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# Abdominal examination using pressure pain threshold algometer reflecting clinical characteristics of complementary and alternative medicine in Korea

## A systematic review and a brief proposal

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**Abstract**

**Background:** A review was conducted to determine a pressure algometry measurement during abdominal examination that reflects clinical settings of traditional Korean medicine.

**Methods:** After reviewing the previous studies, we have proposed a reference index, common posture and method for performing pressure algometry during abdominal examination. Keyword search using eight databases was performed. To identify the characteristics of pressure algometry during abdominal examination, keywords (e.g., abdomen, abdominal examination) were searched in national Korean databases, including Korean studies Information System (KISS), Research Information Sharing Service (RISS), and Oriental Medicine Advanced Searching Integrated System (OASIS). To examine the methods of measuring pressure pain threshold (PPT) with validity and reliability, combination keywords (e.g., PPT, pressure algometry, pressure pain, validity, reliability) were searched in Pubmed, Cochrane library, Google scholar, Ovid Embase, and China Knowledge Resource Integrated Database (CNKI).

**Results:** A total of 652 articles were identified, and 22 relevant articles were included. The following main indices are proposed as a standardized pressure algometry method during abdominal examination: unit of measurements, measuring tools, target locations, pressure area, pressure rate, posture of patients, and evaluators. Based on the results of the review combined with clinical practice, useful indices for pressure algometer during abdominal examination were derived (target location: CV 12, unit of measurement: MPa, pressure area: 4 $cm^2$, pressure rate: 0.098 MPa/s, posture of patient: supine position, number, and intervals of measurement: three consecutive measurements at intervals of 30 seconds, 5 minutes rest prior to commencement). Postures and method sequence of pressure algometry during abdominal examination are also proposed.

**Conclusions:** Using standardized indices, postures and method for abdominal examination in clinical settings will help make objective assessments.

**Abbreviations:** CAM = complementary and alternative medicine, PPT = pressure pain threshold, TKM = traditional Korean medicine.

**Keywords:** abdominal examination, algometer, complementary and alternative medicine, pressure algometry, pressure pain threshold (PPT), traditional Korean medicine

## 1. Introduction

According to the traditional Korean medicine theory and as one of the complementary and alternative medicine diagnostic methods, abdominal examinations judge a patient's state (e.g., deficiency, excess, cold, heat) by touching the patient's ribs or abdomen to feel the elasticity, thickness, and tension of the abdominal muscle.[1,2] The quantitative properties of abdominal

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examination in traditional Korean medicine (TKM) are relatively stronger in comparison with other diagnostic methods such as asking the patient about the degree of subjective symptoms or examining the external appearance of patients. However, there may be some subjective assessments in abdominal examination, because this is a manual process and has many variations depending on the clinical experience and skill of the examiner. Thus, it is necessary to attempt to acquire objective and quantifiable evaluation indices of abdominal examinations.[3]

According to Kim et al (2016),[4] who analyzed the trends of national research related to abdominal examinations, the majority of national research in traditional Korean medicine was through literature studies and case reports. Moreover, there are no standardized procedures or measures of abdominal examination, and the clinical applicability of diagnostic quantities was low. The accuracy and reliability of measurements made using different criteria and procedures in each study are questionable. Thus, consensus on the standardized method of abdominal examination is essential in clinical settings as well as research.

To acquire objective and quantifiable evaluation indices of abdominal examination, Ko et al (2015)[5] and Lee et al (2016)[3] suggested applying pressure algometry during abdominal examination. Pressure algometry estimates the mechanical sensitivity of the muscles under pressure with an algometer.[6] Pressure pain threshold (PPT) is measured with pressure algometry, and determines the point at which a non-painful pressure stimulus turns into a painful pressure sensation. Several studies have been conducted to determine valid and reliable PPT measurement methods, and guidelines for PPT measurement on the craniofacial muscle using an algometer have also been suggested.[7] However, since the target diseases of the PPT measurement studied so far include myofascial pain syndrome and musculoskeletal disorders, there is no consensus on how to measure PPT using the algometer for the abdominal region.

Therefore, in order to standardize the measurement and index of pressure algometry during abdominal examination, which is widely used in clinical practice, the current study reviewed previous Korean as well as international studies and suggests a method of pressure algometry during abdominal examination which reflects the clinical and research characteristics of complementary and alternative medicine (CAM) in Korea.

## 2. Methods

### *2.1. An overview of research methods*

This study first derived reference indices for pressure algometry during abdominal examination by reviewing previous studies, and suggested postures based on these indices. A two-directional literature review was performed. A literature search using Korean web databases was conducted to identify characteristics of pressure algometry measurement during abdominal examination of TKM. To investigate the use of PPT algometer with reliability and validity, a literature search of foreign databases was conducted. Based on the results of the review, the evaluation index to be considered during abdominal examination was derived. Finally, we briefly proposed a standardized measurement method for evaluation of pressure algometry and postures of the patient when performing abdominal examination (Fig. 1). The ethical approval or patient informed consent were not necessary because this study is a systematic review and a brief proposal for abdominal examination using pressure pain threshold algometer reflecting clinical characteristics of complementary and alternative medicine in Korea.

