Taiwanese Journal of Obstetrics & Gynecology 57 (2018) 32–39

Contents lists available at ScienceDirect

Taiwanese Journal of Obstetrics & Gynecology

journal homepage: www.tjog-online.com

Original Article

Inter-observer variability in fetal biometric measurements

Rami Kilani [a], Wesam Aleyadeh [a, *], Luay Abu Atieleh [b], Abdul Mane Al Suleimat [b], Maysa Khadra [c], Hassan M. Hawamdeh [a]

[a] Hashemite University, Zarqa, Jordan
[b] Al Bashir Hospital, Amman, Jordan
[c] University of Jordan, Amman, Jordan

A R T I C L E I N F O

Article history:
Accepted 30 August 2017

Keywords:
Interclass correlation coefficient (ICC)
Bland–Altman plots
Head circumference (HC)
Abdominal circumference (AC)
Femur length (FL)

A B S T R A C T

Objective: To evaluate inter-observer variability and reproducibility of ultrasound measurements for fetal biometric parameters.

Materials and methods: A prospective cohort study was implemented in two tertiary care hospitals in Amman, Jordan; Prince Hamza Hospital and Albashir Hospital. 192 women with a singleton pregnancy at a gestational age of 18–36 weeks were the participants in the study. Transabdominal scans for fetal biometric parameter measurement were performed on study participants from the period of November 2014 to March 2015. Women who agreed to participate in the study were administered two ultrasound scans for head circumference, abdominal circumference and femur length. The correlation coefficient was calculated. Bland–Altman plots were used to analyze the degree of measurement agreement between observers. Limits of agreement $\pm$ 2 SD for the differences in fetal biometry measurements in proportions of the mean of the measurements were derived. Main outcome measures examine the reproducibility of fetal biometric measurements by different observers.

Results: High inter-observer inter-class correlation coefficient (ICC) was found for femur length (0.990) and abdominal circumference (0.996) where Bland–Altman plots showed high degrees of agreement. The highest degrees of agreement were noted in the measurement of abdominal circumference followed by head circumference. The lowest degree of agreement was found for femur length measurement. We used a paired-sample t-test and found that the mean difference between duplicate measurements was not significant ($P > 0.05$).

Conclusion: Biometric fetal parameter measurements may be reproducible by different operators in the clinical setting with similar results. Fetal head circumference, abdominal circumference and femur length were highly reproducible. Large organized studies are needed to ensure accurate fetal measurements due to the important clinical implications of inaccurate measurements.

Introduction

Ultrasound is currently the cornerstone of obstetric imaging. Patients routinely get ultrasound scans during pregnancy. The most common ultrasound scan is usually performed between 18 and 22 weeks of gestation to exclude fetal anomalies [1]. Further ultrasound scans are common in the third trimester, with clinical indications for small-for-date fetuses or reduced fetal movement.

The measurements taken during the ultrasound scans, especially during the third trimester, are essential for the management of pregnancy and optimal delivery. Sixty percent of neonatal deaths are associated with low birth weight; the identification of growth-restricted fetuses is thereby important. Inaccurate measurement can lead to unnecessary intervention or missing cases with growth restriction. Incorrect diagnoses of normal fetuses may also lead to perinatal compromise [2].

Few studies have examined inter-observer variation despite the importance of fetal measurement in the clinical decision-making process [3]. There are also no recent studies and none that examine inter-observer variation in developing countries [3–5]. Recent, relevant and extensive studies that examine inter-observer variation and reproducibility of fetal measurements are necessary due to the dynamic and continually changing nature of medical equipment which may increase the risk of diagnostic errors [6].

* Corresponding author. Fax: +962 53533333.
E-mail address: wesama@med.hu.edu.jo (W. Aleyadeh).

https://doi.org/10.1016/j.tjog.2017.12.006

There is currently a lack of qualified sonographers and a shortage of ultrasound machines in Jordan. This is most likely due to high cost and maintenance of equipment that may make it difficult to administer routine or frequent patient examinations. Most ultrasound scans are performed by obstetricians who identify specific clinical indications for the examination; important clinical decision are made based on the results of a single ultrasonography examination. This is especially significant for evaluating the accuracy and reproducibility of fetal measurements in developing countries like Jordan.

The aim of the present study is to determine the inter-observer reproducibility of ultrasound measurements of fetal biometric parameters in a major hospital in Jordan. We will discuss the methods and the process of patient examination in Materials and methods. Results will highlight the results, while Discussion will discuss current evidence and explore the significance of our results in real life applications and clinical settings. Conclusion will highlight our conclusions.

Materials and methods

Examination process

Al Bashir Hospital in Amman-Jordan is the main governmental hospital in Amman providing services for over 1,000,000 people and serves as a referral hospital for all other Ministry of Health hospitals in Jordan. Ethical approval was obtained from the Hashemite University Ethical Committee and from Al Bashir Hospital ethical committee.

