THE JOURNAL OF ALTERNATIVE AND COMPLEMENTARY MEDICINE
Volume 18, Number 00, 2013, pp. 1–6

DOI: 10.1089/acm.2012.0141

Original Article

Traditional East Asian Medical Pulse Diagnosis: A Preliminary Physiologic Investigation

Kylie A. O'Brien, PhD,[1,2] Stephen Birch, PhD,[3] Estelle Abbas, BAppSc (ChinMed),[2]
Paul Movsessian, DipApplSc (Acu),[4] Michael Hook, DipAcu, BA,[5] and Paul A. Komesaroff, MB, BS, PhD[6]

Abstract

Background: Toyohari Meridian Therapy (TMT) is a Japanese system of acupuncture that utilizes radial pulse diagnosis to diagnose and guide acupuncture treatment, including ascertaining when the treatment has concluded. The "root" treatment involves manipulation of the body's *Qi* without penetration of the needle. There has been little research into the physiologic correlates of the changes detected through pulse diagnosis by Traditional East Asian Medicine practitioners practicing TMT.
Objectives: The study objective was to investigate whether there were any concurrent changes in physiologic cardiovascular variables, specifically the Central (Buckberg) Sub Endocardial Viability Ratio (SEVR) or Heart Rate (HR) adjusted Augmentation Index (AI), with changes in the radial pulses produced by a TMT "root treatment."
Materials and methods: A parallel, single-blind, randomized controlled design was utilized. Sixty-two (62) healthy volunteers were randomized to receive either a TMT root treatment or a sham-treatment. Two (2) TMT practitioners participated, with the same practitioner conducting the needling in each case. The SEVR and HR-adjusted AI were measured by a third researcher.
Statistical analysis: Within-groups analysis (paired Student *t*-test) and between-groups analysis (analysis of covariance) were used; a *p*-value of 0.05 was designated as statistically significant.
Results: SEVR improved significantly within the treatment group but not in the control group.
Conclusions: Results indicate that changes detected in the pulse by the TMT practitioners were associated with a measurable improvement in the SEVR. The findings of this study offer the possibility for further investigation into radial pulse diagnosis practices in an effort to find a physiologic understanding or basis of TMT practice and the system of pulse diagnosis it uses.

Introduction

Pulse diagnosis has been an integral part of Traditional East Asian medical (TEAM) practice since the Han dynasty (206 BCE–220 CE) developments in medicine in China.[1–5] While a widely used method in TEAM, pulse diagnosis has over time been described and used in many different ways.[6] A number of studies have examined the reliability of pulse diagnosis,[7–13] and some methods of instrumentation have been developed,[14–16] leading in some cases to clinical applications (for example, the ZM-IIIC TCM Pulse Pattern Diagnostic System).[17] Despite several theoretical models,[18] there has been little study of the potential underlying physiologic changes associated with variations in pulse qualities. This is important since pulse diagnosis is used by TEAM practitioners as evidence of change (for the better or worse) in a patient's condition. In Toyohari Meridian Therapy (TMT), a system of Japanese Meridian Therapy (acupuncture) based on Five Phase Theory (in particular the Nanjing Clause 69), the radial pulses are used to diagnose, guide, and assess the treatment. In TMT, needling techniques do not entail skin penetration but rather manipulation of the body's *Qi* with the tip of the acupuncture needle just above or resting only very lightly on the surface of the skin. The practitioner checks the pulses several times during the course of a treatment in order to guide treatment and ascertain the effect of the needling

[1]Deakin University, Melbourne, Victoria, Australia.
[2]Victoria University, Melbourne, Victoria, Australia.
[3]University College of Health Sciences–Campus Kristiania, Oslo, Norway.
[4]Australasian Branch of Toyohari Association, Sydney, New South Wales, Australia.
[5]Australasian Branch of Toyohari Association, Melbourne, Victoria, Australia.
[6]Department of Medicine, Monash University, Alfred Hospital, Melbourne, Victoria, Australia.