### *2.2. Literature search*

The research was conducted from January 28, 2019 to February 28, 2019 using several databases including RISS, KISS, OASIS, Cochrane Library, Google Scholar, Pubmed, Ovid Embase and CNKI. We searched the literature with the following keywords: "abdomen (in Korean and English)," "abdominal region (in Korean and English)," and "abdominal examination (in Korean and English)" in the title or abstract using KISS, RISS and OASIS, which are Korean databases. Then, only the studies which used PPT algometer to measure pressure were selected from the search results. Using Pubmed, Cochrane library, Ovid Embase, and CNKI, we performed a

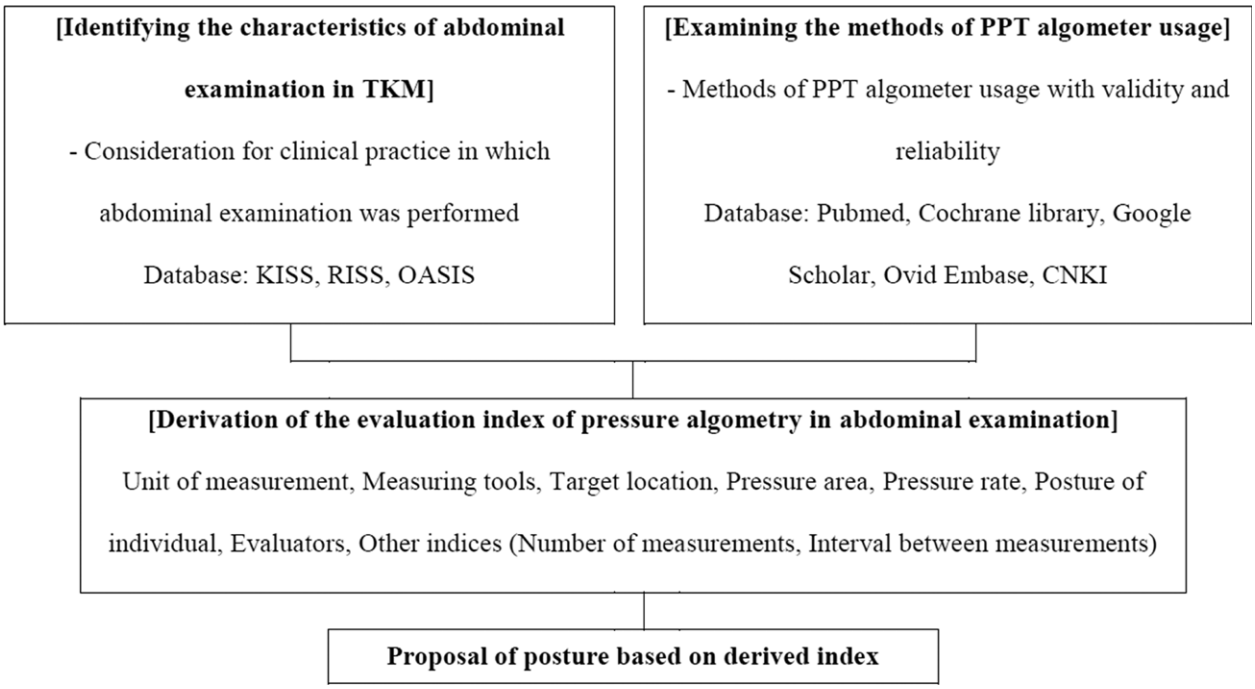



**Figure 1.** Flow diagram of the review.

literature search with the following keywords: "PPT algometer," "algometry," "Pain pressure threshold" in the title or abstract. In order to extract a standardizing method of PPT algometer usage, we selected the research that simultaneously included the above keywords and "Validity" or "Reliability." The publication date of the literature was limited to December 31, 2018. Case reports were excluded from the selection. Studies were included only when the entire text was available. Only papers described in Korean or English were selected, while papers searched in CNKI were selected only when abstracts were provided in English. The selection criteria were set to meet the research theme and the papers were selected accordingly (Table 1).

However, only a few studies examined the reliability and validity of pressure algometry while meeting the criteria for selection in KISS, RISS, OASIS, and CNKI. Four studies that failed to meet the criteria for selection were included with the aim to identify how the abdominal examination is performed in the clinic or research of East Asian traditional medicine. The current study included three studies[10,13,24] that targeted unhealthy people and one study[18] that aimed at measuring the value of PPT only.

### 2.3. Identification of the evaluation index

When performing pressure algometry using PPT algometer, various factors must be considered to ensure the validity of the measured values. Fischer et al (1987)[8] presented PPT reference standards for each muscle in healthy people and identified target locations, pressure area, pressure rate, and posture of individuals that should be considered when performing pressure algometry to assess abnormal tenderness in clinical practice. We also checked the unit of measurement, resting time before starting the measurement, and other indices (e.g., the number and intervals of measurements) related to pressure algometry during abdominal examination.

To estimate pressure rate, the pressure area and the rate of increase applied per unit time (1 second) were considered together and converted to the international standard MPa for comparison between papers (1 kgf/cm$^2$ = 9.81 N/cm$^2$ = 0.098 MPa).

## 3. Results

### 3.1. Flow of literature search

The flow diagram of the study selection is presented in Figure 2. Only publications that had been published until December 2018 and could be searched by electronic databases were searched.

### 3.2. Characteristics of studies

In a total of 22 studies, 645 healthy people and 148 unhealthy people were analyzed. There were 271 males and 522 females. Three studies analyzed only women, while no papers analyzed only men. Nineteen studies analyzed both men and women.

