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Review Article

Accuracy and Precision in Acupuncture Point Location: A Critical Systematic Review

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Abstract
A number of studies have examined the accuracy and precision of acupuncture point location across various point location methods. Accuracy of point location is essential for safe, efficacious and reliable treatments and valid reproducible research outcomes. This review aims to identify, summarize, compare and critically appraise available empirical studies relating to the accuracy and precision of acupuncture point location. A comprehensive search of five electronic databases, World Journal of Traditional Chinese Medicine and Google scholar was performed for studies investigating accuracy and precision in acupuncture point location. 771 studies were screened of which 14 studies were identified, including 9 studies that investigated the localization of acupoints and 5 studies that examined the cun measurement system. Considerable variation in localization of acupoints was reported among qualified medical acupuncturists. Variation in point location among qualified non-medical acupuncturists is unknown due to lack of any identified study. The directional method was found to be significantly inaccurate and imprecise in all studies that evaluated the method. Suitability of other methods for clinical and research purposes and influencing factors such as education, training and experience were identified as topics for future studies.

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1. Introduction

One of the basic tenets of traditional acupuncture theory is point specificity—the notion that needling a particular acupuncture point induces physiological effects particular to that point [1,2]. Many acupuncture points lay in close proximity to others, making accuracy (determined by the proximity of a located acupoint and a deemed correct location) and precision (the ability to locate an acupoint in the same location across a number of attempts) of acupoint location imperative for efficacy and reliability of treatment. In addition to its effects on clinical practice, inaccuracy and imprecision can be a potential cause of type II errors in acupuncture research, particularly where nearby "sham" points are needled [3]. Adverse outcomes such as local trauma, neural injuries, aneurisms, injuries to the eyes, and broken needles can also occur if the incorrect site is needled [4].

There are three basic methods of locating acupuncture points from which all other methods are derived: the anatomical landmark method, the proportional bone (B-cun or skeletal) method, and the finger—cun (F-cun) method, also known as the directional method [5]. The anatomical landmark method (widely considered to be the most accurate one [5]) is used to locate less than half (n = 164) of the 361 acupuncture points distributed over 14 acupuncture channels. The remaining points require measurement from anatomical landmarks for location. The cun or anatomical Chinese inch is the standard unit of measurement and is based on measurements first mentioned in the classical text "Lingshu" [2,5-7]. Various areas of the body have linear cun measurements ascribed to them [5].

The directional, proportional, and direct measurement (using a ruler or elastic) methods all rely on the cun system. The directional method uses cun measurements ascribed to areas of the fingers and hand as a standard measurement and applies F-cun to approximate body-cun (B-cun) [5]. The proportional method subdivides the distance between two anatomical landmarks into equal portions according to cun measurements. The proportional method is recommended in the World Health Organization Standard Acupuncture Point Locations in the Western Pacific Region [5] (the World Health Organization Standard). The limitation of the proportional measurement method is the reliance on the skill of the practitioner to ensure accuracy. Two direct measurement methods—the ruler and elastic methods—are adaptations of the proportional method which are less reliant on skill through the use of standardized measurement tools.

Although accuracy and precision of point location are integral to safe and effective acupuncture practice, there has been little formal examination of this topic in the peer-reviewed literature. The purpose of this article is to remedy this gap by conducting a review and synthesis of empirical research findings related to this topic.

2. Methods

A comprehensive search of the AMED, CINAHL, MEDLINE, PubMed, and Embase databases was conducted from their inception until August 2018 without restriction on language or study type. The following terms or subject headings were used individually and combined: *acupuncture therapy, acupuncture, acupoints, point location, location method, proportional method, directional method, cun, ruler, tape measure, elastic method, aci locator, anatomical Chinese inch locator, Newman locator, acupuncture point*, and professional competence*. Database searches were supplemented by hand searches of the World Journal of Traditional Chinese Medicine and citation lists of all articles reviewed to identify further references. The search strategy was replicated in Google Scholar to capture gray literature and nonindexed sources. The protocol conformed to Preferred Reporting Items for Systematic Review and Meta-analysis Protocols [8].

Search results were imported, stored, and scanned for duplications using Clarivate Analytics Endnote software. Both reviewers (D.G. and J.W.) screened all the remaining 771 titles, using translators as required. Both qualified and student practitioner studies were included in this review. Studies needed to report consistency and accuracy of identified acupuncture point locations or cun measurements on human models. Discussion resolved inclusion or exclusion of any articles that were inconclusive. A quality score was not performed because of heterogeneity in methodologies of included studies. This allowed for comparison of findings on the accuracy and precision of individual method/s across studies. Owing to the paucity of studies, all articles were included in this review.

3. Results

The search identified a total of 771 studies (after duplicates were removed). A total of 14 studies published between 2000 and 2018 were ultimately included for review. Fig. 1 summarizes the search strategy and selection process used in this review.

