

### Computed Tomography (CT) Attenuation Value in Relation with Body Dimension, Gender and Age in Malay population: A Literature Review

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#### ABSTRACT

Interaction of CT's x-ray beams with patient resulted in attenuation process and there are various factors affecting CT attenuation values. The aim of this review is to examine the existed literatures regarding the concept of attenuation in CT and its relationship with body dimension, gender and age in Malay population. Guided by primary question, literature searches were conducted using the established online database; SCOPUS and PubMed. The time frame for literatures was from 2000 to 2019 and only literatures in English language were selected. The size of body dimension has affected the CT attenuation value but it also depending on the type of tissue presence within the region of interest (ROI) such as muscle and fat tissues. Due to larger body framework and higher amount of skeletal muscle mass theoretically males would have higher CT attenuation value than female. CT attenuation value reduces with aging process. Asians including Malay population have smaller body dimension than Caucasians and the mean attenuation value of abdominal region in Asians could differ from 20 HU. Thus, there is a need for future research to investigate the interrelatedness of attenuation in CT (HU) and body dimension within Malay population and close this gap of knowledge.

**KEYWORDS:** abdominal computed tomography, attenuation principle, CT values, CT number, Hounsfield units, body size, body habitus, body composition, ethnic, genetic

#### INTRODUCTION

Body dimension; the general physical characteristics of an individual which is affected the genetic variation and demographic factors; age, gender and ethnicity. As there are limited scientific studies related with the interrelationship of attenuation in CT, body dimension, gender and age particularly in Malay population, the current work intends to narrow the gap of knowledge by reviewing the literatures regarding the topic. Thus, understanding the findings will permit comparison with population in other parts of the world and helps to assess radiation dose management/techniques.

This work started with the overview of attenuation, overview of CT Value, CT number and Hounsfield units (HU) and overview of patient characteristics; body dimension, age and gender. Then,

the work is followed with the methodology of review, result, discussion and conclusion.

#### The Extended Role of CT in Understanding the Body Dimension, Age and Gender in a Population

With the advancement in technology, computed tomography (CT) has been a modality of choice in medical imaging field for diagnosing diseases and assisting in medical treatments. This is due to its high specificity and sensitivity in providing quick diagnosis.

#### Overview of attenuation

Among one of the basic characteristics of the radiation is attenuation process. Interaction of x-ray beam with patient resulted in attenuation process; x-ray beams experience either reduction in x-ray beam energy or



change in their travelling direction after the interaction [1-3].

Photoelectric absorption and Compton scattering are the dominant mechanisms of attenuation in the diagnostic range of energies; 25kV to 150kV [4] and this including CT. The mechanisms of attenuation process are influenced by two major factors; the x-ray

beam and the characteristics of irradiated material involved; effective atomic number ( $Z_{eff}$ ), density and thickness of material (Table 1). These factors affect the mechanism of attenuation process simultaneously. High intensity of x-ray beams increases the transmission of x-ray photon through the material and resulted in less x-ray beams being attenuated by irradiated material [5, 2].

**Table 1** Summary of the factors influencing the mechanism of attenuation process in diagnostic range of energy (25kV to 150kV)

Factors	Mechanism of attenuation process in diagnostic range of energy (25kV to 150kV)		Amount of the attenuated x-ray beams from the interaction with irradiated material
	(Photo-electric absorption)	Compton scattering	
Intensity of x-ray beam energy	High	Decrease	Low
	Low	Increase	High
Irradiated material atomic number ( $Z_{eff}$ )	High	Increase	High
	Low	Decrease	Low
Irradiated material density ( $g/cm^3$ )	High	Increase	High
	Low	Decrease	Low
Irradiated material thickness (cm)	Thick	Increase	High
	Thin	Decrease	Low

Higher amount of x-ray beams are being attenuated during the interaction as the value of the effective atomic number ( $Z_{eff}$ ) [6-9, 1], density [10] and thickness [11, 8] of irradiated material increase respectively. Other factors influencing CT attenuation value are shown in Table 2.

