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Microcardia and cardiomegaly screening using postero-anterior chest X-ray (PA CXR) across university students in Ghana – a retrospective study

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Abstract

Background Microcardia and cardiomegaly are good diagnostic and prognostic tools for several diseases. This study investigated the distribution of microcardia and cardiomegaly among students of the University of Health and Allied Sciences (UHAS) in Ghana to determine the prevalence of microcardia and cardiomegaly across gender, and to evaluate the correlation between the presence of these heart conditions and age.

Methods This retrospective study involved a review of 4519 postero-anterior (PA) chest X-rays (CXRs) between 2020 and 2023. The CXRs were taken using a digital radiography machine. The CXRs were obtained on PA projection, with the students upright, on arrested inspiration and a source-to-detector distance of 180 cm. Only CXR images with no significant rotation (assessed using the distance between the medial ends of the clavicles and the vertebral spinous processes) and lung abnormalities were included in the study. The transverse cardiac diameter (TCD) and transverse thoracic diameter (TTD) were measured and cardiothoracic ratio (CTR) calculated for each CXR. The CTR was calculated as a ratio of TCD/TTD and categorised as microcardia ($CTR < 0.42$), normal heart size ($0.42 < CTR \leq 0.50$) and cardiomegaly ($0.50 < CTR \leq 0.60$). The data was analysed using the Statistical Package for the Social Sciences (SPSS) version 26 and descriptive and inferential statistics were conducted. The Mann-Whitney U Test was conducted to determine statistically significant differences in TCD, TTD and CTR across female and male students. Spearman's rho correlation was conducted to investigate the relationships between age and TCD, TTD and CTR.

Results The students were aged 15–37 years ($mean = 19.60 \pm 2.20$) with a modal age of 18 years. The study included 2930 (64.84%) females and 1589 (35.16%) males. Most of the students [3384 (74.88%)] had normal heart sizes. However, 647 (14.32%) had microcardia whereas 488 (10.80%) had cardiomegaly. Out of the students suffering from cardiomegaly, 478 (97.95%) and 10 (2.05%) had mild/moderate and severe cardiomegaly respectively. Cardiomegaly

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was more common among the female students ($p < 0.05$) and those aged 15–22 years [418 (85.66%)]. There was no correlation between TCD, TTD and CTR and age [$r = 0.01$, $p = 0.42$; $r = 0.02$, $p = 0.17$; $r = 0.01$, $p = 0.66$, respectively].

Conclusion The majority of the students had normal heart sizes, but a few had microcardia and cardiomegaly. Cardiomegaly was more common among the female students. The presence of microcardia and cardiomegaly could have health implications for the students and increase their risks of cardiovascular diseases hence these students should be further screened medically for the underlying causes though they may be asymptomatic. Stakeholders in higher education and public health may find this study useful in developing strategies to minimise the prevalence of cardiac diseases and also improve treatment.

Keywords Cardiomegaly, Microcardia, Chest X-ray, Cardiovascular diseases, Students, University, Ghana

Background

Cardiovascular diseases (CVDs) are disorders of the heart and blood vessels and account for approximately 18 million global deaths annually [1–3]. In Africa, CVDs are the major cause of death. They account for about 13% of all deaths and 37% of deaths resulting from non-communicable diseases in sub-Saharan Africa [4, 5]. Common CVDs include stroke, hypertension, heart failure, myocardial infarction and congenital heart disease (CHD) [6]. These diseases are life-threatening and require timely diagnosis to facilitate prompt management. For example, patients suffering from hypertension usually have hypertrophic or enlarged heart (i.e., cardiomegaly) which could lead to heart failure [7]. Most people with cardiomegaly have no signs and symptoms. But others may have signs and symptoms such as shortness of breath, abnormal heartbeat (arrhythmia), oedema, fatigue and palpitations [8]. Heart size is an essential indicator of microcardia and cardiomegaly, and in most clinical settings, the cardiothoracic ratio (CTR) is used to determine heart size [9, 10]. Cardiothoracic ratio is the ratio of the transverse cardiac diameter (TCD) and the widest internal transverse thoracic diameter (TTD) of a postero-anterior (PA) chest X-ray (CXR) [9–12]. Generally, CTR is categorised as small heart syndrome (i.e., microcardia) (CTR < 0.42), normal heart size (0.42 < CTR ≤ 0.50), mild/moderate cardiomegaly (0.50 < CTR ≤ 0.60) and severe cardiomegaly (CTR > 0.60) [13–15]. The burden of microcardia and cardiomegaly are huge across several countries. For instance, in Ghana, cardiomegaly accounted for over 12% of autopsy series over a 3-year period [16]. Akosa and Armah [16] further indicated that hypertension accounted for over 78% of the causes of cardiomegaly, and almost 50% of deaths from cardiomegaly occurred in patients aged < 50 years.

