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Ultrasound dating at 12-14 gestational weeks. A prospective cross-validation of established dating formulas in in-vitro fertilized pregnancies.

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ABSTRACT

Objectives: To determine the accuracy of established ultrasound dating formulas when used at 12-14 gestational weeks (gws).

Methods: One-hundred and sixty-seven singleton pregnancies conceived after in-vitro fertilization (IVF) underwent a dating scan at 12-14 gws. Gestational age at the dating scan was calculated by adding 14 days to the number of days between the date of oocyte retrieval and the date of the ultrasound scan. Gestational age according to oocyte retrieval was regarded as the true gestational age. True gestational age was compared to gestational age calculated on the basis of 21 dating formulas based on fetal crown-rump length (CRL) measurements and to three dating formulas based on fetal biparietal diameter (BPD) measurements. In a previous study the three BPD formulas tested here had been shown to be superior to four other BPD formulas when used at 12-14 gws. The mean of the differences between estimated and true gestational age and their SD (standard deviation) were calculated for each formula. The SD of the differences was assumed to reflect random measurement error. Systematic measurement error was assumed to exist if zero lay outside the mean difference $\pm$ 2SE (SE; standard error of the mean).

Results: The three best CRL formulas were associated with a mean (non-systematic) measurement error of -0.0, -0.1 and -0.3 days, and the SD of the measurement errors of these formulas varied from 2.37 to 2.45. All but two of the remaining CRL formulas were associated with systematic over- or under-estimation of gestational age, and the SDs of their measurement error varied between 2.25 and 4.86 days. Dating formulas using BPD systematically underestimated gestational age

by -0.4 to -0.7 days, and the SDs of their measurement errors varied from 1.86 to 2.09.

Conclusions: We have identified three BPD formulas that are suitable for dating at 12-14 gws. They are superior to all 21 CRL formulas tested here, because their random measurement errors were much smaller than those of the three best CRL formulas. The small systematic negative measurement errors associated with the BPD formulas are likely to be clinically unimportant.

INTRODUCTION

Nowadays, routine ultrasound examination is offered to most pregnant women in western countries. Very often, these routine scans are carried out at around 18 gestational weeks (gws). One of the objectives of the routine scan is to determine gestational age. Many dating formulas have been designed for dating at this time in gestation. Usually these are based on fetal biparietal diameter (BPD) measurements[1].

Recently, there has been significant interest in offering first trimester routine scans including screening for chromosomal anomalies by sonographic measurements of the fetal nuchal translucency[2]. As a consequence more and more pregnancies are being dated at 12 – 14 gws. Even though most dating formulas using BPD measurements were not originally designed for use at 12 – 14 gws, a few BPD formulas have been shown to work very well in these gestational weeks[1]. At 12 – 14 gws it is also possible to determine gestational age on the basis of fetal crown-rump length (CRL) measurements. However, most CRL formulas have been designed for use before 12 gws (see Table 1)[3-19].

The aim of this study was to determine the performance of published CRL formulas when used for dating at 12 – 14 gws and to compare their performance to that of three BPD formulas that we have found to result in accurate dating when used at 12 – 14 gws[1].

SUBJECTS AND METHODS

Study populations

Women with a singleton IVF pregnancy included in the Swedish NUPP-trial[1] and who had undergone a dating scan at 12-14 gws were eligible for inclusion. Inclusion criteria were: 'true' gestational age based on the day of oocyte retrieval 12 gws + 0 days to 14 gws + 6 days at the dating scan, live born baby with no fetal malformation or chromosomal anomaly. After exclusions (Figure 1) our IVF study population comprised 167 women. Their mean age was 34 years (range 20-45), and 73% (122/167) of them were nullipara.

In a second stage we analyzed the effects of using the dating formulas with the best performance in our IVF population for dating in a larger population of pregnancies conceived spontaneously. This population comprised 2251 pregnancies included in the Swedish NUPP-trial between April 1999 and May 2002 randomized to a dating scan at 12 – 14 gws and fulfilling the following inclusion criteria: singleton pregnancy, BPD at the dating scan 21 - 31 mm, live born baby with no fetal malformation or chromosomal anomaly. After exclusions (Figure 1) calculations were done on the basis of 2023 women, who delivered after spontaneous start of labor. Their mean age was 30 years (range 16 - 43), and 49% (982/2023) of them were nullipara.

