Original Article

Morphometric Analysis of Human Fetus and Fetal Pancreas in Different Gestational Age Groups

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Abstract

Introduction: Fetal biometric parameters are very often utilized for calculating gestational age. The pancreas is a gland with dual functions in our body – exocrine and endocrine, with the latter component being very often discussed in the context of diabetes mellitus. Through evaluation of variations in morphometry in relation to different gestational ages, the research intends to draw attention to various associated developmental correlations that were not mentioned in previous studies. **Materials and Methods:** The current research was carried out on 30 fetuses after obtaining due approval from Institute's Ethical Committee. Fetuses were divided into different gestational age groups and morphometric parameters such as crown-rump length, crown heel length, head circumference, abdomen circumference, chest circumference, hand length, and Foot Length (FL) were noted by measuring with nylon thread in centimetres. Fetal pancreases were removed after stepwise dissection and pancreatic weight along with length and thickness was measured by Vernier calipers. All the parameters were then compared within different gestational age groups. **Results:** All the parameters and the age group of fetuses were positively correlated and showed statistical significance**. Conclusion:** The study would add substantial knowledge in the areas of pancreatic regeneration, surgical pancreatectomy, and treatment protocols for diabetes mellitus and pancreatic cancer. Through evaluation of variations in morphometry in relation to different gestational ages, the research intends to draw attention to various associated developmental correlations.

Keywords: Biometric, diabetes, endocrine, exocrine, gestational, morphometry, pancreatic

Introduction

In order to keep the track of fetal growth, it is important to measure various morphometric parameters of the developing fetus, referred to as fetal biometry.[1] It includes parameters such as crown-rump length (CRL), biparietal diameters, circumference of the head (HC), femur length (FL), and the circumference of the abdomen (AC). An increase in the above-mentioned parameters as well as fetal weight can be a reliable indicator of fetal growth.[2] The accurate determination of gestational age is crucial in obstetric management as well as during postmortem of cases like criminal abortion.[3,4] In previous studies, numerous fetal biometric markers have been used to assess the most accurate fetal age and calculate the expected date of delivery in different populations. However, these fetal anthropometric measures vary greatly across various populations.[5]

The pancreas performs two main functions: digestion and regulation of blood sugar. The acinar cells are responsible for secreting digestive enzymes, thus maintaining exocrine function. The endocrine component comprises alpha, beta, delta, epsilon, and polypeptide cells, which together constitute islets of Langerhans.[6]

The pancreas is an obliquely placed tender glandular organ in the retroperitoneum, reaching up to the hilum of spleen and occupying epigastrium and left hypochondrium regions of the abdomen.[7,8] Embryologically, it is derived from two sources: ventral pancreatic anlage which gives rise to a part of the head of the pancreas along with uncinated process, while dorsal pancreatic anlage which develops into a portion of head, body, tail, and major duct.[9]

Diabetes mellitus is a chronic disease involving endocrine component of pancreas.[10] With time, treatment modalities for diabetes have evolved, with stem cell therapy and

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transplantation of islet cells being the newer options available. Since islet cells for transplantation can be found in the human fetal pancreas, more research are now being focused toward them.[8] For any pancreatic surgery or radiological investigation, it is crucial to understand the normal anatomy and anatomical relations of pancreas.[7,11] Extensive research in the past has been carried out in animal models, which has helped us to know the different events occurring in the process of pancreatic development, but research in human fetuses is lacking due to ethical restraints and technical issues of obtaining human fetal pancreas. Through evaluation of variations in morphometry in relation to different gestational ages, the research intends to draw attention to various associated developmental correlations that were not mentioned in previous studies. The research would also add substantial knowledge in the areas of pancreatic regeneration, surgical pancreatectomy, and treatment protocols for diabetes mellitus and pancreatic cancer.

Materials and Methods

Approval for the present research was granted by the Institutional Ethics Committee (IEC No: AIIMS/IEC/21/485), and clinical trial registration was obtained (Registration No: ECR/736/Inst/UK/2015/RR-21). The present study conforms to the principles of the Declaration of Helsinki.

Study design

This study is a descriptive observational study.

Study setting

Approximately 60 abortions were reported in the Department of Obstetrics and Gynecology, AIIMS Rishikesh, during 18 months of sample collection period. Applying 50% recruitment rate, 30 samples were collected after obtaining a detailed history and proper consent. The study was then performed on these 30 spontaneously and induced aborted fetuses in the Department of Anatomy, AIIMS Rishikesh. Inclusion criteria comprised fetuses of gestational age 12–40 weeks, while exclusion criteria ruled out fetuses below 12 weeks of gestational age and those with malformed pancreas.

Sample size calculation

Assuming the expected population standard deviation to be 6, and employing t-distribution to estimate sample size, the study would require a sample size of 30 to estimate a mean with 95% confidence and a precision of 2.3. In other words, if you select a random sample of 30 from a population, and determine the mean to be say *y*, you would be 95% confident that the mean in the population lies somewhere between y−2.3 and y + 2.3. **Reference:** Dhand, N. K., and Khatkar, M. S. (2014). Statulator: An online statistical calculator. Sample Size Calculator for Estimating a Single Mean. Accessed 22 February 2022 at http://statulator.com/SampleSize/ss1M.html.

Study duration

The duration of the present study was 18 months, i.e., from January 2020 to June 2021.

Fetuses were collected from ages between 12 and 40 weeks, and the gestational age was calculated by maternal history, ultrasonography, and online gestational age calculator software. Fetuses were arranged in seven gestational groups of 4 weeks' interval mentioned as Group 1 (12–16), Group 2 (17–20), Group 3 (21–24), Group 4 (25–28), Group 5 (29–32), Group 6 (33–36), and Group 7 (37–40), as shown in Table 1. Fetuses were collected in 10% formalin immediately after abortion and medical termination of pregnancy. Morphometric analysis was conducted on the fetal groups. After stepwise dissection, fetal pancreas was removed, as illustrated in Figure 1. Morphometric analysis of various parameters related to the fetal pancreas was then carried out.