**Overview of CT Value, CT number and Hounsfield units (HU)**

The attenuation of tissue in CT image is known as CT value, CT number and Hounsfield Units (HU). CT value is measured in HU in honor after the name of Sir Godfrey Hounsfield, the inventor of Computerized Tomography. A two-dimensional (2D) CT image consists of picture element (pixel) and slice thickness.

The combination of the pixel and slice thickness creates a volume element (voxel) on CT image. Each voxel in a CT image is assigned a CT value, which represents a quantitative value of the tissue attenuation in that voxel.

CT value of material such as tissue is defined in relation to the attenuation coefficient of water. CT value of water (0 HU) is considered as the reference value for every CT scanner because water is a major component of body tissues. Thus, the CT value of a material at a given kVp is calculated by utilizing its linear attenuation coefficient ( $\mu$ ) and the attenuation coefficient of water ( $\mu_{water}$ ) at the same kVp, as the equation (1).

$$CT\ value = 1000 \times (\mu - \mu_{water})/\mu_{water} \ (1)$$

**Table 2** The factors influencing the CT value were categorized into two different categories, technical factors and patient/phantom factors.

Factors	Explanation	References
Technical factors	CT scanner models and generations	Due to differences specifications and technologies [11] [55]
	CT acquisition parameters	Collimation, effective mAs per rotation, image slice width, acquisition field of view (FOV) setting and different beam shaping filters applied on different FOV [56]
	CT x-ray beam spectra	Increase in CT x-ray beam, increase the CT value [7] [5] [55] [7]
	CT reconstruction algorithms	[56]
Patient/phantom factors	Filtration of x-ray tube in CT (Bowtie filter)	Allow higher intensity of x-ray beams at the thickest part of patient (center of patient) and lower at the thinnest part of patient (peripheral of patient body) [57]
	Size of the patient	Increase in patient size resulted in the increase of CT value [11]
	Patient's positioning	Center of ROI has higher CT value than the peripheral, thus need for careful positioning of patient during the CT examination [55]

Materials with greater attenuation than water will show a positive HU and materials with less attenuation than water will depict negative HU. This can be appreciated through different CT attenuation values of tissues and internal organs within the abdominal region. The abdominal adipose and muscle tissues are between -190 HU to -30 HU and -29 HU to +150 HU respectively [12]. The CT attenuation value of liver is within the range of + 50 HU to +70 HU [13], spleen (+ 45 HU) [14] renal cortex and medulla (+ 33.2 HU and + 34.2 HU) respectively [15]. Pathological condition also altered the CT attenuation value. Liver tissue with

greater fat content is known as fatty liver and it caused the reduction in liver CT attenuation value, < + 40 HU [16] and <1.0 of liver-to-spleen ratio [17].

On the Hounsfield scale, the CT value for air is -1000 HU and it appeared black on the gray scale, meanwhile the bone tissue is measured between the range of +700 for cancellous bone to +3000 for denser bone tissue. Due to the characteristic of the bone tissue which is higher density than surrounding soft tissues as well as appeared white on the gray scale, bone tissue can be easily appreciated on CT image. Thus, CT is considered as a gold standard in investigating skeletal anatomy.

Clinically CT value has been used to characterize and differentiate various type of tissue such differentiating between normal and pathologic tissues, soft tissues and bony tissues. Among clinical application of CT value are detection and staging of cancerous tissues [18-20], determination the extent of coronary atherosclerosis [21], quantitative evaluation of adrenal masses [22], characterizing renal cysts [23] as well as characterization of urinary stone composition [24]. Other than that, CT value is also utilized for attenuation correction in hybrid imaging such as PET/CT [12].

Among the Quality Assurance Programs (QAP) to maintain the accuracy, sensitivity as well as specificity of CT value are CT value (HU) uniformity and CT value calibration testing. The CT values are calibrated to the corresponded CT value of water for that particular CT scanner regularly.