Several studies [17–19] have investigated heart sizes from PA CXRs across various populations. In Saudi Arabia, Alghamdi et al. [17] indicated that 36% of the participants had cardiomegaly and it was more prevalent among males and middle-aged participants. Also, in a single center study involving 1989 Ghanaian patients, Mensah et al. [12] indicated that the patients had normal heart sizes with an average CTR of 0.46. Similarly, two other studies [11, 19] among Ghanaian adults concluded that the participants had normal heart sizes with significant sex and age-related differences in cardiac size parameters. These differences, if applied in clinical decision-making, may result in effective patient management. Although CVDs are usually prevalent among the more elderly population, recent studies [12, 20–23] have highlighted increasing prevalence, incidence and mortality from CVDs among young adults due to lifestyle factors such as stress, unhealthy eating habits, inappropriate drug use and lack of exercise that put them at an increased risk of developing CVDs. To the authors' knowledge, no research has been conducted to screen for microcardia and cardiomegaly in students at the University of Health and Allied Sciences (UHAS) in Ghana. To address this knowledge gap, a four-year retrospective study was conducted to review PA CXRs of male and female students of UHAS so as to achieve the following objectives:

- to determine the prevalence of microcardia and cardiomegaly.
- to evaluate the correlation between the presence of these heart conditions and age.

Methods

Study setting

Our study was conducted at UHAS, which has two main campuses in Ho and Hohoe, in the Volta Region of Ghana. The university was established in 2012, and it is the only state-owned university in the country wholly dedicated to the training of health professionals. Currently, the university runs 22 undergraduate and several postgraduate programmes across eight schools. There are about ten thousand students spread over its two campuses.

Study Design

The study employed a retrospective study design and involved a review of PA CXRs of newly admitted university students between 2020 and 2023.

Data extraction

The data was accessed from the students' medical archives of the university. The CXRs were obtained on PA projection, with the students upright, on arrested inspiration and a source-to-detector distance of 180 cm. The CXRs were taken using a digital radiography machine (ATX QUANTpower 400 DR). All the CXRs met the following characteristics – no significant rotation (assessed using the distance between the medial ends of the clavicles and the vertebral spinous processes), and no obvious thoracic cage, lung and cardiac abnormalities. Data extracted from the CXRs included age, sex, TCD and TTD. The age and sex of the students were obtained from the annotations on the CXRs. As shown in Fig. 1, TCD for each CXR was obtained by measuring the maximum transverse diameter of the cardiac silhouette (A), whereas the widest inner transverse diameter of the thorax was measured to obtain TTD (B). CTR was further calculated using the formula; $CTR = \frac{TCD\ (A)}{TTD\ (B)}$ [15].

To assess intra and inter-observer reproducibility, the TCD and TTD of 200 randomly selected CXRs were measured in centimetres (cm) by three of the authors (a radiographer with over 17 years work experience and two research assistants). Intra-class correlation coefficient (ICC) indicated excellent reproducibility (0.94) between the observers [24]. Subsequently, TCD and TTD of 4519 students were measured, and CTR calculated for each student. The heart size for each student was categorised as follows: microcardia ($CTR<0.42$), normal heart size ($0.42<CTR\leq0.50$), mild/moderate cardiomegaly ($0.50<CTR\leq0.60$) and severe cardiomegaly ($CTR>0.60$) [13–15].

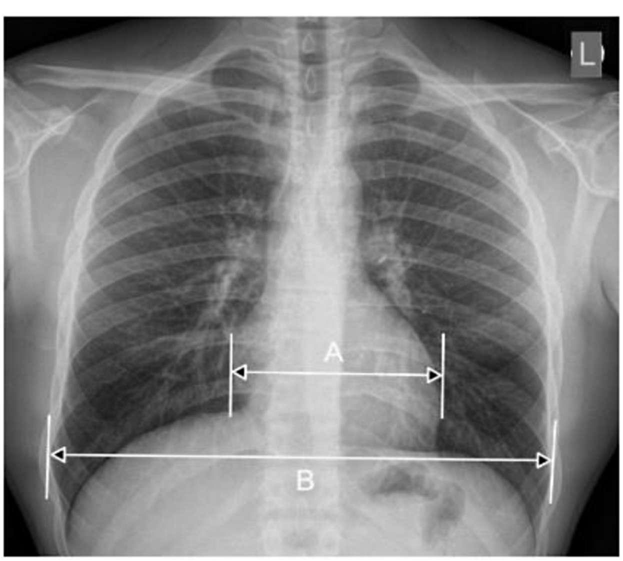

Fig. 1 Pictorial illustration of TCD and TTD measurements (image adopted from Truszkiewicz et al. [15])