Ultrasound examinations

The dating scans were scheduled at 12 – 14 gws according to the day of

oocyte retrieval in the IVF pregnancies and according to the first day of the last menstrual period (LMP) in the spontaneously conceived pregnancies. They were performed by specially trained midwives with 1 – 25 (mean 11) years' experience of routine ultrasound examinations at 15 – 22 gws. Before the study started, all

midwives had received a certificate of competence in the theory and practice of the 11 – 14 week scan from the Fetal Medicine Foundation, London. All examinations were performed transabdominally using any of the following ultrasound systems: Aloka 1400, Aloka SSD 2000, Aloka 4000, or Aloka 5000 (Aloka Co Ltd 6-22-1 Nure, Nitaka-SHI, Tokyo, Japan), Acuson XP 10, or Aspen (Siemens Acuson Inc, Mountain View, CA, USA) with 3.5 - 5 MHz curvilinear transducers. The scan included measurements of CRL, BPD and nuchal translucency. Fetal anatomy was also examined. The longest straight line between the cranial and caudal ends of the fetus in a neutral position on an ultrasound image with good anatomic details was considered the optimal CRL measurement[20,21]. The BPD was measured from the outer to the inner edge of the parietal bone in a transverse plane which aligns the cavum septum pellucidum and the third ventricle with the thalamus[22,23]. Both for BPD and CRL the mean of three replicate measurements was used.

Calculation of gestational age

In the IVF pregnancies gestational age at the dating scan/delivery was calculated by adding 14 days to the number of days between the date of oocyte retrieval and the date of the ultrasound scan/delivery. Gestational age according to oocyte retrieval was regarded as the true gestational age. Gestational age in the IVF population was also estimated using 21 ultrasound dating formulas based on CRL measurements (see Table 1) and three selected BPD formulas, i.e., those found to be superior to four other BPD formulas when used at 12 – 14 gws in one of our previous studies[1].

Definitions

A delivery at ≤258 completed gestational days was considered to be preterm and a delivery at ≥294 completed gestational days to be post-term. Calculating gestational age using dating formulas one gets a result expressed as a number with decimals. When calculating preterm and post-term delivery rates, days with decimals were transformed to completed days. As an example, 258.000 - 258.999 days was transformed to 258 completed gestational days, and 293.000 - 293.999 days was transformed to 293 completed gestational days. The same transformation was used when we compared gestational length calculated on the basis of oocyte retrieval in IVF pregnancies with that calculated using formulas in spontaneously conceived pregnancies.

Preterm delivery rate was defined as the number of pregnancies with spontaneous start of labor and delivery at ≤258 days divided by the total number of pregnancies with spontaneous start of labor. Post-term delivery rate was defined as the number of pregnancies with spontaneous start of labor and delivery at ≥294 days divided by the total number of pregnancies with spontaneous start of labor.

Statistical analysis

Measurement error was defined as the difference in days between the gestational age at the dating scan calculated on the basis of ultrasound fetometry and the gestational age calculated on the basis of oocyte retrieval. The mean of these differences reflects systematic measurement error (i.e., systematic under- or over-estimation of gestational age), whereas the standard deviation (SD) of the differences reflects the random measurement error. To determine if there was any systematic over- or under-estimation of gestational age we calculated the 95% confidence

interval (CI) of the mean difference (mean±2SE; standard error). If zero lay within this interval no systematic measurement error was assumed to exist.

To determine the statistical significance of differences in rates of pre-term and post-term delivery between IVF pregnancies and spontaneously conceived pregnancies we used the Chi-squared test, whereas the statistical significance of differences in pregnancy duration between IVF pregnancies and spontaneously conceived pregnancies was determined using the Mann-Whitey test. Statistical analysis was carried out using the Statview™ software, version 5.0.1 for Windows (SAS Institute Incorp., Statview, 2001, Berkeley, CA, USA). Two-tailed P-values < 0.05 were considered statistically significant.