There are certain tolerances permissible for CT value deviation. For instance, General Electronic (GE) specifies a mean water value within  $\pm 3$  HU of zero when using a specific quality assurance protocol as stated in reference manual [7].

**Overview of patient characteristics**

Patient can be defined as a person who is waiting or under medical care or treatment for a particular disease which he/she suffered. Patient characteristics are the criteria or features referring to a particular patient to identify and differentiate him/her from other patients because no two patients are having the similar patient characteristics even though they are genetically related. Among those patient characteristics are body dimension, weight, height, demographic status; age, gender, ethnicity, socio-economic status, and mental health condition.

*Body dimension*

Body habitus is the terminology that is used to define the general physical characteristics of an individual, which also known as physique, general bearing, and body build [5, 10]. Individuals tend to differ in terms of body habitus. The variation in body habitus resulted in different physical characteristics either in the body shape, body size, body dimension or muscle tones as well as the location of the internal organs within the body [10]. In general, there are four major types of body habitus; hypersthenic, sthenic, hyposthenic and asthenic [25-26], which is based on Western population (Table 3).

**Table 3** The types of body habitus presented within the Western population and its relationship with the body framework and location of internal organs.

Type of body habitus	Hypersthenic	Sthenic	Hyposthenic	Asthenic
<b>Body framework</b>	Large, thick and heavy bony framework. Short and wide thoracic region.	Average and athletic body build with a slight elongation of abdomen and thorax as compared to hypersthenic	Light, taller and smaller body build than sthenic patient	Slender and light bony framework with long and narrow thorax.
<b>Location of internal organs</b>	Heart, diaphragm, gallbladder and transverse stomach are located high and more horizontally located in patient torso.	The locations of internal organs are a little low than in hypersthenic	The internal organs are longer, narrower, more vertical in position and located lower in abdominal region.	The heart is vertically located at the midline of thorax region, the gallbladder and stomach are located at low and medial region of abdomen.
<b>Percentage in population</b>	5%	50%	35%	10%

The body dimension is a terminology used by the authors to refer to the anteroposterior and lateral diameters as well as cross-sectional area of the body [27-29]. Anteroposterior diameter refers to maximum distance measured from the one point on the anterior border to the opposite point on the posterior border of body on axial CT images. Meanwhile, lateral diameter refers to the maximum distance measured from the one point on the right border to the opposite point on the left border of body on CT image.

Based on European Union (EU), the weight of normal-sized adult in Western population is 70 kg [29] and the AP/lateral diameter of abdomen for this normal sized adult was 230/305 mm [27]. Meanwhile, in average, Indonesian males have 204.89/291.64 mm for abdominal AP/lateral diameter and Indonesian females have 195.31/280.99 mm for the similar measurement [28]. This showed that Asians particularly Indonesians have smaller body dimension than Caucasians.

Body composition also differs between different populations. Comparing between Asians and Caucasians, Wulan, Westernterp and Plasqui [30] mentioned that Asians have more abdominal fat mass than Caucasian at the same Body Mass Index (BMI). One of the methods to appreciate this difference is thorough the composition of subcutaneous and visceral abdominal fat content on axial computed tomography (CT) images. The authors also mentioned that Southeast Asian tend to store large amount of fat in visceral layer; deep in abdominal region. Genes, intra-uterine development, dietary as well as physical activities are among the contributing factors for the higher accumulation of body fat content in Asians than Caucasians [31].

Chuan, Hartono and Kumar [32] showed that Singaporeans have larger anthropometric measurements than Indonesians. Geographical origin, high-socio economic status and good educational level allowed the Singaporeans to have knowledge on health dietary lifestyle and improve their nutritional level which resulted in healthy and larger body dimensions than Indonesian. Among three major ethnic groups in Asia, Asian Indians have the highest body fat followed by Malay and Chinese [30].

## *Gender*

World Health Organization (WHO) [33] defines sex as the biological characteristics that define humans into two distinct groups, male and female. The differences between male and female can be observed starting at the level of chromosomes, gene expression, hormones, immune system until to the anatomy. Meanwhile, gender is a term which refers to the socially constructed norms, roles and relations of and among women, men, boys and girls [33]. However, the author chose to use “gender” as referring to the male and female instead of sex throughout the review.