Statistical analysis

The data was analysed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics comprising mean, median, mode, range, distribution frequencies and percentages were adopted in reporting the findings. The data was assessed for normality using histograms and Kolmogorov-Smirnov test. The results of normality testing indicated that the data were not normally distributed. Kolmogorov-Smirnov tests indicated statistically significant p values ($p<0.05$). The non-parametric Mann-Whitney U test was conducted to determine statistically significant differences in TCD, TTD and CTR across female and male students. The differences were categorised per Cohen's effect size classification [25]. Finally, the relationships between age versus TCD, age versus TTD and age versus CTR were investigated using Spearman's rho correlation. For all the inferential statistics, statistically significant level was set at $p\leq0.05$.

Results

The study involved 4519 newly-admitted university students aged 15 to 37 years (mean=19.60±2.20 years) with a modal age of 18 years. The study included 2930 (64.84%) females and 1589 (35.16%) males. The TCD measurements of the students across both sexes and age groups are shown in Table 1. The TCD across the students ranged between 1.5 and 3.8 cm (mean=2.37±0.31). Female students recorded slightly higher TCD values [range=1.5–3.8 cm (mean=2.42±0.32)] compared to the males [range=1.6–3.5 cm (mean=2.27±0.27)]. A Mann-Whitney U test revealed a statistically significant difference in TCD values across female (median=2.40) and male students (median=2.20), $p=0.001$. Using Cohen's classification, the difference in TCD values across female and male students was small (d=0.23). The relationship between age and TCD was investigated using Spearman's rho correlation. There was no correlation between the two variables, $r=0.01$, $p=0.42$.

The TTD measurements of the students across both sexes and age groups are shown in Table 2. The TTD values across the students ranged between 3.6 and 7.1 cm (mean=5.19±0.49). The female students recorded slightly higher TTD values [range=3.6–7.1 cm (mean=5.23±0.49)] compared to the males [range=3.7–6.9 cm (mean=5.11±0.46)]. A Mann-Whitney U test revealed a statistically significant difference in TTD values across female (median=5.20) and male students (median=5.0), $p=0.001$. Using Cohen's classification, the difference in TTD values across female and male students was small (d=0.13). The relationship between age and TTD was investigated using Spearman's rho correlation. There was no correlation between the two variables, $r=0.02$, $p=0.17$.

Table 1 Transverse Cardiac Diameter (TCD) values of the students across both sexes and age

TCD (cm)	No. (%)	Sex		Age in years		
		Male [No. (%)]	Female [No. (%)]	15–22 [No. (%)]	23–30 [No. (%)]	31–37 [No. (%)]
1.5	2 (0.04)	0 (0.00)	2 (100.00)	2 (100.00)	0 (0.00)	0 (0.00)
1.6	7 (0.15)	1 (14.29)	6 (85.71)	7 (100.00)	0 (0.00)	0 (0.00)
1.7	42 (0.93)	19 (45.24)	23 (54.76)	41 (97.62)	1 (2.38)	0 (0.00)
1.8	75 (1.66)	38 (50.67)	37 (49.33)	66 (88.00)	9 (12.00)	0 (0.00)
1.9	166 (3.67)	85 (51.20)	81 (48.80)	154 (92.77)	10 (6.02)	2 (1.20)
2.0	371 (8.21)	187 (50.40)	184 (49.60)	346 (93.26)	24 (6.47)	1 (0.27)
2.1	481 (10.64)	246 (51.14)	235 (48.86)	437 (90.85)	44 (9.15)	0 (0.00)
2.2	609 (13.48)	239 (39.24)	370 (60.76)	560 (91.95)	48 (7.88)	1 (0.16)
2.3	616 (13.63)	224 (36.36)	392 (63.64)	565 (91.72)	50 (8.12)	1 (0.16)
2.4	490 (10.84)	151 (30.82)	339 (69.18)	451 (92.04)	38 (7.76)	1 (0.20)
2.5	578 (12.79)	181 (31.31)	397 (68.69)	523 (90.48)	50 (8.65)	5 (0.87)
2.6	294 (6.51)	74 (25.17)	220 (74.83)	263 (89.46)	31 (10.54)	0 (0.00)
2.7	269 (5.95)	58 (21.56)	211 (78.44)	237 (88.10)	30 (11.15)	2 (0.74)
2.8	192 (4.25)	36 (18.75)	156 (81.25)	166 (86.46)	25 (13.02)	1 (0.52)
2.9	110 (2.43)	17 (15.45)	93 (84.55)	96 (87.27)	14 (12.73)	0 (0.00)
3.0	98 (2.17)	18 (18.37)	80 (81.63)	86 (87.76)	12 (12.24)	0 (0.00)
3.1	48 (1.06)	7 (14.58)	41 (85.42)	42 (87.50)	6 (12.50)	0 (0.00)
3.2	27 (0.60)	3 (11.11)	24 (88.89)	22 (81.48)	5 (18.52)	0 (0.00)
3.3	22 (0.49)	3 (13.64)	19 (86.36)	17 (77.27)	4 (18.18)	1 (4.55)
3.4	8 (0.18)	0 (0.00)	8 (100.00)	7 (87.50)	1 (12.50)	0 (0.00)
3.5	5 (0.11)	2 (40.00)	3 (60.00)	5 (100.00)	0 (0.00)	0 (0.00)
3.6	4 (0.09)	0 (0.00)	4 (100.00)	3 (75.00)	1 (25.00)	0 (0.00)
3.7	3 (0.07)	0 (0.00)	3 (100.00)	2 (66.67)	0 (0.00)	1 (33.33)
3.8	2 (0.04)	0 (0.00)	2 (100.00)	1 (50.00)	1 (50.00)	0 (0.00)
Total	**4519 (100.00)**	**1589 (35.16)**	**2930 (64.84)**	**4099 (90.71)**	**404 (8.94)**	**16 (0.35)**