application on the patient.[19] Prior studies investigating reliability of those radial pulse judgments have demonstrated "fair"[20] levels of reliability.[11]

Pulse diagnosis depends on subjective observation by a TEAM practitioner. In TMT, the basic characteristics of the radial pulse are its "depth" (the depth at which it is felt most strongly), "speed," and "force." A desirable pulse is one that is moderate in speed, depth, and force, while a pulse that is indicative of disharmony tends away from these characteristics (for example, a rapid and superficial pulse). At the end of a TMT treatment, it is desirable for there to be a positive change in the pulse characteristics. Demonstration of physiologic effects would entail identification of correlations between such observations and particular objective measurements (Birch S, Bovey M, unpublished observations), with proof of inter-rater reliability.[9,18,*] among experienced practitioners of the pulse diagnosis method. Studies that have attempted to measure the radial pulses using some form of instrumentation have focused on examining the various diagnostic categories of pulse quality. This approach is limited by the pre-existing, unproven assumption of a relationship between those measured parameters and clinical judgements (see Birch S, Bovey M. op. cit., for further discussion).

At the end of a TMT "root treatment" there may be discernible changes in the pulse characteristics that signify to the practitioner that change has occurred. A root treatment addresses the primary underlying pattern of disharmony or *sho*, the secondary *sho* and any disharmony in the *Yang* meridians (see reference 10 for a more detailed explanation). This change in pulse relates to the state of the body's *Qi* in particular. In TEAM, it is understood that the *Qi* provides the motive force for blood circulation (specifically Heart *Qi*) and the pulse in general, as well as being a key constituent of Blood. Other organ systems are involved in the production of Blood (the Spleen organ system being the main one) and the circulating blood volume (the Liver organ system being primarily involved). In TEAM, it is thought that the demand on the Heart to supply Blood to the body is dependent broadly on the state of *Qi* and Blood within the body (whether it is adequate or deficient), as well as the level of activity of the individual, his or her constitution, and other factors such as age. The central premise of acupuncture, in its various forms, is that it can have an effect on the *Qi* of the body. *Qi* circulates in the meridians and reflects in the radial pulses, which themselves can be examined with appropriate technologies to assess the workload on the heart. Theoretically, it is possible that acupuncture could alter the amount and supply of *Qi*, and in principle the demand on the Heart in a short time period. Likewise, since the Heart in Chinese medicine is said to "dominate the blood and the vessels," with the condition of the "Heart *Qi*" manifested in the pulse, it is also theoretically possible that *Qi* controls the functioning of the blood vessels as understood in biomedicine, including vasodilation, vasoconstriction, and functional aspects of vascular compliance via an effect on the endothelium. This, however, is conjecture and untested.

It was therefore decided to investigate whether changes in the radial pulses produced by a TMT "root treatment" are associated with any changes in physiologic cardiovascular variables detected using a reliable test instrumentation. The key variables chosen for examination were the Central (Buckberg) Sub Endocardial Viability Ratio (SEVR) and the Heart Rate (HR) adjusted Augmentation Index (AI), described below, measured using the Sphymacor Pulse Wave Analysis device. Specifically, the authors examined the null hypothesis that there will be no change in the SEVR and HR-adjusted AI associated with the subjective pulse findings produced by a TMT root treatment.

The SEVR and AI were chosen because they represent two key variables of heart function, reflecting, respectively, the rapidly adjustable energy and pressure relationships and the underlying compliance of blood vessel walls.