The duration of our entire study was 18 months and the materials which were used during this whole process included 10% formalin, scalpel, weighing machine, nylon thread, Vernier calipers, and measuring scale.

After spontaneous or induced abortion, fetuses were collected in 10% formalin. External appearance of fetuses was noted and tabulated. Figure 2 represents some of the grossly appearing normal fetuses collected for our study. Parameters of fetuses such as sex, weight, and gestational age were recorded. Weight in grams was recorded with the help of an electronic weighing machine. Morphometric parameters of fetuses such as CRL, crown heel length (CHL), HC, AC, chest circumference (CC), hand length (HL), and foot length in centimeters were measured by nylon thread, as illustrated in Figure 3. All these parameters were compared within the gestational age groups. A midline incision was made from jugular notch to the pubic symphysis. Pancreas was identified and removed from abdominal cavity.

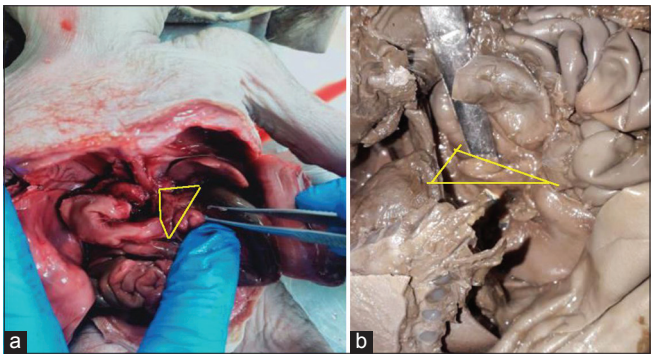

Figure 1: Fetal Pancreas: Stepwise dissection (a) Opening up of abdominal cavity and (b) Dissecting out pancreas

Table 1: Group of fetuses with gestational week

Groups	Gestational week	Number of fetuses
1	12-16	5
2	17-20	6
3	21-24	6
4	25-28	2
5	29-32	6
6	33-36	4
7	37-40	1
8	Total	30

Different parts of pancreatic specimen such as head, body, and tail were noted by topographical location in the abdominal cavity. Weight, length, width, and thickness of the pancreas were noted by Vernier calipers [Figure 4] and tabulated.

Observation and Results

Twenty-one (70.0%) out of thirty participants were male, while nine (30.0%) were females in our study, as shown in Table 2 and Figure 5.

The mean gestational age (Weeks) was 24.53 ± 7.38. The distribution of participants in terms of gestational age is represented in Table 3 and Figure 6.

The mean for different parameters was calculated as follows: CRL: 24.10 ± 8.37; CHL: 39.71 ± 15.63; abdominal circumference: 16.90 ± 5.53; CC: 18.39 ± 6.96; HC: 21.23 ± 7.57; foot length: 4.38 ± 2.10; HL: 3.33 ± 1.35; pancreas weight (Gram): 1.43 ± 1.11; pancreas length (cm): 1.87 ± 1.00; and pancreas thickness: 0.62 ± 0.22. For intergroup comparison, Kruskal–Wallis Test was used.

Figure 2: Grossly normal appearing fetuses

Figure 4: Measurement of different parameters of pancreas

As shown in Table 4, the mean of CRL in different gestational age groups was as follows: 12–16 weeks group: 12.96 ± 1.85; 17–20 weeks group: 19.13 ± 1.75; 21–24 weeks group: 23.32 ± 1.49; 25–28 weeks group: 24.05 ± 1.06; 29–32 weeks group: 28.73 ± 5.18; 33–36 weeks group: 35.20 ± 6.76; and 37–40 weeks group: 42.20.

The median (interquartile range [IQR]) of CRL in different gestational age group was as follows: 12–16 weeks group: 13.5 (12.5–14); 17–20 weeks group: 19.6 (19.25–20.18); 21–24 weeks group: 24.1 (22.5–24.35); 25–28 weeks group: 24.05 (23.68–24.42); 29–32 weeks group: 27.2 (25.35–33.1); 33–36 weeks group: 37.25 (32.35–40.1); and 37–40 weeks group: 42.2 (42.2–42.2). The difference between the seven groups was found to be statistically significant in terms of CRL (χ^2 = 26.132, $P \leq 0.001$), with the median CRL being greatest in the gestational age: 37–40 weeks group.

Table 2: Distribution of the participants in terms of gender (*n*=30)

Gender	Frequency (%)	95% CI
Male	21 (70.0)	50.4-84.6
Female	9 (30.0)	15.4-49.6

CI: Confidence interval

Figure 3: (a-c) showing measurement of CRL, HC and FL, respectively. CRL: Crown-rump length, HC: Head circumference, FL: Foot Length

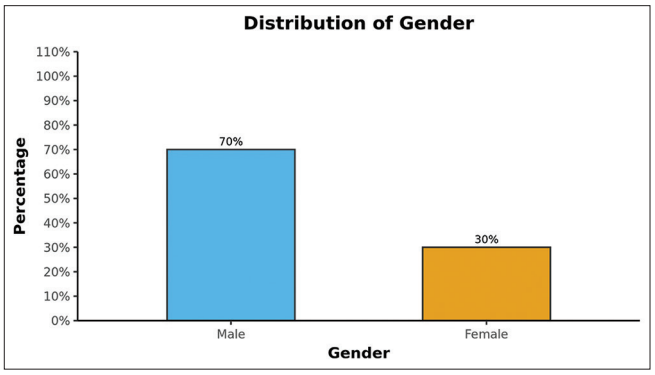

Figure 5: Gender distribution

Table 3: Distribution of the participants in terms of gestational age (weeks) (*n*=30)

Gestational age (weeks)	
Statistical Analysis	**Values**
Mean±SD	24.53±7.38
Median (IQR)	23.5 (19-30)
Range	12-38

SD: Standard deviation, IQR: Interquartile range

The strength of association (Kendall's Tau) was 0.85 (large effect size). Figure 7 represents a bar graph depicting the mean of CRL in the seven different groups.