The CTR values across the sample ranged between 0.32 and 0.68 (mean=0.46±0.04). The females recorded slightly higher CTR values [range=0.32–0.68 (mean=0.46±0.04)] compared to the males [range=0.34–0.67 (mean=0.44±0.03)]. A Mann-Whitney U test revealed a statistically significant difference in CTR values across female (median=0.46) and male students (median=0.44), $p=0.001$. Using Cohen's classification, the difference in CTR values across female and male students was small (d=0.19). The relationship between age and CTR was investigated using Spearman's rho correlation. There was no correlation between the two variables, $r=0.01$, $p=0.66$.

Most of the students 3384 (74.88%) had normal heart sizes but 647 (14.32%) students had microcardia (Table 3). Similarly, 488 (10.80%) students had cardiomegaly of which 478 (97.95%) had mild/moderate and 10 (2.05%) had severe cardiomegaly, respectively (Table 4). Cardiomegaly was more common among the female students [$n=416$ (85.25%)] than male students [$n=72$ (14.75%)], ($p<0.05$), and those aged 15–22 years [$n=418$ (85.66%)]. The distribution of microcardia, normal heart size and cardiomegaly across male and female students are shown in Fig. 2.

Discussion

Heart size categorisation to determine microcardia and cardiomegaly is a good prognostic tool for CVDs because it is a good indicator of cardiac function [15]. This study was conducted to review PA CXRs of students of UHAS to determine the prevalence of microcardia and cardiomegaly among male and female students, and to evaluate the correlation between the presence of these heart conditions and age. The results of this study showed that the female students recorded higher TCD and TTD values than the males. There was no statistically significant relationship between TCD, TTD and age. These findings are inconsistent with other studies [11, 12, 19] conducted in Ghana which indicated that TCD and TTD are associated with age. The difference in the findings between our study and the previous studies could be attributed to the ages of the participants involved in the studies. Whereas in our study the students had a narrower age range [15–37 years (mean=19.6±2.2 years)], the other studies had participants from wider age ranges; 21–80 years [16], 10–60^{+} years (mean=30.9±12.4 years) [17] and 20–80 years (mean=39.4±14 years) [24].

Our study showed that most of the students [$n=3384$ (74.9%)] had normal heart sizes. This outcome is

Table 2 Transverse Thoracic Diameter (TTD) values of the students across both sexes and age