All 22 studies measured PPT using a handheld algometer and additionally indentation depth,[3] conditioned pain modulation (CPM) PPT,[9] and pressure depth[3] were also measured in some studies. Measuring tools included FDIX 50, FDK 20, FDK 30, FDN 100, FDN 200 (Wagner instrument, Connecticut), DD-500 (Instrutherm Measuring instruments, São Paulo, Brazil), PTH-AF2 (Pain Diagnostic and Treatment Corporation, New York), and algometers commercially available from Pain Diagnostics and Thermography (NY), Somedic SenseLab AB (Sweden), and J-Tech Commander™ (Wisconsin), and Sauter (Balingen, Germany). The modified algometer[10] or computerized indentation system[11] was designed and used for comparison with a commercial handheld algometer. One publication[12] did not specify the exact company name or product name of the algometer.

The important items commonly found in each publication and outcome of the studies are described in Table 2.

### 3.3. Results from data extraction

We retrieved common evaluation indices for pressure algometer during abdominal examination including target locations, pressure area, pressure rate, posture of individual, evaluators, and other items in each study.

***3.3.1. Target locations*** Pain pressure measurements were acquired for various areas. For studies conducted in Korea, a few studies measured only one location in the abdomen,[3,5,10] while other studies compared abdominal measurements with other measurement locations not in the abdomen.[13] The studies which examined the reliability or validity of algometer measurement methods measured the back, shoulders, arms, and lower limbs alone or in combination depending on the purpose of the study.

***3.3.2. Pressure area*** Fifteen studies have adopted a 1 cm$^2$ pressure area. Lee et al (2016)[3] adopted the area of 3 cm$^2$ and three studies[14–16] used a tip with 1 cm diameter. The round or circular tip was the most commonly used. Three studies[10,11,17] did not refer to the area or shape of the algometer tip.

***3.3.3. Pressure rate*** Pressure rate was kept constant in all studies except for Kelly-Martin et al (2018)[17] who did not refer to exact numerical values. The rate of increase was between approximately 0.01 MPa/s (100 g/s)[8] and 0.098 MPa/s (1 kgf/

**Table 1**

**Inclusion/exclusion criteria.**

| | Inclusion | Exclusion |
|---|---|---|
| Individuals, population | - Healthy individuals (asymptomatic)<br>- Recruiting healthy and unhealthy individuals | - Recruit only unhealthy individuals<br>- Recruit only specific age groups (old age, infant) |
| Intervention | Not applicable | Not applicable |
| Comparison | Not applicable | Not applicable |
| Instrument and outcome values | Pushpull gauge, pressure pain threshold | Aesthesiometer |
| Measurement location | Including trunk | - Teeth<br>- Only fingers or toes<br>- Only cephalic region |
| Language | English (papers written in Chinese that provide abstract in English), Korean | Other languages |
| Studies (international) | Reliability and validity of Pressure pain threshold measurement method | Measuring only the value of Pressure pain threshold |
| Studies (national) | Pressure algometry in abdominal examination | Other than pressure algometry in abdominal examination |

**Table 2**

**Study characteristics.**

| Author (yr of publication) | Population | Outcome | Device | Target location; main position – number of points‡ | Probe size | Pressure rate | Posture of patients | Evaluators | Detailed method of Pressure algometry<br>#: Number of measurements in the same location<br>R: Measurements between locations were conducted in randomized order<br>T: Test measurements were conducted prior to commencement | Interval between measurements (on the same location) | Resting time prior to commencement |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lee et al (2016) | 15 healthy individuals (M 6, F 9) | Indentation depth (mm)<br>PPT (kg/cm$^2$/s) | FDIX 50, Wagner instruments, USA | Abdomen—1 | 3 cm$^2$ | 1 kg/cm$^2$/s | Supine position (full relaxed, with knee stretched out) | 2 well-trained investigators | #: 2 | 1 min | NA |
| Ko et al (2016) | 36 patients with epigastric discomfort or pain (M 8, F 28) | PPT (kg/cm$^2$) | 1. FPK 20®, Wagner instruments, USA<br>2. Modified algometer (developed by Kyungmo Park) | Abdomen—1 | NA† | NA† | Supine decubitis position on the bed* | 1 TKM practitioner | #: 2 | 1 min | 5 min* |
| Ko et al (2015) | 12 healthy individuals & 21 patients with functional dyspepsia (M 6, F 27) | PPT (kg/cm$^2$) | FDK 20, Wagner Instruments, Greenwich, CT, USA | Abdomen—1 | 1 cm$^2$ | 1 kg/cm$^2$/s | Supine decubitis position* | 2 examiners with more than 3 yr of clinical experience | #: 2 | 1 min | 5 min* |
| Kang et al (2012) | 30 patients with Burning Mouth Syndrome (M 7, F 23) | PPT (kg/cm$^2$) | Algometer (Wagner Instruments, CT, USA) | Abdomen—1<br>Lower limbs—1 | 1 cm$^2$ | 0.5 kg/cm$^2$/s | Lying on bed | 1 well-trained investigator | #: 2 | NA | 5 min |
| Ko et al (2011) | 28 patients with Irritable Bowel Syndrome, diarrhea-predominant (M 20, F 8) | PPT (kg/cm$^2$) | FDK 20, Wagner Instruments, USA | Abdomen—13<br>Back—4<br>Upper limbs—2<br>Lower limbs—2 | 1 cm$^2$ | 0.5 kg/cm$^2$/s | NA | 1 well-trained TKM practitioner | #: 2 | NA | NA |