Table 1 summarizes the articles that met inclusion criteria. Studies included in this review fell into two broad categories: those that examined the cun measurement system without investigating accuracy or precision of individual acupuncture points (n = 5) [9—13] and those that specifically investigated the localization of acupoints (n = 9) [3,14—21]. Only one study specifically targeted the reliability of localizing points near anatomical landmarks [20]. Five studies specifically investigated points requiring measurements to locate acupoints, [3,14,16—18], whereas three studies [15,19,21] investigated acupuncture points requiring localization with a mixture of both anatomical landmarks and cun measurement.

3.1. Methodological quality

Selection bias, attrition bias, and detection bias were adequately controlled for in all studies. Point location method was not specified in five point location studies [15,16,19—21]. One study (by Baumler et al) [16] surveyed point location methods in general use by participants but did not specify whether those were the methods participants used within the study.

There was a high or unclear risk of performance bias in all nine studies in which participants localized acupuncture

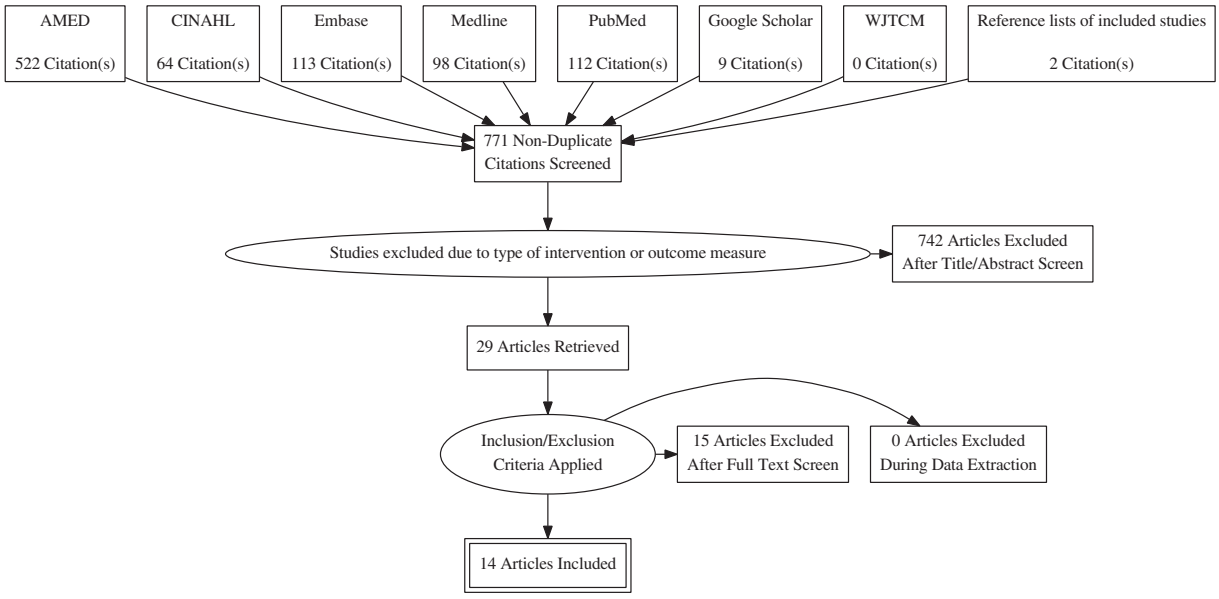

Figure 1 PRISMA flow chart for Accuracy and Precision in Acupuncture Point Location: A Critical Systematic Review detailing the database searches, the number of abstracts screened and the full texts retrieved. Note. Adapted from Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6(7):e1000097. https://doi.org/10.1371/journal.pmed.1000097.

points. Only one study (by Aird et al) specified whether participants had prior training in the method/s being evaluated [14]. Students were participants in three studies, either exclusively [3,14] or partially [16]. Medical practitioners of variable acupuncture training (less than 100 to more than 500 hours) were participants in five studies, [16—20] with acupuncture-specific training of between less than 100 and more than 500 hours. Clinical acupuncture experience ranged from less than 1 year to more than 30 years. Performance was not an important factor for bias in studies that solely compared cun lengths as these measurements are not heavily skill based.

There was low risk of bias due to choice of control in five studies that conducted comparison of cun lengths [9—13] and in those studies that used ruler or tape measures as the gold standard to assess accuracy of point location [17,18]. Points localized by a lecturer or experienced acupuncturist were used as the standard in two trials, rather than more standardized measures [14,20]. One study (Aird) used a "sham" acupuncture point 20 mm adjacent to the target acupuncture point as a control for tenderness with palpation [15]. Scatter size [3,16,19] and interrater or intrarater agreement [20] were used as the outcome measures in four studies that focused on precision rather than accuracy.

A novel trial [21] measuring the dislocation of acupoints when human models held a histological human lung slide used points as identified using the Atlas of Acupuncture chart Seiren as control points. The method/s used to implement these descriptions was not given in the study.