In general, male and female have different body dimension, body composition, fat distribution pattern and hormonal system [34]. For instance, at the same Body Mass Index (BMI), women have lower skeletal muscle mass [28, 35-36] and higher percentage of body fat which are located subcutaneously than men [37-38]. Sex hormones; estrogen and progesterone in females and androgen in males are among the factors that responsible for the differences in amount of fat and lean mass (muscle and bone) between men and women [39]. These differences between genders are also attributed to the interrelated relationship between genetic, ethnicity, environmental, lifestyle, dietary, educational level and socio-economic status that resolves within around the population [40, 32].

## *Age*

Age is defined as the length of time that a person has lived or existed. Human’s life-cycle started from neonate or newborn, infant, adolescent or teenager, adult and geriatric. Through the aging process, individual will experience the changes in their anatomical, physiological, psychological and emotional functionality.

According to World Health Organization (WHO) [41], infant is a child aged less than one year old and adolescent is a person aged between 10 to 19 years old. Adult refers to a person who is fully developed, matured, has attained intellectual capacity, emotional and psychologic stability as well as has attained the legal age. Thus, adult is a person who is older than 19 years old age unless the national law of a particular country defines a person as being an adult at

earlier age [41]. As for Malaysian, there are three age structures; young age (<14 years old), working age (15-64 years old) and old age (> 65 years old) [42].

Aging men are more profound to have fat accumulation within and around the abdomen rather than in the subcutaneous tissue of the limbs and chest [43]. Meanwhile, women in postmenopausal state are associated with increase in visceral adiposity due to decrease in estrogen level than premenopausal women [39]. This condition also resulted in decreasing trunk muscle density in older women much greater than men due to present of fatty infiltration in muscle tissue [36].

Aside from muscle's density, aging also reduces muscle's size in males and females [36] and led to lower muscle function in older population. Another study showed the similar outcome, older adults (75–87 years old) have lower trunk muscle attenuation than in younger adults (35–50 years old) [44]. The variability of age-related differences in muscle attenuation varies between specific muscles; psoas major and latissimus dorsi had higher lower overall attenuation respectively. Among the reason for age-related increase in fatty infiltration in skeletal muscle tissues is due to inability of muscle fibers to process triglyceride and led to storage of lipid within the muscle tissues [45].

### *Genetic and Ethnicity*

Genetic is one of the field in biology which study about the genes and hereditary traits in organism. The genetic variation contributes to the diversity of body dimension and framework which make each individual unique and different from one another especially within different ethnicity and populations [30-32].

Malaysia is a country rich in diversity with multi-ethnic and multi-cultural as the majority the population is Malay, followed by Chinese, Indians, and indigenous peoples. Up until mid-year 2019, the total citizen in Malaysia is 29.4 million which is 69.3% (Bumiputera), 22.8% (Chinese), 6.9% (Indians) and 1.0% (other ethnics) [42]. Bumiputera is the combination of Malay, indigenous peoples and natives in Sabah and Sarawak.

Each ethnic has its own genetic traits that affect the differences in facial, physical as well as anatomical appearances.

Thus, the aim of this review is to examine the existed literatures regarding the concept of attenuation in CT and its relationship with body dimension, gender and age in Malay population. The possible knowledge gaps within the literatures will be examined and few suggestions will be indicated for the future research.

### **METHODOLOGY**

The type of review conducted is literature review. To formulate research question and search for best evidence, the authors utilized PICOT as shown in Table 4. Guided by the primary question, “*What is the current understanding of attenuation in CT in relation with body dimension, gender and age in Malay population?*”; literature searches were conducted using the specific and established search engine and journals through the online database. These included SCOPUS, PubMed, MYCITE, Journal of American College of Radiology, European Journal of Radiology, RadioGraphis, Medical Physics, Iranian Journal of Medical Physics, Medical Journal of Malaysia (MJM), International Medical Journal of Malaysia (IMJM) and Malaysian Journal of Public Health Medicine.