The SEVR is a measurement of the ratio of energy supply and demand on the heart. A decreased SEVR is a reflection of a higher propensity for myocardial ischemia[21] and has been found to be significantly lower in persons with hypertension,[22] metabolic syndrome,[23] and diabetes types 1 and 2.[21,24] A low SEVR has been associated with increased age, higher body–mass index, higher pulse rate, smoking, higher total cholesterol and triglycerides, and fasting plasma glucose and lower HDL-cholesterol.[22,25] The AI is a marker of arterial stiffness and has been found to be an independent predictor of cardiovascular disease (CVD) events, including coronary artery disease (CAD) and CVD mortality.[26–28] Since Heart *Qi* is the motive force that drives the circulatory system, and TMT aims to manipulate *Qi*, and the state of *Qi* and Blood is detected via pulse diagnosis, it is theoretically possible that a TMT treatment could have an effect on the energy supply and demand on the heart, as detected by the SEVR, which also corresponds to an observable effect on the radial pulse (in pulse diagnosis).

The stiffness of arterial walls is associated with structural and functional changes of blood vessels, and there is evidence that the vascular endothelium is involved with the functional (and therefore potentially reversible) regulation of stiffness.[29,30] AI has also been found to be elevated in hypercholesterolemia[31] and in smokers.[32] Several therapeutic interventions have been found to decrease arterial stiffness and AI, including exercise in older persons, endurance athletes,[33] and in patients with CAD.[34] Therapeutic medicinal interventions have lowered AI significantly over relatively short periods, including the AT_1 receptor antagonist valsartan (over 6 weeks) in patients with essential hypertension,[35] taurine supplementation over 2 weeks in young, normoalbuminuremic males with type 1 diabetes,[21] and ascorbic acid supplementation in people with type 2 diabetes (4 weeks).[36] The Heart in Chinese medicine is said to "dominate the blood and the vessels" and provides the motive force for circulation, and the state of *Qi* and Blood can be detected via pulse diagnosis. It is theoretically possible that *Qi* controls the functional aspects of vascular compliance via an effect on the endothelium that may be detectable via an effect on the AI as well as discerned through a change in the radial pulse (by the practitioner).

---

*Birch S. Preliminary investigations of the inter-rater agreement reliability of traditionally based acupuncture diagnostic assessments. In: Birch S. Doctoral thesis: An exploration with proposed solutions of the problems and issues in conducting clinical research in acupuncture. University of Exeter, 1997.

Materials and Methods

The study employed a parallel single-blinded, randomized controlled design, and was conducted at the School of Health Sciences Teaching Clinics at Victoria University (VU), Melbourne, Australia over 4 months. The protocol included an inter-rater reliability substudy reported elsewhere.[10] Ethics approval was provided by the VU Faculty of Health, Engineering and Science Human Research Ethics Committee.

Participants were recruited via advertisements at VU campuses and in local newspapers. Inclusion criteria were as follows: age 18–40 years with no diagnosed medical condition. Exclusion criteria included the following: established CVD, other serious medical or psychologic conditions, pregnancy, and current use of vasoactive medications. Participants were asked to refrain from drinking tea, coffee, and other stimulants at least 8 hours prior to their visits. If taking omega-3 tablets/fish oil tablets, potential participants were asked to abstain from taking these for 2 weeks prior to the assessment visit. Participants were randomized to either a treatment group (TMT) or comparison group (non-TMT protocol, described later) via a randomization code generated by the Chief Investigator by flipping a coin.

Two (2) experienced TMT practitioners participated in the study (PM and MH). Both are instructors in the TMT systems of acupuncture in Australia. Both assessed and diagnosed each subject separately prior to beginning treatment as part of the reliability substudy[10] and then discussed their findings and reached consensus on treatment to apply. One (1) practitioner then applied the treatment on each subject and, after each point was needled, both confirmed the radial pulse findings. A research assistant who was blinded to the treatment/control groups conducted the tests of vascular compliance.

At the assessment visit, anthropometric measurements including weight and height were measured, from which body–mass index was calculated. After subjects rested for approximately 10 minutes supine on a treatment couch, peripheral brachial systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured with a validated blood pressure measuring device (the "Dynamap" blood pressure device). HR and the two main indices of systemic arterial compliance (SEVR and HR-adjusted AI, described below) were then measured at two time-points: before and after either a TMT treatment (treatment group) or the nontreatment protocol (control group).

