

# The Palm-Heart Diameter: A Prospective Simple Screening Tool for Identifying Heart Enlargement

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## Abstract

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**BACKGROUND:** Several speculations have linked the size of the fist to be equal to the size of the heart. However, the substantial scientific report still lacks to support this theory.

**AIM:** This study aims to provide the validity of the fist-heart assumption by correlating the palm and heart diameters while benchmarking it as a reference tool for determining the normal heart size.

**MATERIALS AND METHOD:** Volunteers from the public were recruited during a health fair organised by the school. A self-administered questionnaire for necessary information was distributed after the volunteers signed the consent forms. The palm of both hands was measured in duplicates using a flexible ruler. Ultrasound examination was used in measuring the diameter of the heart with the landmark being from the anterior fibrous pericardium to the lowest part of the posterior fibrous pericardium. The level of significance was kept at  $P < 0.05$ .

**RESULTS:** A total of 275 people, consisting of 123 males and 152 females participated in the study. The age range was from 15 to 80 years with a mean age of  $28.16 \pm 16.18$ . The measurement showed that the size of both palms correlated with the heart diameter,  $p < 0.05$ . Other factors such as age and height showed a substantial level of correlation. However, this correlation ceased with older participants. Palm size did not correlate among participants with previously diagnosed prehypertension. However, participants with previously diagnosed hypertension with good medication compliance maintained the correlation.

**CONCLUSION:** This study establishes the correlation between the palm and heart diameters. Since the heart tissue and the upper limb share a similar embryonic origin, being the mesoderm, this study prospects the fact that heart enlargement could be preliminarily identified by measuring the size of the hand.

## Introduction

The universal perception that the size of the fist and heart are equal has been well known among the general population. Various individuals have presented their views on how the size of the heart and the hand correlate. However, there has been no proper scientific report on the validity of this theory until now. The fact that the heart muscles and musculoskeletal system are both derivatives of the mesodermal layer [1, 2] gives a logical reason why the hand and the heart could be characteristically related, as some properties may be residual in these tissues.

The limbs and the cardiac muscles share a similar mesodermal origin which is the lateral plate of the mesoderm. Similarly, these mesodermal cells share some transcription factors such as Nkx2.5, GATA, Mef2, Tbx and Hand [3]. Other factors like

fibroblast growth factor (FGF) [4], WNT [2, 3], and transforming growth factor beta (TGF $\beta$ ) superfamily to include bone morphogenic proteins (BMP) [4, 5] have been demonstrated to influence both heart and limb development. Detailed and well laid out reviews on the development of the heart and upper limb have already been properly documented [3-8]. To further support this association, it has been recorded that the defect in some of these factors has resulted in both cardiac and limb abnormalities. For instance, defect in the TGF $\beta$ -1 has not only been associated with heart abnormalities such as congenital aortic stenosis, regurgitation [9], and arrhythmogenicity [10] but the differential expression of BMP (a member of the TGF $\beta$ -1 superfamily) as a result of Tfp2b loss has been shown to result in both heart and limb abnormalities [11].

It is, however, astonishing that an organ as important and critical as the heart still lacks reliable referencing data for the dimensions of the heart

cavities. Though it is a known fact that the body surface area (BSA) determines the dimensions of the heart chambers, this is however not resulted in any concrete and reliable referencing data. However, predictors such as age, sex, height, and weight have been linked to the heart dimensions [12].

Hence, this study was to find a customised value for easy and fast identification of a possible heart enlargement from any underlying cause by relating the heart to the palm, which is another structure of similar embryological origin. The findings from this study are expected to help redirect and solve the heart referencing issues for better diagnosis and prognostication.

## Materials and Method

### Participants

Volunteers from the public were recruited during a health fair organised by the school. A consent form detailing the procedure to be performed given to the volunteers, and the procedure was duly explained to them. The participants were asked about any history of palmar injuries, and the palms were equally observed for any form of injury. A total of 275 people, 123 males and 152 females with an age range of 15 to 80 years, agreed to participate by signing the consent after which a self-administered questionnaire was given.

### Selection Criteria

The participants used for this study were only right-handed people. Left-handed individuals were left out of the study for the sake of consistency, and moreover, we could not gather a significant number of left-handed people. Also, we excluded subjects with known cardiac problems like valvular stenosis or insufficiencies and other conditions and activities that can predispose to remodelling of the heart tissue like athletics, subjects with known hemodynamic states like Sick cell disease, hyperthyroidism, and pregnancy. Also, participants with known and established abnormal blood pressure were used for a further study.