The keywords used for the literature search were “Computed Tomography (CT)”, “abdominal computed tomography”, “attenuation principle”, “Hounsfield Units (HU)”, “CT values”, “CT numbers”, “attenuation in CT”, “body size”, “body composition”, “abdominal circumference”, “genetic”, and “ethnic”. The time frame for the published literatures was from 2000 to 2019. The language used for the literature search is English.

The relevant articles that could possibly answer the research question were identified and selected based on the title and/or abstract and the articles were retrieved in pdf file type. The retrieved articles were read carefully to identify the current understanding of attenuation in CT and to relate the understanding with the body dimension, gender and age in Malay population.

**Table 4** The PICOT criteria for developing research question and searching for evidence

PICOT criteria	Description
<b>P:</b> patient population	Malay population
<b>I:</b> intervention/issue of interest	The population of interest is Malays in Malaysia Body dimension, gender and age  The body dimension refers to the anteroposterior and lateral diameters of body. All articles related with differences in body dimension and CT attenuation value between gender and age were selected.
<b>C:</b> comparison intervention/issue of interest	Comparison with other populations.  Among the population used for comparison are Caucasians and Southeast Asians. Caucasian is chosen due to most regulatory guidelines were made based on the Caucasians. Southeast Asian is chosen because Malays in Malaysia is one country in the Southeast Asian's countries. Comparing the intervention with the similar region is important.
<b>O:</b> outcome	Effect on CT attenuation value
<b>T:</b> time frame	All the articles related with the CT value, CT number, Hounsfield units (HU), CT attenuation values were selected. 2000-2019 The authors used long time frame due to limited literatures.

## RESULTS

From the literature search, the author found several other factors influencing the CT value other than the factors affecting the mechanism of attenuation mentioned in Table 1. For intelligibly purposes, the author categorized and tabulated the factors into two different categories, technical factors and patient/phantom factors (Table 2). These factors are important to be known as they also affect the attenuation in CT and precaution measures based on these factors should be taken during performing CT examination to avoid inaccuracy in CT value produced on CT images. The summary of current understanding on the attenuation in CT in relation with body dimension, gender and age in Malay population existed on literatures were tabulated in Table 5 and the result was further discussed in discussion part.

## DISCUSSION

### Body Dimension and Attenuation in CT

Variation in body dimension does affect the radiographic examination particularly in attenuation process. A study [46] was conducted based on facial and

maxillofacial region, which showed that large head's size attenuates more x-ray beam compared to the thin one. Large head's size contained more bony and soft tissues which attenuate x-ray beam greater. This could also be hypothesized that patient with large body dimension for instance hypersthenic patient is associated with increase in the body thickness and attenuate more x-ray photons as compared to the thin patient (hyposthenic or asthenic patient).

In relation with CT examination, patients with large body habitus would have large body diameters and cross-sectional area. However, the CT attenuation value of this region is depending on the tissues contained within the region of interest (ROI). A study of cross sectional area (CSA) of mid-thigh showed that infiltration of fatty tissue within lean muscle tissue reduced the CT attenuation value to 26 HU from 38.6 HU [45]. Less attenuation and more transmission processes of x-ray beam occur in fat tissue due to low effective atomic number ( $Z_{eff}$ ) and density. Thus, patient who has large body dimension and more muscle such as abdominal muscle in his/her body attenuate more x-ray photons and has high CT attenuation value as compared with high amount of fat [2].

**Table 5** The summary of the current understanding on the attenuation in CT in relation with body dimension, gender and age in Malay population existed on literatures.

