The Reliable Measurement of Radial Pulse Characteristics

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Introduction

One of the four basic underpinnings of TCM clinical diagnosis involves palpation of the radial pulse and interpretation of the characteristics detected in the pulse. Over time, a complex system of pulse qualities and pulse measurement evolved that associated pulse with particular imbalances in bodily functioning. However, pulse terminology has never been standardised and gradually, different meanings have been ascribed to the same pulse qualities.1 This is illustrated in Table 1 by the range of definitions given for the Full Pulse in various TCM texts. Descriptive metaphors that had particular relevance to everyday life at the time of the pulse system's development were used to convey the subtleties of many pulse qualities. For example, in his classic text on pulse diagnosis, written in the 1500s, Li Shi-zhen described the choppy pulse as being 'like a light knife scraping bamboo... Like a diseased silkworm eating a leaf'.1 However, it is questionable whether such descriptive metaphors remain relevant or helpful in the 21st Century.

Interpretation of specific pulse terms has been further clouded over time by their use in different contexts from those originally intended. For example, the term 'full' is used to name one of the specific pulse types, traditionally meaning a pulse that can be felt forcefully at both the superficial and deep levels and 'also long, slightly bowstring'.2 However, the term is often used as a general descriptor of any pulse that hits the finger with considerable force on palpation. In addition, a specific pulse type may sometimes be used as a general descriptive term when defining other specific pulse types. This can be demonstrated from the previous example where the term 'bowstring', itself a specific pulse type (otherwise known as the Wiry Pulse), is used in the description of the Full Pulse.

Summary

The use of the radial pulse as a diagnostic tool is an integral part of the Traditional Chinese Medicine (TCM) patient evaluation. In spite of its long history of use, there is little systematic information available to support the many claims about the relationship between pulse qualities and physiological condition contained in the ancient Chinese texts and echoed in modern pulse terminology. This study reports the development of a reliable means of measuring and recording pulse characteristics. This was achieved by reporting on the physical sensations that are detected under the fingertips when the radial pulse is palpated, rather than attempting to translate these into the complex and typically ambiguously defined TCM pulse qualities. The study involved development of a standardised pulse taking procedure and development of concrete operational definitions for each of the characteristics of the pulse being measured. The inter-rater reliability of the pulse taking procedure and operational definitions was assessed by determining agreement levels between two independent pulse assessors for each characteristic. Inter-rater agreement averaged 80% between the two assessors in both the initial data collection (66 subjects) and in a replication collection (30 subjects) completed two months later. Demonstrating reliability of the procedure represents an essential first step for examining the validity of TCM pulse diagnosis assumptions.

Keywords

Inter-rater reliability, TCM, pulse diagnosis, radial pulse, palpation, diagnostic techniques.
A frequent criticism of pulse diagnosis is the procedure’s inherent subjective nature in relation to both the physical examination of the radial pulse and the identification of specific pulse quality. Different practitioners may interpret the same patient’s pulse in different ways (inter practitioner reliability) or the same practitioner may interpret the same patient’s pulses differently on repeated palpation (intra practitioner reliability). It has been suggested that, at least in part, this variability is due to the sensitivity of the pulse to external short-term influences such as physical activity and emotional upsets. That is, the reliability of the method is not at fault, but rather, it is the inherent variability in the patient’s pulse that is responsible. However, in the absence of a standardised terminology and procedure with which to palpate the pulse, this claim remains untested. Indeed, without demonstration of the reliability of the pulse taking procedure it is not possible to have confidence in any assertions concerning stability or variability of the pulse itself. Given that palpation techniques differ slightly between texts in relation to positioning of fingers, pressure exerted to locate the different levels of the pulse and methods of assessing individual positions, it is possible that these alone may account for the perceived differences in a patient’s pulse characteristics.