### Measurements

A double-blinded technique was used for measurements of the heart and palm dimensions. Here, the ultrasound measurements were taken by an investigator in the ultrasound room and records kept away from the other investigator, taking the palm dimensions to avoid an observer bias.

### Palm measurement

The right and the left palms were measured with a soft ruler from medial to lateral, specifically from the edge of the first palmar crease (heart line), where the fist is made, to the edge of a secondary palm line (headline) if visible or by extension [13] (Fig. 1). The measurement for each palm was done twice with the mean measurements calculated.

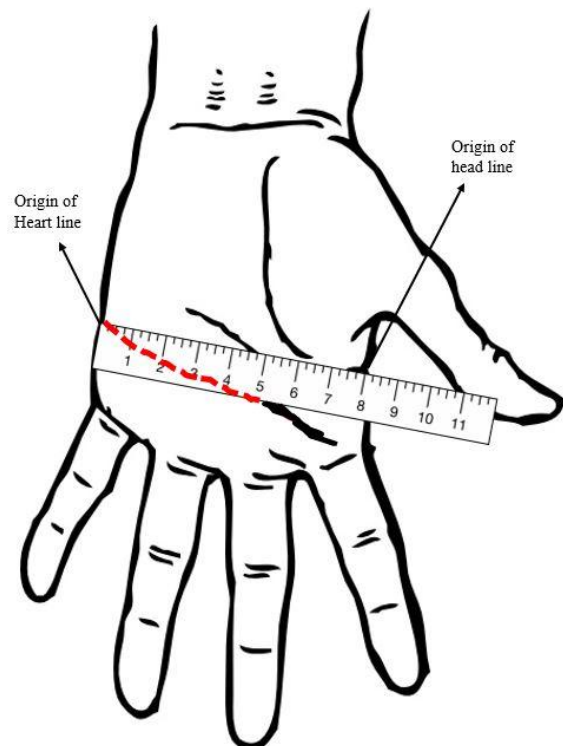


Figure 1: Schematics for palm measurement

### Ultrasound measurement

The measurement of the heart diameter was carried out by a single experienced investigator using a DUS 5000 ultrasound machine (Miami, Florida, USA) using a low-frequency micro-convex transducer preset to "adult cardiac" with a default frequency of 4MHz.

The participants were requested to expose their chest to around the 5th intercostal and were given a clean drape to cover themselves to make them comfortable and were required to lie supine on the examination bed. During the scan, only the required area was exposed (the left thoracic region up to about the 5th intercostal space). The transducer was applied to the subject's chest wall to find a window on the 2nd to the 5th intercostal space left the parasternal area looking at the heart at its longitudinal axis (left parasternal view), PLAX [14, 15]. Using this view, we can visualise and measure the largest diameter of the heart in two-dimensions from the anterior fibrous pericardium to the lowest part of the posterior fibrous pericardium. The measurement is taken in late diastole when the mitral valve is almost

closing, and also this is when the left ventricular wall is expected to be thinnest. Although the 4-chambered view is the mainstay 2D echocardiographic technique for the imaging of the left ventricle [12] but requires more time, skill and exposure of the subject. Whereas, the PLAX is opposite regarding time, skill and exposure, especially if a quick view is desired. In this view, we can capture from superficial to deep the right ventricle, the interventricular septum, the left ventricle, the left atrium and two valves, aortic and mitral. Other studies have concentrated on the size of the left ventricular chamber [16-22]. However, reference ranges are still very limited for the other cavities despite the known prognostic significance of the left atrium and its volume [12]. Using this simple approach (PLAX), we can capture the essential cavity and volumetric changes from any underlying defects that might alter the normal size (diameter) of the heart.

### Statistical analysis

Statistical analysis was performed by STATA/IC 13.0 (for windows). The Chi-square test was used for comparing categorised variables. Multiple regression analysis was also performed to predict the diameter of the heart from both the right and left hands measurements. Statistical hypothesis tests with  $p < 0.05$  were considered as significant. ANCOVA was used so that measurements of the right palm, left palm, and heart diameter could be taken into account when comparing the groups regarding varying blood pressures. Values are presented as mean  $\pm$  standard deviation or number (%).

