



Normal Adrenal Gland Thickness on Computerized Tomography Among Indian Adults Living in Coastal Regions: A Retrospective Study

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ABSTRACT:

Objective: The aim of the present study was to establish the baseline reference range for normal adrenal gland thickness in Indian adults living in the coastal regions.

Methods: This was a retrospective observational study conducted in the Department of Radiology, Vinayaka Missions Medical College & Hospital, Karaikal, Puducherry, India (tertiary healthcare facility) in south India between September 2022 and August 2023 among adult patients who underwent Computed Tomography (CT) of the upper abdomen.

Results: The present study included a total of 180 patients. The mean (SD) age of the patients was 49.4 years (17.6). More than half (57.8%) were males. The mean (SD) thickness of the right adrenal gland body was 7.4 millimetres (2.1), medial limb was 4.5 millimetres (1.3) and lateral limb was 4.7 mm (1.3). Similarly, the mean (SD) thickness of the left adrenal gland body was 9.1 mm (2.3), medial limb was 4.9 mm (1.0) and lateral limb was 5.1 mm (1.1). It was found that the left adrenal gland was larger than the right – the body of left adrenal gland was 1.7 mm larger than the right ($p<0.001$); the medial limb of left adrenal gland was 0.4 mm larger than the right ($p=0.001$); and the lateral limb of left adrenal gland was 0.4 mm larger than the right ($p=0.002$). Cumulatively, the left adrenal gland was 2.5 mm larger than the right adrenal gland – a statistically significant difference ($p<0.05$). The mean (SD) thickness of the body, medial and lateral limb of male adrenal glands were larger than females – a statistically significant difference ($p<0.05$). The results of correlation analysis showed that the age and adrenal right gland thickness had positive significant moderate correlation ($r_s=0.426$; $p<0.001$). Similarly, the age and left adrenal gland thickness had positive significant moderate correlation ($r_s=0.456$; $p<0.001$).

Conclusion: These findings contribute to the understanding of normal adrenal gland anatomy in the specified population, providing clinicians and radiologists with valuable reference ranges for interpreting adrenal imaging results.

Introduction

The assessment of adrenal limb size plays a crucial role in evaluating adrenal glands to determine normalcy or

identify diffuse enlargement.(1) Previous investigations into the dimensions of normal adrenal glands did not specifically outline the width of individual adrenal



limbs.(2-4) Although these studies utilized early-generation CT systems with extended data acquisition times and generated images of suboptimal resolution, the CT representations of adrenal gland size and configuration exhibited consistent correlation with post-mortem study data.(5) However, challenges arise due to the potential misinterpretation of these measurements and the absence of a clearly defined normal range for adrenal limb size.(6)

Montagne et al.(3) and Karstaedt et al.(7) conducted measurements on the maximum width or thickness of adrenal glands, measured perpendicular to the long axis of the gland or one of its limbs. Given the anatomical arrangement of the gland, the maximum width typically occurs at the junction of the medial and lateral limbs. Notably, the maximum width consistently surpasses the width of individual limbs. Unfortunately, an erroneous application of the maximum width measurement has occurred, as it has been mistakenly utilized as the upper limit of normal for adrenal limb width.(8, 9) The aim of the present study was to establish the baseline reference range for normal adrenal gland thickness in Indian adults living in the coastal regions.

Methods

This was a retrospective observational study conducted in the Department of Radiology, Vinayaka Missions Medical College & Hospital, Karaikal, Puducherry, India (tertiary healthcare facility) in south India between September 2022 and August 2023 among adult patients who underwent Computed Tomography (CT) of the upper abdomen. The study was approved by the Institutional Human Ethics Committee (IHEC). After obtaining necessary approvals from the Dean, Medical Superintendent, and the Head of Medical records department (MRD), the electronic medical records (EMR) and radiological reports were accessed. The patients undergoing CT abdomen (in order to ensure uniformity in slice thickness, image quality, and data across all the study cases) for unrelated clinical indications were included in the present study. However, we excluded patients with clinical, biochemical, or radiological evidence of adrenal disease/lesions (including those with nodular thickening), patients with inflammatory changes around adrenals (acute pancreatitis, acute pyelonephritis), very minimal fat

around adrenal glands, patients with history of chronic steroid use, and CT images with movement artifacts.

