically-based analyses of the data. As unwieldy as this framework may seem, it brings useful order to investigations of complex systems where developmental outcomes are the key topic of inquiry. Thus, these frameworks may prove useful in the study of other mind-body practices or as a guide in the construction of future interventions where multiple practices are combined to optimize developmental effects.

Appendices

Appendix A: IRB Approval letter



Office of Research Compliance
Institutional Review Board
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PWA0000572(expires 1/20/2010)
IRB # is IRB00000667

DATE: June 12, 2009

MEMORANDUM

TO: Rosemary Blieszner
Matthew Komelski
Thurmon E. Lockhart

Approval date: 6/12/2009
Continuing Review Due Date: 5/28/2010
Expiration Date: 6/11/2010

FROM: David M. Moore 

SUBJECT: IRB Expedited Approval: "Determinants of Efficacious Tai Chi Practice in Regular Practitioners" , IRB # 09-514

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective June 12, 2009.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtain re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

Important:

If you are conducting federally funded non-exempt research, please send the applicable OSP/grant proposal to the IRB office, once available. OSP funds may not be released until the IRB has compared and found consistent the proposal and related IRB application.

cc: File

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Appendix B: Review of SOC-related Findings

Research on SOC, as a life management strategy, has demonstrated that individuals who utilize this strategy, consciously or unconsciously, tend to have higher outcomes in various indicators of successful aging, including life satisfaction and quality of life (Baltes & Smith, 2003; Freund & Baltes, 2002). It also plays a role in reducing job-related stress and family-work life conflicts (Young, Baltes, & Pratt, 2007). But problematically, instances of SOC strategy usage decline in late adulthood, just when it seems most crucial for improving quality of life (Riediger et al., 2006). The decline in implementation of this life management strategy is not attributed lack of familiarity, but rather to a decline in the physical and cognitive resources needed to employ it (Baltes & Smith, 2003; Freund & Baltes, 2002; Riediger, et al., 2006). So while the presence of SOC is predictive of key indicators of successful adaptive development, namely quality of life, its implementation seems to be dependent on continued access to the very resources that decline with age.

In Appendix C I discuss how participating in the art of Taijiquan not only involves the implementation of SOC strategies, but that it is likely to support the continued use of SOC across the lifespan. This is due to the specific nature of practice goals, means of optimization, and compensatory strategies in Taijiquan, which all converge to create enduring multidimensional resources. Taijiquan provides a framework in which practitioners can steward and encapsulate key resources needed for adaptive development across the lifespan.

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Appendix C: Review of Traditional Selection Goals Found in the Taiji Practice Literature

To provide a clear understanding of how Taijiquan may guide individuals in the process of optimal aging, this appendix addresses key aspects of the traditional Taijiquan goal hierarchy and suggests important areas of correspondence between these traditional concepts and findings in developmental science literature. Readers should keep in mind that I am not suggesting all US practitioners maintain these exact structures, but the presence of these concepts in the literature suggests that experienced practitioners may be familiar with them. Each also sheds light on potential disparities in selection between experienced practitioners and nonpractitioners.

Traditional proponents of Taijiquan have consistently described its ultimate goal as healthy longevity accompanied by peace and equanimity (Da, 1986; Frantzis, 2006; Ni, 1993; Yang et al., 2005). Explicit in this paradigm is an understanding that neither health nor peace of mind are the reality of aging for many, and that avoiding illness and turmoil is possible through practice, awareness, and wisdom. Thus, experienced Taiji practitioners have, in very a forward-thinking way, selected Taijiquan as a complex means to optimize their development across the life course. Tightly related to this ultimate goal are a number of supporting and auxiliary structures that are likely to contribute to success in adaptive development. A nonexhaustive consideration of a few key structures is presented below.