## Results

A total of 275 individuals volunteered in the study. Participants included 123 (44.73%) males and 152 (55.27%) females. Mean age was  $28.16 \pm 16.18$  years. Age distribution of the participants (Table 1) showed that the most predominant age bracket was between 15-20 year.

**Table 1: Age distribution of participants with their palmer and heart measurements**

Age group	Frequency n (%)	Right palm Mean (cm) $\pm$ S.D	Left palm Mean (cm) $\pm$ S.D	Heart Diameter Mean (cm) $\pm$ S.D
15-20	131 (47.64)	8.54 $\pm$ 0.67	8.40 $\pm$ 0.70	8.38 $\pm$ 0.84
21-26	68 (24.73)	8.78 $\pm$ 0.72	8.55 $\pm$ 0.76	8.78 $\pm$ 0.92
27-32	14 (5.09)	8.69 $\pm$ 0.77	8.55 $\pm$ 0.76	8.76 $\pm$ 0.74
33-38	9 (3.27)	8.57 $\pm$ 0.50	8.39 $\pm$ 0.57	9.12 $\pm$ 0.84
39-44	10 (3.64)	8.87 $\pm$ 0.51	8.76 $\pm$ 0.54	9.29 $\pm$ 0.62
45-50	9 (3.27)	8.51 $\pm$ 0.56	8.44 $\pm$ 0.55	9.50 $\pm$ 0.53
51-56	8 (2.91)	8.88 $\pm$ 0.72	8.36 $\pm$ 0.60	8.93 $\pm$ 1.27
57-62	5 (1.82)	8.50 $\pm$ 0.19	8.70 $\pm$ 0.74	9.58 $\pm$ 0.79
63-68	5 (1.82)	8.50 $\pm$ 0.19	8.24 $\pm$ 0.18	9.94 $\pm$ 0.83
69-74	10 (3.64)	8.82 $\pm$ 0.40	8.67 $\pm$ 0.43	9.7 $\pm$ 1.07
75-80	6 (2.18)	8.73 $\pm$ 0.77	8.61 $\pm$ 0.62	9.73 $\pm$ 0.89

In this study, relating the palm size of both hands using linear regression showed a good fit ( $P = 0.000$ ), with 91.2% coefficient of determination (95% confidence interval from 0.89 to 0.96). Multiple regression to predict the diameter of the heart from the palm size of both the right and left palm statistically significantly predicted the diameter of the heart,  $F(2, 273) = 96.18$ ,  $p < 0.0005$ ,  $R^2 = 0.4133$ ,  $p = 0.008$  (95% confidence interval from 0.15 to 1.0)

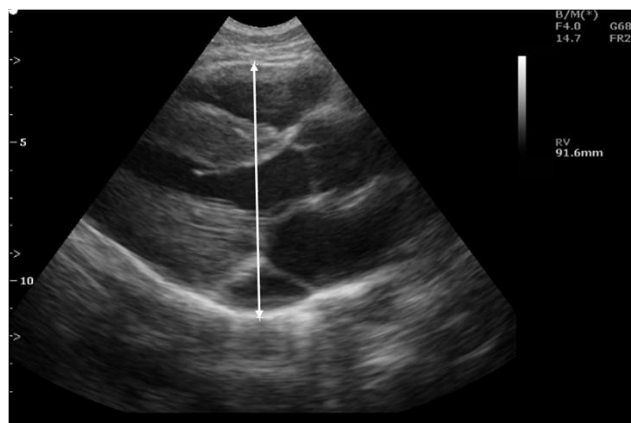
Also, among the participants, 56 individuals were identified with previously diagnosed cases of abnormal blood pressures, with an equal number of 28 persons in each category of prehypertensive and hypertensive blood pressure, respectively. The hypertensive volunteers also acknowledged being on medication with good compliance. A control group of 28 individuals with normal blood pressure and belongs to the same age group of those with abnormal blood pressure was also selected for further comparisons (Table 2). Efforts were also made to ensure no gender was predominating in any of the study groups.