(*Continued*)

**Table 2**
(*Continued*)

| Author (yr of publication) | Population | Outcome | Device | Target location; main position – number of points‡ | Probe size | Pressure rate | Posture of patients | Evaluators | Detailed method of Pressure algometry<br>#: Number of measurements in the same location<br>R: Measurements between locations were conducted in randomized order<br>T: Test measurements were conducted prior to commencement | Interval between measurements (on the same location) | Resting time prior to commencement | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eva Kosek et al (1993) | 12 healthy volunteers (F 12) | PPT (kPa) | Hand-held electronic pressure algometer (Somedic AB®, Farsta, Sweden) | Head—2<br>Neck—4<br>Back—19<br>Upper limbs—3<br>Lower limbs—2 | A diameter of 10 mm (Round) | 50–60 kPa/s | Relaxed prone position | 1 investigator | #: 2<br>R<br>Same measurements were repeated after 1 wk and approximately 10 wk (10–13 wk) later | 3–10 s | NA | |
| Bisset et al (2015) | 13 healthy participants (M 5, F 8) | PPT (kPa) | Electronic pressure algometer (Somedic AB, Hörby, Sweden) | Back—2<br>Shoulders—2<br>Upper limbs—2<br>Lower limbs—2 | 1 $cm^2$ | 40 kPa/s | Prone | 2 undergraduate physiotherapy students | #: 3<br>R<br>T | 30 s (cluster protocol)<br>1 measurement of PPT was acquired at each of the 8 anatomical locations and "the circuit" was repeated a total of 3 times (Circuit protocol) | NA | |
| Koo et al (2013) | 16 healthy volunteers (M 8, F 8) | Computerized indentation:<br>PDT (pressure discomfort threshold) ($kg/cm^2$)<br>PPT ($kg/cm^2$)<br>Manual (handheld):<br>PPT ($kg/cm^2$) | Custom-made computerized indentation system<br>Handheld: FDN 100, Wagner Instruments, Greenwich, CT | Back—6 | Computerized indentation: 1 $cm^2$<br>Handheld: NA | Computerized indentation: 2 mm/s<br>Handheld: ~1 $kg/cm^2/s$ | Computerized indentation: lying prone on a treatment table with a headrest<br>Handheld: Relax completely, exhale to a comfortable extent, and suspend breathing | Handheld: 1 senior doctor of chiropractor student | #: 5<br>R | 45 s | NA | Handheld PPT measurements were performed according to the standard protocol described in Pöntinen et al (1998)[39] |
| Waller et al (2015) | 20 pain-free individuals (M 10, F 10) | PPT (kPa) | Algometer (Somedic AB, Sweden) | Back—2<br>Upper limbs—1<br>Lower limbs—1 | Circular, 1 $cm^2$ | 50 kPa/s (over a 10 s period) | Positioned in a standardized manner | 5 female research assistants | #: 2<br>T | 10 s | NA | |

(*Continued*)

**Table 2**
(*Continued*)

| Author (yr of publication) | Population | Outcome | Device | Target location; main position – number of points‡ | Probe size | Pressure rate | Posture of patients | Evaluators | Detailed method of Pressure algometry<br>#: Number of measurements in the same location<br>R: Measurements between locations were conducted in randomized order<br>T: Test measurements were conducted prior to commencement | Interval between measurements (on the same location) | Resting time prior to commencement | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Montenegro et al (2012) | 21 healthy women | PPT (kg/cm$^2$) | Instrutherm DD-500 pressure algometer, instrutherm Instrumentos de Medição Ltda., Brazil | Abdomen—14 | 1 cm in diameter | 1 kg/cm$^2$/s | Supine position | 2 examiners (A, B) | #: 3<br>R<br>T | 5 s | NA | |
| Pelfort et al (2015) | 50 healthy volunteers (M 25, F 25) | PPT (kPa) | Handheld electronic pressure algometer (Somedic Sales, Hörby, Sweden) | Lower limbs—1 | 1 cm$^2$ | 20 kPa/s | Knee flexed at 90° | 2 trained raters | #: 3<br>T | 1 min | NA | The method described by Nussbaum et al (1998)[12] was used to determine PPT |
| Nussbaum et al (1998) | 35 individuals without complaints of pain (M 5, F 30) | PPT (kg/cm$^2$) | Fischer algometer | Upper limbs—1 | 1 cm$^{[2]}$ | 1 kg/cm$^2$/s | Sitting with their test arm positioned on a padded support in 90° of horizontal abduction, with full elbow extension and forearm supination | 2 physical therapists with many yr of clinical experience | #: 3<br>T<br>PPT was measured during 3 consecutive d by each examiner | 10 s | NA | |
| Potter et al (2006) | 10 asymptomatic individuals (M 5, F 5) | PPT (kg/cm$^2$) | PTH-AF 2, pain diagnostic and treatment corporation, NY, USA | Back—8 | 1 cm$^2$ | 1 kg/s | NA | 1 registered osteopath with 15 yr of experience | R<br>T<br>Individuals attended on three occasions (separated by the period of at least a wk) and at each visit the muscles were tested in the same order on two occasions | 5 min | NA | |