SphygmoCor pulse wave analysis system

Pulse wave analysis is a noninvasive method of measurement of systemic arterial compliance. An applanation tonometer is used to detect the radial pulse and generate a peripheral arterial waveform. The ascending aortic pressure waveform is then derived from the peripheral blood pressure waveform using a generalized transfer function.[37] From the aortic pressure waveform, several central aortic hemodynamic indices are derived. The main central hemodynamic indices of interest are the SEVR and the HR-adjusted AI.

The SEVR is a measurement of the ratio of energy supply and demand on the heart[37] and is defined as: SEVR = AD/AS = DPTI/TTI, where AD is area under the diastolic curve, AS is area under systolic curve, DPTI is the diastolic pressure time index, and TTI is the tension time index.

The AS is reflective of the oxygen consumption and work of the heart (TTI).[37] The AD relates to the pressure and time for coronary perfusion (DPTI) and thus the energy supply to the heart.[37] The normal range is 130%-200%. When the SEVR is below 100%, the subendocardium is underperfused.[37]

The AI provides a measure of the contribution to the ascending aortic pressure waveform by the reflected pressure wave and is a measure of arterial stiffness.[31] The "augmentation" is representative of the difference between the first and second systolic peaks of the central pressure waveform. The AI is the augmentation expressed as a percentage of the pulse pressure (PP), as set out below:[31] AI (%) = P2-P1/PP $\times$ 100, where AI is the Augmentation Index, P1: early systolic peak; P2: late systolic shoulder, and PP is the pulse pressure (= SBP-DBP). Since the AI is dependent on HR,[31] the HR-adjusted AI is then calculated.

Treatment and sham-treatment protocol

The TMT primary and secondary patterns (*sho*) were diagnosed by each of the TMT practitioners separately as part of the reliability substudy,[10] with their results handed to the research assistant so that they remained blinded to each other's diagnoses until this part of the study was completed. The practitioners were then free to discuss the diagnosis and reached consensus through discussion of the examination findings and if necessary, palpation of the pulse again. The same practitioner conducted the needling in both groups. Choice of acupuncture points and supplementation or draining technique was tailored to the patient, depending on the diagnosis and according to the points indicated by TMT theory. Briefly, a supplementation technique is one in which the needle manipulation results in an increase in the participant's *Qi*, and a draining technique is one that results in a decrease of *Qi* where there is an excess amount. The study participants' eyes were covered with a blindfold during the treatment session. In a TMT treatment, the appropriate meridian is palpated to find the acupoint and then the appropriate needling technique is applied (see references 6 and 38 for descriptions of techniques). For the non-TMT control group, a wooden toothpick at nonacupoints was utilized in the same manner as for the treatment group. Since the intention of the practitioner is believed to be important in the therapeutic effect of TMT, for the control group, the practitioner attempted to distract his mind during the time when the wooden toothpick was near the participant's body. In order to mimic the sounds associated with a real TMT treatment, following the non-TMT treatment, a real needle was dropped into a sharps container. The TMT treatment stopped when the 2 practitioners agreed that the radial pulses had changed sufficiently for the better. The control treatment stopped after a similar period of time had passed and the 2 practitioners agreed on whether or not there had been a change in the radial pulses.

The main pulse characteristics are the speed, depth (or location), and force of the pulse. A normal pulse will have a speed of approximately 4 beats per breath of the patient. The force of the pulse will be moderate in strength in a normal situation. The depth of the pulse is located by first palpating the pulse with minimal pressure at the surface of the skin, then progressively pressing downwards almost to the bone. A pulse felt most strongly when only light pressure is applied is considered a "superficial pulse," whereas one felt most strongly on palpation almost to the bone is considered a "deep pulse." A normal pulse will be felt at a position midway between these two extremes.

Statistical analysis

Because this study is the first of its kind, there is a lack of prior experience with this form of treatment in relation to the proposed tests. Accordingly, an estimation of the expected magnitude of the effects of TMT was not possible, and the study was powered only in relation to within-group changes in the primary outcome variables. To achieve a power of 0.8 to identify a change of 10% with a type 1 error of 0.05, it was estimated that a population size of 60 was required.