As shown in Table 5, the mean of CHL in different gestational age groups was as follows: 12–16 weeks group: 18.46 ± 1.54; 17–20 weeks group: 30.93 ± 3.29); 21–24 weeks group: 37.22 ± 2.08; 25–28 weeks group: 37.80 ± 3.11; 29–32 weeks group: 51.58 ± 12.56; 33–36 weeks group: 59.40 ± 9.53; and 37–40 weeks group: 67.40. The median (IQR) of CHL in different gestational age group was as follows: 12–16 weeks group: 19 (18–19.5); 17–20 weeks group: 31.65 (29.42–33.5); 21–24 weeks group: 38.3 (35.58–38.62); 25–28 weeks group: 37.8 (36.7–38.9); 29–32 weeks group: 53.1 (41.15–61.9); 33–36 weeks group: 63.2 (57.4–65.2); and 37–40 weeks group: 67.4 (67.4–67.4). The difference between the seven groups was again found to be statistically significant in terms of CHL (χ^2 = 25.575, P = < 0.001), with the median CHL being greatest in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.83 (large effect size). Figure 8 represents a bar graph depicting the mean of CHL in the seven different groups.

As shown in Table 6, the mean of abdominal circumference in different gestational age group was as follows: 12–16 weeks group: 9.28 ± 2.14; 17–20 weeks group: 14.22 ± 1.45; 21–24 weeks group: 16.55 ± 1.14; 25–28 weeks group: 17.25 ± 1.34; 29–32 weeks group: 19.40 ± 2.93; 33–36 weeks group: 23.55 ± 4.46; and 37–40 weeks group: 31.00. The median (IQR) of abdominal circumference in different gestational age groups was as follows: 12–16 weeks group: 10 (8–11); 17–20 weeks group: 14.35 (14.05–15.02); 21–24 weeks group: 17.15 (15.65–17.3); 25–28 weeks group: 17.25 (16.78–17.72); 29–32 weeks group: 18.6 (17.12–21.95; 33–36 weeks group: 25.25 (22.62–26.18); and 37–40 weeks group: 31 (31–31). The difference between the seven groups was found to be significant in terms of the abdominal circumference (χ^2 = 24.061, P = 0.001), with the median abdominal circumference being greatest in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.8 (large effect size). Figure 9 represents a bar graph depicting the mean of abdominal circumference in the seven different groups.

As shown in Table 7, the mean of CC in different gestational age group was as follows: 12–16 weeks group: 10.02 ± 2.32; 17–20 weeks group: 14.78 ± 1.62; 21–24 weeks group:

Table 4: Comparison of crown-rump length in gestational age groups (weeks) (*n*=30)

CRL	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	*P*
Mean±SD	12.96±1.85	19.13±1.75	23.32±1.49	24.05±1.06	28.73±5.18	35.20±6.76	42.20±NA	26.132	<0.001
Median (IQR)	13.5 (12.5-14)	19.6 (19.25-20.18)	24.1 (22.5-24.35)	24.05 (23.68-24.42)	27.2 (25.35-33.1)	37.25 (32.35-40.1)	42.2 (42.2-42.2)		
Range	10-14.8	15.7-20.4	20.9-24.4	23.3-24.8	23-35.2	25.9-40.4	42.2-42.2		

SD: Standard deviation, IQR: Interquartile range, CRL: Crown-rump length, NA: Not available