Patient characteristics		Body dimension	Attenuation in CT
Gender	Male	Large body dimension, higher skeletal mass, visceral fat distribution (abdominal)	Generally high (depending on the type of tissues contained)
	Female	Small body dimension, lower skeletal mass and subcutaneously fat distribution (lower extremities)	Generally low (depending on the type of tissues contained)
Age	Infant, adolescent, adult	Body dimension, body fat accumulation, skeletal muscle mass, bone density correlates negatively with the aging process.	Aging reduces the CT value
Genetic and ethnicity	Worldwide populations	Caucasians do have larger body framework than Asians [55, 41] and Asians have lower BMI than Caucasians [54]	The attenuation values based on Caucasians is not valid to be applied to Asian populations, especially Malay population in Malaysia
	Southeast Asian populations	Singaporeans have larger body dimension than Indonesian [56]	
	Singaporeans	Chinese have longer upper trunk than Malay and Indian [57]	
	Malaysians	Malay male and Chinese female have largest body size [58]	

Average CT attenuation of cross sectional area of chest in adult is – 300 HU compared to 20 HU for average CT attenuation of cross sectional area of abdomen in adult [27]. These measurements were conducted on normal sized adult weighted 70 kg. CT attenuation of chest is lower than abdomen because chest region contains lungs which have low attenuation values due to present air within the lungs. The authors also showed that increased in fat tissue in abdominal region reduced the average CT attenuation to -50 HU in largest patient, 120 kg. This study showed that the size of body dimension does affect the CT attenuation value of abdominal region and it depending on the type of tissue presence within the ROI.

### Gender, Body Dimension and Attenuation in CT

There are various studies shown the differences in body dimension between male and female. Zarb, Rainford, and McEntee [29], showed that based on the studied population, males have larger anteroposterior (AP)

diameters for both chest and abdominal region than females when the measurements were taken on axial CT images. Male tend to have larger body dimension than female maybe due to their sex hormones, dietary style and dominancy in heavy workload occupations which required a lot of energy. The similar finding is also found in Indonesian population as males have larger AP and lateral abdominal dimensions than the female counterparts [28]. This shows that, in general male's body dimension is larger than women.

The combination of abdominal diameter with the composition of fat and muscle tissues within the abdominal region and the volume of internal organs could result in different CT attenuation value of abdomen between male and female. Due to larger body framework, higher amount of skeletal muscle mass and large volume of internal organs, theoretically males would have higher CT attenuation value for abdominal region than female [11, 8]. A study showed that, in general, trunk muscle attenuation values were 6.9 HU lower in women than in men [44]. However, greater amount of adipose tissue presented in abdominal region

due to abdominal obesity could result the CT attenuation value in abdominal region for males to be reduced also.

### **Age, Body Dimension and Attenuation in CT**

Various studies show that aging can affect the body dimension, shape and composition. Body fat accumulation correlates negatively with the aging. Aging also reduce the skeletal muscle mass. A gradual muscle loss which is also known as sarcopenia can be detected starting at 50 years old and continuously until 80 years old [47-48].

Muscle attenuation was on average 15.9 HU lower in older adults (75–87 years old) than in younger adults (35–50 years old) [44]. Increase amount of fat within trunk muscle tissues reduces the muscle attenuation on CT images in older adults and also led to low quality of life such as poor physical function and low back pain.

Aging does result in the changes of body dimension, shape and composition in negative correlation. Thus, the CT attenuation value of abdominal region reduces with aging process [49] in which CT attenuation value in the elderly people should be less than the non-elderly population.

### **Genetic, Ethnicity and body dimension**

Genetic is one of the field in biology which study about the genes and hereditary traits in organism. Studies showed that genetic variation contributes to the diversity of body dimension and framework which make each individual unique and different from one another. In a study, genetic variation together with other interrelated factors; dietary and physical activities influence Asians to have higher body fat accumulation than Caucasians at the same BMI level [30-31]. This can be seen by the differences in trunk-to-leg ratio and slenderness of body build between these populations [50].

Comparing between Singaporean and Indonesian populations, Chuan, Hartono and Kumar, [56] concluded that Singaporeans have larger body dimension and within the Singaporean population itself, Chinese have the longest trunk with shortest both upper

and lower limbs than other races; Malay and Indian [51] and they are also associated with larger lung volume due to this body framework. Compared with those two races, Malays have intermediate size of trunk, upper and lower limbs.