Between November 2014 and March 2015, one hundred and ninety-two pregnant women were recruited for the study. Participants were women with singleton pregnancies scheduled for delivery at Al Bashir Hospital. Inclusion criteria include:

- Maternal age between 18 and 35 years
- Singleton pregnancy
- A known last menstrual period (LMP)
- Regular cycles and gestational age between 18 weeks and 36 weeks

Exclusion criteria include:

- Pregnancy complications, such as preeclampsia and vaginal bleeding
- Significant past medical history, i.e. maternal or familial hypertension, diabetes, heart disease, history of smoking and a previous pregnancy complicated with intra uterine growth restriction (IUGR)

Women who met the inclusion criteria and agreed to participate in the study were administered two abdominal ultrasound scans performed by two different operators within 10 min of each other. The first scan was performed by “Operator 1” and the second scan was performed by “Operator 2”. Each examiner was given 15 min to complete the exam. Only one operator was present in the exam room during patient examination. All ultrasound tests were performed using the same machine, Samsung Medison R5 (South Korea), with a curvilinear abdominal transducer. The machine was programmed to not show obtained measurements on the screen during examination. The two obstetricians perfuming the examination were certified obstetricians and gynaecologists with significant experience in performing ultrasound scans.

A strict protocol was followed:

Each examiner started with fetal head measurements after obtaining an image of the head. They then measured head circumference using the ellipse facility followed by an image and measurement of the abdomen using an ellipse facility. They then obtain an image of the femur and record femur length. Each operator completed a set of four stored images for each examination that consisted of a head image, an abdominal image, an image of the femur and a report image showing all three measurements.

Head measurements were taken in the trans-thalamic plane measuring the outer border of the skull at the time of scan using an ellipse region-of-interest (ROI) built into the ultrasound unit. Abdominal measurements were taken with the umbilical vein in the anterior third of a transverse section of the fetal abdomen at the level of the portal sinus, with the stomach bubble visible measuring the outer border of the abdomen using an ellipse as well. The femur closest to the probe was measured for femur length with its long axis placed as horizontal as possible. Calipers were placed on the outer borders of the diaphysis of the femoral bone (‘outer to outer’) and excluding the trochanter.

Estimated fetal body weight was calculated using the most common equation in literature for the EFW, Hadlock formula [11,12].

Hadlock formula: $\text{Log } 10 \text{ (weight)} = 1.304 + 0.05281*Ac + 0.1938*FL - 0.004*AC*FL$.

All measurements of estimated fetal weight are supplied in the supporting material section in the appendix. All measurements and image were retrieved at the end of data collection.

Statistical analysis

Data used for the descriptive statistics were obtained from clinical. The comparisons for each fetal biometric part were assessed using the six measurements taken in each fetus (three measurements by Operator 1 and three measurements by Operator 2). Variability was assessed by calculating the differences between the two measurements made by the two operators on the same fetus ($n = 180$). The resultant standard deviation (SD) values of the differences of the measurements were then corrected to obtain the equivalent value for single measurements by using the Bland–Altman formula.

Results

A total of 192 women met the inclusion criteria and agreed to participate in the study. It was not possible to obtain acceptable images of the ovaries in 12 participants, i.e. high body mass index, fetal activity and fetal head position. Acceptable images and measurements were obtained and included in the study in 180 participants. Mean maternal age was 24.4 years with a range of 18.0–35.0 years. Mean maternal BMI was 23.2 years with a range of 18–34. Mean gestational age was 27.45 with a range of 18–35 + 6 weeks. Head circumference, abdominal circumference, and femur length measurements can be seen in Table 1.

It can be seen in Figs. 1–3 that fetal biometric measurements between observers has a high degree of agreement and there is random distribution around the equality line indicating lack of bias.

Table 1
Descriptive statistics for fetal biometric measurements.

Fetal Biometry	Number	Mean	Max.	Min.	GA (Mean)	GA (Range)
HC A	180	252.1	333	150	27w + 3d	18w–35w + 6d
HC B	180	253.3	329	151	27w + 3d	18w–35w + 6d
AC A	180	224	303	122	27w + 3d	18w–35w + 6d
AC B	180	223.3	300	120	27w + 3d	18w–35w + 6d
FL A	180	501.1	670	262	27w + 3d	18w–35w + 6d
FL B	180	499.4	672	261	27w + 3d	18w–35w + 6d

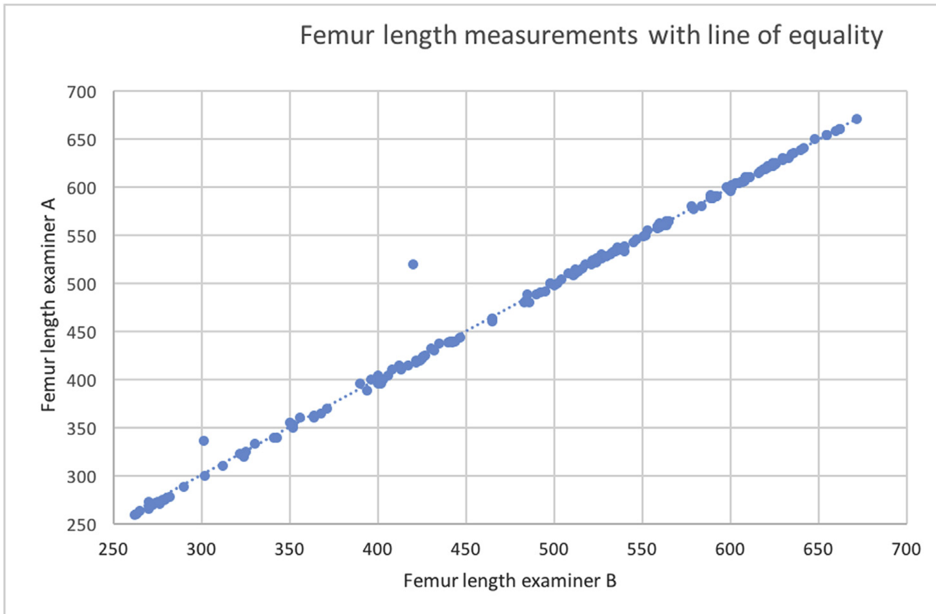

Fig. 1. Femur length measurements by examiner A and B.