TTD (cm)	No. (%)	Sex		Age in years		
		Male [No. (%)]	Female [No. (%)]	15–22 [No. (%)]	23–30 [No. (%)]	31–37 [No. (%)]
3.6	5 (0.11)	0 (0.00)	5 (100.00)	5 (100.00)	0 (0.00)	0 (0.00)
3.7	4 (0.09)	1 (25.00)	3 (75.00)	4 (100.00)	0 (0.00)	0 (0.00)
3.8	3 (0.07)	1 (33.33)	2 (66.67)	3 (100.00)	0 (0.00)	0 (0.00)
3.9	9 (0.20)	0 (0.00)	9 (100.00)	9 (100.00)	0 (0.00)	0 (0.00)
4.0	10 (0.22)	1 (10.00)	9 (90.00)	8 (80.00)	2 (20.00)	0 (0.00)
4.1	16 (0.35)	7 (43.75)	9 (56.25)	14 (87.50)	2 (12.50)	0 (0.00)
4.2	25 (0.55)	12 (48.00)	13 (52.00)	22 (88.00)	3 (12.00)	0 (0.00)
4.3	42 (0.93)	20 (47.62)	22 (52.38)	39 (92.86)	3 (7.14)	0 (0.00)
4.4	90 (1.99)	38 (42.22)	52 (57.78)	82 (91.11)	8 (8.89)	0 (0.00)
4.5	139 (3.08)	60 (43.17)	79 (56.83)	127 (91.37)	12 (8.63)	0 (0.00)
4.6	180 (3.98)	87 (48.33)	93 (51.67)	161 (89.44)	18 (10.00)	1 (0.56)
4.7	229 (5.07)	115 (50.22)	114 (49.78)	209 (91.27)	19 (8.30)	1 (0.44)
4.8	349 (7.72)	149 (42.69)	200 (57.31)	319 (91.40)	28 (8.02)	2 (0.57)
4.9	351 (7.77)	143 (40.74)	208 (59.26)	327 (93.16)	23 (6.56)	1 (0.28)
5.0	423 (9.36)	175 (41.37)	248 (58.63)	389 (91.96)	33 (7.80)	1 (0.24)
5.1	408 (9.03)	129 (31.62)	279 (68.38)	366 (89.71)	40 (9.80)	2 (0.49)
5.2	401 (8.87)	119 (29.68)	282 (70.32)	364 (90.77)	37 (9.23)	0 (0.00)
5.3	348 (7.70)	98 (28.16)	250 (71.84)	322 (92.53)	25 (7.18)	1 (0.29)
5.4	262 (5.80)	91 (34.73)	171 (65.27)	233 (88.93)	26 (9.92)	3 (1.15)
5.5	324 (7.17)	87 (26.85)	237 (73.15)	293 (90.43)	31 (9.57)	0 (0.00)
5.6	180 (3.98)	56 (31.11)	124 (68.89)	163 (90.56)	17 (9.44)	0 (0.00)
5.7	161 (3.56)	42 (26.09)	119 (73.91)	142 (88.20)	19 (11.80)	0 (0.00)
5.8	136 (3.01)	37 (27.21)	99 (72.79)	113 (83.09)	20 (14.71)	3 (2.21)
5.9	108 (2.39)	33 (30.56)	75 (69.44)	95 (87.96)	12 (11.11)	1 (0.93)
6.0	85 (1.88)	23 (27.06)	62 (72.94)	79 (92.94)	6 (7.06)	0 (0.00)
6.1	64 (1.42)	24 (37.50)	40 (62.50)	61 (95.31)	3 (4.69)	0 (0.00)
6.2	41 (0.91)	12 (29.27)	29 (70.73)	37 (90.24)	4 (9.76)	0 (0.00)
6.3	39 (0.86)	12 (30.77)	27 (69.23)	36 (92.31)	3 (7.69)	0 (0.00)
6.4	21 (0.46)	8 (38.10)	13 (61.90)	18 (85.71)	3 (14.29)	0 (0.00)
6.5	17 (0.38)	3 (17.65)	14 (82.35)	15 (88.24)	2 (11.76)	0 (0.00)
6.6	8 (0.18)	1 (12.50)	7 (87.50)	6 (75.00)	2 (25.00)	0 (0.00)
6.7	12 (0.27)	2 (16.67)	10 (83.33)	11 (91.67)	1 (8.33)	0 (0.00)
6.8	16 (0.35)	2 (12.50)	14 (87.50)	15 (93.75)	1 (6.25)	0 (0.00)
6.9	7 (0.15)	1 (14.29)	6 (85.71)	6 (85.71)	1 (14.29)	0 (0.00)
7.0	4 (0.09)	0 (0.00)	4 (100.00)	4 (100.00)	0 (0.00)	0 (0.00)
7.1	2 (0.04)	0 (0.00)	2 (100.00)	2 (100.00)	0 (0.00)	0 (0.00)
Total	**4519 (100.00)**	**1589 (35.16)**	**2930 (64.84)**	**4099 (90.71)**	**404 (8.94)**	**16 (0.35)**

consistent with previous studies conducted in Ghana which indicated normal heart sizes among young adults [11, 12, 19]. The fact that most of the students had normal heart sizes is a sign that they have healthy hearts, and consequently good health, because the heart is central to the overall health of every individual. The key functions of the heart include pumping nutrient-rich blood and supplying oxygen throughout the body while removing toxins and waste [26]. A heart size within the normal range is usually associated with brain health and function because there is a close link between the health of the heart and that of the brain [27]. For example, a magnetic resonance imaging (MRI) study has shown that the positive features of the left ventricle of the heart were strongly associated with better white matter microstructure in the brain [28].