RESULTS

Dating in the IVF population

Mean gestational age at the dating scan was 13 gestational weeks + 2 days according to oocyte retrieval, mean BPD was 24.3 mm ±1.76 (SD) **(range 20-28)** and mean CRL was 71.9 mm ±6.15 **(range 55-84)**. Measurement errors are shown in Table 2. They ranged from -15 to +14 days. Five CRL formulas were associated with no systematic measurement error (Selbing and Fjällbrant 1984, formula a[3], Koornstra et al. 1990 formula a[4], Volleberg**h** et al. 1989[5], Izquierdo et al. 1991[6], Hadlock et al. 1992[7]; see Table 2). Of these, three (Selbing and Fjällbrant 1984, formula a[3], Koornstra et al. 1990 formula a[4], Volleberg**h** et al. 1989[5]) had smaller random measurement error than the other two (Izquierdo et al. 1991[6], Hadlock et al. 1992[7]). These three formulas (Selbing and Fjällbrant 1984, formula a[3], Koornstra et al. 1990, formula a[4], Volleberg**h** et al. 1989[5]) were considered by us to be the best CRL

formulas for dating at 12 – 14 gws. Nine CRL formulas (MacGregor et al. 1987[9], **Nelson** et al. 1981[10], Drumm et al. 1976[11], Selbing 1982[16], Grisolia et al. 1993[17], Goldstein et al. 1991[18], Silva et al. 1990[19]; see Table 2) resulted in substantial overestimation of gestational age and seven (Selbing and Fjällbrant, formula b, 1984[3], Koornstra et al., formula b, 1990[4], Rossavik et al. 1988[8], Robinson and Fleming 1975[12], Von Kaisenberg et al. 2002[13], Daya 1993[14], **W**isser et al. 1994[15]; see Table 2) in substantial underestimation of gestational age.

The three BPD formulas[24,25] systematically underestimated gestational age by 0.4 to 0.7 days, but the SDs of the measurement errors of the BPD formulas were smaller than those of the CRL formulas (see Table 2).

Pregnancy duration

Pregnancy duration and pre- and post-term delivery rates in the IVF pregnancies are presented in Table 3. Table 4 shows pregnancy duration according to ultrasound fetometry using the three best CRL formulas and the three BPD formulas in spontaneously conceived pregnancies with spontaneous start of labor. Irrespective of how gestational length was calculated, preterm delivery rate was slightly higher, post-term delivery rate was slightly lower and gestational length was slightly shorter in the IVF pregnancies than in the spontaneously conceived pregnancies **(see Tables 3 and 4),** but none of the differences was statistically significant.

DISCUSSION

In this study we have identified three CRL dating formulas that seem to be superior to 18 others when used for dating at 12-14 gws, i.e., the formulas designed by Selbing och Fjällbrant (formula a) in 1984[3], by Koornstra et al. (formula a) in 1990[4], and by Volleberg**h** et al in 1989[5]. We consider these three CRL formulas to be superior to the

other 18 CRL formulas, because they were associated with no systematic measurement error and small random measurement errors. Two other CRL formulas (Izquierdo et al. 1991[6], Hadlock et al. 1992[7]) also had no systematic measurement error, but because they were associated with larger random measurement errors, we considered them to be inferior to the three CRL formulas that we selected to be the best. Most of the remaining CRL formulas were associated with substantial systematic over- or under-estimation of gestational age. The three selected BPD formulas had smaller random measurement errors than the three CRL formulas that we considered to be the best. On the other hand, the BPD formulas were associated with a systematic underestimation of gestational age. However, this underestimation was small, 0.4 to 0.7 days, and therefore probably clinically unimportant. We believe that it is important that dating formulas have small random measurement error, and we therefore suggest that one of the three BPD formulas be recommended for dating at 12 – 14 gws, preferably the formula designed by Selbing and Kjessler in 1985[24]. Our argument is that this formula had only a small systematic measurement error (-0.37 days) and was associated with the smallest random measurement error of all formulas tested (1.86 days).

The fact that random measurement errors were larger for CRL formulas than for BPD formulas is probably explained by CRL measurements being strongly dependent on the fetal position and therefore being likely to be difficult to reproduce. CRL measurements should be taken when the fetus is in a 'neutral' position. However, there is no absolute definition of what constitutes a 'neutral' fetal position. A small flexion or deflexion of the fetus could change the CRL, even though the fetus might still be defined as being in a neutral position. Despite extensive literature search, we have been unable to find a properly designed study investigating the reproducibility of

CRL measurements taken at 12 – 14 gws, or a comparison between the reproducibility of CRL measurements and BPD measurements at this time in pregnancy.