Two (2) kinds of analyses were employed: a within-groups analysis and a between-groups analysis. A within-groups analysis was conducted on all defined outcome variables. Where data were normal, the paired Student *t*-test was used. Where data were non-normal, the Wilcoxon Signed Ranks Test was used. A *p*-value of 0.05 was considered statistically significant.

A one-way analysis of covariance was conducted for the between-groups analysis for each of the defined outcome variables. The independent variable was the post-treatment outcome variable value, and the dependent variable was the treatment group. The covariates used in the analyses were the initial (pretreatment) outcome variable value, and HR (which was dissimilar between the groups), except for the between-group analysis for HR-adjusted AI (%), which already adjusts for heart rate. Body–mass index, age, SDP, DBP, and drinks/week at baseline were similar between groups and not included in the model. In the control group, there were 4 smokers and only 1 smoker in the TMT treatment group. Smoking status was not included in the model. Where Levene's test of Homogeneity was violated, the Mann-Whitney *U* test was utilized.

Results

A total of 62 persons participated in the study. The results for 1 participant in the treatment group were deleted when it became apparent that she was taking hydrocortisone for a chronic cardiac condition, and of another participant in the control group who had not complied with the protocol for washing-out intake of omega-3 tablets. The results of an additional 2 participants in the control group were deleted because the Quality Index for the SphygmoCor was outside the acceptable range for results to be reliable. Accordingly, 58 participants were included in the final analysis.

The baseline characteristics are set out in Table 1. Alcohol consumption varied only a little between the 2 groups. In the treatment group, there were 8 nondrinkers, 16 who stated that they had "little" or "very little" intake, and seven who were "moderate or social drinkers", while in the control group there were 7 nondrinkers, 16 whose intake was little/very little, and 3 who were moderate or social drinkers. There were 4 smokers in the control group compared with 1 in the treatment group. There was no significant difference between the 2 groups in terms of mean age, body–mass index, mean SBP, and mean DBP.

Table 1. Baseline Characteristics

	Treatment group	*Control group*
Number of participants	31	27
Sex (females/males)	17/14	19/8
Mean age (±std dev) years	41.2 (±12.6)	44.4 (±11.2)
Mean SBP (±std dev) (mm Hg)	119.0 (±15.5)	113.0 (±14.3)
Mean DBP (±std dev) (mm Hg)	69.4 (±9.0)	68.8 (±9.5)
Number of smokers	1	4
Mean body-mass index (±std dev)	25.8 (±5.5)	24.2 (±3.6)
Alcohol consumption	8 nondrinkers	7 nondrinkers

Std dev, standard deviation; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Data were normal for SEVR, central AI, and HR-adjusted AI for both groups. Results of the within-group and between-group analyses for SEVR, HR-adjusted AI, and central AI are set out in Tables 2, 3, and 4 respectively.

Discussion

This exploratory study documents physiologic changes that correlate with observations of the radial pulses made by traditional East Asian practitioners: namely, a change in a key cardiovascular variable after TMT noninserted needling root treatment. This study in healthy volunteers found that the radial pulse changes that are judged by TMT practitioners following a single TMT root treatment appear to match changes in one cardiovascular parameter, the SEVR, but not the AI. The changes in the SEVR were significant within the TMT treatment group, but not in comparison with the sham treatment control group. The authors are not aware of any studies that have explored the physiologic effects of traditionally based nonsymptomatic, "root" treatment by acupuncture.