A key finding in our study was that 647 (14.32%) students had microcardia whereas 488 (10.79%) had cardiomegaly. Out of the students suffering from cardiomegaly, 478 (97.95%) had mild/moderate and 10 (2.05%) had severe cardiomegaly, respectively. The presence of microcardia (Fig. 3) and cardiomegaly could result in impaired or reduced cardiac performance among the students [29]. For example, it has been shown that people suffering

Table 3 Distribution of students with microcardia and normal heart sizes across sex and age

CTR	No. (%)	Sex		Age in years		
		Male [No. (%)]	Female [No. (%)]	15–22 [No. (%)]	23–30 [No. (%)]	31–37 [No. (%)]
Microcardia						
0.32	1 (0.15)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)
0.34	3 (0.46)	1 (33.33)	2 (66.67)	2 (66.67)	0 (0.00)	1 (33.33)
0.35	8 (1.24)	5 (62.50)	3 (37.50)	8 (100.00)	0 (0.00)	0 (0.00)
0.36	18 (2.78)	11 (61.11)	7 (38.89)	17 (94.44)	0 (0.00)	1 (5.56)
0.37	32 (4.95)	15 (46.88)	17 (53.13)	29 (90.63)	3 (9.38)	0 (0.00)
0.38	72 (11.13)	37 (51.39)	35 (48.61)	65 (90.28)	7 (9.72)	0 (0.00)
0.39	87 (13.45)	40 (45.98)	47 (54.02)	80 (91.95)	7 (8.05)	0 (0.00)
0.40	214 (33.08)	113 (52.80)	101 (47.20)	201 (93.93)	13 (6.07)	0 (0.00)
0.41	212 (32.77)	97 (45.75)	115 (54.25)	198 (93.40)	13 (6.13)	1 (0.47)
Total	**647 (100.00)**	**319 (49.30)**	**328 (50.70)**	**600 (92.74)**	**44 (6.80)**	**3 (0.46)**
Normal Heart						
0.42	398 (11.76)	170 (42.71)	228 (57.29)	371 (93.22)	27 (6.78)	0 (0.00)
0.43	431 (12.74)	187 (43.39)	244 (56.61)	400 (92.81)	31 (7.19)	0 (0.00)
0.44	444 (13.12)	156 (35.14)	288 (64.86)	406 (91.44)	37 (8.33)	1 (0.23)
0.45	456 (13.48)	176 (38.60)	280 (61.40)	419 (91.89)	36 (7.89)	1 (0.22)
0.46	422 (12.47)	145 (34.36)	277 (65.64)	383 (90.76)	37 (8.77)	2 (0.47)
0.47	407 (12.03)	124 (30.47)	283 (69.53)	365 (89.68)	41 (10.07)	1 (0.25)
0.48	335 (9.90)	114 (34.03)	221 (65.97)	302 (90.15)	33 (9.85)	0 (0.00)
0.49	280 (8.27)	81 (28.93)	199 (71.07)	245 (87.50)	32 (11.43)	3 (1.07)
0.50	211 (6.24)	45 (21.33)	166 (78.67)	190 (90.05)	21 (9.95)	0 (0.00)
Total	**3384 (100.00)**	**1198 (35.40)**	**2186 (64.60)**	**3081 (91.05)**	**295 (8.72)**	**8 (0.24)**