3.2. Point location methods

A total of nine studies evaluated the cun measurement system either by localization of acupoints or by comparison of *cun* sizes in various locales on the body. Studies focused on a variety of point location methods and are summarized in the following:

3.2.1. Directional (F-*cun*) method

The directional method was found to be significantly inaccurate and/or imprecise in all eight studies that evaluated the method [3,10—14,16,17]. One study (by Chen) [9] evaluated the cun measurement system and examined internal consistency of various finger measurements converted to cun measurements without a comparison to body-cun, making it of little value in determining the validity of the directional method. All studies that compared F-cun with B-cun found significant variance in cun length across different body areas and concluded that the directional method is unreliable and has been confirmed in Australian, Chinese, Korean, and US populations [10—13].

3.2.2. Proportional, ruler, and elastic methods

Two studies specifically reported on the localization of acupuncture points using the proportional method found this method to be similarly imprecise and/or inaccurate as the directional method, with significant skill-related error in the localization of points [3,14]. Both studies focusing on the proportional method suffered from significant risk of performance bias due to the participants being students. Proportional measurement may have been used by some participants in other studies that did not report the location method used. One study (by Aird et al) [3] that examined directional and proportional methods also investigated two variants of the proportional method, using ruler and elastic methods. These methods were found to be far more precise than the directional and proportional methods; however, they were not well received by students due to concerns around the method's practical application and patient perception [3]. This study did not report on point location

Table 1 Characteristics of included studies.

Author, year	Country	Method/ design	Participants*	Human models†	Intervention	Main outcomes measures	Results	Additional key findings or comments
Aird et al, 2002 [3]	Australia	Randomized controlled trial	Acupuncture students (n = 72)	The same volunteer used with every participant (n = 1)	Each participant attempted to locate a fictitious acupoint on a volunteer using two of the following four point location methods. The location was marked using ink invisible under normal florescent lighting, but visible when later illuminated by UV light. Participants made three attempts using each allocated method on each arm. • Directional (finger/hand cun method) • Proportional (subdivision between two landmarks of a body region into equal sections according to cun measurements) • Elastic is marked into equal sections with a permanent marker and used to divide into the relevant number of cun units. • Ruler method is based on a metric measurement divided by the relevant number of cun units. The locations were plotted onto a plastic film, and the scatter size was determined and recorded.	Comparison of scatter size in mm^2 between each of the four acupoint location methods Participants completed a short questionnaire about ease and comfort of the use of the methods used.	Scatter size: Directional = 12.7 cm^2 Proportional = 7.8 cm^2 Elastic = 3.3 cm^2 Ruler = 2.9 cm^2 A significant difference was found between methods ($F_{3,120} = 11.74$, $p < 0.0001$). No significant difference was found between the two traditional methods of point location (directional mean = 11.35, and proportional mean = 11.17) ($p < 0.998$), nor between the two variant methods of point location (elastic mean = 7.63, and ruler mean = 6.34) ($p < 0.68$). The directional method was less precise than either the elastic method ($F_{3,120} = 11.74$, $p < 0.007$) or the ruler method ($p < 0.00009$). The proportional method was also less precise than either the elastic method ($F_{3,120} = 11.74$, $p < 0.011$) or the ruler method ($p < 0.0002$).	Two more precise methods were not well received by participants because of the application of the method and patient perception.

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Table 1 (*continued*)

Author, year	Country	Method/ design	Participants*	Human models†	Intervention	Main outcomes measures	Results	Additional key findings or comments
Aird 2005, [15]	Australia	Controlled trial	Aird	Healthy, right-handed volunteers (n = 20)	Pressure was applied to ST 36, SP 6, SP 9, PC 6, and control point located 20 mm adjacent to the actual acupoints using an algometer until the participant indicated pain.	Comparison of pressure in kg required to elicit pain between genuine and control points.	No statistically significant difference was found between the pressure tolerated on the genuine acupoints and the control points.	Note: This study forms part of an unpublished thesis. The thesis also included the Aird 2002 study above which is not repeated due to duplication.
Aird et al, 2000 [14]	Australia	Controlled trial	Students (n = 20)	Volunteer (n = 1)	Each participants located acupoints LI 10 and ST 40 contralaterally using directional and proportional methods. A lecturer completed the same process on two occasions with variation <5 mm.	Mean location of the lecturer's located points was accepted as the correct locations. Measurements were taken between participants' locations and the assumed correct locations. Scatter graphs were created to display the results	Large scatter size was noted for both points using both methods with no significant difference in the accuracy between the directional and proportional methods. ST 40 y axis $t = 0.59$, $p = 0.57$, x axis $r = 0.77$, $p < 0.01$ LI 10 y axis $t = 1.05$, $p = 0.31$, x axis $r = 0.55$, $p = 0.01$ Scatter size for ST40 was larger than for LI10.	Significant skill-related errors occurred in localization of each point in the lateral and medial axis unrelated to directional or proportional methods. Participants had received prior in-class training in both methods. Larger scatter size on ST 40 attributed to the measurement being made over a greater distance, resulting in amplification of errors.
Baumler, 2012 [16]	Germany	Uncontrolled trial	Trained acupuncturists (n = 12) Lecturer and students (n = 12) Participant marked acupoints but did not complete the questionnaire (n = 1).	Member of study staff (n = 1)	Participants located and marked acupoints LI 10 and TE 5 on the volunteers' left arm.	Identified points were transferred into a coordinate system, and the respective bivariate distribution function was calculated. In addition, participants filled out a questionnaire about their acupuncture education and experience, the acupuncture style and point localization techniques used most	The areas of the ellipses, theoretically containing 95% of AP localizations, varied between 44.49 and 5.18 cm^2. The largest distance between the 2 identified points was 8.45 cm for LI 10 and 5.3 cm for TE 5. No correlation existed between the point location method used and the precision in localization.	Higher congruity was noted from practitioners trained at the same school (DAGfA). The following point location methods were self-reported to be used in body acupuncture. Cun, 78% Skin resistance, 12% Very point technique, 29% Intuition, 39% RAC, 10%