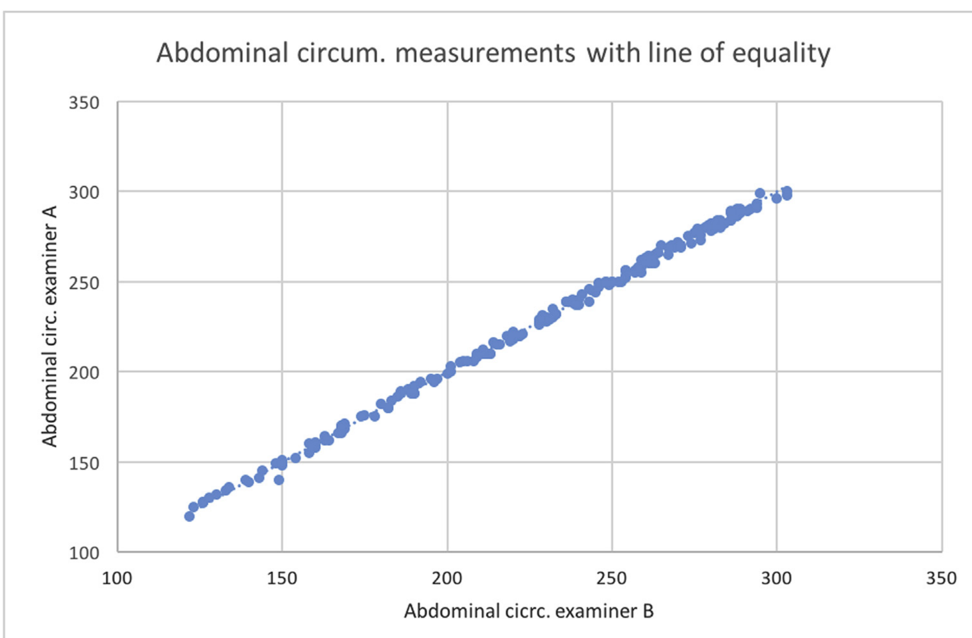

Fig. 2. Abdominal circumference measurements by examiner A and B.

It can also be seen in Table 2 that there is high inter-observer correlation after measuring the value of ICC. This may be explained by the wide range of fetal measurements made and the small differences between operators.

The Bland–Altman graph is a scatterplot of variable means plotted on the horizontal axis and the differences plotted on the vertical axis which shows the amount of disagreement between the two measurements. This plot includes approximate 95% limits. If differences observed in this plot are not deemed clinically important, this is a confirmation of agreement. Bland–Altman graphs for the differences in follicular number count measurements between observers against the mean with the limits of agreement (±2 Standard Deviation) are plotted in Figs. 4–6. We notice that the 95% limits for the differences between examiners are not clinically significant and there is good agreement in all three measurements. The highest agreement was noted in the measurement of the abdominal circumference followed by the head circumference. The lowest agreement was for the femur length measurement. We used the paired-sample t-test to find that the average difference between duplicate measures was not significant ($p < 0.05$); there is no systematic difference between the pairs of results, indicating no bias among or between observers.

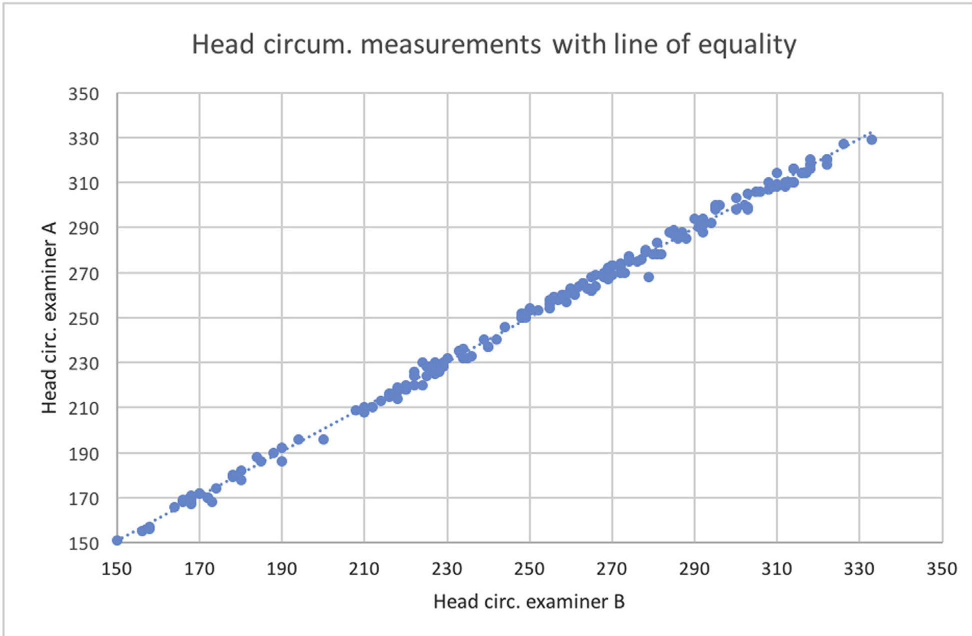

Fig. 3. Head circumference measurements by examiner A and B.