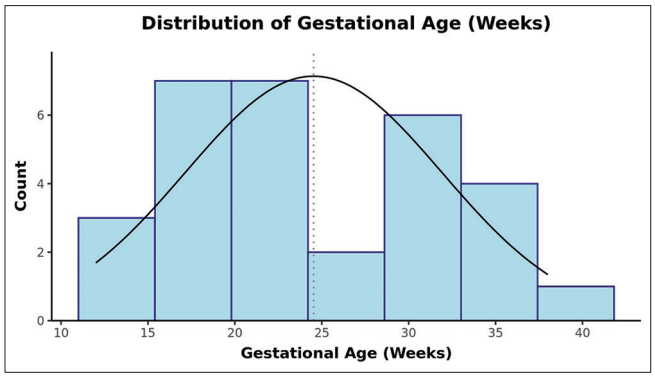

Figure 6: Distribution of fetuses in different gestational age

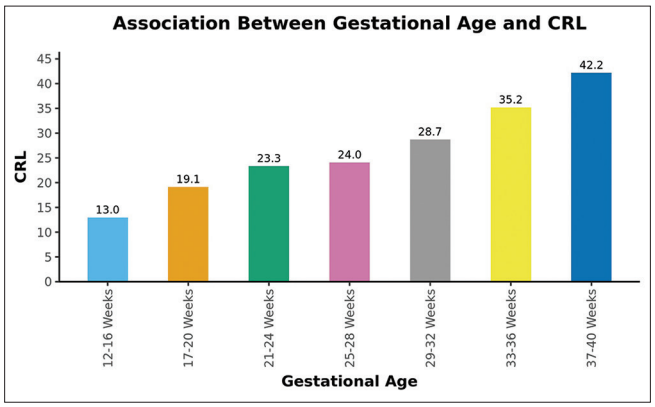

Figure 7: Gestational age (weeks) and CRL (n = 30). CRL: Crown-rump length

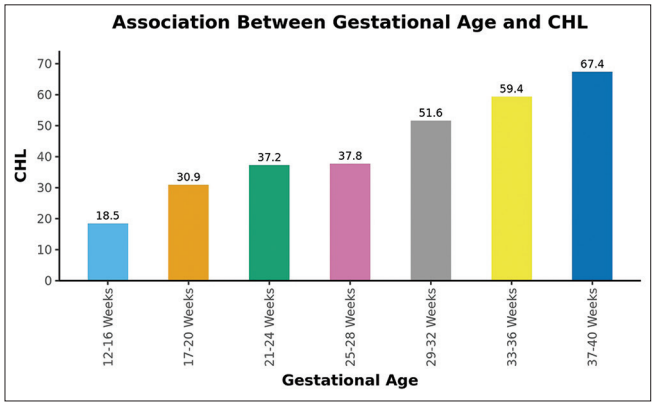

Figure 8: Gestational age (weeks) and CHL (n = 30). CHL: Crown heel length

17.53 ± 0.62; 25–28 weeks group: 17.50 ± 1.84; 29–32 weeks group: 20.92 ± 3.86; 33–36 weeks group: 27.80 ± 7.27; and 37–40 weeks group: 35.90. The median (IQR) of CC in different gestational age group was as follows: 12–16 weeks group: 10 (9.4–12); 17–20 weeks group: 15.45 (13.5–15.83); 21–24 weeks group: 17.7 (17.05–17.98); 25–28 weeks group: 17.5 (16.85–18.15); 29–32 weeks group: 22.1 (17.73–23.55); 33–36 weeks group: 30.5 (26.05–32.25); and 37–40 weeks group: 35.9 (35.9–35.9). The difference between the seven groups was found to be significant statistically in terms of CC ($\chi^2 = 23.388$, $P = 0.001$), with the median CC being highest

Table 5: Comparison of crown heel length in gestational age groups (weeks) (n=30)

CHL	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	P
Mean±SD	18.46±1.54	30.93±3.29	37.22±2.08	37.80±3.11	51.58±12.56	59.40±9.53	67.40±NA	25.575	<0.001
Median (IQR)	19 (18-19.5)	31.65 (29.42-33.5)	38.3 (35.58-38.62)	37.8 (36.7-38.9)	53.1 (41.15-61.9)	63.2 (57.4-65.2)	67.4 (67.4-67.4)		
Range	16-19.8	25.5-34	34.4-38.9	35.6-40	36.5-64.8	45.4-65.8	67.4-67.4		

SD: Standard deviation, IQR: Interquartile range, NA: Not available, CHL: Crown heel length

Table 6: Comparison of abdominal circumference in gestational age groups (weeks) ($n=30$)

Abdominal circumference	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	*P*
Mean±SD	9.28±2.14	14.22±1.45	16.55±1.14	17.25±1.34	19.40±2.93	23.55±4.46	31.00±NA	24.06	0.001
Median (IQR)	10 (8-11)	14.35 (14.05-15.02)	17.15 (15.65-17.3)	17.25 (16.78-17.72)	18.6 (17.12-21.95)	25.25 (22.62–26.18)	31 (31-31)		
Range	6.2–11.2	11.6-15.8	15-17.5	16.3-18.2	16.5-23	17–26.7	31–31		

SD: Standard deviation, IQR: Interquartile range, NA: Not available

Table 7: Comparison of chest circumference in gestational age groups (weeks) ($n=30$)

CC	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	*P*
Mean±SD	10.02±2.32	14.78±1.62	17.53±0.62	17.50±1.84	20.92±3.86	27.80±7.27	35.90±NA	23.388	0.001
Median (IQR)	10 (9.4-12)	15.45 (13.5-15.83)	17.7 (17.05-17.98)	17.5 (16.85-18.15)	22.1 (17.73-23.55)	30.5 (26.05-32.25)	35.9 (35.9-35.9)		
Range	6.5-12.2	12.6-16.4	16.7-18.2	16.2-18.8	16-25	17.2-33	35.9-35.9		

SD: Standard deviation, IQR: Interquartile range, NA: Not available, CC: Chest circumference

in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.76 (large effect size). Figure 10 represents a bar graph depicting the mean of CC in the seven different groups.

As shown in Table 8, the mean of HC in different gestational age group was as follows: 12–16 weeks group: 10.98 ± 1.18; 17–20 weeks group: 17.38 ± 2.35; 21–24 weeks group: 20.20 ± 1.28; 25–28 weeks group: 20.10 ± 2.69; 29–32 weeks group: 25.83 ± 6.19; 33–36 weeks group: 31.58 ± 4.17; and 37–40 weeks group: 35.00. The median (IQR) of HC in different gestational age group was as follows: 12–16 weeks group: 11.2 (11–11.7); 17–20 weeks group: 17.3 (16.1–19.02); 21–24 weeks group: 20.45 (19.15–21.3); 25–28 weeks group: 20.1 (19.15–21.05); 29–32 weeks group: 22 (22–30.4); 33–36 weeks group: 33.2 (31.1–33.67); and 37–40 weeks group: 35 (35–35).). The difference between the seven groups was found to be significant statistically in terms of HC ($\chi^2 = 25.670$, $P \leq 0.001$), with the median HC being highest in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.83 (large effect size). Figure 11 represents a bar graph depicting the mean of HC in the seven different groups.

As shown in Table 9, the mean of foot length in different gestational age group was as follows: 12–16 weeks group: 1.60 ± 0.20; 17–20 weeks group: 3.10 ± 0.45; 21–24 weeks group: 4.25 ± 0.59; 25–28 weeks group: 3.90 ± 0.85; 29–32 weeks group: 5.78 ± 1.72; 33–36 weeks group: 7.10 ± 0.84; and 37–40 weeks group: 8.50. The median (IQR) of foot length in different gestational age group was as follows: 12–16 weeks group: 1.7 (1.5–1.7); 17–20 weeks group: 3 (2.73–3.35); 21–24 weeks group: 4.4 (3.75–4.68); 25–28 weeks group: 3.9 (3.6–4.2); 29–32 weeks group: 5.05 (4.62–6.97); 33–36 weeks group: 7.3 (6.68–7.73); and 37–40 weeks group: 8.5 (8.5–8.5). The difference between the seven groups was again found to be statistically significant in terms of foot length ($\chi^2 = 25.253$, $P \leq 0.001$), with the median foot length being highest in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.8 (large effect size). Figure 12 represents a bar graph depicting the means of foot length in the seven different groups.