						frequently, and their estimation of the size of an acupoint.		Palpation, 37% Structure knowledge, nil
Chen and Li, 2010 [9]	China	Observational study	n/a	Volunteers from various regions of China (n = 398) Female (n = 200) Male (n = 198).	Measurement of cun converted to cm of three different parts of finger and hand that are commonly used in the cun measurement system. A tape measure was used to measure with accuracy of 0.1 cm. The three distances measured were as follows: • Width of interphalangeal joint of thumb • Distance between medial end of the creases of the interphalangeal joints of the middle fingers when the middle finger was doubled to the palm • Distance across the dorsum of four fingers when placed side by side at the level of the crease of the proximal interphalangeal joint of the middle finger. Not stated whether only one hand or both hands were measured on each volunteer.	Comparison of the mean measurement in cm for one finger cun was performed for each of the 3 measurements across the 398 volunteers.	Thumb cun = 1.99 ± 0.01 Middle finger cun = 2.03 ± 0.01 Four finger cun 2.06 ± 0.01 ($p < 0.01$ when middle finger and four finger compared with that of the thumb)	The three individual finger cun lengths have a small degree of variance in the Chinese population.
Coyle 2000, [10]	Australia	Observational study	n/a	Adults (n = 50) Female (n = 28) Male (n = 28) Ages: 20–30 (n = 13) 31–41 (n = 13) 42–52 (n = 8)	Bilateral measurements of each of the following finger reference measurements and the lengths of the forearm and lower leg were recorded in mm for each volunteer. • Width of the interphalangeal joint of the thumb (1 cun)	Data converted to ratios for analysis.	Significant differences between traditional measurements and sample means for all hand and leg measurements with the exception of the once *cun* (thumb) measurement and distance for the arm. The sample means were significantly less than the	Overall results were similar across gender and age groups. Cun ratio measurements of women were found to be proportionally larger than those of men.

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Table 1 (*continued*)

Author, year	Country	Method/ design	Participants*	Human models†	Intervention	Main outcomes measures	Results	Additional key findings or comments
					• Width of the index and middle finger, measured at the level of the proximal interphalangeal joint of the index finger (1.5 cun) • Length of the two distal phalanges of the index finger (2 cun) • Width of all four fingers, measured at the level of the proximal interphalangeal joint of the index finger (3 cun).		traditional measurements for the arms and significantly greater than the traditional measurements for the legs ($-22.38 < t < 12.11$, in each case, $p < 0.0001$).	
Dorsher and Johnson, 2010 [17]	USA	Controlled trial	Physician acupuncturists (n = 20)	Adult volunteers (n = 2)	Participants (n = 11) independently marked the location of LU 4. Acupuncturists (n = 9) marked the location of TE 8 by directional method on the volunteers. Participants were blinded from the others' point location findings. The optimal locations for the 2 acupoints were determined by direct measurement using a tape measure.	Distances in mm of the participants' acupuncture point localizations from the optimal point positions.	Mean inaccuracy using traditional directional method LU 4: 22.3 mm (range, 5 −44 mm; SD = 10.9 mm) TE 8: 8.4 mm (range, 1 −21 mm; SD = 5.4 mm).	Years of acupuncture experience ($\leq$10 vs $>$ 10) did not affect accuracy.
Groenemeyer, 2009 [18]	Germany	Controlled trial	Experienced medical acupuncturists located points (n = 2). Experienced medical acupuncturist (18 years) performed needling (n = 1).	"White" patients with lower back pain (n = 58) Male (n = 26); Female (n = 32)	BL 25 and BL26 were located and needled vertically using proportional measurement based on interscapular 6 cun distance. Needles were manipulated until both patient and therapist confirmed "de qi". De qi was confirmed when the patient reported a feeling of heaviness, paresthesia, or aching sensation in the needling area. A total of 107 needlings were documented	Needle depth and needle placement were measured using CT scan. Metric data were converted into the proportional cun system	Difference between the needle site that obtained "de qi" and theoretical distance of acupuncture point to vertebral line was not statistically significant (p = 0.527 for BL 25 and p = 0.105 for BL 26). Correlation between needle position and individual anatomical landmarks suggests that the use of proportional	Depth of insertion close to the intermuscular region was required to elicit de qi.