Subjectivity of the TCM diagnostic process has generated debate about whether the treatment and choice of acupoints should be based upon TCM theories or conventional medical diagnostic procedures. Advocates of the latter argue that the former procedures do not conform to scientific methodology. For pulse diagnosis, for example, measurement of pulse characteristics must be shown to be reliable. This would involve the development of appropriate operational definitions of both pulse variables and measurement procedures. Inter-rater reliability testing is the process by which a measurement tool can be shown to reproduce similar results when used by two or more independent assessors. It is used in clinical settings to assess the extent to which practitioners are able to agree with each other in their assessment of patients and is evaluated by having two or more assessors carry out independent assessments of the same group of patients. A high level of agreement between the assessors means a high level of inter-rater reliability. Comparisons between the findings of inter-rater reliability studies are difficult because different methods of pulse taking are often used to assess the pulse characteristics. The few published studies concerning the reliability of TCM pulse diagnosis have generally reported fairly low levels of inter-rater agreement concerning pulse characteristics. These studies varied in relation to the systems of pulse taking procedures used to assess the pulse. Within the same study, all practitioners were assumed to be using the same pulse taking system and definitions of pulse qualities, although this was not necessarily stated in the methodology. Further, within the same study, individual interpretation of pulse qualities
(such as Full or Empty) could have influenced the assessment of the pulse characteristics.

Cole's (1977) study concerning the use of pulse diagnosis in Britain, reported generally low levels of inter-rater agreement between TCM practitioners, as well as a tendency for individual practitioners to favour particular pulse patterns when recording pulse information. For example, one practitioner tended to record a higher number of 'normal' pulses while another practitioner, examining the same group of subjects, recorded approximately equal numbers of 'normal' and 'unbalanced' pulses. Cole surmised that this could have been due to both the practitioners' preconceived notions about what to expect in the pulse and to their individual interpretation of the pulse characteristics. Kass reported that inter-rater reliability decreased as more subtle levels of pulse discrimination were required, although, in this case, inter-rater reliability was determined between manual palpation and an electronic pulse detection device. Craddock examined the reliability of the TCM pulse diagnostic process in a pilot study that involved four practitioners and eight subjects, with the raters blinded to their subjects. He reported that the levels of inter-rater and intra-rater reliability decreased with the increasing complexity of pulse qualities being measured. Birch found a wide range of inter-rater reliability agreement (from zero to near perfect) in the pulse assessment aspects of a study that examined diagnostic assessment methods and involved five practitioners and 26 subjects. However, the practitioners were able to see and question the subjects whose pulses they were palpating and it is possible that assessments may have been influenced by other subject variables. A recent study that examined inter-rater reliability levels among undergraduate TCM students by Walsh and Cobbin reported that overall levels of agreement about basic pulse characteristics (such as depth, speed and length) differed little from those predicted by chance alone. Using a single blind study design and large sample size, students were tested on three occasions: at commencement and completion of 14 weeks of pulse diagnosis classes, and one year later. Further, the lowest levels of inter-rater agreement were obtained in the last collection.

The authors suggested that, rather than stemming from an inability to learn pulse diagnosis, these final low levels of agreement reflected the conflicting and subjective information concerning pulse diagnosis in the available TCM literature.

In the present research, complex TCM pulse terminology was not used, thereby limiting this source of variability. Instead, the pulse was considered in terms of the simple physical sensations that are detected under the fingertips when the radial pulse is palpated. The aim of the study was to determine whether this approach could produce reliable measurement of the simple pulse parameters. If so, reliable measurement of more complex pulse characteristics might be possible, if they represented specific clusters of values for several simple pulse parameters.

Methods

The operational definitions and palpation method were developed by the two pulse assessors (King and Walsh) through a cumulative process that included a review of the current relevant literature on pulse definitions and pulse taking methods (18 sources), together with a practical test-retest method. The formative 'theoretical' evaluation identified key pulse characteristics common to the pulse descriptions in the reviewed literature. Through a process of practical test-retest, the assessors gradually developed and refined the identified 'commonalities' in the pulse, thereby evolving a set of operational definitions for the identified key pulse characteristics. This process involved ongoing discussion between the two pulse assessors, in conjunction with extensive palpation of various subjects' pulses in order to identify the key descriptive terms that each assessor was using to interpret the physical characteristics palpated in the pulse. This process was instrumental in developing a standardised terminology that was common to both assessors and that subsequently formed the basis of the formalised operational definitions.

Operational definitions used in pulse palpation

Location of the TCM locations used (Cun, Guan, Chi) when palpating the radial pulse

It was essential that the positioning of the fingers in relation to these three TCM locations...
was standardised. To do this, the same positioning of fingers was always applied and subjects’ wrists were always similarly presented, by having them seated with both forearms resting on a table, level with the heart, with palms facing upward. The Guan location was identified using the styloid process of the radius as an anatomical landmark, that was marked. This location was used as a guide for the placement of the assessor’s middle finger, with the index and ring fingers falling naturally into place either side of the middle finger (Cun and Chi respectively). To ensure both assessors used the same finger positions, the skin above the styloid process was marked with a felt pen. These fingers were always used for each of these positions. Further reference to the use of the ‘appropriate’ finger refers to this finger positioning. Beyond Cun was located by moving the index finger one finger breadth distal to the Cun position. Beyond Chi was located by moving the ring finger proximally from the Chi position, one finger breadth away. The presentation of the pulse at any level of depth was sufficient for the pulse to be rated as present at the beyond Cun position or beyond Chi.