We resorted to complete enumeration of all cases (in accordance to prespecified inclusion and exclusion criteria) during the study period and therefore, sample size was not estimated. A purpose predesigned, semi structured, pretested questionnaire was used to collect data on sociodemographic characteristics (age in years and gender) and adrenal gland thickness. The CT studies included thin-slice axial images (less than or equal to 2.5 mm slice thickness). The following measurements were made in each late arterial or early portal venous phase CT on the axial image in an abdominal soft tissue window setting (window level 40 to 60, window width 400) using a standard described method – the maximum thickness of the body, the medial and the lateral limbs were measured perpendicular to their long axis, in both adrenal glands. The measurements were recorded in millimetres (mm) to the nearest single decimal point.

The data obtained was entered in Microsoft Excel, coded, recoded, and analysed using Statistical Package for Social Sciences (SPSS) v23. Descriptive analysis was done – numbers and percentages, mean and standard deviation was calculated. The association between adrenal gland thickness and gender was analysed using independent “t” test. Graphical representation using Box and Whisker plots were made. Based on data normality tested using Kolmogorov–Smirnov test and the Shapiro–Wilk test, Spearman’s correlation coefficient was used to measure correlation between age and adrenal gland thickness – scatter plots were made. In the present study, statistical significance was considered at $p < 0.05$.

Results

The present study included a total of 180 patients undergoing CT abdomen for unrelated clinical indications during the study period. The mean (SD) age of the patients was 49.4 years (17.6); ranging between 19 and 78 years. The median (IQR) age of the patients was 49 years. More than half the patients (57.8%) were males. The mean (SD) thickness of the right adrenal gland body was 7.4 millimetres (2.1), medial limb was 4.5 millimetres (1.3) and lateral limb was 4.7 mm (1.3). Similarly, the mean (SD) thickness of the left adrenal gland body was 9.1 mm (2.3), medial limb was 4.9 mm (1.0) and lateral limb was 5.1 mm (1.1).



We tested for statistical difference between the measurements in right and left sides. It was found that the left adrenal gland was larger than the right – the body of left adrenal gland was 1.7 mm larger than the right ($p<0.001$); the medial limb of left adrenal gland was 0.4 mm larger than the right ($p=0.001$); and the lateral limb of left adrenal gland was 0.4 mm larger than the right ($p=0.002$). Cumulatively, the left adrenal gland was 2.5 mm larger than the right adrenal gland – a statistically significant difference ($p<0.05$). Similarly, in the subgroup analysis by gender, the left adrenal gland was significantly larger than the right adrenal ($p<0.05$).

The mean (SD) thickness of the body of male right adrenal gland was 8.1 (2.0) in comparison with females (Mean 6.7, SD 1.0) – a statistically significant difference ($p<0.05$). Similarly, the medial limb (Mean 4.7, SD 1.1) and lateral limb of male right adrenal gland (Mean 5.0, SD 1.1) was significantly larger than the medial (Mean 3.8, SD 1.1) and lateral limbs (Mean 4.1, SD 0.9) of female right adrenal gland.

The mean (SD) thickness of the body of male left adrenal gland was 9.6 mm (1.9) in comparison with females (Mean 8.3, SD 1.2) – a statistically significant difference ($p<0.05$). Similarly, the medial limb (Mean 5.2, SD 0.9) and lateral limb of male left adrenal gland (Mean 5.4, SD 0.9) was significantly larger than the medial (Mean 4.6, SD 0.9) and lateral limbs (Mean 4.4, SD 1.1) of female left adrenal gland.

Correlation analysis: We conducted correlation analysis between adrenal gland thickness and age (in years). The results showed that the age and right adrenal gland thickness had positive significant moderate correlation ($r_s=0.426$; $p<0.001$). Similarly, the age and left adrenal gland thickness had positive significant moderate correlation ($r_s=0.456$; $p<0.001$).

Discussion

The study included a diverse sample of 180 adult patients undergoing CT abdomen for unrelated clinical indications in a tertiary healthcare facility in south India. The demographic characteristics, including a mean age of 49.4 years and a slight male predominance (57.8%), contribute to the representativeness of the sample. The study measured adrenal gland thickness using CT abdomen, providing detailed insights into the dimensions of both the right and left adrenal glands. The reported

mean thickness values for the right adrenal gland body, medial limb, lateral limb, left adrenal gland body, medial limb, and lateral limb offer valuable baseline data for this population. To contextualize these findings, it is essential to compare them with existing literature. Previous studies on adrenal gland thickness in diverse populations have reported variations influenced by factors such as age, sex, and ethnicity.(10, 11)