Our decision to use gestational age calculated on the basis of oocyte retrieval in IVF pregnancies as an estimate of true gestational age may be criticized, because IVF pregnancies might not be representative of naturally conceived pregnancies. An alternative would have been to use pregnancies conceived after insemination, but a purist could bring forth the same type of criticism against such an approach. An estimate of true gestational age in naturally conceived pregnancies in women with regular menstrual cycles and known LMP is probably less reliable than an estimate based on time of insemination or on oocyte retrieval during IVF treatment because of the biological variation in menstrual cycle length even in regularly menstruating women[26,27]. We believe that gestational age calculated on the basis of oocyte retrieval in IVF pregnancies is probably the closest one can come to true gestational age. Nonetheless, we are aware of the weakness associated with the lack of a true gold standard. The fact that among women who gave birth spontaneously those who had conceived by IVF had slightly shorter duration of pregnancy (even though not statistically significantly shorter) than women who had conceived spontaneously suggests that there might be true differences in ‘normal‘ gestational length between the two types of pregnancy. Alternatively, our gold standard was imperfect: either adding 14 days to the number of days between the date of oocyte retrieval and the date of the ultrasound scan is an inappropriate way of calculating true gestational age in IVF pregnancies, or the size of fetuses in IVF pregnancies differs systematically from that of fetuses of identical gestational age in spontaneously conceived pregnancies. **The higher proportion of multiparae is unlikely to explain the longer duration of pregnancy in spontaneously conceived pregnancies, because the BPD**

of fetuses of multiparae has been reported to be smaller than that of nulliparae[28,29], and this would result in an apparently shorter not longer gestational length. However, only the systematic measurement error would be affected by an imperfect gold standard, not the random measurement error. This makes it even more reasonable to recommend the dating formula with the smallest random measurement error, i.e., the BPD formula of Selbing and Kjessler published in 1985[24].

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Table 1 Dating formulas tested. Some of the formulas have been modified to calculate gestational age in days using CRL measurements in millimetres

Reference	Formula	No. women/ no. measurements	Gest. age (weeks)	Type of pregnancy	Pregnancy length based on	Ultrasound technique
CRL formula						
Selbing and Fjällbrant 1984[3] (formula a)	$14 + 35.05 + 0.7828 * CRL - 0.002328 * CRL^2$	24	7-12	Donor insemination	hCG injection and insemination	TAS, static or real time
Koornstra et al. 1990[4] (formula a)	$7.71 * CRL^{1/2} + 27.8$	111/154	7-12	Natural conception	LMP, regular cycles	TAS, real time
Volleberg**h** et al. 1989[5]	$7.23 * CRL^{1/2} + 31.7$	47	6-13	Natural conception	BBT	TAS, real time
Izquierdo et al. 1991[6]	$50.86 + 0.587 * CRL$	92	8-12	Natural conception	LMP, regular cycles	TVS, real time
Hadlock et al. 1992[7]	$[LN(1.684969 + 0.0315646 * CRL - 0.00049306 * CRL^2 + 0.000004057 * CRL^3 - 0.0000000120456 * CRL^4)] * 7$	416	5-20	Natural conception	LMP, regular cycles	TAS or TVS, real time
Rossavik et al. 1988[8]	$49.5 + 0.6 * CRL$	35/106	7-15	IVF or natural conception	ET or monitored ovulation	TAS, real time
MacGregor et al. 1987[9] (formula a)	$44.89 + 0.972 * CRL - 0.004001 * CRL^2$	37	7-13	Insemination	Monitored ovulation	TAS, real time
Nelson 1981[10]	$51.0008 + 0.6 * CRL$	83	7-14	Natural conception	LMP, regular cycles	TAS, real time
Selbing and Fjällbrant 1984[3] (formula b)	$14 + 33.06 + 0.9433 * CRL - 0.004326 * CRL^2$	19	7-12	Natural conception or donor insemination	BBT	TAS, static or real time
Drumm et al. 1976[11]	$[0.374 + (0.374^2 + 0.048 * CRL)^{1/2}] / 0.024$	253	7-14	Natural conception	LMP, regular cycles	TAS, static

cont.