Depth

The three subdivisions of depth were superficial, middle and deep. Pulse was assessed at each level as follows:

Superficial level: defined as being located directly below the skin level. Located by resting the fingers lightly on the three positions of Cun, Guan and Chi, directly above the radial artery (the only pressure exerted being the passive weight of the resting fingers).

Deep level: defined as the innermost level, situated directly above the surface of the radius. Located by first occluding the radial artery by exerting heavy pressure upon the artery, pushing it against the surface of the radius until the pulsations ceased and then slowly releasing the pressure slightly until the pulsation returned. This type of occlusion causes a subsequent initial rush in the blood flow and it was therefore necessary to allow a few seconds for the pulse to equalise, while maintaining the same finger pressure, before pulse assessment could continue. (In some cases, it may be very difficult to occlude the pulse, with a slight pulsation still felt beyond Chi.)

Middle level: located midway between the superficial and deep levels and was located after initially locating the superficial and deep levels, in order to ascertain the amount of pressure required to palpate to the middle level.

Width

This refers to the palpable breadth of the radial artery. There were two basic subdivisions: thin and not thin. Width was evaluated by using the three fingers to apply consistent pressure over all three TCM locations simultaneously, at the superficial and deep levels.

Thin: the pulse form had a definite edge-like feel to the artery, that was distinctly palpable on a longitudinal axis (ie along the arterial length) but did not displace a wide surface area of the fingertip laterally.

Not thin: a pulse that was ‘not thin’ was defined as any pulse with a diameter wider than the thin pulse. This included pulses with well defined arterial walls or alternatively where the arterial wall was not clearly palpable, with the pulse instead presenting itself as a region of pulsation, with no clear delineation between the radial arterial wall and the surrounding tissue. In both variations, expansion of the pulse occurred both longitudinally and laterally.

Force and Relative Force

In this study, the term ‘force’ was used in reference to the overall intensity of the pulsation as it struck the finger, while the term ‘relative force’ was used as a more subtle comparison of overall force. For example, both the left and right sides may have the same force values (forceful, forceless or neither) but one side may be relatively more so than the other. In all such comparisons by body side, TCM location or depth positions, the term ‘relative force’ was used.

Force: force referred to the impetus of the arterial pulsation striking the fingertip when the pulse was palpated. It was measured using two criteria: the amplitude of the pulse pressure wave with respect to time, and the area of the artery coming into contact with the receptors of the
finger tips, irrespective of depth. Force was reported on a three point scale: forceful, neither forceful nor forceless, and forceless.

**Forceful**: a forceful pulse was defined as having a large pulse pressure wave, with the change in pressure occurring rapidly so that the pulse struck the finger strongly and displaced a wide surface area on the fingertip. It was defined as being forceful in at least two of the three TCM locations, with the pulse likely to be found beyond the three locations.

**Forceless**: a forceless pulse was defined as either a small pulse pressure wave striking the fingertip weakly with a small displacement of area on the fingertip, or a slow rate of change in the pulse pressure wave (amount of time required to reach maximum systolic pressure) and a wide displacement of surface area on the fingertip.

**Relative force**: this was measured by depth, TCM location and by body side.

i. **Relative force according to depth**: this was examined using two different methods:

   (a) At two levels of depth (superficial and deep) at each of the three TCM locations separately to determine which level was relatively greater.

   (b) At three levels of depth (across the three TCM locations) to determine the level at which the pulsations were greatest overall (irrespective of TCM location).

ii. **Relative force according to TCM location**, irrespective of depth: this was evaluated at each of the three TCM location separately and, regardless of depth, assessing the relative pulse force at each location. The three TCM locations were then ranked in terms of their relative pulse force on a three point scale, where ‘one’ was ranked most forceful.

iii. **Relative force by side**: this was determined by simultaneously palpating the left and right radial pulses at all three TCM location, using an even pressure. To exclude a dominant hand bias on the part of the assessor, the subject was asked whether the pressure exerted by each hand was equal. If necessary, the finger pressure was adjusted and then the pulse on each side was examined at each of the levels, simultaneously.