Xiulian

Xiulian is a state of commitment to the fundamental project of Taijiquan, deepening the connection between mind, body, and universe through disciplined practice for the purpose of attaining health, longevity, and equanimity (Yang & Grubisich, 2000). “Deepening the connection” refers to both a cognitive-conceptual and an embodied-experiential understanding of development. Taiji takes its name, after all, from the *Taijitu*, part of the Taoist model of ontogeny and evolution (Da, 1986; Ni, 1993; Wong, 1997). *Xiulian*, then, refers to the ethical and sincere pursuit of developmental truths through practice. This form of sincere effort is essential to success for Taiji practitioners at all stages of development (Yang et al., 2005).

Xiulian shares much with the modern scientific method in that they both entail a commitment to transcend personal ignorance through the disciplined accumulation of observations and experience within communities of practitioners. Moreover, the modern scientific method has come to recognize the necessity to temper the pursuit of truth with ethical considerations, which are also an essential aspect of *xiulian*. Chief among these are (a) the belief that individuals should work toward the common good with their skills and abilities, (b) the mandate that practices should not involve harming oneself or others, and (c) the expectation that

conflict should be settled in the most humane way possible, even while defending oneself against direct attack (Yang & Grubisich, 2000).

Thus *xiulian* can be seen to contribute to optimal development in two very explicit ways: (a) *xiulian* is a commitment to achieving optimal aging through practice, understanding, and community, and (b) *xiulian* involves a dimension of moral or ethical principle that prohibits excessive, destructive, and unhealthy behaviors. The latter of these, the avoidance of unhealthy behaviors, is key factor in the health-promotion model of optimal aging because hostility and substance abuse hasten aging and disease processes (Aldwin, et al., 2006).

A third way of understanding the contribution of *xiulian* to optimal development is found in the work of positive psychology. Research in this field has demonstrated that individuals who regularly experience states of involvement or service to larger worlds typically show above average levels of quality of life and life satisfaction. These pursuits may include service or involvement with family and community or more abstract pursuits such as fostering goodness, justice, or transcendent spiritual goals (Seligman, 2002). The practice of Taijiquan with *xiulian* fits well within this model and thus should contribute quality of life, life satisfaction, and health benefits that are known to accompany positive emotions (Sternberg, 2000).

Gong

Among the most important goals in the practice of Taijiquan is the achievement of *Gong*. This is often translated as mastery or expertise. *Gong* is considered the fruit of practicing with *xiulian* (Yang & Grubisich, 2000). *Gong* is not a one-time achievement, but rather a state from which skill can accumulate.

Gong is the foundation of Taijiquan. “Physically, the accumulation of *gong* refers to constant improvements in balance, coordination, agility, flexibility, sensitivity, and strength or power. Mentally and spiritually the accumulation of *gong* refers to improved awareness, confidence, and constant advancement toward realizing tranquility...” (Yang et al., 2005, p. 17)

Gong refers not only to skill but to the vitality and versatility that can accompany high levels of expertise. Humans can achieve many kinds of expertise, such as expertise in mathematics, music, or languages. While Taiji is no less cognitively complex than these other pursuits, much of the time spent developing *gong*, in Taijiquan, involves exercise. Exercise has many general benefits that relate to physical health, disease prevention, and the maintenance of optimal cognitive functioning across the life course (Aldwin et al., 2006; Colcombe, Kramer, McAuley, Erickson, & Scalf, 2004; Fotuhi, 2003).

While the exercises in which practitioners engage to cultivate *gong* contribute to both the short-term and long-term health benefits of Taiji, exercise is not *gong*; and *gong* is not exercise.

According to traditional Taiji theory, it is possible to exercise frequently and still not achieve *gong* (Yang et al., 2005). *Gong* has benefits for health and quality of life that go far beyond exercise. Without a clear understanding of this subtle distinction, the most enduring gains in Taiji will be overlooked.