Table 2
Interclass correlation coefficient between observers.

Biometric measurement	ICC
Femur Length	0.990
Abdominal Circumference	0.996
Head Circumference	0.994

Discussion

Accurate fetal ultrasound measurements are important for making correct diagnoses and clinical decisions in obstetrics health care. The fetal biometric measurements are used mainly for estimating gestational age and to diagnose intra-uterine growth restrictions. The use of ultrasound in obstetrics is highly operator-dependent. There is a significant risk of diagnostic errors if the ultrasound exam is performed by an unqualified ultrasound operator [6]. Ensuring appropriate training in ultrasound technique and interpretation is an important part in the curriculum of obstetrics and gynecology residency programs.

The aim of this study was to determine the degree of reproducibility of ultrasound fetal biometry measurements at a major hospital in a developing country. We have demonstrated that there is high reproducibility of measurements of head circumference,

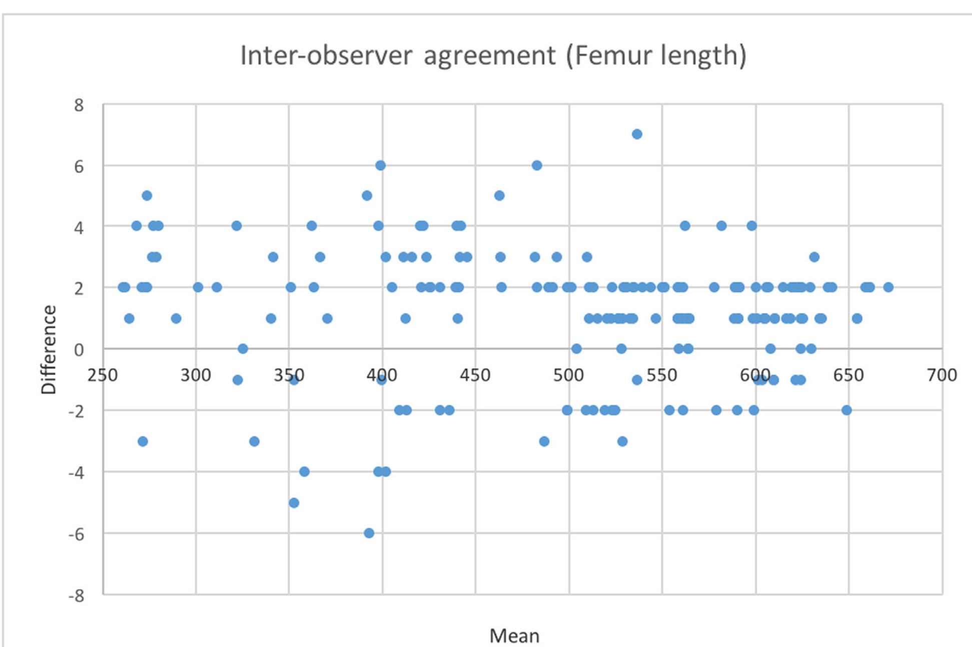

Fig. 4. Bland–Altman plot for inter-observer agreement between examiner A and B for femur length.

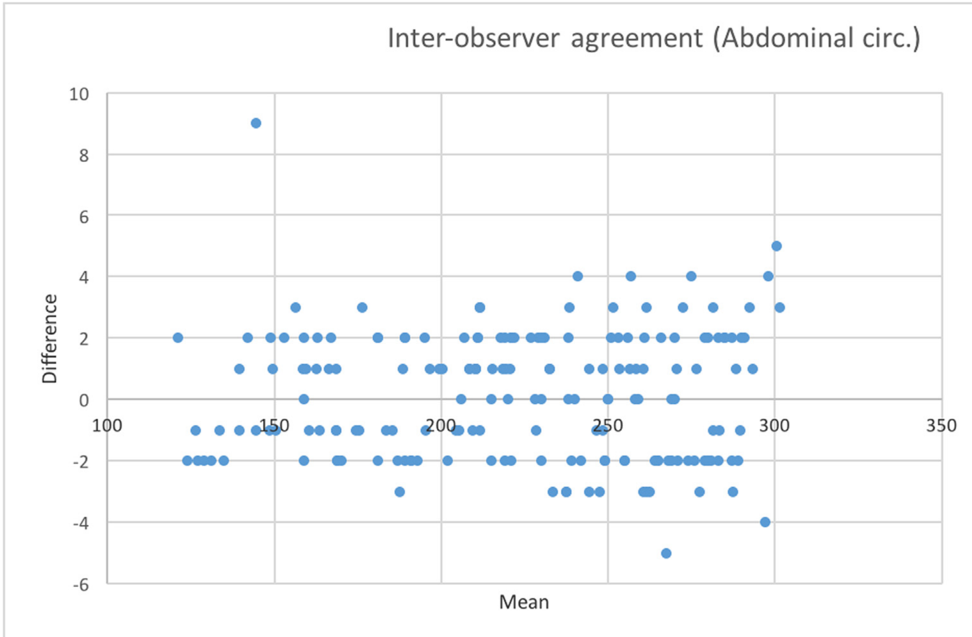

Fig. 5. Bland–Altman plot for inter-observer agreement between examiner A and B for abdominal circumference.