The SEVR Index is a measure of the ratio of energy supply and demand on the heart and indicative of the subendocardium's risk of ischemia.[39] The subendocardium is particularly susceptible to ischaemia due to anatomic factors (it is not as well perfused as the more superficial layers of the heart muscle) and functional factors (the compression of blood out of the arteries is greatest in the subendocardium).[†‡] Other factors that exacerbate this susceptibility are arterial rarefaction that occurs in aging and hypertension,[‡] and

[†]Nichols WW, O'Rourke MF. McDonald's blood flow in arteries: Theoretical, experimental and clinical principles. 4th ed. New York: Oxford University Press, 1998. In: Heyman P. Hemodynamic parameters of patients with treated hypertension and coronary artery disease. Doctoral thesis, University of Florida, 2003. Online document at: http://etd.fcla.edu/UF/UFE0000701/heyman_p.pdf Accessed December 31, 2011.

[‡]Heyman P. Hemodynamic parameters of patients with treated hypertension and coronary artery disease. Doctoral thesis, University of Florida, 2003. Online document at: http://etd.fcla.edu/UF/UFE0000701/heyman_p.pdf Accessed December 31, 2011.

Table 2. Central Subendocardial Variability Ratio

Group	*Before treatment mean SEVR (std dev)*	*After treatment mean SEVR (std dev)*	*Change in mean SEVR*	p-*Value (paired Student's* t-*test)*	*Between-groups analysis* F-*value* (p-*value)*
Treatment group	146.9 (20.8)	154.5 (18.5)	+7.6	0.02[a]	0.66 (0.84)
Control group	164.3 (32.7)	164.2 (30.0)	−0.1	0.96	

[a]Significant within-group change.
SEVR, Sub Endocardial Viability Ratio; std dev, standard deviation.

smoking, alcohol ingestion, and deficiency in physical activity have also been found to be associated with decreased SEVR.[21] This study was conducted in healthy participants, with mean SEVR values within normal ranges. The finding that TMT was able to improve the energy efficiency of the heart in healthy volunteers is suggestive of some kind of physiologic effect of the TMT ("root treatment") on the heart. This result is plausible within the framework of TEAM. The Heart is deemed the "commander of Blood," and Heart *Qi* is said to be the motive force that drives the circulatory system. TMT is directly aimed at manipulating *Qi*, driven by the Heart organ system as understood within the theoretical framework of TEAM. The effects of a TMT root treatment are felt by the practitioner at the end of a session through palpation of the pulse, and it is the state of *Qi* (and Blood) that the practitioner is said to detect through pulse diagnosis.

The study findings suggest the possibility that the TMT might produce beneficial effects in some patients with CVD. A decline in the SEVR has been shown to be an early marker of CVD,[21] and its restoration may indicate improvements in myocardial energy efficiency. To investigate this, the study needs to be repeated with a larger sample size to confirm these results, in patients with compromised cardiovascular systems. Additional studies would then need to explore whether these changes persist for some time after the treatment has been applied.

Table 3. Heart Rate-Adjusted Augmentation Index

Group	*Before treatment HR adjusted AI (%)*	*After treatment HR adjusted AI (%)*	*p-Value (paired Student's* t-*test)*	*Between-groups analysis*[a] p-*value*
Treatment group	12.9 (11.3)	12.4 (12.4)	0.67	1.00
Control group	14.9 (14.2)	13.0 (13.9)	0.12	

[a]Mann-Whitney *U*-test.
HR, heart rate; AI, augmentation index.

Table 4. Central Augmentation Index

Group	*Before treatment mean central AI (%) (std dev)*	*After treatment mean central AI (%) (std dev)*	p-*Value (paired Student's* t-*test)*	*Between-groups analysis* F-*value* (p-*value)*
Treatment group	15.7 (9.5)	17.3 (11.4)	0.19	0.48 (0.49)
Control group	20.5 (14.8)	19.4 (14.1)	0.37	

Std dev, standard deviation.

Arterial stiffness is associated with structural and functional changes of the arterial blood vessels, with evidence that the vascular endothelium is involved with the functional regulation of stiffness.[29,30] It is the functional changes that are most likely to be reversible or more readily alterable. Studies of other therapeutic interventions that have demonstrated improvements in AI (mentioned previously) had treatment regimens of at least 2 weeks. The current study found no change in a measure of arterial stiffness following one TMT root treatment. It is possible that a series of treatments may be necessary to potentially effect change. A future study to investigate the potential for TMT to alter arterial stiffness may best be designed over a period of several weeks.