Expertise in Taijiquan involves encapsulation of a highly refined and very literal language of the body. Empirical research in the area of expertise has demonstrated that over the course of thousands of hours of practice, experts are capable of encapsulating domains of knowledge, motor skills, and processing ability for mastered symbol systems in ways that buffer them against age-related declines (Ericsson, 2000; Hoyer & Rybash, 1994; Johansson, 2002). These findings are highly resonant with traditional conceptions of *gong* and crucial to understanding one of the ways that Taiji contributes to health and quality of life over time.

This phenomenon is likely one of the key reasons experienced Taiji practitioners exhibit better than expected performance, by age, in many areas of cognitive and sensorimotor function (Chan et al., 2005; Hong & Li, 2007; Pei et al., 2008; Wong, Lin, Chou, Tang, & Wong, 2001). These are the benefits of Taiji that are purported to save Taiji practitioners from falls and near accidents of all sorts, and most certainly contribute to feelings of self-esteem and confidence. While well-planned interventions may establish a foundation and show substantive gains after only a few weeks of regular practice (Gatts & Woollacott, 2006; Yang, Verkuilen, Rosengren, Grubisich et al., 2007), the enduring benefits of *gong*, like expertise, may take thousands of practice hours to accrue (Ericsson, Krampe, & Tesch-Römer, 1993).

Zhongding

Zhongding, as a goal state, refers to a refined capacity to maintain physical, mental, and emotional balance, even and especially, in challenging environments. While it is sometimes understood simply as balance, it has also been contrasted with balance as typically understood. “Balance can be attained by intention and strain, even in a very distorted body position, while *zhongding* is natural...as if one were supported on all sides” (Zee, 2002, p. 20). Thus one cannot achieve *zhongding* by pure effort alone, but rather, through practice and skill development. Achieving *zhongding* requires *gong*, and the more challenging the situation the more skill is necessary to maintain *zhongding*.

Although *zhongding* is usually translated as central equilibrium, its multidimensional qualities might be better represented through terms such as poise or equanimity. “Central equilibrium is primarily a spiritual function. The physical manifestation of *zhongding* is a perfectly balanced body...achieved only by a calm and peaceful mind...therefore *zhongding* will be lost every time the ego seeks to exert itself, and in direct proportion to the magnitude of the

desire” (Yang, 2005, p. 30). Thus, *zhongding* is also a tenuous state that must be maintained at the intersection of skills and challenges. In this regard, and in several other aspects as well, *zhongding* is strikingly similar to the experience of Flow described by Mihaly Csikszentmihalyi (1990).

Flow is a state that arises when an individual’s levels of skill and interest are engaged and challenged by the difficulty level of a task and the person is absorbed in performance. Csikszentmihalyi and others have documented the flow experiences of Taijiquan practitioners (Csikszentmihalyi, 1990; Kiehne, 2003). Like *zhongding*, Flow is tenuous and can be broken or lost if the difficulty level becomes unmanageable and especially if one becomes emotionally or psychologically unstable during performance.

Flow experiences are not only enjoyable and engaging but also evince direct and indirect developmental benefits (Csikszentmihalyi, 1990). The attainment of Flow or *zhongding* in Taijiquan is likely to play a role in increasing and sustaining involvement in practice activities, contributing both to depth of learning and frequency of practice. Such experiences also contribute to long-term happiness and overall life satisfaction (Seligman, 2002).

Xujing

Xujing refers to the experience of transcendence, a state of deep peace and connectivity. The two characters embedded in this word can be translated as “empty”(xu) and “serenity”(jing). Together they refer to a deep state of relaxed awareness. *Xujing* has been described as the “essence of Taiji and its ultimate goal” (Yang et al., 2005, p. 55). This state is often learned through still meditative practices, but for those very skilled at *xujing*, it may accompany movement as well. Entering *xujing* is ascribed with many positive benefits including improved awareness or insight, quick executive function, and healing. It is a state in which the body and mind rebalance, recharge, and deepen their interconnections. (Yang et al., 2005).