As shown in Table 10, the mean of HL in different gestational age group was as follows: 12–16 weeks group: 1.48 ± 0.59; 17–20 weeks group: 2.53 ± 0.35; 21–24 weeks group: 2.95 ± 0.37; 25–28 weeks group: 3.70 ± 0.42; 29–32 weeks group: 4.38 ± 0.72; 33–36 weeks group: 4.97 ± 0.46; and 37–40 weeks group: 6.00. The median (IQR) of HL in different gestational age group was as follows: 12–16 weeks group: 1.3 (1–2); 17–20 weeks group: 2.55 (2.25–2.85); 21–24 weeks group: 2.9 (2.8–3.22); 25–28 weeks group: 3.7 (3.55–3.85); 29–32 weeks group: 4.25 (4.2–4.38); 33–36 weeks group: 5.05 (4.7–5.32); and 37–40 weeks group:

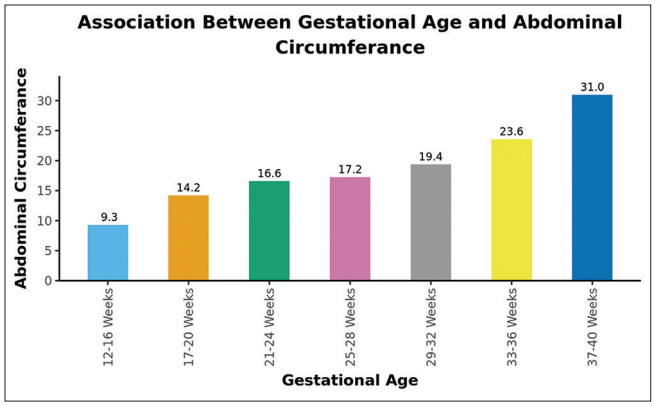

Figure 9: Gestational age (weeks) and abdominal circumference ($n = 30$)

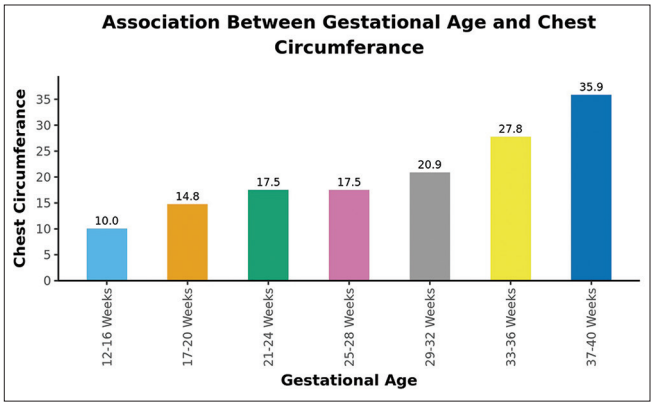

Figure 10: Gestational age (weeks) and chest circumference ($n = 30$)

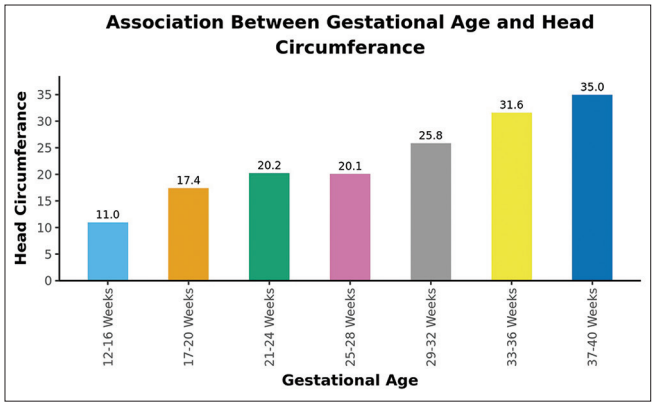

Figure 11: Gestational age (weeks) and head circumference ($n = 30$)

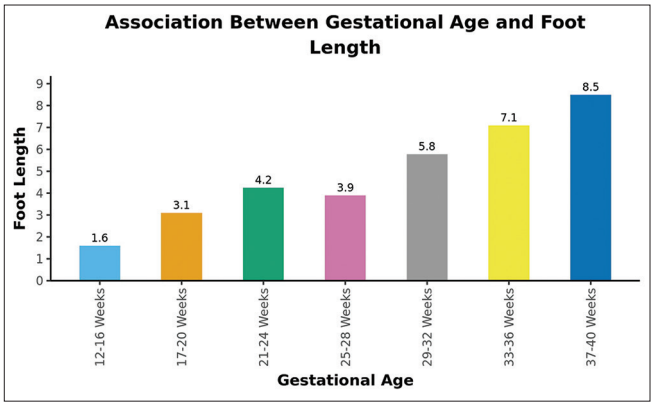

Figure 12: Gestational age (weeks) and foot length ($n = 30$)

Table 8: Comparison of head circumference in gestational age groups (weeks) (n=30)

HC	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	*P*
Mean±SD	10.98±1.18	17.38±2.35	20.20±1.28	20.10±2.69	25.83±6.19	31.58±4.17	35.00±NA	25.670	<0.001
Median (IQR)	11.2 (11-11.7)	17.3 (16-19.02)	20.45 (19.15-21.3)	20.1 (19.15-21.05)	22 (22-30.4)	33.2 (31.1-33.67)	35 (35-35)		
Range	9-12	14-20.4	18.6-21.4	18.2-22	21.4-34.4	25.4-34.5	35-35		

SD: Standard deviation, IQR: Interquartile range, NA: Not available, HC: Head circumference

Table 9: Comparison of foot length in gestational age groups (weeks) (n=30)

FL	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	*P*
Mean±SD	1.60±0.20	3.10±0.45	4.25±0.59	3.90±0.85	5.78±1.72	7.10±0.84	8.50±NA	25.253	<0.001
Median (IQR)	1.7 (1.5-1.7)	3 (2.73-3.35)	4.4 (3.75-4.68)	3.9 (3.6-4.2)	5.05 (4.62-6.97)	7.3 (6.68-7.73)	8.5 (8.5-8.5)		
Range	1.3-1.8	2.7-3.8	3.5-4.9	3.3-4.5	4.2-8.3	6-7.8	8.5-8.5		