					during scheduled routine CT scans.		methods is appropriate for the successful acupuncture therapy.	
Molsberger, 2012 [19]	Germany	Controlled trial	Medical doctors with >200 hours of acupuncture training and > 2 years of clinical experience (n = 71) And those with >350 hours of training (n = 62) and >10 years of experience (n = 37).	Male volunteer with muscle definition that allowed easy identification of the anatomical landmarks (n = 1)	23 commonly used acupuncture points including those located in proximity to anatomical landmarks and those using cun distances were marked on a male volunteer, using sticky transparent films with an X/Y grid placed asymmetrically around acupuncture points. Localizations were recorded on an Excel spreadsheet, and the film was wiped clean after recording for each participants.	Area in cm^2 was determined by 95% (second standard deviations) and 68% (first standard deviation) confidence intervals (CIs; *t*-distribution) around the mean value of all marks on the respective piece of film.	For each acupuncture point, the field covering 95% (68%) of all point locations varied from 2.7 (0.7) cm^2 for PC-6 up to 41.4 (10.2) cm^2 for ST-38. Commonly used acupuncture points showed unexpectedly large variance in location: 95% (or 68%) areas were as follows: SP 6: 12.2 cm^2 (3.0 cm^2) ST 36: 20.7 cm^2 (5.1 cm^2) LI 15: 18.7 cm^2 (4.6 cm^2) BL 23: 22.4 cm^2 (5.6 cm^2) BL 54: 22.5 cm^2 (5.6 cm^2). Points close to anatomical landmarks (forearm, ankle, and poplitea: BL 60, BL 40, TE 5, and PC 6) were located with less variance.	Precision of point location was independent of the length of acupuncture experience, kind of training, or medical specialty. Authors recommend a minimum distance of 6 cm between verum and sham points on face, hands, and feet and up to 12 cm for all other parts of the body recommended for the design of sham-controlled trials.
Park 2006, [11]	Korea	Observational study	n/a	Healthy Korean women (n = 47) Mean (SD) age, 30.5 (6.2) years Height, 160.0 (5.0) cm	The lengths of bone from several parts of the body in 47 Korean women were measured by dual-energy X-ray absorptiometry (DXA).	Data obtained by the DXA were converted to a value equivalent to one cun for analysis. The lengths of each part of the body were compared with 3 cun measured by proportional methods, and the width of all four fingers was measured at the level of the proximal	One cun measured by the directional method was significantly different from one cun by proportional methods. Statistical significance was inferred at the $p < 0.05$ levels. The actual length of one cun (2.29 ± 0.12 cm), measured by the directional method was significantly greater than the length measured by	The directional method is likely less dependent on locating acupoints than the proportional method.

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Table 1 (*continued*)

Author, year	Country	Method/ design	Participants*	Human models†	Intervention	Main outcomes measures	Results	Additional key findings or comments
						interphalangeal joint used in the directional method.	the proportional method in the arm (2.04 ± 0.10 cm, $p < 0.001$) and thigh (medial side 1.87 ± 0.11 cm, $p < 0.001$ and lateral side 2.13 ± 0.10 cm, $p < 0.001$). No significant difference was found in the lower legs (medial side 2.36 ± 0.15 cm and lateral side 2.21 ± 0.11 cm).	
Rivers and Zollman, 2013 [20]	USA	Controlled trial	Physician acupuncturists; expert (8 years experience) ($n = 1$); junior ($n = 2$) (2 and 1 year experience, respectively) All were trained in Helms Medical Institute Medical Acupuncture for Physicians course	Volunteers ($n = 22$) Participated in the intrarater valuation ($n = 11$) Participated in the between-rater evaluation ($n = 15$) Participated in both evaluations ($n = 4$)	Junior acupuncturists marked KI 3, HT 3, BL 60, LI 4, LR 3, and PC 7 on 14 volunteers once during each of 4 passes using red ink visible only under ultraviolet (UV) light. 1 expert acupuncturist then marked these same acupoints on the same volunteers using blue ink. None of the physician acupuncturists were able to see these marks on the skin under the standard fluorescent lighting used during point-marking sessions.	Intrarater agreement: A transparent template with a single point surrounded by a 0.5-cm radius circle was overlaid against the skin under the UV illumination using "best fit" to determine how many points fell within the circle. Interrater agreement: Localizations by the experienced acupuncturist were considered the "gold standard" with which the junior acupuncturists' marks were compared. Any mark that was on or within the 0.5 circle template centred on the expert acupuncturist's mark was counted as an	Agreement was expressed as total agreement probability (TAP) for the aggregated point locations. Intrarater agreement was very high for both junior acupuncturists. Each acupuncturist made 528 marks with 42 and 20 discrepancies with TAPs of 0.92 (95% CI, 0.89—0.94; $p < 0.05$) and 0.96 (95% CI, 0.94—0.97; $p < 0.05$), respectively. Interrater agreement: Agreement between the junior acupuncturists and between each junior acupuncturist and the expert acupuncturist was much less robust. Of 179 marks, there were of 93 and 78 disagreements with TAP of 0.48 (95% CI, 0.41—0.55; $p =$ not	Finding is clear despite the proximity of anatomical landmarks to each of the selected points, the similar training of the acupuncturists, and the calibration sessions.