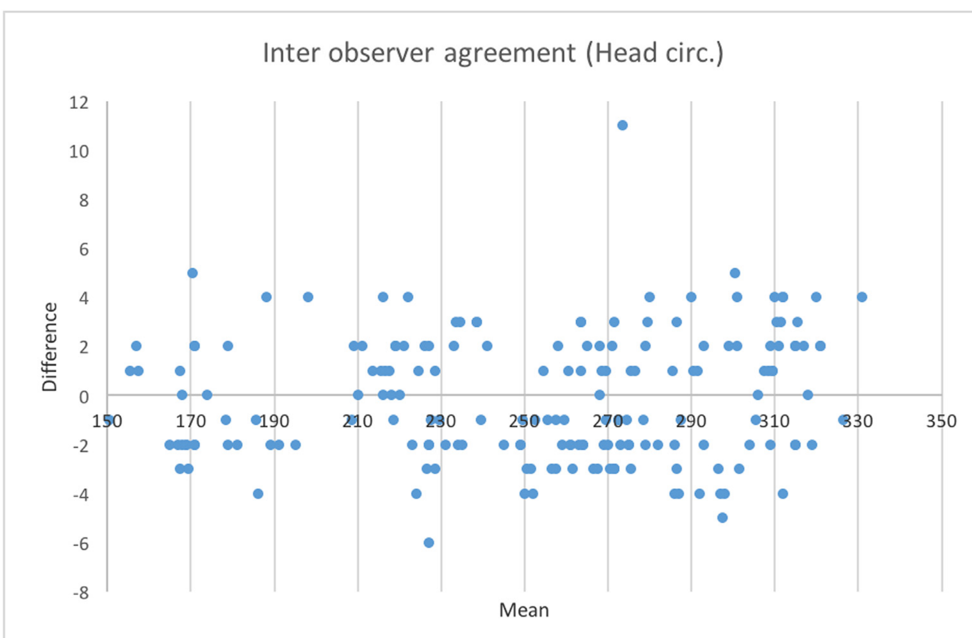

Fig. 6. Bland–Altman plot for inter-observer agreement between examiner A and B for head circumference.

abdominal circumference and femur length in singleton gestations using trans abdominal ultrasound. All biometric parameters are highly reproducible by different operators.

Previous studies examining the variability and reproducibility of obstetric ultrasound measurement have not been sufficient. They evaluated fetal biometric measurements and indicated similar findings to ours with good agreement between observers. The first study looking into fetal measurement accuracy dates back to 1977 and compared the biparietal diameter using bistable ultrasonography on 50 study participants. The researchers were able to show good reproducibility of measurements [7]. Another study looking into the reproducibility of ultrasound fetal biometric measurement looked at the reproducibility of biparital diameter and femur length on 30 participants and also showed good reproducibility of results [4]. However, the aforementioned studies examined a small patient sample population and did not include all fetal measurements. The researchers in Ref. [3] conducted a study on a larger sample of 122 participants and looked at reproducibility of all three important measurements: head, abdomen and femur. This study may not be adequate for reference due to the use of inter/intra class coefficient to assess reproducibility. Rijken et al. [8] aimed to assess reproducibility of fetal measurements in the hands of locally trained health providers. This study looked at all three measurements and was also able to show good reproducibility. The most recent study looking at fetal measurements reproducibility was published in 2012 and looked at 175 patients and was able to show reproducibility of all measured parameters but noted that variability of measurements increases with advanced gestational age [5].

Biparietal diameter (BPD) is obtained using a cross-sectional view of the fetal head at the level of the thalami. Both calipers are placed according to specific criteria; more than one technique has been described. i.e. outer edge to outer edge or outer edge to inner edge. The technique used in the measurement of our study has been introduced and described in Ref. [9]. It must be noted that the BPD is less reliable than head circumference (HC) in determining gestational age especially when there is variation in the skull shape, such as dolichocephaly or brachycephaly. It was also found that HC correlates better to gestational age than BPD [10]. The objective of this study was to evaluate inter-observer variability and reproducibility of measurements. The authors of this study felt that obtaining a cross sectional view of the fetal head at the correct level and measuring the more reliable fetal biometric measurement is sufficient.

This study was necessary because it expands on the sample population and it included all parameters. Examinations were also done in a busy tertiary hospital. This is the only study showing reproducibility in a real clinical sitting in a developing country. The high number of participants when compared to previous publications gives us a more reliable measurement of bias, and the short time between each abdominal ultrasound scan allowed for more accurate measurements. This is the only study showing reproducibility in a true clinical sitting. The short time between each scan allowed for better comparison. In our literature search, there were no other prospective studies with a higher number of participants. Sarris and colleagues performed a study with approximately the same number of participants; 175 [5]. The ultimate aim of the study was to show reproducibility of fetal measurement in a clinical setting similar to daily practice.

Differences in measurements between different racial groups have been noted by researchers examining inter- and intra-race variations in measurement of fetal biometric parameters. Shipp and colleagues found that there are significant differences between white, black, and Asian ethnic groups in femur length measurements [13]. Authors of [14] have also found a significant difference in head circumference, abdominal circumference, femur length, and estimated fetal weight between migrant Moroccan and Turkish pregnant mothers and autochthonous Belgian pregnant mothers. Interracial differences thereby exist between fetuses from different maternal race groups. However, intra-racial differences have to be examined further before discerning any significance to measured fetal biometric values in these groups. Jordan presents as a suitable area for measuring biometric parameters of fetuses since it is a relatively a small country that comprises of 98% Arabs [15]. Most of the migrants in the country are from bordering countries such as Syria, Palestine and Iraq, thereby decreasing the possibility of any significant differences in measurement due to racial and ethnic variation.