SD: Standard deviation, IQR: Interquartile range, NA: Not available, FL: Foot length

Table 10: Comparison of hand length in gestational age groups (weeks) (n=30)

HL	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	P
Mean±SD	1.48±0.59	2.53±0.35	2.95±0.37	3.70±0.42	4.38±0.72	4.97±0.46	6.00±NA	26.336	<0.001
Median (IQR)	1.3 (1-2)	2.55 (2.25-2.85)	2.9 (2.8-3.22)	3.7 (3.55-3.85)	4.25 (4.2-4.38)	5.05 (4.7-5.32)	6 (6-6)		
Range	0.9-2.2	2.1-2.9	2.4-3.4	3.4-4	3.5-5.7	4.4-5.4	6-6		

SD: Standard deviation, IQR: Interquartile range, NA: Not available, HL: Hand length

6 (6–6). The difference between the seven groups was found to be statistically in terms of HL (χ^2 = 26.336, $P \leq 0.001$), with the median HL being greatest in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.86 (large effect size). Figure 13 represents a bar graph depicting the mean of HL in the seven different groups.

As shown in Table 11, the mean of pancreas weight (gram) in different gestational age group was as follows: 12–16 weeks group: 0.52 ± 0.08; 17–20 weeks group: 0.64 ± 0.05; 21–24 weeks group: 0.75 ± 0.14; 25–28 weeks group: 0.85 ± 0.13; 29–32 weeks group: 2.35 ± 0.77; 33–36 weeks group: 3.16 ± 0.09; and 37–40 weeks group: 3.50. The median (IQR) of pancreas weight (gram) in different gestational age group was as follows: 12–16 weeks group: 0.56 (0.5–0.56); 17–20 weeks group: 0.64 (0.64–0.66); 21–24 weeks group: 0.76 (0.64–0.86); 25–28 weeks group: 0.85 (0.8–0.9); 29–32 weeks group: 2.34 (2.23–2.85); 33–36 weeks group: 3.2 (3.16–3.2); and 37–40 weeks group: 3.5 (3.5–3.5). The difference between the seven groups was again found to be statistically significant in terms of pancreas weight (gram) (χ^2 = 25.704, $P \leq 0.001$), with the median pancreas weight (gram) being greatest in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.84 (large effect size). Figure 14 represents a bar graph depicting the mean of pancreas weight (gram) in the seven different groups.

As shown in Table 12, the mean of pancreas length (cm) in different gestational age group was as follows: 12–16 weeks group: 0.34 ± 0.12; 17–20 weeks group: 1.21 ± 0.51; 21–24 weeks group: 2.08 ± 0.33; 25–28 weeks group: 2.16 ± 0.34; 29–32 weeks group: 2.56 ± 0.62; 33–36 weeks group: 2.81 ± 0.49; and 37–40 weeks group: 3.70. The median (IQR) of pancreas length (cm) in different gestational age group was as follows: 12–16 weeks group: 0.3 (0.3–0.42); 17–20 weeks group: 1.42 (0.79–1.55); 21–24 weeks group: 2 (1.8–2.35); 25–28 weeks group: 2.16 (2.04–2.28); 29–32 weeks group: 2.34 (2.26–3); 33–36 weeks group: 2.78 (2.49–3.1); and 37–40 weeks group: 3.7 (3.7–3.7). The difference between the seven groups was again found to be statistically significant in terms of pancreas length (cm) (χ^2 = 24.359, $P \leq 0.001$), with the median pancreas length (cm) being maximum in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.79 (large effect size). Figure 15 represents a bar graph depicting the mean of pancreas length (cm) in the seven different groups.

As shown in Table 13, the mean of pancreas thickness in different gestational age group was as follows: 12–16 weeks group: 0.31 ± 0.12; 17–20 weeks group: 0.62 ± 0.07; 21–24 weeks group: 0.56 ± 0.06; 25–28 weeks group: 0.61 ± 0.10; 29–32 weeks group: 0.75 ± 0.16; 33–36 weeks group: 0.72 ± 0.17; and 37–40 weeks group: 1.30. The median (IQR) of pancreas thickness in different gestational age group was as follows: 12–16 weeks group: 0.3 (0.2–0.4); 17–20 weeks group: 0.61 (0.6–0.68); 21–24 weeks group: 0.56 (0.52–0.59); 25–28 weeks group: 0.61 (0.58–0.64); 29–32 weeks group:

Table 11: Comparison of pancreas weight (g) in gestational age groups (weeks) (n=30)

Pancreas weight (g)	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	*P*
Mean±SD	0.52±0.08	0.64±0.05	0.75±0.14	0.85±0.13	2.35±0.77	3.16±0.09	3.50±NA	25.70	<0.001
Median (IQR)	0.56 (0.5-0.56)	0.64 (0.64-0.66)	0.76 (0.64-0.86)	0.85 (0.8-0.9)	2.34 (2.23-2.85)	3.2 (3.16-3.2)	3.5 (3.5-3.5)		
Range	0.4-0.6	0.54-0.7	0.6-0.92	0.76-0.94	1-3.2	3.02-3.2	3.5-3.5		

SD: Standard deviation, IQR: Interquartile range, NA: Not available

Table 12: Comparison of pancreas length (cm) in gestational age groups (weeks) (n=30)

Pancreas length (cm)	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	*P*
Mean±SD	0.34±0.12	1.21±0.51	2.08±0.33	2.16±0.34	2.56±0.62	2.81±0.49	3.70±NA	24.359	<0.001
Median (IQR)	0.3 (0.3-0.42)	1.42 (0.79-1.55)	2 (1.8-2.35)	2.16 (2.04-2.28)	2.34 (2.26-3)	2.78 (2.49-3.1)	3.7 (3.7-3.7)		
Range	0.2-0.5	0.52-1.7	1.8-2.5	1.92-2.4	1.8-3.4	2.28-3.4	3.7-3.7		