						agreement, and any mark that was outside was counted as a disagreement.	significant) and 0.56 (95% CI, 0.49—0.63; p = not significant), respectively.	
Suko, 2011 [21]	Brazil	Controlled trial	Not stated	Healthy individuals without respiratory symptoms aged 11—76 years, mean age 35 years (n = 41) Male n = 20 Female n = 21 Long-time smokers (44—76 years old) n = 7	Acupoints from LU 1 to LU 11 that were drawn on participants according to locations from the Atlas of Acupuncture Chart SEIRIN—LUNG MERIDIAN were compared with similar points drawn using locations determined by Bi-Digital O-Ring Test electromagnetic field resonance phenomenon between 2 identical substances using a histological human lung slide by BDORT.	Identical matches, nonidentical matches, or partial matches were recorded.	Almost identical matches in all points n = 26 (63.4%) No identical matches at any point (n = 15) (36.5%). In all cases of no identical matches for LU 1, the new point was displaced in the direction of midpoint of thorax below the clavicle. On the arm, there was a medial deviation in comparison to the line obtained from the TCM points; for example, the new LU 9 point was located on the midpoint of the wrist.	Further research is required to understand the phenomenon, which can be temporary or permanent. The possibility of differences in the locations of acupuncture points of the lung meridian leads to questions such as: a. How often do deviations occur? b. Under what circumstances may deviations occur? c. What is the efficiency of stimulation by acupuncture on the traditional lung meridian points in these situations?
Wu, 2011 [12]	China	Controlled trial	n/a	Volunteers (n = 100) (age: 18—25 years, body weight: 64.0 ± 8.2 kg, and height: 169.3 ± 5.7 cm)	The distances of the bilateral isonym acupoints (ST 8), LU 2), etc.] or two sites on the body surface such as the bilateral nipples, CV 22, umbilicus, etc., were detected using a soft ruler or a detector in accordance with the methods of anthropometry for locating acupuncture points (GB/T 23237-2009, "National Standard")	Cun converted to mm for various body areas were calculated and then compared using descriptions from the book *"Lingshu Gudu"* and the current "National Standard".	The length of a cun differs across different body regions. With the exception of the distances between the superior border of the pubic symphysis and the superior border of patella and between the superior border of patella and the patella, the real distances are not identical to the descriptions in the	

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Table 1 (*continued*)

Author, year	Country	Method/ design	Participants*	Human models†	Intervention	Main outcomes measures	Results	Additional key findings or comments
							current "National Standard" on acupoints location. The distance between CV 22 and the umbilicus center and that between the umbilicus center and the superior margin of the pubic symphysis were identical to the descriptions of the book *"Lingshu Gudu"*,	
Yin, 2005 [13]	Korea	Controlled trial	n/a	(n = 93) Males (n = 43) Females (n = 50) Excluded due to lack of consent (n = 18)	Measurement of anthropometric data on contemporary Korean patients was made according to the cun measurement system. The following distances were measured in mm using a tape for body parts and calipers for fingers. Finger measurements were accurate to .10 mm. The B-cun measurement of body parts was performed by a tape measure as follows; • from the end of the body of the sternum to the umbilicus; • from the umbilicus to the upper border of the symphysis pubis; • between the two scapular bones at the level of the scapular spine;	To compare the results of the two cun methods, all B-cun measurements were transformed into F-cun lengths using standards of 1, 1.5, and 3 F-cun. The F-cun lengths calculated using three kinds of F-cun standards were compared by analysis of variance (ANOVA). The body mass index (BMI) was calculated, and individuals with a BMI of 25 or higher were considered to be obese, whereas those with a BMI below 25 were considered to be nonobese. The F-cun lengths of the obese and nonobese groups were compared using	F-cun measurements were significantly different from the B-cun measurements and varied significantly according to the arbitrarily selected F-cun standard. Greater differences in F-cun measurements were noted in the extremities of obese participants.	It is concluded that the F-cun method is unreliable. Suggested further research should be conducted to determine a more accurate point locating method primarily based on the B-cun method.