**Table 2: Role of high blood pressure on the relationship between the fist size and heart diameter**

Group	Right palm Mean (cm) $\pm$ S.D	Left palm Mean (cm) $\pm$ S.D	Heart diameter Mean (cm) $\pm$ S.D	Chi-Squared evaluation in comparing right and left palm to the diameter of the heart, respectively
Normal blood pressure	8.42 $\pm$ 0.55	8.27 $\pm$ 0.59	8.83 $\pm$ 0.96	0.00 and 0.02
Prehypertensive blood pressure	8.79 $\pm$ 0.49	8.62 $\pm$ 0.5	9.74 $\pm$ 0.83	0.355 and 0.682
Hypertension	8.39 $\pm$ 0.79	8.25 $\pm$ 0.76	8.91 $\pm$ 1.0	0.001 and 0.042

There was no relationship when the right palm, left palm, and heart diameter of prehypertensive and hypertensive blood pressure groups was collectively analysed using ANCOVA, with P values of 0.39, 0.54, and 0.07, for right palm, left palm, and heart diameter, respectively.

The sonographic images demonstrate how the measurements were taken during the scan (Fig. 2).



**Figure 2: Ultrasound scan of a heart from the anterior fibrous pericardium to the lowest part of the posterior fibrous pericardium**

Age distribution showed a link between age and heart diameter (chi-square with 210 degrees of freedom = 356.65,  $p = 0.000$ ). However, there was no correlation when compared with the palm sizes of both hands ( $P > 0.05$ ). A simple regression was run to predict the diameter of the heart from the age group of teenagers to middle-aged adults (15-55 years).

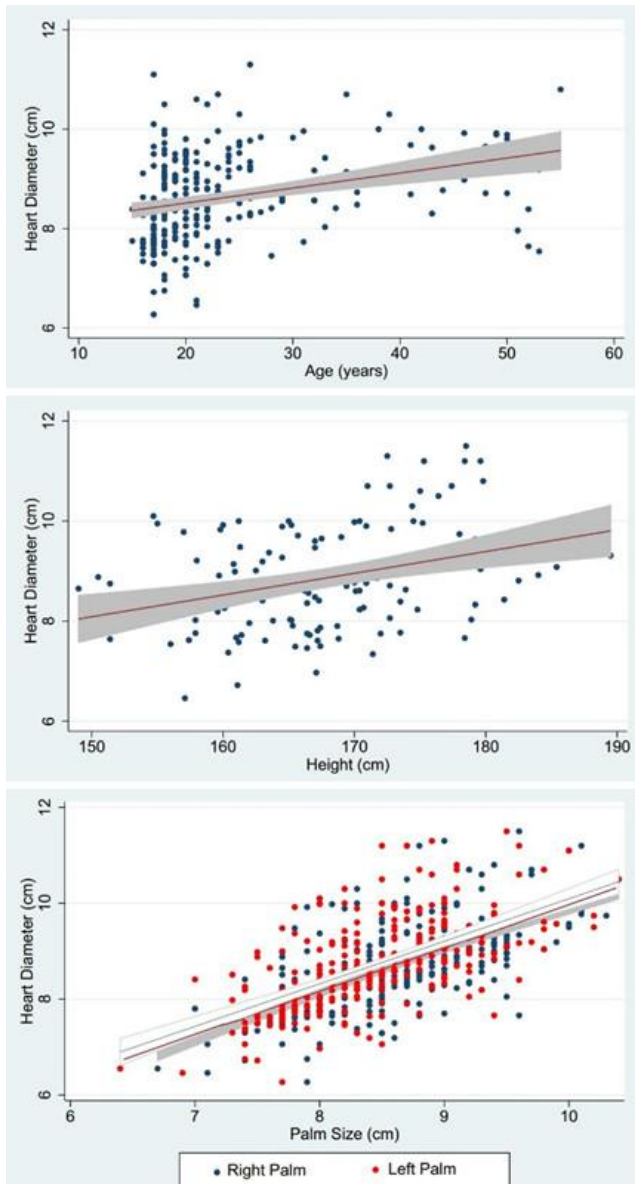


Figure 3: Predictive graph, showing the relationship of age (A), height (B), and the fist size (C) of both palms on the diameter of the heart. (Confidence interval of 95% of means,  $P < 0.05$  in each plot)