SD: Standard deviation, IQR: Interquartile range, NA: Not available

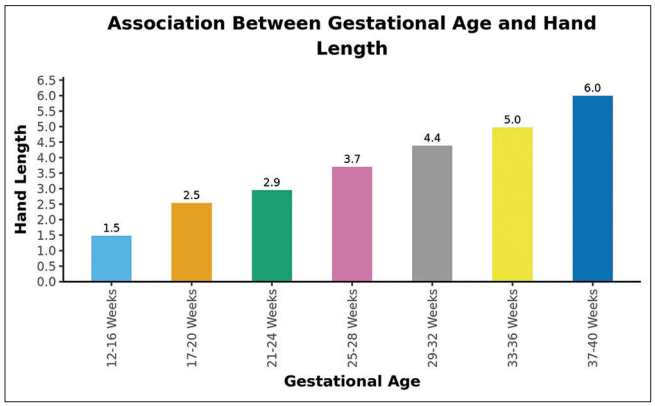

Figure 13: Gestational age (weeks) and HL (n = 30). HL: Hand length

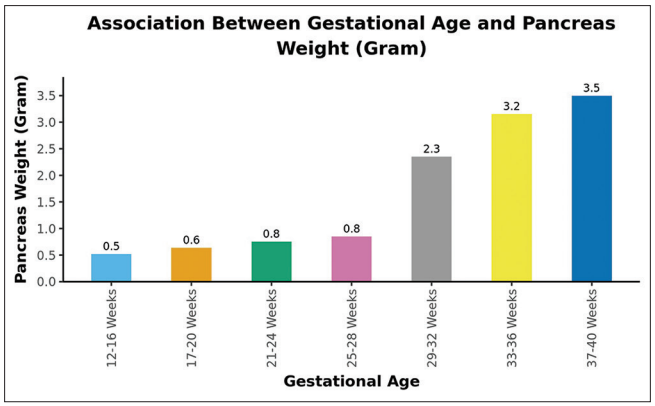

Figure 14: Gestational age (weeks) and pancreas weight (n = 30)

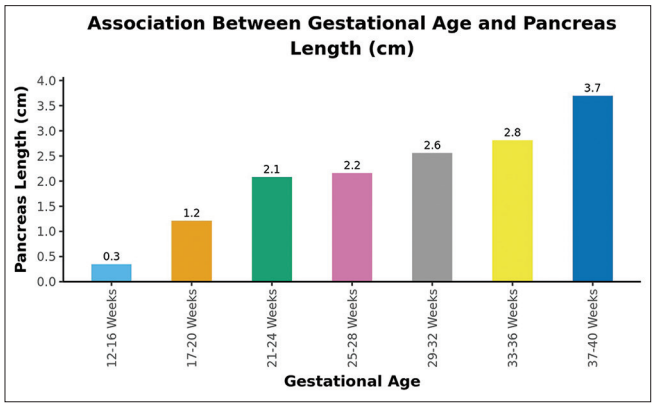

Figure 15: Gestational age (weeks) and pancreas length (n = 30)

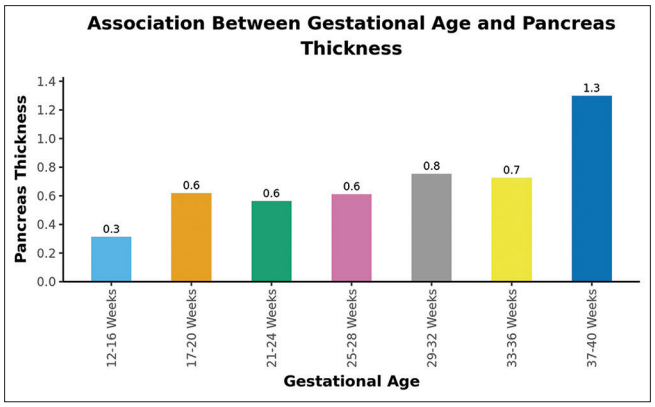

Figure 16: Gestational age (weeks) and pancreas thickness (n = 30)

0.7 (0.64–0.85); 33–36 weeks group: 0.75 (0.65–0.83); and 37–40 weeks group: 1.3 (1.3–1.3). The difference between the seven groups was again found to be statistically significant in terms of Pancreas Thickness ($\chi^2 = 19.350$, $P = 0.004$), with the median pancreas thickness being maximum in the gestational age: 37–40 weeks group. The strength of association (Kendall's Tau) was 0.56 (large effect size). Figure 16 represents a bar graph depicting the mean of pancreas thickness in the seven different groups.

Discussion

The study of fetal morphology and morphometric analysis of fetus as well as fetal pancreatic parameters is of paramount importance these days with regard to understanding of development and treatment in diabetes and pancreatic diseases.

Patil *et al*., 2013, studied on 100 fetuses found a statistically significant linear association between gestational age and CRL, with CHL increasing with gestational age (r = 0.979, $P < 0.0001$).[12] In the current study, performed on 30 fetuses, we found that there was a significant difference between gestational age and CHL ($\chi^2 = 25.575$, $P \leq 0.001$) and a significant difference between gestational age and CRL ($\chi^2 = 26.132$, $P \leq 0.001$).

Chikkannaiah and Gosavi, 2016, studied 60 fetuses with gestational ages ranging from 15 to 41 weeks. They found that fetal measurements such as CRL, CHL, HC, abdominal circumference, and foot length increased as gestational age increased. There were substantial associations between foot length and other variables.[4] Our study was performed on 30 fetuses from 12 to 38 weeks divided into seven groups. Group 1 (12–16 weeks) Group 2 (17–20) Group 3 (21–24), Group 4 (25–28), Group 5 (29–32), Group 6 (33–36), and Group 7 (37–40). There was a significant difference between the seven groups in terms of CRL (χ^2 = 26.132, $P \leq 0.001$), with the median CRL being highest in the gestational age: 37–40 weeks group. There was a significant difference between the seven groups in terms of CHL (χ^2 = 25.575, $P = \leq 0.001$), with the median CHL being highest in the gestational age: 37–40 weeks group. There was a significant difference between the seven groups in terms of abdominal circumference (χ^2 = 24.061, P = 0.001), with the median abdominal circumference being highest in the gestational age: 37–40 weeks group. There was a significant difference between the seven groups in terms of foot length ($\chi^2 = 25.253$, $P \leq 0.001$), with the median Foot Length being highest in the gestational age: 37–40 weeks group.