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**Rhythm**

The rhythm of the pulse refers to the pattern formed by the pulsations of the radial artery and is related to the duration of the interval between each pulsation (or beat). The rhythm was examined for a minimum of one minute at a time and was repeated at least once in order to detect any irregularities in rhythm or rate.

There are two types of patterns that may be seen in the pulse, regular or irregular.

**Regular**: a regular pulse was defined as having consistent intervals between each beat.

**Irregular**: an irregular pulse was defined as a pulse pattern that does not have consistent intervals between each pulsation. This may present as a missed beat or may involve a change in the duration between beats. This may occur on a regular basis or may occur intermittently. Note that missed beats are common in the normal population and especially so among the elderly.

**Pulse occlusion**

Pulse occlusion was defined by the degree of pressure required to completely halt the pulsation of the radial artery underneath the three fingers by compressing it against the radius. This was achieved by exerting an increasing pressure upon the radial artery with evenly distributed pressure across the three palpating fingers until the pulsations of the radial pulse were no longer felt. This was held for five seconds and then released.

**Easily occluded**: this required little pressure to be exerted upon the arterial wall to overcome the internal pressure. There was relatively low resistance in the wall so that the wall compressed easily.

**Occluded with difficulty**: this required significant pressure to occlude the pulsations, equal to the amount of pressure that was required to palpate to the deep level. Even with this amount of pressure, the pulse may still be detected beyond the Chi location. A pulse that could not be completely occluded (ie where the pulsation of the artery could still be felt underneath any of the three palpating fingers) was categorised as ‘occluded with difficulty’. 

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**Papers**


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Standardised manual palpation procedure

The pulse information was recorded during the pulse taking process on the data collection form for the appropriate hand, shown in Figure 1. This procedure was then repeated on the other hand, with the assessors changing seats in order to examine the other radial pulse. During the pulse taking procedure the assessors did not discuss the information being recorded or compare their complete pulse recording forms. The order in which subjects’ left and right wrists were palpated by each assessor was alternated throughout the data collection to minimise variation due to variables such practice or fatigue effects. Each assessor always used the right hand to examine the subject’s left radial artery and the left hand to examine the right radial artery (note: fortuitously, one assessor was right handed and the other, left handed).

Depending upon the parameter being measured, one or other of the following palpation techniques were applied:

i. Using one finger at a time to palpate individual TCM locations at different depths.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse presence by TCM location and depth level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beyond Cun (at any level)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At superficial level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At deep level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At superficial level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At deep level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At superficial level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At deep level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beyond Chi (at any level)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Relative force by TCM location irrespective of depth level

Choose one or more:

<table>
<thead>
<tr>
<th>Force level</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cun</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Relative force by depth level irrespective of TCM location

Choose one or more:

<table>
<thead>
<tr>
<th>Force level</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse most forceful at the superficial level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse most forceful at the middle level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse most forceful at the deep level</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pulse force

<table>
<thead>
<tr>
<th>Force level</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forceless</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neither forceless nor forceful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forceful</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pulse occlusion

<table>
<thead>
<tr>
<th>Occlusion</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse occluded easily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse occluded with difficulty (Note if the pulse can still be felt)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pulse width

<table>
<thead>
<tr>
<th>Width</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not thin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At deep level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not thin</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pulse rhythm

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irregular</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Turn this form over to record data for the other radial pulse. When both pulses have been palpated, determine the more forceful pulse by body side and record below.

<table>
<thead>
<tr>
<th>More forceful radial pulse by body side</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left more forceful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right more forceful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both equally forceful</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using three fingers simultaneously, to exert a consistent pressure over all three TCM locations to palpate to the required depths, according to standard procedures.

Data for the radial pulse were recorded for the 16 categories listed in Table 2. Pulse data for each subject were collected at the same time by the two independent assessors; one examining the left and the other the right radial artery. The same procedure and order were used to examine the radial pulse at each wrist in turn. Each measurement period required approximately 30 minutes.