Table 1 cont

Reference	Formula	No. women/ no. measurements	Gest. age (weeks)	Type of pregnancy	Pregnancy length based on	Ultrasound technique
Robinson and Fleming 1975[12]	$8.052 * CRL^{1/2} + 23.73$	334	6-14	Natural conception	LMP, regular cycles	TAS, static
von Kaisenberg et al. 2002[13]	49.1115 + 0.5954 * CRL	660	11-14	Natural conception	LMP, regular cycles	TAS, real time
Daya 1993[14]	$40.447 + 1.125 * CRL - 0.0058 * CRL^2$	94	6-12	IVF	Oocyte retrieval	TAS or TVS, real time
Wisser et al. 1994[15]	$35.72 + 1.082 * CRL^{1/2} + 1.472 * CRL - 0.09749* CRL^{3/2}$	160	7-14	IVF, GIFT, insemination	Oocyte retrieval or insemination	TAS or TVS, real time
MacGregor et al. 1987[9] (formula c)	$45.96 + 0.849 * CRL - 0.002223 * CRL^2$	65	7-13	Insemination or natural conception	hCG injection or monitored ovulation	TAS, real time
Selbing 1982[16]	$40.16 + 1.093 * CRL - 0.00443 * CRL^2$	13/52	6-15	Natural conception	LMP, regular cycles	TAS, static
Grisolia et al. 1993[17]	$50.5456 + 1.4455 * CRL - 0.0112 * CRL^2$	248	5-13	Natural conception	LMP, regular cycles	TVS, real time
Goldstein et al. 1991[18]	27.15579 + 0.96071 * CRL	137	5-12	Natural conception	LMP, regular cycles	TVS, real time
Koornstra et al. 1990[4] (formula b)	$7.57 * CRL^{1/2} + 25.7$	17/27	7-12	Natural conception	BBT	TAS, real time
MacGregor et al. 1987[9] (formula b)	$46.66 + 0.752 * CRL - 0.000691 * CRL^2$	28	7-13	Natural conception	hCG injection or monitored ovulation	TAS, real time
Silva et al. 1990[19]	26.0 + 0.99 * CRL	36	6-9	Insemination	LH test or hCG injection	TVS, real time

cont.

Table 1 cont

Reference	Formula	No. women/ no. measurements	Gest. age (weeks)	Type of pregnancy	Pregnancy length based on	Ultrasound technique
BPD formula						
Selbing and Kjessler 1985[24]	$14 + 44.65 + 1.07 * BPD + 0.0138 * BPD^2$	970	9-22	Natural conception	CRL measurements <12 gws	TAS, real time
Mul et al. 1996[25] (formula a)	$46.56 + 1.87 * BPD + 0.0013 * BPD^2$	64/124	14-24	IVF	ET	TAS, real time
Mul et al. 1996[25] (formula b)	$44.17 + 1.99 * BPD$	64/124	14-24	IVF	ET	TAS, real time

CRL = crown-rump length (mm); No. = number of; gest. age = gestational age, weeks; gws = gestational weeks; BPD = biparietal diameter (mm); LN = natural logarithm; BBT = basal body temperature; LMP = last menstrual period; ET = embryo transfer; LH = luteinizing hormone, TAS = transabdominal scanning, TVS = transvaginal scanning

Table 2 Difference between gestational age estimated by ultrasound fetometry and that calculated from oocyte retrieval in pregnancies conceived after in vitro fertilization.

	Difference in days (measurement error)				
Formula	Mean	95% CI	SD	Range	
CRL formulas *(n=167)*					
Selbing and Fjällbrant 1984[3] (formula a) *	-0.041	-0.419 – 0.337	2.437	- 9.938 – 6.945	
Koornstra et al. 1990[4] (formula a) *	-0.136	-0.516 – 0.244	2.450	-10.021 – 6.893	
Volleberg**h** et al. 1989[5]*	-0.302	-0.670 – 0.066	2.379	-9.681 – 6.554	
Izquierdo et al. 1991[6]	-0.188	-0.634 – 0.278	2.876	- 11.855 – 7.646	
Hadlock et al. 1992[7]	0.285	-0.127 – 0.697	2.668	- 10.209 – 7.789	
Rossavik et al. 1988[8]	-0.614	-1.068 – -0.160	2.929	- 12.500 – 7.300	
MacGregor et al. 1987[9] (formula a)	0.691	0.329 – 1.053	2.341	-8.753 – 7.364	
Nelson 1981[10]	0.887	0.433 – 1.341	2.929	- 10.999 – 8.801	
Selbing and Fjällbrant 1984[3] (formula b)	-0.893	-1.241 – -0.545	2.248	-9.145 – 5.318	cont.