Meditation research has so far yielded findings in two areas that correspond with traditional beliefs about the benefits of *xujing*, the relaxation response and the neurocognitive correlates of meditation. The relaxation response describes changes in homeostatic function that include a reduction in blood pressure and heart rate along with improvement in heart rate variability and an increase in nitric oxide levels important to healthy endothelial function (Benson & Proctor, 2010). A number of studies have documented the relationship between Taiji and this effect (Juan, Yingjie, & Aijun, 2009; Motivala, Sollers, Thayer, & Irwin, 2006; J. S. Wang, Lan, Chen, & Wong, 2002).

In addition to cardiovascular benefits associated with the relaxation response, improvements in endocrine and immune system function are also associated with this process in

Taiji practitioners and those who engage in other forms of meditation as well (Sternberg, 2000; Yang, Verkuilen, Rosengren, Mariani et al., 2007; Yeh et al., 2007). As both *xujing* and the relaxation response are accessed through meditation and are related directly to states of relaxation, they are likely to be correspondent constructs with overlapping attributed effects.

Evidence produced so far has demonstrated differences in function and in cortical thickness among meditators in areas of the brain associated with attentional processing. These differences tend to be most pronounced in older subjects suggesting that meditative practices preserving vital cognitive resources that might otherwise be declined with age (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007; Lazar et al., 2005; Pagnoni & Cekic, 2007; Sarang & Telles, 2007) Additionally, in one study using high-resolution MRI, meditators showed significantly larger volumes of the right hippocampus and orbitofrontal cortex, which might account for meditators' singular abilities and habits to cultivate positive emotions, retain emotional stability, and engage in mindful behavior (Luders, Toga, Lepore & Gaser. 2009).

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Appendix D: TSRS SURVEY

1. Would you say that in general your health is:
 1. Excellent
 2. Very Good
 3. Good
 4. Fair
 5. Poor

2. Thinking about your physical health, which includes physical illness and injury, for how many of the past 30 days was your physical health not good?

3. Thinking about your mental health, which includes stress, depression, and problems with emotions, for how many of the past 30 days was your mental health not good?

4. During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?

5. During the past 30 days, for about how many days have you felt you did not get enough rest or sleep?

6. On a scale of 1 to 4, with 1 being the healthiest diet and 4 being the poorest diet, please rate your diet. Note: Typically the healthiest diets include several servings of fruits and vegetables a day, consumption of whole grains in moderation, healthy sources of calcium and protein, with no regular consumption of fast foods or junk foods. At the other end of the spectrum, very unhealthy diets would include daily consumption of fast foods and junk foods with frequent overeating.
 1. Very healthy
 2. Healthy
 3. Somewhat unhealthy
 4. Very unhealthy

7. What is your age?

8. Are you Hispanic or Latino? (includes persons of Cuban, Mexican, Puerto Rican, decent as well as other Spanish cultures in Central and South America)

Yes, No

9. Which of the following would you say is your race?

White, Black or African American, Asian, Native Hawaiian or Other Pacific Islander, American Indian or Alaskan Native, Other

10. Are you currently...?

1. Married (or remarried)
2. Divorced (not remarried)
3. Widowed
4. Separated
5. Never Married
6. A member of an unmarried couple

11. State or province

12. Country of residence

13. Please indicate your highest level of education:

1. No school
2. Grade 1-8
3. Grade 9-12
4. Technical/Vocational Certificate
5. Associate's Degree
6. Bachelor's Degree
7. Graduate Degree