Evaluation of inter-rater reliability

The pulse assessors were King and Walsh, both graduates of the four year BHealth Science (Acupuncture) at the University of Technology, Sydney (UTS) and educators in the College of TCM at UTS, with five and seven years of clinical experience respectively. These two independent assessors both completed the two separate data collection phases (CI and CII) of healthy subjects that were conducted two months apart. In both, overall inter-rater reliability was measured as percentage agreement. CI was an initial evaluation of the reliability of the procedure and underlying operational definitions, while CII provided a subsequent replication evaluation. Manual palpation of the radial pulses of each subject was carried out by both assessors, according to the procedure described above. The levels of inter-rater agreement for all 16 pulse characteristics were tested against the appropriate chance alone models (Chi square I, goodness of fit) for the number of possible combination for a given characteristic (alpha was set at < 0.05).

### Subjects

There were 66 subjects (27 males and 39 females, mean age: 27.7 ± 8.6 years) in CI and a further 30 subjects (13 males and 17 females, mean age: 32.7

### Table 2

The following table shows the percentage agreement achieved by the two assessors for the 16 data categories in CI (N = 66), CII (N = 30) and for the two collections combined (CT). Agreement levels are shown separately for left (L) and right (R) radial pulses, and averaged across left and right sides (L+R). The percentage agreement expected by chance alone appears in the first column.

<table>
<thead>
<tr>
<th>Pulse category</th>
<th>Chance alone</th>
<th>CI L+R</th>
<th>CI L</th>
<th>CI R</th>
<th>CII L+R</th>
<th>CII L</th>
<th>CII R</th>
<th>CT L+R</th>
<th>CT L</th>
<th>CT R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Presence of pulse beyond Cun location</td>
<td>50</td>
<td>68</td>
<td>69</td>
<td>61</td>
<td>69</td>
<td>52</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Presence of pulse beyond Chi location</td>
<td>50</td>
<td>83</td>
<td>83</td>
<td>82</td>
<td>80</td>
<td>83</td>
<td>82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Presence of pulse at superficial and/or deep level at Cun location</td>
<td>25</td>
<td>98</td>
<td>97</td>
<td>99</td>
<td>62</td>
<td>53</td>
<td>70</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Presence of pulse at superficial and/or deep level at Guan location</td>
<td>25</td>
<td>96</td>
<td>94</td>
<td>98</td>
<td>84</td>
<td>80</td>
<td>87</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Presence of pulse at superficial and/or deep level at Chi location</td>
<td>25</td>
<td>80</td>
<td>82</td>
<td>79</td>
<td>82</td>
<td>83</td>
<td>80</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. More forceful level of pulse (superficial or deep) at Cun location</td>
<td>33</td>
<td>72</td>
<td>74</td>
<td>71</td>
<td>95</td>
<td>97</td>
<td>93</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. More forceful level of pulse (superficial or deep) at Guan location</td>
<td>33</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>70</td>
<td>90</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. More forceful level of pulse (superficial or deep) at Chi location</td>
<td>33</td>
<td>86</td>
<td>88</td>
<td>83</td>
<td>99</td>
<td>100</td>
<td>97</td>
<td>92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Relative pulse force by TCM location (Cun, Guan, Chi)</td>
<td>17</td>
<td>56</td>
<td>59</td>
<td>52</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Relative pulse force by three depth levels (superficial, middle, deep)</td>
<td>14</td>
<td>69</td>
<td>70</td>
<td>68</td>
<td>72</td>
<td>67</td>
<td>77</td>
<td>71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Determination of overall pulse force</td>
<td>33</td>
<td>74</td>
<td>70</td>
<td>77</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Relative pulse force by body side</td>
<td>33</td>
<td>86</td>
<td>86</td>
<td>86</td>
<td>85</td>
<td>80</td>
<td>90</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Pulse width at superficial level</td>
<td>50</td>
<td>86</td>
<td>86</td>
<td>86</td>
<td>85</td>
<td>80</td>
<td>90</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Pulse width at deep level</td>
<td>50</td>
<td>93</td>
<td>92</td>
<td>94</td>
<td>94</td>
<td>87</td>
<td>100</td>
<td>93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Ease of occlusion of the pulse</td>
<td>50</td>
<td>73</td>
<td>75</td>
<td>71</td>
<td>67</td>
<td>66</td>
<td>67</td>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Irregularity of pulse rhythm or rate</td>
<td>50</td>
<td>98</td>
<td>97</td>
<td>100</td>
<td>88</td>
<td>86</td>
<td>90</td>
<td>93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Participants were volunteers, recruited from TCM undergraduate students and Health Science staff at UTS and from the general population. Approximately 70% of subjects were of European descent and 30% of Asian background. Health status was established from self-report of subjects via completion of a questionnaire about current and past illnesses and medication. Subjects were only assessed when free from acute illness, such as upper respiratory tract infections.