### **Influence of Genetic, Ethnicity on Body Dimension and Attenuation Process**

During the interaction of x-ray photons with the irradiated material such as human body, the proportion of x-ray photons being transmitted, scattered and absorbed is depending on the shape, size as well as composition of tissue within the region of interest. The differences in human size and shape are affected by the genetic variation; geographical as well as environmental factors and because Asians have lower BMI than Caucasians [50].

Based on European Union (EU) guidelines, adult who has weight of 70 kg is considered as standard-sized adult [29]. This guideline is not valid for Asians as Asian populations have smaller body dimension and organ volumes than Caucasians [52]. The differences in body dimension also resulted different attenuation process between Asians and Caucasians, thus the attenuation values based on Caucasians is not valid to be applied to Asian populations.

The mean attenuation of abdomen of normal sized adult (70 kg) who has both AP/lateral and lateral/AP dimensions; 230/305 mm and 305/230 mm respectively, is around 20 HU [27]. Weight of 70kg is defined as normal adult size by European Union (EU) and this is based on Western population. The normal adult size of Asian could be less than 70 kg and this can be acknowledged through the finding by a study in Indonesian population [28]. By averaging all the data collected, Indonesian males have 204.89/291.64 mm for the ratio of abdominal AP/lateral dimension and Indonesian females have 195.31/280.99 mm for the similar measurement. Generally, this proved that Asians particularly Indonesians have smaller body dimension than Caucasians and the mean attenuation value of abdominal region in Asians particularly Malay population could be less than 20 HU.

Thus, patient body dimension depends on genetic as well as ethnicity and the attenuation values of

abdominal region in one particular population cannot be generalized to all populations.

### **Gaps of Knowledge and Future Research**

In the medical imaging field, the study on the attenuation in CT (HU) and body dimension are more related with the radiation protection domain; to estimate the radiation dose received by patient from a particular CT examination [53]. There are limited scientific studies to investigate the interrelationship of attenuation in CT, body dimension, gender and age. Thus, this provides an opportunity for researcher to explore this field of knowledge. Understanding the findings will permit comparison with population in other parts of the world and helps to assess radiation dose management/techniques.

Body dimension, body size and body habitus are referred to the general physical characteristics of an individual which is affected the genetic variation and demographic factors; age, gender and ethnicity. Based on European Union (EU) guidelines, the standard-size adult is weight at 70 kg and the mean CT attenuation value of abdomen is around 20 HU. Asian populations have smaller body dimension than Caucasians and this resulted the abdominal CT attenuation values based on Caucasians (20 HU) is not valid to be applied to Asian populations. As Malay population are different from the ethnicities/populations discussed above (Indonesians and Caucasians) and there is limited study conducted to investigate the association between attenuation in CT (HU) and body dimension within Malay population, there is a need for future research to be conducted close this gap of knowledge.

### **CONCLUSION**

Based on the existing literatures, this review managed to explore and compile the knowledge regarding the current understanding of the attenuation in CT in relation with body dimension, gender, age and its availability in Malay population. This review helped to enhance and strengthen the understanding about the CT attenuation and aided in empowering the education level among the researchers, students and lectures as well as contributing to the expansion body of knowledge.

To conclude, taking into considerations the above review and knowledge gaps, there is need for a future research to investigate the concept of CT attenuation value in relation with body dimension, gender and age within Malay population in Malaysia. The future study could help to prove that how would the differences in body dimension between Caucasians and Malay population affect the CT attenuation value (HU). As Malaysia is still lacking in the anthropometric database especially in medical imaging [54], the future research also could serve as a pioneer work to study the impact CT attenuation process on body dimension in Malay population and contribute an improvement in Malaysian anthropometry database.

### **Conflict of Interest**

Authors declare none

### **Authors contribution**

The authors contribute comprehensively to the manuscript, starting from development of concept, acquisition of data, analysis and interpretation of data, discussion until to the conclusion of the manuscript.

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