(*Continued*)

**Table 2**
(*Continued*)

| Author (yr of publication) | Population | Outcome | Device | Target location; main position – number of points‡ | Probe size | Pressure rate | Posture of patients | Evaluators | Detailed method of Pressure algometry<br>#: Number of measurements in the same location<br>R: Measurements between locations were conducted in randomized order<br>T: Test measurements were conducted prior to commencement | Interval between measurements (on the same location) | Resting time prior to commencement | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fischer et al (1986) | 50 healthy individuals (M 24, F 26) | PPT (kg/cm$^2$) | Pressure threshold meter (pain diagnostics and thermography, NY, USA) | Back—16<br>Upper limbs—2 | 1 cm$^2$ | 100 g/s | Prone<br>Sitting position (M. pectoralis major) | NA | NA | NA | NA | |
| Jakorinne et al (2018) | 33 individuals with unilateral or bilateral knee OA (M 9, F 24) and 32 healthy volunteers (M 20, F 12) | PPT (kg/cm$^2$) | Hand-held digital pressure algometer (SAUTER, Balingen, Germany) | Lower limbs—3 (for TDT and PPT measurement) | 1 cm$^2$ | 0.5 kg/s | Sitting position with the knee flexed at 90º. | 2 trained physicians | #: 3<br>R | NA | NA | |
| Kelly-Martin et al (2017) | 59 individuals with normal abdominal tissue (M 28, W 31) | PPT (N) | The Wagner model FDIX digital pressure algometer | Abdomen—1 | NA | Gently and slowly pressed into the selected point | Lay supine on a plinth with arms at their sides and legs straight | 3 physical therapy students and 1 experienced physical therapist | #: 2 | 1–3 min | NA | |
| Marcuzzi et al (2017) | 42 healthy people (M 21, F 21) | PPT (kPa)<br>CPM PPT (conditioned pain modulation, kPa) | FDK40, Wagner Instrument | Back—2<br>Hands—1 (for PPT measurement)<br>Back—1 (for CPM PPT measurement) | 1 cm$^2$ | 50 kPa/s | NA | 1 DFNS-trained researcher | #: 3<br>T | NA | NA | CPM PPT conditioning stimulus: cold bath - foot contralateral side |

(*Continued*)

**Table 2**
(*Continued*)

| Author (yr of publication) | Population | Outcome | Device | Target location; main position – number of points‡ | Probe size | Pressure rate | Posture of patients | Evaluators | Detailed method of Pressure algometry<br>#: Number of measurements in the same location<br>R: Measurements between locations were conducted in randomized order<br>T: Test measurements were conducted prior to commencement | Interval between measurements (on the same location) | Resting time prior to commencement | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nothnagel et al (2017) | 22 healthy volunteers (M 10, F 12) | PPT (kPa) | FDN200, Wagner Instruments, CT, USA | Back—1<br>Hands—1 | 1 $cm^2$ | 50 kPa/s | NA | 1 DFNS-trained examiner | #: 3 | NA | NA | |
| Aytar et al (2014) | 100 healthy individuals (M 23, F 77) | PPT ($lbs/cm^2$) | Pressure algometer (J-Tech Commander, WI, USA) | Back—1<br>Upper limbs—1<br>Feet—1 | 1 $cm^2$ | 2 pounds/s | Sitting with hands rested on a table (supraspinatus tendon and the extensor digitorum communis muscle belly)<br>Aside-lying position (Anterior talofibular ligament) | 2 physical therapists with 11 yr of experience | #: 3<br>T | 60 s | NA | |
| Lacourt et al (2012) | 66 healthy individuals (F 66) | PPth (kPa)<br>PPtol (pressure pain tolerance)<br>pressue-pain rating | FDX 50, Wagner Instruments | Back—2<br>Upper limbs—2<br>Lower limbs—2<br>(for PPth measurement)<br>Hands—1<br>(for PPtol measurement) | 1 $cm^2$ | 98 kPa/s | Prone position on a massage table with the head facing down in a face res (PPth)<br>Sitting in a chair (PPtol) | 1 trained investigator | #: 3<br>T<br>to enable the investigator to increase the pressure at a constant rate, a digital metronome was used to indicate 1 s time intervals (with soft ticking sounds) | 30–40 s | NA | PPth: the pressure at which the participant first indicated that pressure becomes unpleasant<br>PPtol: the maximum pressure at which the participant indicated that pressure becomes too painful |

(*Continued*)

**Table 2**
(*Continued*)

| Author (yr of publication) | Population | Outcome | Device | Target location; main position – number of points‡ | Probe size | Pressure rate | Posture of patients | Evaluators | Detailed method of Pressure algometry<br>#: Number of measurements in the same location<br>R: Measurements between locations were conducted in randomized order<br>T: Test measurements were conducted prior to commencement | Interval between measurements (on the same location) | Resting time prior to commencement |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Chen et al (2010) | 37 healthy individuals (M 18, F 19) | PPT (kg/cm$^2$) | FDK20, Wagner Instruments | Head—2<br>Neck—2<br>Back—4<br>Hands—2<br>Lower limbs—2 | 1 cm$^2$ | 0.5 kg/cm$^2$/s | Sitting on the chair with neck and shoulder muscle relaxed (M. mastoid and M. trapezius)<br>Sitting with hands positioned flat on the table to keep hands muscle relaxed (Muscle of dorsal hands)<br>Lying on the examination bed with waist and calf muscle fully relaxed (muscle of back and lower limbs) | 1 rater | #: 3 | NA | 10 min |
| Frank et al (2012) | 33 asymptomatic participants (M 13, F 20) | PPT (kPa) | Somedic Algometer Type II, Sweden | Back—3 | A diameter of 1 cm | 40 kPa/s | Lie prone | 1 examiner | #: 3<br>R<br>T | 10 s | NA |

PPT = pressure pain threshold, TKM = traditional Korean medicine.
*No reference of algometer. AE was manually conducted.
†The process of the measurement followed the guidelines from Fischer (1987).[8]
‡Left or right side were each counted. If there was no reference regarding which side was used, it was counted as one side.