Limitations of this study include the two-dimensional nature of the imaging involved in the study which is deemed inferior to the more advanced 3-D technology used in other institutions worldwide, and the lack of intra-observer measurement variance. However, the aim was to assess fetal variability in a true clinical sitting in a busy hospital. Assessing intra-observer variation would have increased the time required to perform a single exam. Another limitation is that participants were low-risk women and no growth restricted fetuses or macrosomic fetuses were scanned. This may be examined in the future to calculate any inter- or intra-observer bias and variation in the fetal biometric measurements.

Conclusion

This study shows that inter-observer agreement was high when testing biometric fetal parameter measurements. It is also reproducible by different individuals in the same clinical sitting. Fetal head circumference, abdominal circumference and femur length were highly reproducible with small variation between different operators. Higher variability between different operators is noted at older gestational age. Large well organized studies are always needed to ensure accurate feta measurements due to the important clinical implications of inaccurate measurements.

Disclosure of interests

The authors report no conflict of interest.

Contribution to authorship

This paper was written by Wesam Aleyadeh and Rami Kilani. Measurements were performed by Luay Abu Atieleh, Abdul Mane' Al Suleimat, Maysa Khadra, and Hassan M Hawamdeh.

Details of ethics approval

Ethical approval was obtained from the Hashemite University Ethical Committee and from Al Bashir Hospital ethical committee.

Funding

No external source of funding.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Acknowledgements

This paper would not have been possible without the support of AlBashir Hospital.;

Appendix. Master list of measurements.

Patient	GA	Obstetrician 1			Obstetrician 2			Hadlock Eq
		HC	AC	FL	HC	AC	FL	EFW
1	28.00	262	221	508	264	220	510	−337.64659
2	22.28	210	158	350	210	155	355	−143.72202
3	32.42	300	274	609	303	271	610	−533.66586
4	26.72	248	214	514	252	216	512	−327.76546
5	27.00	252	219	524	253	218	526	−344.60341
6	25.56	234	209	486	232	208	480	−299.76791
7	19.14	164	128	276	166	130	271	−79.75952
8	18.00	150	123	263	151	125	261	−70.62697
9	35.28	333	294	662	329	291	660	−633.38626
10	33.14	314	279	608	310	281	608	−544.65961
11	20.56	168	126	270	168	127	266	−75.79594
12	32.14	310	284	635	309	282	634	−581.99496
13	28.00	265	228	516	262	226	515	−357.24652
14	27.42	249	219	511	252	217	510	−335.73481
15	26.28	234	201	465	236	203	463	−271.82419

(continued on next page)

(*continued*)

Patient	GA	Obstetrician 1			Obstetrician 2			Hadlock Eq
		HC	AC	FL	HC	AC	FL	EFW
16	24.42	226	189	422	228	188	418	−225.96331
17	29.42	272	239	533	270	237	532	−392.32701
18	24.14	225	183	426	228	184	424	−218.30497
19	32.00	306	280	624	306	282	625	−561.858
20	24.00	222	174	408	224	175	410	−194.40466
21	34.72	322	295	655	320	299	654	−629.07805
22	32.86	296	271	599	300	270	598	−517.61429
23	29.86	278	257	589	280	255	588	−476.46763
24	33.56	310	283	624	309	280	622	−569.18757
25	35.86	322	300	672	318	296	670	−659.0194
26	31.42	308	248	561	310	250	560	−433.38932
27	21.14	168	149	275	170	140	273	−101.43231
28	22.00	200	182	402	196	180	396	−203.83298
29	31.14	285	236	545	287	239	543	−395.09184
30	34.00	295	292	662	298	290	660	−628.19588
31	26.28	240	211	465	237	210	460	−289.89609
32	27.00	250	223	530	253	221	528	−356.96537
33	24.42	220	211	444	218	210	440	−276.24189
34	21.56	190	150	302	186	149	300	−113.4469
35	35.00	310	289	660	314	288	658	−618.48591
36	25.28	229	195	413	230	196	412	−230.49865
37	26.14	235	212	495	232	210	492	−311.32928
38	27.14	250	231	523	254	229	522	−368.39149
39	19.86	168	143	278	171	141	275	−96.28377
40	18.42	158	126	265	156	128	264	−74.24494
41	21.14	170	130	272	172	132	270	−80.5571
42	33.14	322	267	606	320	265	605	−514.36093
43	31.14	287	259	579	288	255	577	−472.65201
44	20.00	174	160	341	174	159	340	−142.4006
45	30.00	269	238	552	268	238	550	−404.65362
46	31.28	280	261	591	278	264	590	−487.38079
47	20.56	170	133	282	172	134	278	−87.04467
48	22.72	214	168	394	213	170	389	−178.23472
49	24.86	227	201	412	228	200	414	−239.48359
50	28.28	269	232	521	271	235	520	−368.96,228
51	26.14	233	220	492	235	222	490	−324.6882
52	21.56	180	158	352	182	160	353	−144.59842
53	24.42	228	206	432	226	206	430	−260.06354
54	29.56	274	236	535	276	239	534	−387.58984
55	28.72	266	238	540	264	240	538	−395.55522
56	21.86	194	168	406	196	170	404	−183.97312
57	26.14	240	196	425	237	194	422	−239.18024
58	28.28	269	243	547	272	246	546	−411.53857
59	26.42	242	197	485	240	196	488	−276.47943
60	28.42	268	232	524	268	230	522	−371.16488
61	33.28	303	277	616	299	276	614	−547.21483
62	31.28	292	263	592	294	260	590	−492.86137
63	33.56	318	276	622	316	279	620	−550.26484
64	34.14	312	294	640	310	293	638	−611.77786
65	31.72	300	286	626	298	284	625	−578.41754
66	30.72	279	271	605	268	269	604	−522.95549
67	29.86	270	248	565	273	249	564	−436.58212
68	21.72	185	164	364	186	162	360	−158.27596
69	30.28	284	267	607	288	269	605	−515.23513
70	32.72	318	269	611	320	269	610	−523.51431
71	31.56	285	264	603	289	266	604	−504.66076
72	29.14	266	246	559	269	249	558	−427.42654
73	31.56	290	259	598	294	262	600	−488.65381
74	22.28	210	167	368	208	166	365	−164.38233
75	23.56	218	190	413	218	188	410	−222.5027
76	24.86	227	186	422	230	188	420	−221.05774
77	27.72	258	213	500	260	210	498	−316.54747
78	19.86	168	150	280	170	148	277	−104.5105
79	21.72	184	160	364	188	158	362	−152.6632
80	23.86	216	180	441	216	182	440	−221.2444
81	35.14	326	288	655	327	286	654	−611.10772
82	33.00	310	286	611	308	288	610	−564.16454
83	21.00	172	160	322	170	161	323	−133.9228
84	27.00	248	218	518	250	220	520	−338.49102
85	27.14	259	228	522	260	228	524	−361.55572
86	26.28	239	205	443	240	206	440	−265.27655
87	26.86	248	212	498	250	210	500	−313.29188
88	18.56	156	122	262	155	120	260	−69.33358
89	33.42	313	291	633	310	289	630	−597.46489