The mean (SD) thickness of the right adrenal gland body was 7.4 millimetres (2.1), medial limb was 4.5 millimetres (1.3) and lateral limb was 4.7 mm (1.3). Similarly, the mean (SD) thickness of the left adrenal gland body was 9.1 mm (2.3), medial limb was 4.9 mm (1.0) and lateral limb was 5.1 mm (1.1). Adrenal gland thickness is typically measured using imaging techniques such as CT abdomen (typically measured in the axial plane (cross-sectional view) at the widest point of each gland; measurements taken from the outer edge of the adrenal cortex to the inner edge of the adrenal medulla).(12) Adrenal glands are paired endocrine glands located on top of each kidney, and they play a crucial role in producing hormones such as cortisol and adrenaline.(13) Measuring the thickness of the adrenal glands is important in assessing various medical conditions, including adrenal disorders. Establishing reference ranges for adrenal gland thickness is crucial for clinical practice. Deviations from these normal ranges may indicate underlying pathology, such as adrenal hyperplasia or tumours. Clinicians in the coastal regions of India can use these baseline values to assess patients more accurately, enhancing diagnostic precision.

The study findings reveal a statistically significant asymmetry in adrenal gland size, with the left adrenal gland consistently larger than the right. This observation aligns with existing literature on adrenal gland anatomy, where mild asymmetry is considered normal.(14-16) Studies by Boland et al. and Song et al. have reported similar findings, noting that the left adrenal gland is often larger in size compared to the right.(17, 18) While the exact reasons for this asymmetry are not fully understood, it's believed to be related to differences in blood supply, venous drainage, or embryological development.(19) Understanding the normal anatomical variations in adrenal gland size is crucial for accurate clinical assessments. The observed left-sided predominance may impact diagnostic interpretations. The results of subgroup analysis by gender further



strengthens the significance of the left adrenal gland's larger size.(20) This finding is noteworthy as it emphasizes the consistency of the asymmetry across different demographic groups. However, the exact mechanisms underlying gender-specific adrenal size differences warrant further investigation.(21) Exploring associations with genetic factors, hormonal influences, or specific environmental exposures could provide a more comprehensive understanding of the observed variations.

The study findings highlight statistically significant gender-based differences in the thickness of both the right and left adrenal glands. These differences across various segments of the adrenal glands, including the body, medial limb, and lateral limb, underscore the importance of considering gender-specific variations in adrenal anatomy. The observed gender differences in adrenal gland size are consistent with existing literature. Studies by Gao et al. and Zhang et al. have reported similar findings, indicating that male adrenal glands are generally larger than those in females.(22, 23) These differences may be attributed to hormonal influences (including sex hormones), particularly the effects of androgens on adrenal gland development and function.(24) Androgens, such as testosterone, have been implicated in promoting adrenal gland growth.(25) The observed larger size of male adrenal glands, particularly in the body, medial limb, and lateral limb, may be linked to the androgenic effects on adrenal cortical cells.(26)

The correlation analysis reveals a positive and statistically significant moderate correlation between age and adrenal gland thickness, both for the right and left adrenal glands. This observation suggests that as individuals age, there is a tendency for the adrenal glands to undergo changes in size, with an increase in thickness. The positive correlation between age and adrenal gland thickness aligns with existing literature. Several studies, including those by Bielohuby et al. and Mouritzen et al., have reported age-related changes in adrenal gland morphology, demonstrating that adrenal glands tend to increase in size with advancing age.(27, 28) These changes are likely multifactorial, involving factors such as hormonal influences, alterations in vasculature, and changes in adrenal tissue composition. The adrenal glands are subject to hormonal regulation, and changes in hormone levels with age could contribute to the observed correlation. The gradual decline in certain

hormones, such as dehydroepiandrosterone (DHEA) and DHEA sulfate, which are produced by the adrenal glands, may influence adrenal gland morphology.(29) Moreover, alterations in the renin-angiotensin-aldosterone system with age could also play a role in adrenal size changes.(30)

The present study is not without limitations. The retrospective nature of the study may introduce selection bias limiting the generalizability of the findings to the broader population. The study was conducted in a single tertiary healthcare facility, which may not fully capture the diversity of the entire population. Healthcare-seeking behaviour, access to medical facilities, and regional variations could influence the characteristics of the study population. The study provides age and gender information, but other demographic factors such as socioeconomic status, lifestyle, and specific ethnic subgroups within the population were not considered. These factors could potentially influence adrenal gland characteristics. The study relies on CT abdomen for assessing adrenal gland thickness. While CT is a commonly used imaging modality, it has limitations, such as exposure to ionizing radiation. The use of alternative imaging techniques, like magnetic resonance imaging (MRI), could provide additional insights. Hormonal status, including levels of adrenal hormones such as cortisol and DHEA, was not considered in the analysis. Hormonal influences can significantly affect adrenal gland morphology, and the absence of this information may limit the interpretation of the results.