These variables statistically significantly predicted the diameter of the heart,  $F(1, 246) = 21.79$ ,  $p < 0.0005$ ,  $R^2 = 0.0814$ . The variable added statistically significantly to the prediction,  $p < 0.05$ . The coefficient indicated that for each increase in age there is a 2% increase in heart diameter (95% confidence interval from 0.04 to 0.02). However, for participants above 55 years, the variable was not statistically significant. History retrieved from each participant revealed 26 (9.42%) with previous palmar

injuries. However, the injuries had no impact on the correlation between the fist size and the diameter of the heart when analysed (chi-square with 10 degrees of freedom = 8.30,  $p = 0.60$ ). Comparing the diameter of the heart based on gender showed that within a particular age group, males had a bigger heart diameter and palm size of both hands than females,  $P = 0.000$ , in all comparisons. Multiple regression analysis in comparing males to females further indicated that in any age group, males had their heart diameter, palm size of both the right and left hands bigger than females by 11.4%, 29.3%, and 18.5%, respectively, with 59.52% coefficient of determination. The linear regression of participants' heights below 40 years of age related to the diameter of the heart ( $P = 0.000$ , 95% confidence interval from 0.07 to 0.02). No correlation was observed among patients above the age of 40. The Linear prediction graph was also used in interpreting the link between age (15-55 years), height, and fist size on the diameter of the heart (Fig. 3).

## Discussion

Heart disease remains one of the major illnesses leading to increased mortality rate [23]. An estimate of 17.5 million people dies each year from cardiovascular-related diseases, thus giving an estimate of 31% of deaths worldwide [24]. Cardiovascular problems can be diagnosed by electrocardiogram, echocardiogram, chest x-rays, cardiac computed tomography, cardiac magnetic resonance, positron emission tomography, coronary angiography, single-photon emission tomography and radionuclide ventriculography. Other additional diagnostic tests include haematological and biochemical analysis of Brain-type Natriuretic peptide (BNP), exercise testing, endomyocardial biopsies, and genetic testing. Amongst all, echocardiography has been proven to be the most useful and widely available test in diagnosing cardiac problems. It has also been shown to be accurate, safe and cost-effective [25]. Cardiovascular diseases are usually as a result of various illnesses. However, not all of these illnesses lead to heart muscle hypertrophy or enlargement [26]. The idea of linking the size of one's heart to their palm dimensions may appear irrational. However, few speculations have proposed the theory with several debates, but without any substantial evidence until now. The objective of this study was not just to confirm the speculations but also prospect how the information could prove beneficial in clinical medicine. As previously stated, the cardiac muscles and the appendages share the lateral plate mesoderm layer as a common derivative [1, 2]. This could also illustrate that all cells from the mesoderm, irrespective of differentiation may share a few linking properties [27].

### **Correlation with Previous studies**

This study showed a considerable association between heart size and factors such as age, sex, and height (Table 1 and Figure 2), which was similar to previous reports [12, 28]. Previous studies have demonstrated that age has a direct proportionality with the heart diameter until the age of 50 years, where the heart begins to achieve a constant size, although the rate of growth was not elucidated upon [29, 30, 31]. However, this study demonstrates a 2% increase in heart diameter for each increase in age till 55 years. Further longitudinal studies might be required to validate this finding.

Studies correlating height with the heart size have been investigated in previous reports with emphasis on the role of body weight as major determinant [12, 30]. Similarly, the current study showed a relationship between height and heart diameter amongst participants only below 40 years, although, the influence of body weight was not captured. The observed relationship could be due to the pubertal growth spurt defined by age, which is approximately linear until maturity, where a further increase in age indicates no further growth [31].

Similar to other studies, sex was shown to be a predictor of heart diameter [27, 29, 30, 32]. The female frame regardless of race is known to be smaller than the male, hence, its reflection on the dimensions of the heart. Bainton et al., 1932, reduced the transverse diameter of the male heart by 0.8cm to derive the female diameter, while Oberman et al., 1967, came up with a 0.5-1.0cm consistent difference between men and women within the same group and matched for height and weight. However, our study, though not matched for height and weight revealed an 11.4% increase in the diameter of males relative to females matched for the same age group.

### **Deductions from this study**

In this study, it was shown that the right palm was bigger than the left palm, although, the difference did not distort the analysis that both palms correlated with the diameter of the heart. The right hand being bigger is attributed to the increased neuronal firing and hypertrophy in right-handed people, due to high usage [33]. Studies involving left-handed individuals in the current study was not feasible due to small sample size. From this study, it could be speculated that the heart diameter ranges from the measurement of the left palm to that of the right palm with the right palmar diameter being the upper limit of normal heart size for the measured individual.