		• from the midpoint of the elbow crease to the midpoint of the distant wrist crease; • from the middle of the lateral side of the knee joint to the prominence of the lateral malleolus. The length of the F-cun standards was measured as follows: • the width of the interphalangeal joint of the thumb for 1 F-cun; • the width of the index finger and the middle finger at the level of the proximal interphalangeal joint of the index finger for 1.5 F-cun; • the width of all four fingers at the level of the proximal interphalangeal joint of the index finger for 3 F-cun.	the independent sample *t* test. The SPSS for Windows v11.0 statistical package was used. Two-tailed tests were performed, and significance was accepted at the level of $p < 0.05$.

* Participants refer to acupuncturists who took part in the trial. In trials in which only measurements were performed, participants were not relevant to outcomes, so were recorded as n/a.

† Studies measured variation on human models.

method/s that students had been instructed in. Other studies [17,18] used ruler or tape measures as a gold standard by which to measure the accuracy of the other methods is being investigated.

3.2.3. Palpation for tenderness

Palpation (either of a hollow or for tenderness) is a method used clinically in conjunction with any of the aforementioned methods [6,22,23]. Location by palpation for tenderness was investigated in one study and demonstrated no significant difference between pressure tolerated on genuine acupuncture points versus control points in healthy individuals [15]. However, interpretation of the results of this study is limited by the fact that the method of locating the "genuine" points was not stated.

3.2.4. Electronic point detectors

Another method not entirely dependent on either anatomical or cun system uses electronic point detectors that measure the electrical resistance of the skin. Located studies that measured electrical skin resistance examined the nature of acupuncture points or the reliability of the device being investigated rather than accuracy of point localization and thus were not included in this review.

3.2.5. Anatomical locations

All of the aforementioned methods rely at least to some extent on correct identification of anatomical landmarks. One study (by Rivers et al) investigating the anatomical method demonstrated a lack of agreement in the localization of points between participants [20]. However, another study (by Molsberger et al) found that points located in proximity to anatomical landmarks were located with less variance than other points [19].

3.2.6. Other point location methods

More than half (n = 5) of the included studies examining localization of acupoints did not state the point location method/s used [15,16,19–21]. Some used multiple methods. For example, skin resistance, "very point technique," intuition, Reflex-Auricula-Cardiaque (RAC), and palpation were identified as methods used by the participants in one study (by Baumler et al), yet did not adequately define palpation methods [16]. Most participants (78%) in this study also used the cun method, although it was not stated whether that referred to the directional or proportional method. All methods were found to be equally imprecise.

3.2.7. Other factors influencing accuracy and precision of acupoint location

Point location method may not be the only factor that influences point localization. Participants in all studies were either students or medical acupuncturists. Studies that reported medical acupuncturist training showed significant heterogeneity, with participants completed <100 to >500 hours of training for their qualification [16,19,20]. Length of training, experience, acupuncture style practiced, point location methods used, and country of origin were not correlated with any increase or decrease in congruity of localizations studies that documented these factors [16,17,19]. However, participants who were trained at the same school did demonstrate a higher congruence in localization in one study (by Baumler et al), although the point location method taught was not stated [16]. In another study (by Aird et al), localizations by student participants were clustered into quadrants in relation to "correct locations" as identified by individual lecturers, suggesting that students are influenced heavily by lecturer perceptions of accuracy [14]. However, other studies found a lack of congruence in localization despite similar training of participants [3,14,19] or prior calibration sessions [17,20].

4. Discussion

Inaccuracies observed in these studies appear large enough to affect clinical and research outcomes. Given the differences in accuracy and reliability in point location methods identified, it is essential that the acupuncture community critically examine and identify the most suitable point location methods for implementation in training and practice. Point location methods, individual practitioner skill, and practitioner education and training are key areas that have been identified as affecting point location accuracy and precision.

Accuracy is paramount when determining suitable point location methods, although methods must also be well accepted and practical to have successful implementation in clinical practice. The anatomical method of point location is widely considered to be the most accurate method [5] and benefits from being simple to implement in practice. However, conflicting results in studies that involved the anatomical landmark method challenge this view. Training was also a confounder in these studies, so the interface between point location method and the way in which training occurs warrants further investigation. Wide variance in the identification of surface anatomical landmarks has also been problematic in other health professions [24,25], suggesting that this issue may relate to factors beyond acupuncture-specific training.

The traditional directional (F-cun) method is popularly used by practitioners, most likely due to its ease of use, but may be unsuitable for clinical or research purposes due to its inaccuracy. Although the proportional method was found by this review to result in similar inaccuracy and imprecision as the directional method, most studies on proportional method did not report participant training, which may be particularly problematic considering the proportional method is heavily skill dependant, relying on mental calculations and manual dexterity to achieve good outcomes. As such, decisions around the utility of proportional method require further study of the method with trained practitioners.