Conclusion

The present study documented the dimensions of the right and left adrenal glands. The key findings of the study included significant variations in adrenal gland thickness between the right and left sides, with the left adrenal gland consistently larger than the right. Gender-specific differences were identified, indicating that male adrenal glands tend to be larger than female glands, both on the right and left sides. Correlation analysis revealed a positive and significant moderate correlation between age and adrenal gland thickness, suggesting age-related changes in adrenal morphology.

These findings contribute to the understanding of normal adrenal gland anatomy in the specified population, providing clinicians and radiologists with valuable



reference ranges for interpreting adrenal imaging results. The observed asymmetry and gender-specific differences underscore the importance of considering these factors in clinical practice to avoid misinterpretations and unnecessary interventions.

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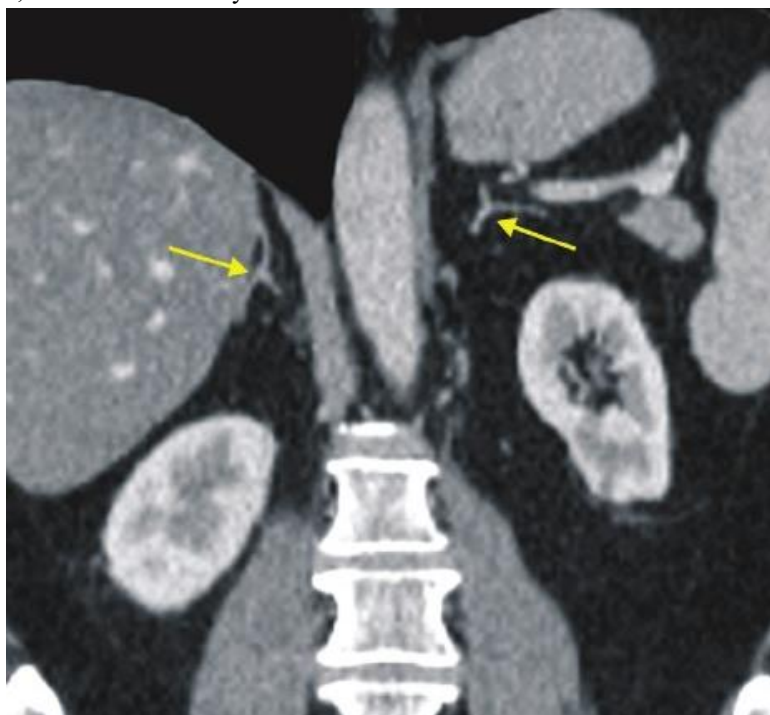


Figure 1: Normal triangular adrenal glands

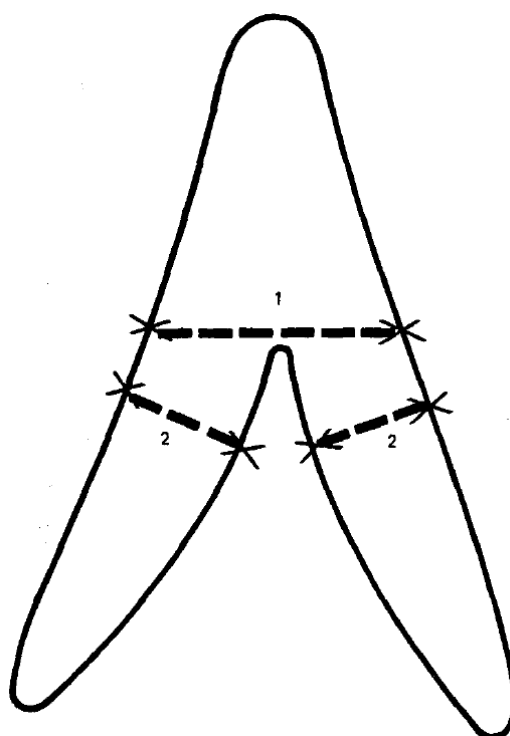


Figure 2: Adrenal gland measurement technique (Note: 1 – Indicates the maximum width of the adrenal gland; 2 – Indicates the maximum width of the limbs of the adrenal gland)

Table 1: Association between adrenal gland thickness, side (right/left) and gender