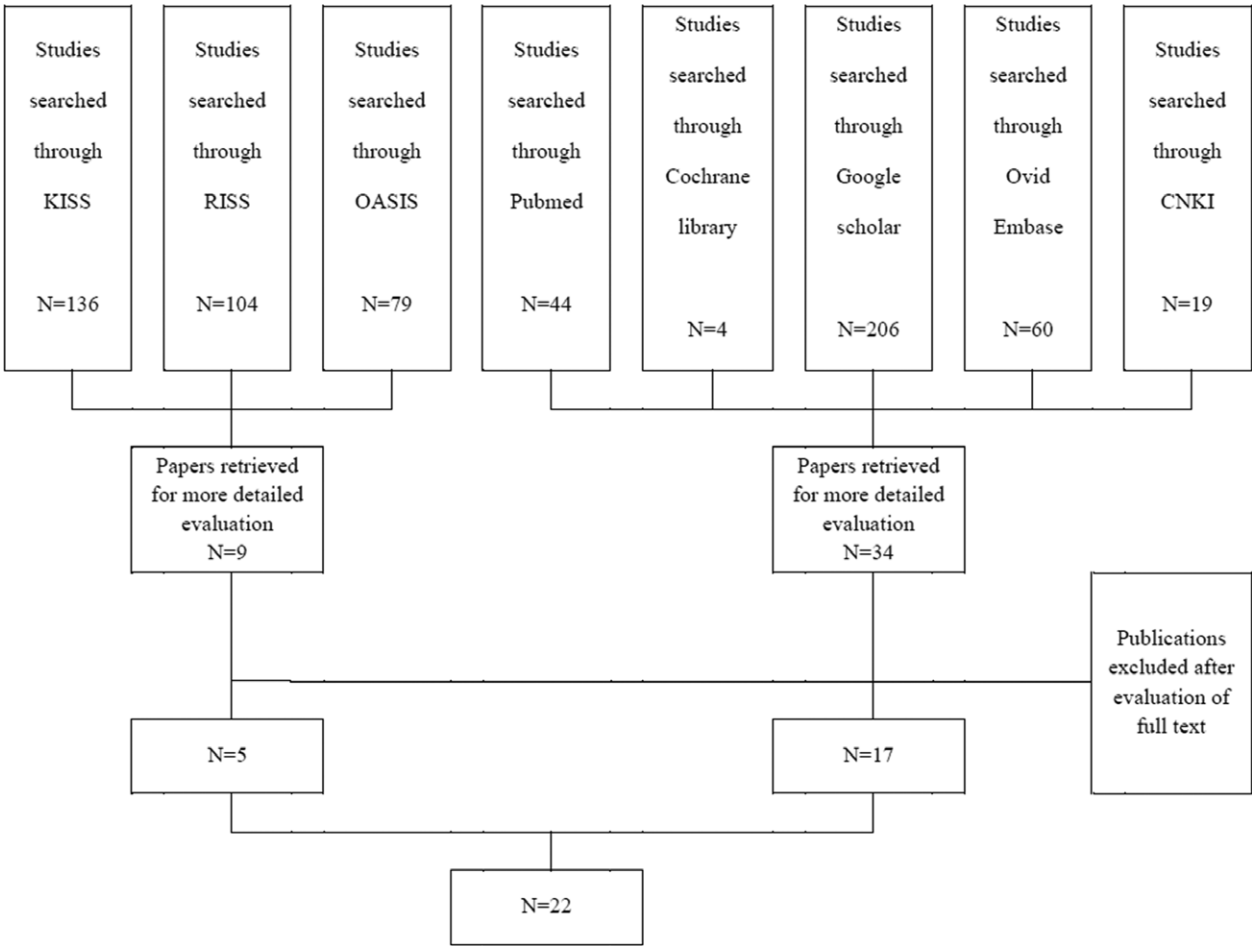



**Figure 2.** Flow diagram of publication selection.

$cm^2$/s). The rate of 0.049 MPa/s (0.5 kgf/$cm^2$/s) or 0.098 MPa/s (1kgf/$cm^2$/s) was most commonly studied.

***3.3.4. Posture of individuals*** Individuals were placed in a comfortable position during the measurement, with the measurement location visible. A supine or supine decubitis position for the abdomen, a prone position for the back or lower back, and a sitting position for the upper or lower limbs was mainly used. In four studies,[5,10,13,18] individuals rested before the measurement. Seven studies[9,14–16,19–21] performed a test pressure algometry on the same or different measurement locations before starting the measurement.