Elastic and ruler methods were more precise but were not well received by participants in this review. However, it is unclear whether this finding was due to lack of training or familiarity in these methods rather than the methods themselves. These two methods are more technical in application than either the directional or proportional methods but are less skill dependent. Lower dependency on individual practitioner skill could be the reason for better accuracy using these methods compared to others. Existing

measuring tools, such as the "ACI- or Acu-Locator" expandable ruler, may reduce inaccuracy of the direct measurement method because calculations are not required. However, although more accurate, there may be problems in achieving acceptance, uptake, and implementation of these methods in practice. As such, further research on barriers and facilitators of implementation of more accurate point location methods may be warranted. Given their unequivocally higher accuracy in our review, ruler or elastic methods [3] should be considered for use as the gold standard for locating acupuncture points as controls in future studies on accuracy in point location and encouraged for implementation in clinical practice.

The notion that any of the aforementioned methods should be combined with palpation to effect an accurate location [6,22,23,26] is almost universally accepted in clinical practice [26]. However, there appears to be insufficient empirical evidence to confirm the use of palpation as a suitable adjunctive point location method. There is relatively little research on whether combining these approaches results in accuracy or clinical improvements, suggesting that this may be a fruitful area for further investigation.

The degree of variance in point localization among practitioners is sufficient to raise concerns regarding safety and efficacy of treatment. A number of acupuncture points lie in close proximity to arteries and other structures prone to damage by needling [1,5]. Serious adverse events associated with acupuncture treatment are rare; however, local trauma, neural injuries, aneurysms, injuries to the eyes, and broken needles are all potential adverse outcomes that have been reported due to the incorrect site being needled [4,27].

There is also the possibility of no response or a detrimental response to clinical treatment if a nonpoint or nearby acupoint is inadvertently needled due to inaccurate or imprecise point location. Many acupoints carry specific indications not shared by acupoints in their proximity. HT 6, for example, is indicated for night sweating, whereas nearby acupoints HT 5, HT 7, PC 6, and PC 7 are not [1]. The variability of point localizations contributes to both sides of the ongoing debate about the specificity of acupuncture points and the attendant need for accuracy. Failure to needle the intended acupoint may be a factor in poor or variable patient outcomes and may even potentially invalidate results of research, particularly if imprecise and inaccurate point location has extended to use of "sham" control points. To reduce the impact of imprecise or inaccurate point location on research error, direct measurement method by a ruler or elastic should be encouraged in locating of "verum" acupoints in all future clinical trials.

The similarity of outcomes in some "sham" versus "verum" acupuncture also raises the question about the size of acupuncture points. Some authors have suggested that acupuncture points could be better described as a "field of fuzziness" and may be an alternate explanation for seemingly nonspecific effects of acupuncture [19]. While this infers that it would be easier to needle an intended acupoint, decreasing the need for accuracy, it would also be easier to needle a nearby acupoint inadvertently, making the need for accuracy even more critical. These ongoing debates, coupled with the findings of our review which suggest inconsistency of acupoint location in practice, demonstrate that further research on the anatomical and histological entity of acupoints in the skin is necessary.

Point location is a highly skill-dependant activity. The role of method-specific training is unclear due to lack of reporting in many studies. Reporting of relevant background of participating practitioners is essential an acupuncture studies [28]. Lack of ongoing maintenance of skills or lack of reskilling may contribute to discrepancies and variability in point location even among experienced acupuncturists. As such, further research on the impact of training on point location precision and accuracy is warranted, in relation to both anatomical and acupuncture-specific training.

This review does have some limitations. Studies to date have only included either students or medical acupuncturists as participants, limiting the findings of this review to a subset of the acupuncture community. Similarly, small numbers of participants in some studies and lack of reporting on participant training highlight the need for further research rather than allowing for analysis of results in many areas. The most significant limitation of this review is that Chinese databases were not searched, although articles written in Chinese language indexed in the major international databases were included. Our search terms were comprehensive but may still have missed relevant articles, especially any not available in electronic format. Nevertheless, this article represents an important first step toward uncovering the most accurate and precise point location methods and factors that might affect the application of these methods.

5. Conclusion

Research to date has identified point location methods and practitioner skill as the two crucial factors that determine this accuracy and precision in point location. Given the clear and obvious significance of point location for effective and safe acupuncture treatment, further examination of this area is required.

The lack of accuracy and precision in qualified and experienced acupuncturists is a cause for concern. The most suitable point location method for clinical work is still to be elucidated based on accuracy, ease of use, and practitioner acceptance. Some methods, such as the directional (F-cun) method, are demonstrably inaccurate and imprecise and should be discouraged from stand-alone use in both clinical practice and research. However, more precise and accurate methods may be difficult to implement in practice due to low practitioner acceptance or familiarity.

Pending the outcome of further studies, it would be prudent to use either of the most precise ruler or elastic methods clinically and in research, which may require reskilling of practitioners.

Disclosure statement

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