Adrenal gland thickness	Right	Left	P value
	Mean (SD)	Mean (SD)	
Overall (n = 180)			
Body	7.4 (2.1)	9.1 (2.3)	<0.001*
Medial limb	4.5 (1.3)	4.9 (1.0)	0.001*
Lateral limb	4.7 (1.3)	5.1 (1.1)	0.002*
Males (n = 104)			
Body	8.1 (2.0)	9.6 (1.9)	<0.001*
Medial limb	4.7 (1.1)	5.2 (0.9)	0.021*
Lateral limb	5.0 (1.1)	5.4 (0.9)	0.028*
Females (n = 76)			
Body	6.7 (1.0)	8.3 (1.2)	<0.001*
Medial limb	3.8 (1.1)	4.6 (0.9)	0.007*
Lateral limb	4.1 (0.9)	4.4 (1.1)	0.041*
*Statistically significant at p<0.05			
SD, Standard deviation			

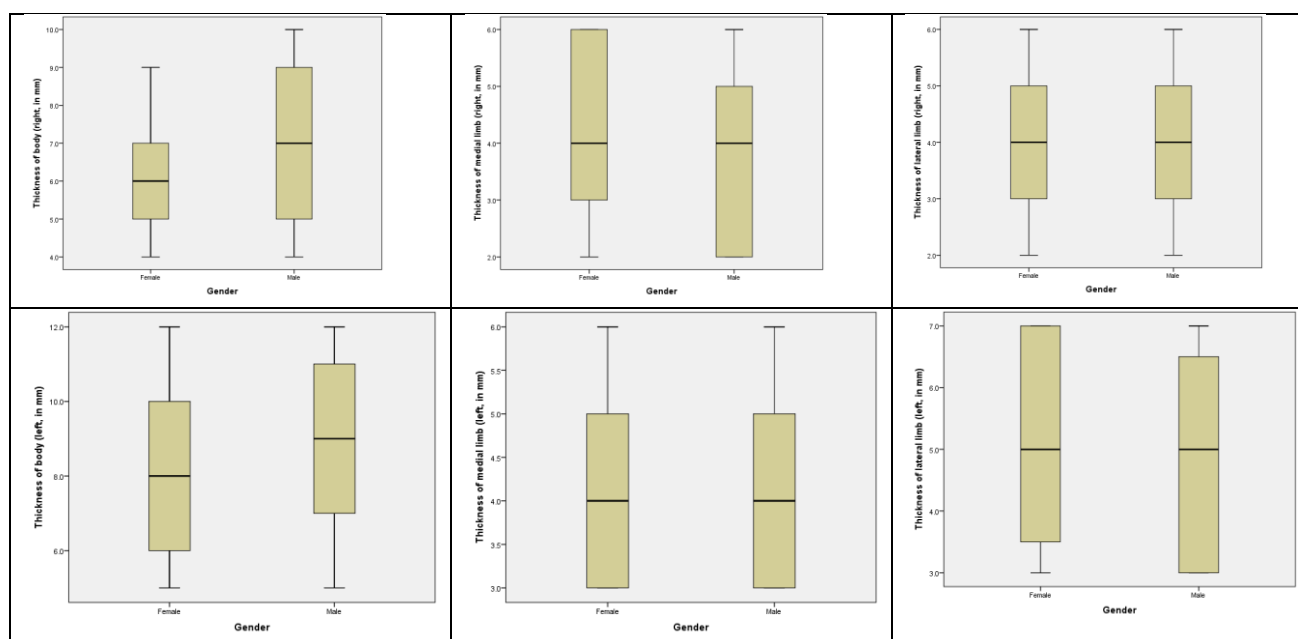


Figure 3: Association between adrenal gland thickness and gender – box and whisker plots