Results
The results are a comparison of inter-rater agreement for the two collection phases and overall.

Table 2 shows the levels of agreement achieved for the 16 pulse categories for both collection phases (CI and CII) and for both collections combined (CT) together with agreement levels predicted by the appropriate chance alone model for each category. For the two collections, the results are presented separately for left and right sides and for both sides combined (ie overall). There were no significant differences in inter-rater agreement levels by body side (ie p>0.05).

For CI, inter-rater agreement levels in excess of 70% were achieved for 13 of the 16 categories and for ten of these, the agreement level was greater than 80%. For CII, levels of agreement of at least 80% were obtained for 11 of the data categories. For all categories, inter-rater agreement levels were statistically significantly better than chance alone. For example, for categories 9 and 10, chance alone models would predict inter-rater agreement levels of 17% and 14% respectively, compared with the assessors’ agreement levels that ranged from 56% to 72%.

Table 3 compares the overall percentage agreement by category for CI and CII, together with the percentage differences for each category for the two collection phases. Only two categories did not achieve inter-rater agreement levels in excess of 70% for both collection phases. These were category 1 (presence of pulse beyond the Cun location) and category 9 (rating of relative pulse force at Cun, Guan and Chi). It is unlikely that these lower inter-rater agreement levels reflected the complexity of the categories involved, since category 1 was dichotomous while category 9 had six possible response values. Category 1, that involved merely identifying the presence or absence of pulse beyond Cun, scored the lowest percentage agreement in CII (61%) and second lowest in CI (68%). These lower levels of agreement were likely due to the large number of possible responses and the subjectivity involved in determining whether a pulse was present beyond the Cun location.

<table>
<thead>
<tr>
<th>Pulse category</th>
<th>CI</th>
<th>CII</th>
<th>% difference</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Presence of pulse beyond Cun location</td>
<td>68.0</td>
<td>61.0</td>
<td>-7</td>
<td></td>
</tr>
<tr>
<td>2. Presence of pulse beyond Chi location</td>
<td>83.0</td>
<td>82.0</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>3. Presence of pulse at superficial and/or deep level at Cun location</td>
<td>98.0</td>
<td>62.0</td>
<td>-36</td>
<td>0.0001</td>
</tr>
<tr>
<td>4. Presence of pulse at superficial and/or deep level at Guan location</td>
<td>96.0</td>
<td>84.0</td>
<td>-12</td>
<td>0.002</td>
</tr>
<tr>
<td>5. Presence of pulse at superficial and/or deep level at Chi location</td>
<td>80.0</td>
<td>82.0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>6. More forceful level of pulse (superficial or deep) at Cun location</td>
<td>72.0</td>
<td>95.0</td>
<td>23</td>
<td>0.0004</td>
</tr>
<tr>
<td>7. More forceful level of pulse (superficial or deep) at Guan location</td>
<td>80.0</td>
<td>80.0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8. More forceful level of pulse (superficial or deep) at Chi location</td>
<td>86.0</td>
<td>99.0</td>
<td>13</td>
<td>0.003</td>
</tr>
<tr>
<td>9. Relative pulse force by TCM location (Cun, Guan, Chi)</td>
<td>56.0</td>
<td>67.0</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>10. Relative pulse force by three depth levels (superficial, middle, deep)</td>
<td>69.0</td>
<td>72.0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>11. Determination of overall pulse force</td>
<td>74.0</td>
<td>80.0</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>12. Relative pulse force by body side</td>
<td>86.0</td>
<td>82.0</td>
<td>-4</td>
<td></td>
</tr>
<tr>
<td>13. Pulse width at superficial level</td>
<td>86.0</td>
<td>85.0</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>14. Pulse width at deep level</td>
<td>93.0</td>
<td>94.0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>15. Ease of occlusion of the pulse</td>
<td>73.0</td>
<td>67.0</td>
<td>-5</td>
<td></td>
</tr>
<tr>
<td>16. Irregularity of pulse rhythm or rate</td>
<td>98.0</td>
<td>88.0</td>
<td>-10</td>
<td>0.002</td>
</tr>
<tr>
<td>All pulse categories combined</td>
<td>81.0</td>
<td>80.0</td>
<td>-1</td>
<td></td>
</tr>
</tbody>
</table>
agreement may be due to difficulties in detecting
the pulse at this location, as a result of
physiological variability, such as deviation of
the artery, medially or laterally. Category 9 (ranking
pulse at Cun, Guan and Chi in terms of relative
force) had the lowest agreement in CI (56%), and
third lowest (67%) in CII, however this level was
still far higher than the 17% agreement predicted
by chance alone.