(*continued*)

Patient	GA	Obstetrician 1			Obstetrician 2			Hadlock Eq
		HC	AC	FL	HC	AC	FL	EFW
90	31.42	309	268	600	308	270	596	−511.46292
91	31.00	281	265	601	283	270	599	−505.28755
92	34.28	316	289	636	314	290	635	−595.39311
93	20.56	166	148	290	169	149	289	−106.35812
94	21.14	178	140	270	179	139	273	−90.1766
95	23.86	218	190	442	219	192	440	−238.9225
96	28.86	260	262	559	262	260	558	−462.35758
97	23.56	216	168	390	215	169	396	−176.32192
98	22.28	212	163	356	210	162	360	−153.20717
99	23.56	217	159	343	216	159	340	−141.97381
100	25.56	229	204	484	228	205	482	−289.06756
101	34.86	314	286	642	316	289	640	−593.62074
102	28.14	263	228	529	265	229	528	−366.58312
103	26.42	244	188	483	246	190	480	−258.37832
104	30.72	288	250	584	285	250	580	−456.3143
105	29.14	274	250	561	276	250	560	−437.7717
106	33.42	312	280	620	309	278	618	−558.1532
107	32.86	316	281	605	314	279	604	−546.62739
108	30.56	274	260	592	277	263	590	−485.9158
109	28.14	269	230	527	270	230	530	−369.2571
110	20.86	178	150	312	180	151	310	−117.5089
111	21.00	168	163	325	167	164	325	−139.00297
112	23.86	222	168	371	220	166	370	−167.23612
113	28.86	272	254	559	273	253	559	−444.89206
114	31.86	314	275	621	310	277	622	−546.92345
115	32.72	303	273	601	298	275	600	−524.09707
116	29.86	278	245	562	279	244	560	−427.60195
117	21.14	180	144	324	178	145	320	−114.92416
118	24.42	222	222	465	226	220	462	−309.77518
119	24.42	226	209	447	228	210	444	−274.72211
120	27.86	264	211	504	263	212	504	−315.25389
121	30.00	273	258	590	270	258	588	−479.60902
122	31.28	292	254	578	291	256	580	−460.51386
123	33.14	318	288	609	318	290	610	−567.03052
124	31.42	295	263	601	299	265	602	−500.58517
125	27.42	256	220	511	259	218	508	−337.726
126	28.42	270	252	565	273	250	564	−445.41088
127	19.56	166	139	279	168	140	275	−92.40921
128	30.28	294	259	590	292	259	588	−481.91621
129	20.28	167	168	352	169	169	350	−158.15032
130	27.72	261	220	527	260	220	526	−348.7052
131	30.14	282	240	553	278	240	555	−409.7302
132	25.28	230	200	424	232	199	420	−245.1628
133	24.14	224	190	417	220	192	414	−224.7675
134	31.72	302	277	619	300	273	618	−549.95743
135	31.56	292	270	617	288	270	616	−531.2227
136	34.00	312	278	625	308	280	624	−557.88982
137	28.56	272	246	551	273	247	549	−421.10494
138	27.14	255	213	498	254	210	500	−315.23107
139	29.00	265	259	563	262	258	562	−459.17681
140	28.14	270	233	536	273	232	534	−382.06647
141	29.86	285	270	608	288	272	606	−523.2469
142	26.86	249	222	528	250	220	528	−353.50978
143	21.86	188	169	403	190	168	400	−184.09771
144	29.14	270	254	564	269	252	564	−449.00306
145	28.28	265	254	559	268	256	557	−444.89206
146	27.56	255	233	535	258	232	533	−381.32827
147	22.86	220	175	396	220	176	400	−189.90945
148	28.14	260	230	532	263	228	530	−372.8881
149	29.42	274	243	536	275	239	537	−402.97837
150	30.28	277	241	560	276	243	558	−417.28079
151	33.28	317	286	626	314	284	624	−578.41754
152	32.56	305	303	624	306	298	622	−618.05137
153	22.72	220	182	435	218	180	437	−221.46158
154	24.00	227	185	430	225	186	432	−223.79215
155	24.56	225	209	440	224	208	438	−270.22671
156	27.42	259	216	512	257	215	510	−330.43144
157	29.72	272	253	564	274	250	564	−446.79987
158	23.56	218	169	400	217	171	404	−182.65111
159	22.28	208	186	400	209	189	396	−208.95334
160	21.86	190	190	442	192	188	438	−238.9225
161	27.28	257	220	512	258	219	514	−338.4122
162	29.72	281	249	560	278	248	562	−434.77831
163	30.00	291	261	589	290	260	591	−485.68039