Table 4 Distribution of students with cardiomegaly across sex and age

CTR	No. (%)	Sex		Age in years			Diagnosis
		Male [No. (%)]	Female [No. (%)]	15–22 [No. (%)]	23–30 [No. (%)]	31–37 [No. (%)]	
0.51	149 (30.53)	28 (18.79)	121 (81.21)	127 (85.23)	21 (14.09)	1 (0.67)	**Mild/moderate Cardiomegaly**
0.52	101 (20.70)	11 (10.89)	90 (89.11)	87 (86.14)	13 (12.87)	1 (0.99)	
0.53	74 (15.16)	10 (13.51)	64 (86.49)	65 (87.84)	9 (12.16)	0 (0.00)	
0.54	51 (10.45)	5 (9.80)	46 (90.20)	46 (90.20)	5 (9.80)	0 (0.00)	
0.55	36 (7.38)	7 (19.44)	29 (80.56)	30 (83.33)	6 (16.67)	0 (0.00)	
0.56	22 (4.51)	2 (9.09)	20 (90.91)	17 (77.27)	3 (13.64)	2 (9.09)	
0.57	21 (4.30)	7 (33.33)	14 (66.67)	19 (90.48)	2 (9.52)	0 (0.00)	
0.58	17 (3.48)	1 (5.88)	16 (94.12)	16 (94.12)	1 (5.88)	0 (0.00)	
0.59	5 (1.03)	0 (0.00)	5 (100.00)	4 (80.00)	1 (20.00)	0 (0.00)	
0.60	2 (0.41)	0 (0.00)	2 (100.00)	0 (0.00)	2 (100.00)	0 (0.00)	
0.61	3 (0.61)	0 (0.00)	3 (100.00)	3 (100.00)	0 (0.00)	0 (0.00)	**Severe Cardiomegaly**
0.62	1 (0.21)	0 (0.00)	1 (100.00)	1 (100.00)	0 (0.00)	0 (0.00)	
0.64	2 (0.41)	0 (0.00)	2 (100.00)	1 (50.00)	0 (0.00)	1 (50.00)	
0.67	3 (0.61)	1 (33.33)	2 (66.67)	2 (66.67)	1 (33.33)	0 (0.00)	
0.68	1 (0.21)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	
Total	**488 (100.00)**	**72 (14.75)**	**416 (85.25)**	**418 (85.66)**	**65 (13.32)**	**5 (1.02)**	

from microcardia have significantly reduced left ventricular stroke volume and cardiac output [30]. Similarly, microcardia could predispose the students to chronic fatigue syndrome (CFS) and cardiovascular complaints such as chest pain, palpitation, dyspnoea and dizziness. These symptoms are caused by diminished venous return, diminished cardiac output, ischaemic heart muscle and decreased oxygen saturation of the blood as a result of a small heart [31].

Students suffering from cardiomegaly (such as that shown in Fig. 4) also have a higher risk of blood clots, which can impede blood flow and lead to a heart attack, stroke or pulmonary embolism (clot in the lungs) [32]. To make matters worse, the health risks of the students suffering from microcardia and cardiomegaly could be compounded by the high levels of stress that come with being engaged in laborious academic tasks. Anaman-Torgbor et al. [33] reported that most students attending

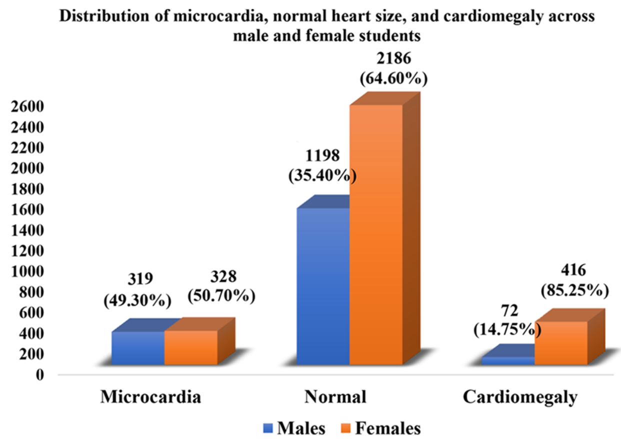

Fig. 2 The distribution of microcardia, normal heart size and cardiomegaly across male and female students

Fig. 3 Chest X-ray of a student with microcardia

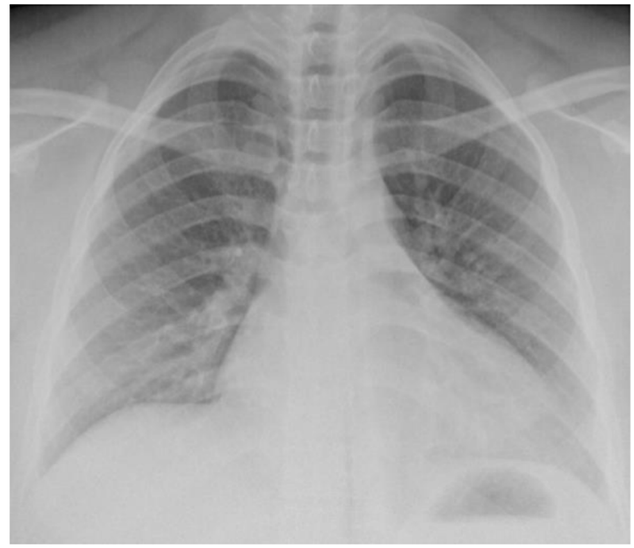

Fig. 4 Chest X-ray of a student with cardiomegaly

UHAS experience high academic workload. This causes stress and impacts negatively on their cognitive, behavioural and emotional well-being. Hence, this can be further complicated among students with microcardia and cardiomegaly.