Study limitations

This pilot study utilized a modest number of participants, and only a single TMT treatment was administered. Although the within-groups analysis indicated a change in the SEVR in the treatment group, the between-groups analysis did not show a significant difference. To confirm the findings of an effect on the SEVR, the study would need to be repeated using a larger sample size. It is likely that to effect any sustained changes in the energy efficiency of the heart, or in vascular compliance, TMT would need to be applied over a longer time period. Further studies are therefore indicated using TMT root treatment over several weeks in order to investigate this further. It is unknown whether the smoking status of study participants could have contributed to the SEVR findings of the study, given the small sample size.

Conclusions

This study shows that the pulse wave analysis may explain the mechanisms underlying the radial pulse observations of TMT practitioners experienced in radial pulse diagnosis. The findings suggest that there is an observable physiologic effect associated with subjective changes detected through radial pulse diagnosis following a TMT root treatment. The study offers the possibility for further investigation into radial pulse diagnosis practices in an effort to find a physiologic understanding or basis of TMT practice.

Disclosure Statement

There are no competing interests.

References

1. Kuriyama S. The Expressiveness of the Body and the Divergence of Greek and Chinese Medicine. New York: Zone Books, 1999.
2. Lu GD, Needham J. Celestial Lancets. Cambridge: Cambridge University Press, 1980.
3. Unschuld PU. Medicine in China: A History of Ideas. Berkeley: University of California Press, 1985.
4. Unschuld PU. *Nan Ching*: The Classic of Difficult Issues. Berkeley: University of California Press, 1986.
5. Unschuld PU. *Huang Di Nei Jing Su Wen*: Nature, Knowledge, Imagery in an Ancient Chinese Medical Text. Berkeley: University of California Press, 2003.
6. Birch S. Naming the unnameable: A historical study of radial pulse six position diagnosis. Trad Acupunct Soc J 1992;12:2–13.
7. Debata A. Experimental study on pulse diagnosis of *rokubujoi*. Jpn Acup Mox J 1968;17:9–12.
8. King E, Cobbin D, Walsh S, Ryan D. The reliable measurement of radial pulse characteristics. Acup Med 2002;20:150–159.
9. O'Brien KA, Birch S. A review of the reliability of Traditional East Asian Medicine diagnoses. J Altern Complement Med 2009;15:353–366.
10. O'Brien KA, Abbas E, Movsessian P, et al. Investigating the reliability of Japanese Toyohari Meridian Therapy diagnosis. J Altern Complement Med 2009;15:1099–1105.
11. O'Brien KA, Abbas E, Zhang J, et al. Understanding the reliability of diagnostic variables in a Chinese medicine examination. J Altern Complement Med 2009;15:727–734.
12. Ogawa T. To establish new "Chinese medicine": Searching for the contemporary significance of the "meridian controversy" [in Japanese]. Chin Med 1978;1:151–158.
13. Walsh S, Cobbin D, Bateman K, Zaslawski C. Feeling the pulse: Trial to assess agreement level among TCM students when identifying basic pulse characteristics. Eur J Oriental Med 2001;3:25–31.
14. Abhinav, Sareen M, Kumar M, et al. *Nadi Yantra*: A robust system design to capture the signals from the radial artery for assessment of the autonomic nervous system non-invasively. J Biomed Sci Eng 2009;2:471–479.
15. Lee YJ, Lee J, Lee HJ, Kim JY. A study on correlation between BMI and oriental medical pulse diagnosis using ultrasonic wave. IFMBE Proc 2009;23:2052–2055.