For five pulse categories, there were
statistically significant differences in levels of
agreement between the first and second collections.
Higher agreement levels for CII were attained for
category 6 (determination of the relative force of
superficial and deep levels at the Cun location)
and category 8 (determination of the more
forceful level at the Chi location). Although not
shown in the table, for each, the levels of
agreement increased significantly for both left and
right sides (p < 0.01 and 0.05 respectively). While
CII agreement levels were lower for three
categories, with the exception of category 3
(presence/absence of pulse by depth at the Cun
location), these levels were still in excess of 84%
categories 4 and 16). Thus, overall, the results for
the two collection phases indicate that high levels
of inter-rater agreement were achieved for both
simpler (that is, dichotomous) and more complex
categories.

Discussion
Objectively defined methodology and terminology
are essential for current TCM education where the
intensive one-on-one teaching scenario of the
traditional system is becoming uncommon. With
the inclusion of TCM degree courses within the
university system, TCM students are expected to
critically evaluate the information they receive.
Western medicine itself is being increasingly
subjected to rigorous demands to demonstrate the
practice of evidence based medicine. Given that
the dominant medical paradigm in western society
is required to meet these standards, it is to be
expected that alternative medical systems will also
be similarly scrutinised. Thus, for TCM pulse
measurement and diagnosis to be recognised as a
credible diagnostic tool, their validity and
reliability must be established.

Variability in TCM definitions for pulse terms
has meant that reliable pulse measurement has
not been possible. This was addressed in the
present study by defining the pulse in terms of a
set of physical sensations that could be detected
under the fingertips during palpation of the radial
pulse rather than the traditional terms. These
physical factors related to the TCM location,
depth, relative force, overall force, width, rate,
rhythm and degree of difficulty of occlusion of the
pulse. Each of these parameters was operationally
defined and the reliability of the measurement
system demonstrated using two independent
assessors. Two phases of inter-rater reliability
testing were conducted.

The study findings have demonstrated that
high levels of inter-rater agreement were achieved
in both the initial collection and the replication
collection phases, with the mean percentage
agreement for pulse characteristics, for both
collection phases reaching at least 80%. These
results demonstrate that the operational
definitions and pulse taking methodology
developed for the study were sufficiently reliable
to permit the accurate identification by two
separate assessors of the defined pulse
characteristics.

Given that the two assessors involved were
both experienced in pulse palpation, possibly the
high levels of inter-rater agreement that were
achieved reflected their expertise and familiarity
with the unambiguous, concrete operational
definitions and standardised procedures
developed for this study. However, more recently,
the broader robustness of the system has been
demonstrated by Walsh et al, when used by
undergraduate TCM students who had been taught
the new pulse taking methodology. This
longitudinal study adopted similar methodology
to that previously reported by these authors, and
discussed earlier in this paper.

The pulse data gathered in this research
comprised simple attributes of the pulsations
perceived underneath the fingertips, during
manual palpation of the radial pulse (termed
parameters for this study). No attempt has been
made to develop clusters of specific values of
these parameters in order to build them into
complex pulse types along the lines of the TCM
pulse qualities such as Wiry or Slippery. This
decision was justified in view of the absence of any reliable basis that might suggest which groupings of particular values of different parameters would form particular TCM pulse types. This would be appropriate if specific pulse types were shown to correlate with the manifestation of a specific disease state. For example, if a specific pulse type does relate to a certain disease state and this specific pulse type serves as a valid diagnostic tool, then it would be appropriate to examine the relevant simple pulse parameters to determine if they also exhibited specific clusterings of values. However, such a study is directed at evaluating validity of TCM pulse diagnosis. This was not the aim of the current research, which was primarily undertaken to develop a reliable method for pulse measurement and reporting, using a group of healthy subjects.

Reference list
The reliable measurement of radial pulse characteristics

Emma King, Deirdre Cobbin, Sean Walsh and Damien Ryan

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