To mitigate the effects of microcardia and cardiomegaly and promote good health, stakeholders in higher education and healthcare must actively promote positive health and lifestyle attitudes among university students. For instance, there must be aggressive and innovative campaigns using both traditional and social media to ensure that students do not engage in or continue cigarette smoking. Also, students must be encouraged to get physically active, eat healthy diets, maintain healthy weights, get quality sleep, manage stress, get regular medical screening and take steps to prevent infections. These habits can have a positive impact on their cardiovascular health. Specifically, regular physical activity – irrespective of the duration – offers health benefits [21]. Also, evidence show that a healthy diet can help protect the heart, improve blood pressure and cholesterol, and lower the risk of type 2 diabetes mellitus [1, 2]. Students must be encouraged to eat heart-healthy meals such as fruits and vegetables, beans or other legumes, fatty fish rich in omega-3, lean meats and whole grains [34]. All these recommendations can positively impact the overall health and academic wellness of the students.

Finally, our study has shown that microcardia and cardiomegaly were more common among female students and those aged 15–22 years. The reasons for this could be diverse but are beyond the scope of this paper; anthropometric parameters (weight and height), medical indicators (lipid profile and blood pressure) and lifestyle habits (eating and physical activity patterns) were not assessed in our study. These factors could influence heart size and health and could have provided a complete description of students' cardiac health. It is recommended that further studies are conducted taking into consideration anthropometric, medical and lifestyle data and their relationships with microcardia and cardiomegaly across the same or similar population.

Conclusion

In this study, the female students recorded higher TCD and TTD values than the males, and these values were not related to age. Most of the students had normal heart sizes, however some students had microcardia and cardiomegaly. Cardiomegaly was more common among the female students and those aged 15–22 years. The presence of microcardia and cardiomegaly could have health implications for the students and increase their risk of CVDs, as well as impact on their overall wellness. Campaigns need to be developed to promote healthy lifestyles among students at UHAS to enhance their overall wellness.

Limitations

Anthropometric parameters (weight and height), medical indicators (lipid profile and blood pressure) and lifestyle habits (eating and physical activity patterns) were not assessed in our study.

Abbreviations

Cm	Centimetres
CFS	Chronic fatigue syndrome
CHD	Congenital heart disease
CTR	Cardiothoracic ratio
CVDs	Cardiovascular diseases
CXR	Chest X-ray
ICC	Intra-class correlation coefficient
MRI	Magnetic resonance imaging
PA	Postero-anterior
REC	Research Ethics Committee
SPSS	Statistical Package for the Social Sciences
TCD	Transverse cardiac diameter
TTD	Transverse thoracic diameter
UHAS	University of Health and Allied Sciences

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Author contributions

Conception and design of the research: Seth Kwadjo Angmorterh; Acquisition of data: Seth Kwadjo Angmorterh & Evans Alesu-Dordzi; Analysis and interpretation of the data: Seth Kwadjo Angmorterh, Evans Alesu-Dordzi, Patience Nyamekye Agyemang, & Nathaniel Awentiirin Angaag. Statistical analysis: Seth Kwadjo Angmorterh, Evans Alesu-Dordzi, Patience Nyamekye Agyemang, & Nathaniel Awentiirin Angaag. Writing of the manuscript: Seth Kwadjo Angmorterh, Evans Alesu-Dordzi, Patience Nyamekye Agyemang, Nathaniel Awentiirin Angaag, Huseini Alidu, Sonia Aboagye, Olawale Ogundiran, Mariella Mawunyo Amoussou-Gohoungo, Adam Inusah & Klenam Dzefi-Tettey. Critical revision of the manuscript for intellectual content: Seth Kwadjo Angmorterh, Riaan van de Venter, Evans Alesu-Dordzi, Patience Nyamekye Agyemang, Nathaniel Awentiirin Angaag, Huseini Alidu, Sonia Aboagye, Olawale Ogundiran, Mariella Mawunyo Amoussou-Gohoungo, Adam Inusah & Klenam Dzefi-Tettey. All authors read and approved the final draft.

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Data availability

The datasets used and/or analysed during the current study are available in the manuscript file.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was granted by the Research Ethics Committee (REC) of UHAS prior to accessing the data [A.8(114) 22–23]. Informed consent was also obtained from the students. Also, because the age of adulthood in Ghana is 18 years, informed consent was obtained from guardians of the students less than 18 years of age involved in the study. To ensure confidentiality, the CXRs were made available only to the researchers and each CXR was coded and personal identifying information removed to ensure anonymity. The study conformed with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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