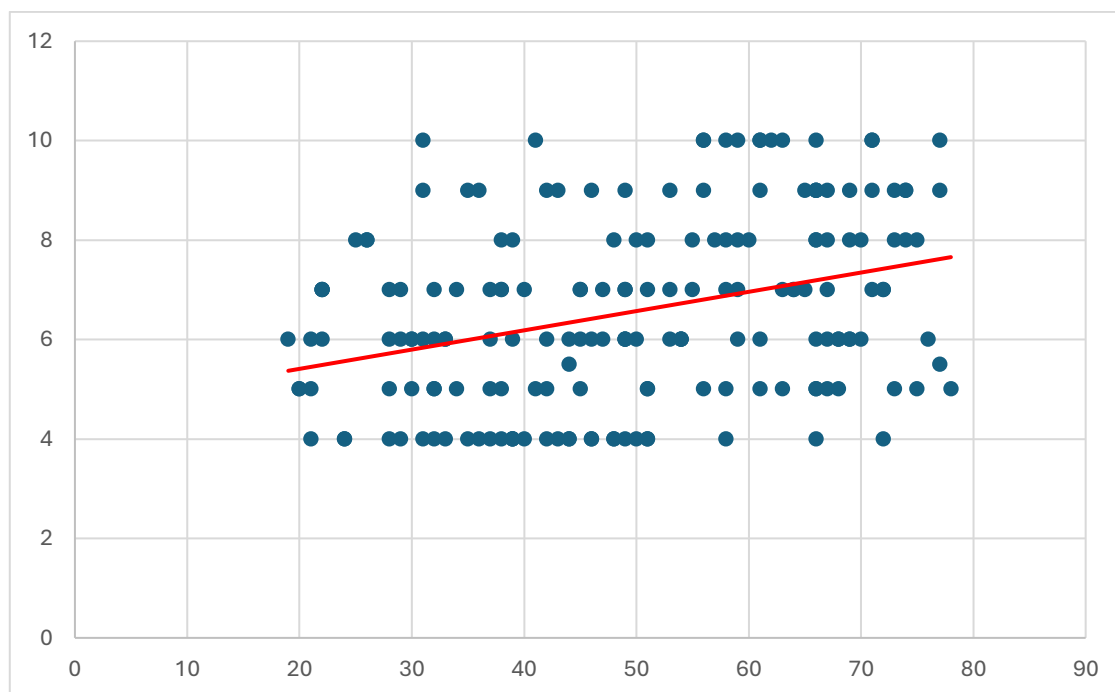


Figure 4: Correlation between age and right adrenal gland thickness

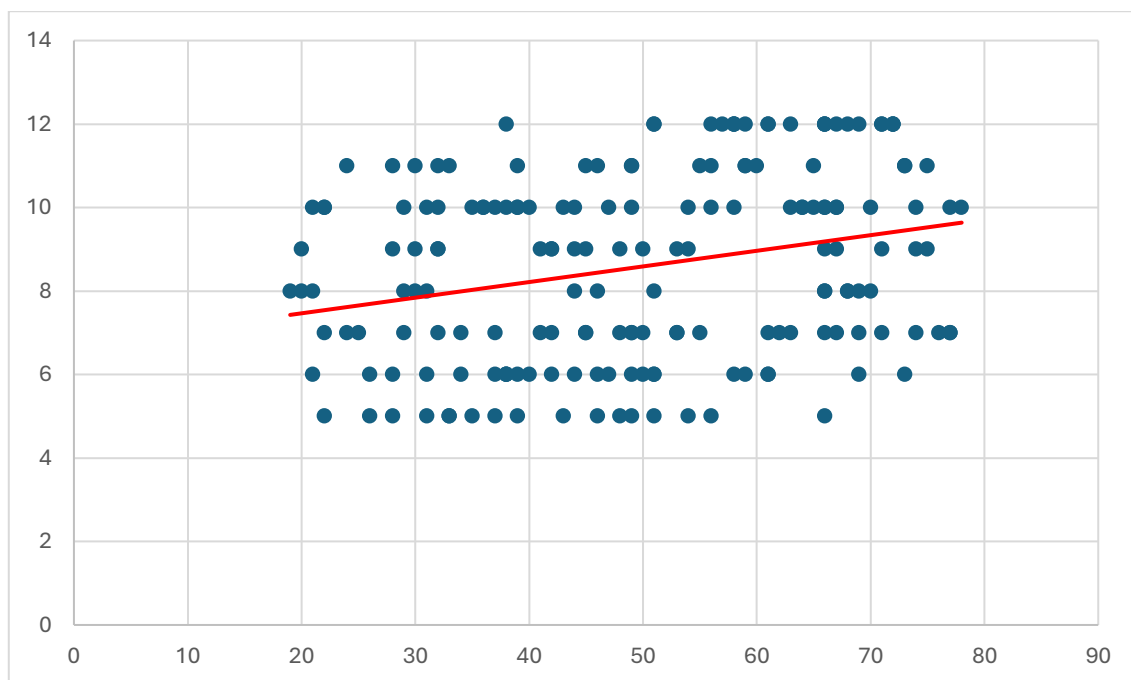


Figure 5: Correlation between age and left adrenal gland thickness