16. Xu LS, Wang KQ, Zhang D, et al. Objectifying researches on traditional Chinese pulse diagnosis. Infor Med Slov 2003; 8:56–63.
17. Medical-Model Pty Ltd. ZM-IIIC TCM Pulse Pattern Diagnostic System. 2006. Online document at: www.medical-model.com/en/Product-825.html Accessed January 2, 2011.
18. Walsh S, King E. Pulse Diagnosis: A Clinical Guide. Edinburgh: Churchill Livingstone, 2007.
19. Birch S, Felt RO. Understanding Acupuncture. Edinburgh: Churchill Livingston, 1999.
20. Landis RJ, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–174.
21. Moloney MA, Casey RG, O'Donnell DH, et al. Two weeks taurine supplementation reverses endothelial dysfunction in young male type 1 diabetics. Diabetes Vasc Dis Res 2010; 7:300.
22. Liu Z, Lu F, Zhao Y, et al. Subendocardial viability ratios in residents of a community in Jinan City, Shandong Province. Heart 2010;96:A84.
23. Lee JI, Sohn TS, Kwon HS, et al. The changes of central aortic pulse wave analysis in metabolic syndrome. Korean Diabetes J 2008;32:522–528.
24. Brooks BA, Molyneaux LM, Yue DK. Augmentation of central arterial pressure in type 2 diabetes. Diabetic Med 2001;18:374–380.
25. Saito M, Kasuya A. Relationship between the subendocardial viability ratio and risk factors for ischemic heart disease [in Japanese]. Sangyo Eiseigaku Zasshi 2003; 45:114–119.
26. Nichols WW. Clinical measurement of arterial stiffness obtained from noninvasive pressure waveforms. Am J Hypertens 2005;1S:3S-10S.
27. Hayashi T, Nakayama Y, Tsumura K, et al. Reflection in the arterial system and the risk of coronary heart disease. Am J Hypertens 2002;15:405–409.
28. Weber T, Auer J, O'Rourke M, et al. Arterial stiffness, wave reflections, and the risk of coronary artery disease. Circulation 2004;109:184–189.
29. Wilkinson IB, Quasem A, McEinery CM, et al. Nitric oxide regulates local arterial distensibility in vivo. Circulation 2002;105:213–217.
30. Wilkinson IB, Cockcroft JR. Cholesterol, endothelial function and arterial stiffness. Curr Opin Lipidol 1998;9:237–442.
31. Wilkinson IB, Prasad K, Hall IR, et al. Increased central pulse pressure and augmentation index in subjects with hypercholesterolaemia. J Am Coll Cardiol 2002;39:1005–1011.
32. Mahmud A, Feely J. Effect of smoking on arterial stiffness and pulse pressure amplification. Hypertension 2003;41: 183–187.
33. Edwards DG, Lang JT. Augmentation Index and systolic load are lower in competitive endurance athletes. Am J Hypertens 2005;18:679–683.
34. Edwards DG, Schofield RS, Magyari PM, et al. Effect of exercise training on central aortic pressure wave reflection in coronary artery disease. Am J Hypertens 2004;17:540–543.
35. Klingbeil AU, John S, Schneider MP, et al. AT1-receptor blockade improves augmentation index: A double-blind, randomized, controlled study. J Hypertens 2002;20:2423–2428.
36. Mullan BA, Young IS, Fee H, McCance DR. Ascorbic acid reduces blood pressure and arterial stiffness in type 2 diabetes. Hypertension 2002;40:804–809.
37. Skinner S (Chairman). A Clinical Guide: Pulse Wave Analysis. Sydney, Australia: AtCor Medical Pty Ltd., 2002.
38. Fukushima K. Meridian Therapy. Tokyo: Toyo Hari Medical Association, 1991.
39. Buckberg GD, Fixler DE, Archie JP, Hoffman JI. Experimental subendocardial ischemia in dogs with normal coronary arteries. Circ Res 1972;30:67–81.

Address correspondence to:
Kylie O'Brien, PhD
Deakin University
221 Burwood Highway
Burwood
Victoria 3125
Australia

E-mail: kylie.obrien@deakin.edu.au