(*continued*)

Patient	GA	Obstetrician 1			Obstetrician 2			Hadlock Eq
		HC	AC	FL	HC	AC	FL	EFW
164	18.86	158	134	274	157	136	272	−85.38226
165	24.28	224	192	427	230	194	425	−233.73988
166	28.72	269	248	552	267	250	550	−426.20552
167	21.00	172	159	330	170	158	333	−136.22521
168	34.72	314	303	648	316	300	650	−642.48817
169	33.56	295	282	630	300	284	628	−572.34958
170	29.42	276	229	527	275	231	526	−367.20191
171	28.56	268	240	540	270	237	533	−399.7696
172	27.86	260	211	502	262	210	500	−313.95349
173	21.00	173	154	301	168	152	336	−117.64546
174	30.00	286	264	591	285	266	590	−494.31436
175	27.14	255	215	420	256	215	520	−267.14585
176	26.28	236	208	490	233	206	488	−300.42952
177	23.42	218	178	399	214	175	400	−196.05762
178	29.00	263	257	564	265	256	560	−455.61263
179	33.56	303	283	630	305	284	630	−574.81677
180	32.00	308	281	624	307	282	624	−564.30119

References

[1] Smith-Bindman R, Hosmer W, Feldstein VA, Deeks JJ, Goldberg JD. Second-trimester ultrasound to detect fetuses with Down syndrome: a meta-analysis. JAMA 2001 Feb 28;285(8):1044–55.

[2] Mongelli M, Ek S, Tambyrajia R. Screening for fetal growth restriction: a mathematical model of the effect of time interval and ultrasound error. Obstet Gynecol 1998 Dec 1;92(6):908–12.

[3] Perni SC, Chervenak FA, Kalish RB, Magherini-Rothe S, Predanic M, Streltzoff J, et al. Intraobserver and interobserver reproducibility of fetal biometry. Ultrasound Obstet Gynecol 2004 Nov 1;24(6):654–8.

[4] Nakai A, Oya A. Accuracy and reproducibility of ultrasound measurements in obstetric management. Gynecol Obstet Invest 2002;54(1):31–6.

[5] Sarris I, Ioannou C, Chamberlain P, Ohuma E, Roseman F, Hoch L, et al. Intra- and interobserver variability in fetal ultrasound measurements. Ultrasound Obstet Gynecol 2012 Mar 1;39(3):266–73.

[6] Salvesen KÅ, Lees C, Tutschek B. Basic European ultrasound training in obstetrics and gynecology: where are we and where do we go from here? Ultrasound Obstet Gynecol 2010 Nov 1;36(5):525–9.

[7] Lawson TL, Albarelli JN, Greenhouse SW, Greenbaum LD. Gray scale measurement of biparietal diameter. J Clin Ultrasound 1977 Feb 1;5(1):17–20.

[8] Rijken MJ, Lee SJ, Boel ME, Papageorghiou AT, Visser GH, Dwell SL, et al. Obstetric ultrasound scanning by local health workers in a refugee camp on the Thai–Burmese border. Ultrasound Obstet Gynecol 2009 Oct 1;34(4):395–403.

[9] Shepard M, Filly RA. A standardized plane for biparietal diameter measurement. J Ultrasound Med 1982 May 1;1(4):145–50.

[10] Nyberg DA, editor. Diagnostic imaging of fetal anomalies. Lippincott Williams & Wilkins; 2003.

[11] Hadlock FP, et al. Sonographic estimation of fetal weight. The value of femur length in addition to head and abdomen measurements. Radiology 1984;150(2):535–40.

[12] Shepard MJ, Richards VA, Berkowitz RL, Warsof SL, Hobbins JC. An evaluation of two equations for predicting fetal weight by ultrasound. Am J Obstet Gynecol 1982 Jan 1;142(1):47–54.

[13] Shipp TD, Bromley B, Mascola M, Benacerraf B. Variation in fetal femur length with respect to maternal race. J Ultrasound Med 2001 Feb 1;20(2):141–4.

[14] Jacquemyn Y, Sys SU, Verdonk P. Fetal biometry in different ethnic groups. Early Hum Dev 2000 Jan 31;57(1):1–13.

[15] Minority Rights Group International. World directory of minorities and indigenous peoples – Jordan: Palestinians. 2008. Available at: http://www.refworld.org/docid/49749cfcc.html. [Accessed 20 August 2017].