While further considering the general clinical applicability of this method, a pilot study involving the impact of deranged blood pressure on the palm-heart diameter was carried out. The finding drew our attention to an important clinical phenomenon

previously observed in the MONICA/KORA Augsburg study, which concluded that persistent prehypertension results in heart tissue remodelling which facilitates the occurrence of ventricular hypertrophy resulting in diastolic dysfunction [34]. This study's observation supports the direct applicability of the palm-heart diameter for the normotensive and the hypertensive population on treatment, but not for the prehypertensive group. The reason though not fully understood but might be attributed to the onset of a possible cardiac tissue remodelling [35] which might have resulted in the "subtle" non-symptomatic enlargement which is similarly seen in the endurance-trained athletes' heart [36]. It is assumed that the prehypertensive period is faced with continuous hemodynamic load causing the ventricular myocardium to stretch (Frank-Starling), triggering the heart to subsequently initiate the process of hypertrophy in response to the stress (Laplace law). The correlation with the hypertensive group suggests that medicating hypertensive patients might be experiencing some therapeutic palliation on pressure load and vascular resistance thus ameliorating the net tissue remodelling effect as opposed to the prehypertensives or simply that the process of hypertrophy might have already been established in this group, hence no noticeable net myocardial stretch. The pathophysiological impact of prehypertension is difficult to define, as it represents over 30% of the adult healthy population [37]. Prehypertension has been linked to an increased long-term cardiovascular risk [38] and may be the starting point in the cardiovascular disease spectrum [39]. The observation from this research further corroborates the Strong heart study of 2006, which has advocated for an increasingly aggressive follow-up on patients with persistent prehypertension [40].

### **Prospects of current study in diagnosing heart enlargement**

The study predicts that the relationship between the palm and heart size may give more direction in anticipating cardiac dimension referencing tool. Thus, a one-time diametric measurement of the palm-size might just be sufficient to determine an individual's normal heart diameter which can then be used as a benchmark for comparison of the heart cavities. This benchmark is essential as it will aid the customisation of the heart cavity dimensions as opposed to using a single range of values for everyone. This is soon necessary since BSA which is currently the main tool has been shown to be deficient in certain cases such as when relating the heart dimensions of a short obese person to a tall, slim person who might have the same BSA [12]. Furthermore, the present reference ranges might also result in delayed diagnosis and treatment of heart enlargement in patients possessing small BSA, due to the underestimation of the heart size [12].

Although not fully substantiated, observations from our study revealed that the applicability of this study to the prehypertensive population must be done with caution as a 1cm increase in heart diameter over the expected upper limit (the right palm diameter) might be seen on sonography. Hence, this tool might also prove effective for the screening and identification of early cardiac remodelling in patients with persistent prehypertension.

The PLAX approach used in this study is easy and captures the essential cavities and valves. Therefore, heart enlargement from any underlying defect would likely reflect on the measurement. It suffices to say that this simple procedure could be an alternative to unnecessary exposure to radiation from plain chest X-rays done to screen for cardiomegaly especially in developing countries. Also, this simple technique can be done by medical students at the patient's bedside to screen for a possible cardiomegaly. Hence, this further supports the on-going advocacy for the introduction of ultrasound education into the medical curriculum across the globe.

### Limitations of the study

Though we were limited by the numbers of participants in the age ranges over 26, however, we do not think that would have affected the outcome of our study. However, further studies still need to be carried out to closely investigate the adult population. The study did not account for the impact of other predictors of heart enlargement on the palm-heart relationship, such as participation in sports and hemodynamic conditions like Sickle cell disease amongst others.

In conclusion, the statement linking the sizes of the heart with the size of either hand has been said among few but without scientific backing until now. This study tends to confirm the relationship between details and also offer the prospect on its clinical relevance. This relationship could be employed in the early investigation of heart enlargement, thus reducing the incidence of poor prognosis among patients. However, there is the need for further study to properly understand the relationship between the heart and palm measurements. The study also elucidated on the unclear relationship between the increase in age and the growth of cardiac tissue. With the current trend of attributing more attention to hypertensive blood pressure than prehypertension, the study suggests that both abnormal pressures should receive an equal level of response to avoid cardiac tissue remodelling. It also supports the on-going advocacy for the inclusion of basic ultrasound education in the curriculum for medical students at large.

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