14. Sex: Male, Female

15. What is your weight? (Please indicate pounds or kg.)

16. What is your height? (please indicate inches or cm.)
17. What year did you become a practitioner of taiji, qigong, or similar art? (ex., 1970)
18. What style(s) do you regularly practice?
19. How many minutes is a typical practice session for you?
20. Which practices do you consider most essential to achieving a high level of skill in your art?
21. Please indicate which of the following components are regularly included in your practice:
 1. Music
 2. Lying down meditation or relaxation
 3. Seated meditation
 4. Standing meditation, Zhan Zhuang, Animal postures, etc.
 5. Energy work, including visualization practices
 6. Silk reeling exercises
 7. Walking exercises/drills (may include hand/body techniques)
 8. Short form choreography
 9. Long form choreography
 10. Polearms form/drills(staff, spear, Kwandao)
 11. Sword, stick or cane form/drills (broadsword, jian, etc.)
 12. Fan form/drills
 13. Partner training,(such as sensing hands/push hands)
 14. Partner training with weapons or props (sticks, robes, etc.)
 15. Other (please describe):
22. If you normally practice standing postures while training please indicate how many minutes per session you typically stand (total time for all postures):
23. If you practice standing postures in class, or outside of class, please indicate how many times per week you typically stand:

24. On average, how many times a week do you study taiji, qigong or similar art with a teacher?
(enter 0 if you do not meet to practice with a teacher weekly)
25. On average, how many times a week do you teach taiji, qigong, or similar practice? (enter 0 if you do not teach)
26. On average, how many times a week do you practice without a teacher—alone, with a peer, or with a video?
27. Please indicate the number of times in the last year you have had a fall accident, as well as the immediate cause of that accident (Ex: fell due to vertigo, or medical condition; fell due to medications or alcohol; tripped on sidewalk or slippery surface, ankle twist stepping off curb, etc.)
28. Please indicate the number of prescription medications you take regularly
1. None
 2. 1-3
 3. 4-6
 4. 7-10
 5. 11 or more
29. Please indicate your health insurance status
1. Uninsured (I only seek health care in emergencies)
 2. Under insured (I avoid health care services because of cost)
 3. Fully insured (Cost does not inhibit my access to services)
 4. Other
30. Please indicate your approximate annual household income.
1. Less than \$10,000
 2. \$10,000 to less than \$15,000
 3. \$15,000 to less than \$20,000
 4. \$20,000 to less than \$25,000
 5. \$25,000 to less than \$35,000
 6. \$35,000 to less than \$50,000

7. \$50,000 to less than \$75,000
8. More than \$75,000
9. Non US currency

31. Do you rely on professional complementary medical care like acupuncture, herbal medicine, or massage?

1. Yes, Often
2. Yes, Occasionally
3. Yes, Rarely
4. Tried it once
5. No, never

32. Please indicate if you have any of the following health conditions

1. Cancer
2. Smoker or regularly exposed to secondhand smoke
3. Asthma or Emphysema
4. Arthritis, rheumatoid
5. Arthritis, osteo
6. Chronic back pain
7. Hypertension
8. Diabetes
9. Cardiovascular disease
10. High cholesterol

33. Do you feel your practices (Taiji, qigong, etc.) have benefited your physical health, mobility and/or functionality?

1. Yes
2. No
3. Not sure

34. If you answered "Yes" to the question above please describe the ways that your practices have contributed to your physical health and functionality. If you answered "No" or "Not sure," please comment.

35. Do you feel your practices (Taiji, qigong, etc.) have contributed to your mental health?
1. Yes
 2. No
 3. Not sure
36. If you answered "Yes" to the question above please describe the ways that your practices have contributed to your mental health. If you answered "No" or "Not Sure," please comment.
37. Please tell us about other exercises that you engage in on a weekly basis, along with frequency, duration and time. For instance: "Brisk walking, twice a week for 1 hour, for the last 2 yrs" or "Swimming, once a week for 30 minutes since last year," etc.
38. Please tell us about other mind-body or spiritual practices that you engage in on a weekly basis, along with frequency, duration and time. For instance: "Yoga, twice a week for 1 hour, for the last 2 yrs" or "Zen Meditation, 3 times a week for 1 hour for the last year" or "Church twice a week for one hour for the past 30 years," etc.
39. Please list and discuss any problems or concerns you have encountered in your practice.
40. Please feel free to comment and/or make suggestions to us about the survey, or anything you would like us to know about your experience with Taiji, qigong, and similar practices.