Table 2 cont.

	Difference in days (measurement error)			
Formula	Mean	95% CI	SD	Range
Drumm et al. 1976[11]	1.222	0.808 – 1.636	2.677	-9.946 – 8.698
Robinson and Fleming 1975[12]	-1.309	-1.697 – -0.921	2.507	-11.555 – 5.843
von Kaisenberg et al. 2002[13]	-1.332	-1.782 – -0.882	2.910	- 13.141 – 6.554
Daya 1993[14]	-2.117	-2.465 – -1.769	2.252	-10.223 – 3.910
Wisser et al. 1994[15]	-2.126	-2.472 – -1.780	2.240	- 10.061 – 3.933
MacGregor et al 1987[9] (formula c)	2.174	1.758 – 2.590	2.683	-9.070 – 9.657
Selbing 1982[16]	2.427	2.043 – 2.811	2.482	- 8.126 – 9.462
Grisolia et al. 1993[17]	2.912	2.360 – 3.464	3.565	-7.232 – 12.046
Goldstein et al. 1991[18]	2.966	2.238 – 3.694	4.702	- 15.011 – 13.084
Koornstra et al. 1990[4] (formula b)	-3.422	-3.798 – -3.046	2.428	-13.159 – 3.556
MacGregor et al 1987[9] (formula b)	3.876	3.388 – 4.364	3.159	-9.070 – 12.112
Silva et al. 1990[19]	3.922	3.170 – 4.674	4.863	- 14.550 – 14.220

cont.

Table 2 cont.

Formula	Difference in days (measurement error) Mean	95% CI	SD	Range
BPD formulas *(n=167)*				
Selbing and Kjessler 1985[24]	-0.373	-0.661 – (-0.085)	1.862	-6.131 – 4.025
Mul et al. 1996[25] (formula a)	-0.439	-0.753 – (-0.125)	2.031	-6.671 – 4.123
(formula b)	-0.684	-1.008 – (-0.360)	2.089	-7.050 – 3.920

CRL = crown-rump length; BPD = biparietal diameter; SD = standard deviation; CI = confidence interval.

* CRL formula judged to be among the three best ones.

Table 3 Duration of pregnancy according to oocyte retrieval and to ultrasound fetometry in pregnancies conceived after in vitro fertilization.

Method of estimation of gestational age	Duration of pregnancy (days)				Pre- or post-term delivery; n (%)	
	Mean	SD	Median	Range	Pre-term (≤258 days)	Post-term (≥294 days)
Oocyte retrieval						
All (n=167)	276.8	16.01	279.0	207-302	11 (6.6%)	11 (6.6%)
Spontaneous onset of labor (n=111)	278.2	14.66	281.0	207-302	6 (5.4%)	5 (4.5%)
Spontaneous onset of labor ≥37 gws (n=105)	280.9	8.27	282.0	259-302	-	5 (4.5%)
Ultrasound fetometry						
Spontaneous onset of labor (n=111)						
CRL formulas						
Selbing and Fjällbrant 1984[3] (formula a)	278.2	15.07	280.9	203-302	7 (6.3%)	7 (6.3%)
Koornstra et al. 1990[4] (formula a)	278.1	15.07	280.8	203-302	7 (6.3%)	7 (6.3%)
Volleberg**h** et al. 1989[5]	277.9	15.07	280.5	203-302	7 (6.3%)	7 (6.3%)

cont.

Table 3 cont.

Method of estimation of gestational age	Duration of pregnancy (days)				Pre- or post-term delivery; n (%)	
	Mean	SD	Median	Range	Pre-term (≤258 days)	Post-term (≥294 days)
BPD formulas						
Selbing and Kjessler 1985[24]	277.7	15.10	280.0	203-302	7 (6.3%)	5 (4.5%)
Mul et al. 1996[25] (formula a)	277.6	15.11	280.1	202-302	7 (6.3%)	5 (4.5%)
(formula b)	277.4	15.12	279.9	202-302	7 (6.3%)	3 (2.7%)
Spontaneous onset of labor ≥37 gws (n=104*)						
CRL formulas						
Selbing and Fjällbrant 1984[3] (formula a)	281.2	8.45	281.4	261-302	-	7 (6.7%)
Koornstra et al. 1990[4] (formula a)	281.1	8.44	281.2	261-302	-	7 (6.7%)
Vollebergh et al. 1989[5]	280.9	8.44	281.3	260-302	-	7 (6.7%)
BPD formulas						
Selbing and Kjessler 1985[24]	280.7	8.14	281.3	260-302	-	5 (4.8%)
Mul et al. 1996[25] (formula a)	280.7	8.15	281.2	260-302	-	5 (4.8%)
(formula b)	280.4	8.15	280.9	260-302	-	3 (2.9%)