Dhende *et al*., 2016, concluded that CRL and body weight of fetuses increased with advancing gestational age. The length of pancreas was also found to be increased with increasing age. On 12th week of gestation, average length of pancreas

was noted 1.80 cm and on 40th week of gestation, it was 4.70 cm. The height of pancreas head was also increased with increasing age: 0.80 cm in 12th weeks and 2.70 in 40th weeks of gestation.[13] In our study, 30 fetuses were included from 12 to 38 weeks and we found that CRL (24.10 ± 8.37) and length of pancreas (1.87 ± 1.00) increased with increasing gestational age. The length of pancreas in our study on 12th week was found to be 0.20 cm, while the thickness of pancreas was found to be 0.20 cm. At 38th week, the length was found to have increased to 3.40 cm and thickness to 1.30 cm. There was a very strong positive correlation which was statistically significant ($\rho = 0.92$, $P \leq 0.001$) between gestational age (weeks) and pancreas length (cm). With each 1-unit increase in gestational age (weeks), the pancreas length (cm) increases by 0.12 units. Similarly, there was a very strong positive correlation which was statistically significant ($\rho = 0.7$, $P \leq 0.001$) between gestational age (weeks) and pancreas thickness. With each 1-unit increase in gestational age (weeks), the pancreas thickness increases by 0.02 units. In our study, separate measurements of head, body, and tail were not taken.

Gaharwar and Tiwari, 2019, reported a direct correlation between CRL (measured ultrasonographically) and gestational age in first trimester. The mean CRL for fetuses of gestational age 7–8 weeks, 8–9 weeks, 9–10 weeks, 10–11 weeks, and 11–12 weeks was observed to be between 11–20 mm, 20–24 mm, 24–32 mm, 32–41 mm, and 41–54 mm, respectively. They concluded that CRL can be used as a standard parameter for assessment of fetal gestational age in the first trimester. Since our study sample included fetuses of gestational age beyond 12 weeks, i.e., 12–40 weeks, the values cannot be compared.[3]

Davis and Ramar, 2019, in their morphometric and microscopic study on 24 aborted fetuses, reported a positive linear relationship between length and weight of pancreas and gestational age of fetus. In their 1st Group of fetuses belonging to 10–20 week of gestational age, the length of the pancreas was found to be between 1.5 and 2.5 cm and weight of the pancreas between 10 and 19 g. In their 2nd Group of fetuses belonging to 21–30 weeks, the length of the pancreas was between 2.7 and 3.5 cm and the weight was between 20 and 25 g. Similarly, in their 3rd Group of fetuses belonging to 31–40 weeks of gestational age, the length of the pancreas was between 3.6 and 4 cm and the weight of the pancreas was found to be 29 and 35 g. This upward trend with increasing gestational age was similar to the findings in our present study.[8]

A morphometric study conducted by Baro *et al*., 2020, on 103 Assamese adult pancreas, concluded that the mean length of pancreas was higher in males (13.97 ± 1.39 cm) than in females (13.86 ± 1.43 cm). Similarly, the mean weight of pancreas was found to be higher (78.64 ± 19.14 g) than in females (77.00 ± 15.28 g). This was in concurrence with our study on fetal pancreas where the mean length and weight of pancreas in males (1.97 ± 1.13 and 1.75 ± 1.19 respectively) were higher than those in females (1.62 ± 0.60 and 0.68 ± 0.10, respectively). As seen in our study, they also found that

Table 13: Comparison of pancreas thickness in gestational age groups (weeks) (*n*=30)

Pancreas thickness	Gestational age							Kruskal–Wallis test	
	12-16	17-20	21-24	25-28	29-32	33-36	37-40	χ^2	*P*
Mean±SD	0.31±0.12	0.62±0.07	0.56±0.06	0.61±0.10	0.75±0.16	0.72±0.17	1.30±NA	19.350	0.004
Median (IQR)	0.3 (0.2-0.4)	0.61 (0.6-0.68)	0.56 (0.52-0.59)	0.61 (0.58-0.64)	0.7 (0.64-0.85)	0.75 (0.65-0.83)	1.3 (1.3-1.3)		
Range	0.2-0.47	0.5-0.7	0.5-0.64	0.54-0.68	0.6-1	0.5-0.9	1.3-1.3		

SD: Standard deviation, IQR: Interquartile range, NA: Not available

pancreatic length was increasing with age, but this was in contrast to the belief that pancreatic length and weight reduce with age due to degenerative change.[11]

Nirvan *et al*., 2020, conducted a study on 25 fetuses of Gujrat origin, belonging to gestational age group of 27–40 weeks and observed that fetal parameters such as body weight, CRL, CHL, and HC increased as fetal age advanced. The rate of growth was almost similar for CRL and HC. Twelve fetuses belonging to 27–32 weeks of gestational age group had mean weight, CRL, CHL, and HC to be 1099.42 g, 267, 432.5, and 273.17 mm and mean for them in 13 fetuses belonging to age group of 33–40 weeks were 2474.61 g, 321.61, 461.92, and 330.54 mm, respectively. All these values were slightly lesser than those obtained in our study for the corresponding age groups. This difference could either be due to difference in method of measurement or due to anthropometric differences between the two populations.[1]

Conclusion

All the parameters and the age group of fetuses were positively correlated and showed statistical significance. The study would add substantial knowledge in the areas of pancreatic regeneration, surgical pancreatectomy, and treatment protocols for diabetes mellitus and pancreatic cancer. Through evaluation of variations in morphometry in relation to different gestational ages, the research intends to draw attention to various associated developmental correlations.

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Conflicts of interest

There are no conflicts of interest.

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