***3.3.5. Evaluators*** Nine studies[3,5,12,15,17,20–23] performed pressure algometry using the same measurement method by two or more operators. Evaluators included physicians,[20] CAM doctors,[5,10,24] osteopaths,[19] physical therapists,[12,17] and researchers (DFNS-trained)[9] who were familiar with algometer usage. Individuals not familiar with the usage of the algometer were trained appropriately prior to acquiring measurements.[9,11,20,25,26]

***3.3.6. Other indices*** Other indices of pressure algometry have been used in various ways in each study. The interval between repeated measurements at the same location varied from 3 seconds[14] to 5 minutes.[19] Eight studies[8,9,13,17,18,20,24,26] performed only one measurement at the same location or did not specify the interval between repeated measurements clearly. In case of repeated measurements, all values were averaged, or only specific values among the results were combined to calculate the average.

## 4. Discussion

The current study reviewed previous studies and identified an index to be considered in pressure algometry during abdominal examination in order to standardize the clinical or actual practice of CAM in Korea. Finally, by deriving a representative value from the results, we could determine standardized postures for the patients and the evaluators in the clinic or research.

In Korea, Acupoint CV 12 and acupoint CV 14 are the main target locations studied to standardize the PPT measurement during abdominal examinations.[4] In CAM clinical practice, abdominal examination distinguishes between diseases and at the same time identifies the function of the whole body. In particular, abdominal examination is used when assessing functions related to the digestive system, and acupoint CV 12 is a representative site for diagnosis and treatment as the Front-Mo point (腹募穴) of stomach meridian (胃經).[27] Thus, if the main goal of the abdominal examination is to evaluate the functional system associated with digestion such as the spleen system (脾系) or the stomach system (胃系), evaluators could perform pressure algometry on acupoint CV 12 as a representative area. PPT values measured by pressure algometry may differs depending on many factors as sex or general condition of subject, local condition of target points, investigator, and apparatus.[28] Lower algometer scores would indicate increased point tenderness or pain sensitivity. PPT measured on acupoint CV 12 would reflect local tenderness and, furthermore, the state of the spleen system (脾系) and the stomach system (胃系) in TKM clinical situations. If the goal of abdominal examination is to evaluate other functional systems of the body, other locations could be selected.

Measurement units were expressed in kg/$cm^2$ or g/s, or pounds in some studies. However, kg is the unit of mass, and the

unit of force applied when measuring the PPT is to be denoted as N or kgf. According to the International System of Units,[29] the recommended pressure units are Pa or $N/m^2$. Because PA measures the force applied per unit area, Pa or $N/m^2$ should be used. Since the use of kgf is limited in international standards, it should be converted to N and denoted as N per unit area or Pa.

A round tip and 1 $cm^2$ pressure area was used in most studies. In myofascial pain syndrome or joint related diseases, PPT can be calculated according to the pressure applied to 1 $cm^2$, which is equivalent to the area of one fingertip touched to a body point. However, CAM doctors in Korea use four fingers, rather than just one finger during abdominal examination.[30] Therefore, it is necessary to press an area of approximately 3 to 4 $cm^2$, corresponding to the ends of three or four fingers touching the surface of the abdomen, rather than pressing the area of 1 $cm^2$ in order to perform abdominal examination in a state similar to clinical situations.[3,31] It is also necessary to use an elliptical or a rectangular tip with rounded edges similar to the shape of fingertips when aligned. Except for Kelly-Martin et al (2018),[17] where values were not expressed in exact numerical figures, the pressure rate was kept constant in many studies and the rate of increase was approximately 0.01 MPa/s (100g/s)[8] to 0.098 MPa/s (1 kgf/$cm^2$/s). Initial pressure could be chosen within this range, but the increase rate should be constant. The current study proposes to apply the rate of 0.098 MPa/s (1 kgf/$cm^2$/s ≒ 0.1 MPa/s) as an example based on previous studies conducted in Korea.[3,10] It is also necessary to use a variety of supplementary methods to maintain a constant pressure rate. For example, it is possible to use an assistance tool,[32] to have evaluators trained,[9,11,20,25,26] or monitor the rate of pressure increase,[3] and to develop a device that maintains a constant rate of pressure.

When measuring PPT, individuals were positioned to the most comfortable position also ensuring that the areas of contact were clearly visible. Individuals can be in supine position and at the same time the target location is well exposed when performing abdominal examination. When performing abdominal examination in CAM, the patient's supine posture differs from that in western medicine. The supine position in western medicine bends the knee to soften the tension of the abdominal wall, but the supine position in CAM keeps its natural condition by spreading the knees. At this time, to avoid the risk of misdiagnosis, it is better that patients maintain a relaxed position.[33] Some studies[5,10,13,18] have allowed individuals to have a 5- or 10-minute rest before the first measurement. According to IASP terminology,[34] pain includes the emotional aspect of a person who feels pain. Therefore, to relax the psychological or physical conditions that may affect the perception of pain, a certain time of rest is required before measurement. It is recommended to ask participants more detailed information about their daily eating habits and bowel movements prior to commencement of abdominal examinaion.[33] This also can help patients to take a break to relax. The resting time may be 5 to 10 minutes based on previous studies, but time may be adjusted according to patient's condition so that the examination can be performed when the patient is comfortable.