CRL = crown-rump length; BPD = biparietal diameter; SD = standard deviation; gws = gestational weeks.

* one delivery considered to be at term according to oocyte retrieval was classified as preterm according to all dating formulas. Consequently the number of women delivering >37 gws decreased by one woman when gestational age was calculated on the basis of fetometry instead of on the basis of oocyte retrieval

Table 4

Duration of pregnancy according to ultrasound fetometry in 2023 spontaneously concieved singleton pregnancies with spontaneous start of labor.

	Duration of pregnancy (days)				Pre- or post-term delivery; n (%)	
Formula	Mean	SD	Median	Range	Pre-term (≤258 days)	Post-term (≥294 days)
Ultrasound dating						
Spontaneous onset of labor (n=2023)						
CRL formulas						
Selbing and Fjällbrant 1984[3] (formula a)	280.7	12.57	282.5	180-306	90 (4.4%)	152 (7.5%)
Koornstra et al. 1990[4] (formula a)	280.6	12.57	282.5	180-306	90 (4.4%)	149 (7.4%)
Volleberg**h** et al. 1989[5]	280.5	12.57	282.3	180-306	92 (4.5%)	142 (7.0%)
BPD formulas						
Selbing and Kjessler 1985[24]	280.2	12.47	282.2	178-305	92 (4.5%)	132 (6.5%)
Mul et al. 1996[25] (formula a)	280.0	12.47	282.1	178-305	92 (4.5%)	133 (6.6%)
(formula b)	279.8	12.47	281.9	178-305	93 (4.6%)	106 (5.2%)

cont.

Table 4 cont.

Formula	Duration of pregnancy (days)				Pre- or post-term delivery; n (%)	
	Mean	SD	Median	Range	Pre-term (≤258 days)	Post-term (≥294 days)
Ultrasound dating						
Spontaneous onset of labor ≥37 gws						
CRL formulas						
Selbing and Fjällbrant 1984[3]						
(formula a) (n=1933)	282.6	8.32	283.0	259-306	-	152 (7.9%)
Koornstra et al. 1990[4] (formula a) (n=1933)	282.5	8.31	282.9	259-306	-	149 (7.7%)
Volleberg**h** et al. 1989[5] (n=1931)	282.3	8.29	282.8	259-306	-	142 (7.4%)
BPD formulas						
Selbing and Kjessler 1985[24] (n=1931)	282.0	8.17	282.6	260-305	-	132 (6.8%)
Mul et al. 1996[25] (formula a) (n=1931)	281.9	8.17	282.3	259-305	-	133 (6.9%)
(formula b) (n=1930)	281.7	8.17	282.0	260-305	-	106 (5.5%)

CRL = crown-rump length; BPD = biparietal diameter; SD = standard deviation; gws = gestational weeks.

Singleton IVF pregnancies

Underwent scan at 12-14 gws	184		
	I→	16	CRL measurement missing
	I→	1	fetal anomaly (Down syndrome)
Included in study of measurement error	167		
	I→	25	induction of labor
	I→	30	Caesarean section before start of labor
	I→	1	start of labor unknown
Included in study of gestational length in women with spontaneous onset of labor	111		

Spontaneously conceived singleton pregnancies

Underwent scan at 12-14 gws	2251		
	I→	171	CRL measurement missing
	I→	53	induction of labor and/or Caesarean section before start of labor
	I→	4	delivery date unknown
Included in study of gestational length in women with spontaneous onset of labor	2023		

Legend

Figure 1 Flow chart showing recruitment and exclusion of subjects. CRL, crown-rump length measurements; IVF, *in-vitro* fertilization; gws, gestational weeks.