When one measurement is performed by a single evaluator for the same measurement method, it is possible that a measurement error occurs. To avoid this, two or more evaluators performed measurements in the same way for each individual, and more than two measurements were performed per location. Number of and intervals between measurements should be determined when measuring more than once at the same location. Pressure algometry was repeated various times, and intervals of measurements were determined and implemented in various ways in various studies. When repeated measurements are made at the same location, habituation to the applied pressure or pain should also be considered. Pain perception and control are complex and controversial issues. Thus, it is necessary to be cautious when measuring pressure repeatedly. Habituation of physiological responses to painful stimuli has been reported in several studies.[35–37] It has been reported that after the first measurement, individuals have a better understanding of the stimuli applied and therefore PPT tends to increase.[38] The present study adopts values within the range identified and suggests that the arithmetic mean of three consecutive measurements at intervals of 30 seconds at the same measurement point should be calculated for efficient application in clinical practice.

Table 3 proposes the index values that can be referenced in abdominal examination by identifying the evaluation indices from 22 studies.

In addition, based on the index values proposed in Table 3, it is possible to derive a common posture and measurement sequence of abdominal examination used in the clinic or research (Figs. 3 and 4).

A recent study proposed reference indices, postures, and a procedure of pressure algometry in abdominal examination that can be commonly applied to the clinic and research.[4] They were devised based on many of the indices determined in previous studies, and at the same time, considering the clinical situation of CAM in Korea. Because objective assessment of symptoms is important in CAM, standardized assessments are required. However, we only present indices, postures, and processes based on common and repeatedly identifiable indicators in the existing studies. Reliability and validity of themselves are unknown. Additional studies are necessary to conduct statistical verification and supplementation of pressure algometry method in abdominal examination.

## 5. Conclusion

We reviewed 22 Korean and international papers to identify the indices to be considered when performing the pressure algometry during abdominal examination in CAM clinic. Moreover, we proposed standardized postures for the evaluators and patients. Standardizing the application of this method in clinical setting will help reduce intervention of subjective elements in abdominal examination that occur as the procedure progresses manually.

## Acknowledgments

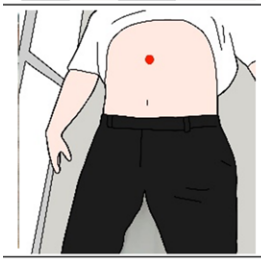
To help illustrate, we used the prototypical device developed by the Korea Institute of Oriental Medicine and presented

**Table 3**

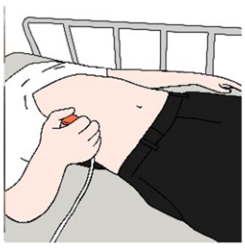
**Reference index proposal.**

| Index | Contents |
|---|---|
| Target location | Acupoint CV 12: Zhongwan (on the upper abdomen, 4 B-cun superior to the center of the umbilicus, on the anterior median line)[40] |
| Unit of measurement | MPa |
| Pressure area | 4 $cm^2$ |
| Pressure rate | 0.098 MPa/s (1 kgf/$cm^2$/s = 0.1 MPa/s) |
| Number of and intervals between measurements | 3 consecutive measurements at intervals of 30 s at the same point (arithmetic mean of the three measurements) |
| Resting time | 5 min prior to commencement |
| Posture of individual | Supine position (with knees stretched out) |

1) Lie in a supine position on the bed.
2) Take a rest for 5 minutes in a supine position prior to commencement of abdominal examination.

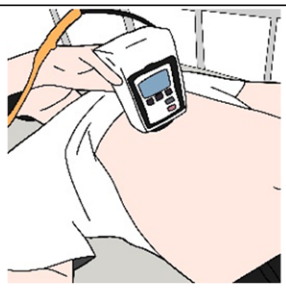


3) Remove the top so that the Zhongwan (Acupoint CV 12, on the upper abdomen, 4 B-cun superior to the center of the umbilicus, on the anterior median line) is visible.
* Red dot shown in image represents the location of acupoint CV 12.

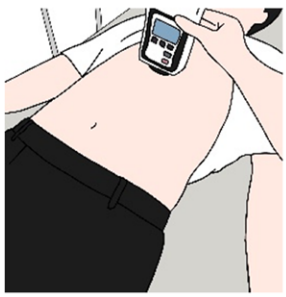


4) Hold the switch* with one hand to report pressure pain.
* When the switch is pressed, a beep sound s, and the evaluators immediately stop the pressure and record the pressure value at that time.

**Figure 3.** Posture of individuals.



1) Ensure that the center of the algometer's† tip touches the abdominal wall perpendicularly.
2) Place the horizontal tip (wide corners) of the algometer parallel to the hypothetical line connecting the individual's bilateral Anterior Superior Iliac Spines.



3) Stand facing the target location from the other side of the individual's hand holding the switch.
4) Maintain a constant pressure rate (0.098 MPa/s = 1 kgf/cm$^2$/s) and press the algometer vertically down.
6) Perform three consecutive measurements at intervals of 30 seconds at the same point.

**Figure 4.** Posture of evaluators. †: To help illustrate, we used the prototypical device[31] developed by the Korea Institute of Oriental Medicine and presented by Professor Park Jae-Woo of Kyung Hee University Korean Medicine Hospital at Gangdong. We would like to thank Professor Park for providing the device.

by Professor Park Jae-Woo of Kyung Hee University Korean Medicine Hospital at Gangdong. We would like to thank Professor Park for providing the device.

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**Visualization:** Yohwan Kim.
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