# Chapter 4

# Specific fundal height growth curve

In the same local setting, pregnant women are still affected by other factors that influence FH such as maternal age, height, weight before pregnancy, prepregnancy BMI, parity and fetal sex.[1-6] Therefore, the derived FH growth curve main concept involves considering those factors to improve the ability of FH to detect abnormal intrauterine growth. These two concepts are described below.

**1. Individual FH growth curve:** the derived FH growth curve follows specific characteristics of each pregnant woman. Hence, each person had their own norm. For example, GROW-charts, customized antenatal growth charts for plotting fundal height and estimated fetal weight, adjust the normal curve using maternal weight, height, parity, ethnic group and fetal sex. These were developed by The West Midlands Perinatal Institute, UK since the early 1990s[7] and were added to the RCOG's guidelines since 2002[8] until the present.[9] The result showed that GROW-charts were able to detect more abnormal fetal growth and decreased unnecessary investigations.[10] Currently, several countries worldwide have developed their own customized growth charts and use as a screening tool in routine ANC practices including Australia, New Zealand, the United States, the Netherlands, Ireland, Spain, Sweden, Brazil and India.[11]

**2. Specific fundal height growth curve:** it was created as a subgroup SFHGC in local settings following the characteristics of a special population when normal norm of FH is not applicable, such as FH growth curve for smoking and non-smoking pregnant women,[1] nulliparous and multiparous,[5] or obese and thin pregnant women.[5] Most of the study noticed that pregnant women's body shapes (obese-thin) were most influence in causing a variety of FH growth curve patterns. Studies have shown that FH of obese or overweight pregnant women is 2 cms higher than the FH of pregnant women who are thin or underweight.[5] Therefore, using a regular FH growth curve based on a normal population to monitor and screen abnormal intrauterine growth in these specific populations may lead to over or under investigation and/or intervention. Some studies have derived FH growth curves for each of these populations.[5, 12]



## Specific FH growth curve in Thailand

In Thailand, no study has created an individual FH growth curve, which may be due to no existing varieties of ethnic groups of pregnant women as in USA[2] or European countries.[11, 13] Therefore, demographically specific FH growth curves or population based charts are applicable. In 2001, Limpanyalert and Manotaya[4] had established specific FH growth curves based on the US confirmed LMP dating and divided in three groups following prepregnancy BMI, i.e., less than 20, 20-24, and more than 24 kg/m$^2$. The study found that FH growth curves of the three groups had different quadratic equations and recommended using FH growth curves divided following the BMI group.

In 2012, Deeluea et al.[14] established the specific FH growth curve for pregnant women in upper northern Thailand using the previously collected data to create the SFHGC for Thai women. The factors that affected FH in centimeters were evaluated using multilevel mixed models regression. The following factors were entered: gestational age, gestational age squared, maternal age, prepregnancy BMI and parity. Prepregnancy BMI was divided following WHO criteria,[15] i.e., less than 18.5 kg/m$^2$: underweight (20.0%), 18.5-24.9 kg/m$^2$: normal weight (63.7%), 25.0-29.9 kg/m$^2$: overweight (12.6%) and $\geq$30.0 kg/m$^2$: obese (3.7%). The obese group had fewer subjects. Therefore, it was combined with the overweight group. The results of multilevel regression analysis are shown in Table 4.1. Gestational age was the strongest predictor followed by prepregnancy BMI and maternal age. Parity was not significantly correlated probably because subjects had primigravida, 51.2%, and second pregnancy, 39.7%. Thus, specific FH growth curve was created by dividing by BMI group, i.e., underweight (BMI <18.5 kg/m$^2$), normal weight (BMI 18.5-24.99 kg/m$^2$) and overweight and obese (BMI ≥25.0 kg/m$^2$).

**Table 4.1** Factors affecting fundal height in cm by multilevel mixed models regression

| Factors | Coefficient | SE | 95% CI | P-value |
|---|---|---|---|---|
| Constant | -22.13 | 0.632 | -23.37 to -20.89 | < 0.001 |
| GA (week) | 2.43 | 0.038 | 2.35 to 2.50 | < 0.001 |
| GA$^2$ (week) | -0.03 | 0.001 | -0.03 to -0.02 | < 0.001 |
| Maternal age (year) | 0.02 | 0.007 | 0.01 to 0.03 | < 0.001 |
| Prepregnancy BMI (kg/m$^2$) | 0.09 | 0.010 | 0.07 to 0.11 | < 0.001 |
| Parity | -0.04 | 0.066 | -0.16 to 0.09 | 0.586 |

Abbreviations: GA, gestational age (wk); GA$^2$, gestational age square; BMI, body mass index (kg/m$^2$); SE, standard error; R-squared of this equation = 0.85.

FH growth curve for the underweight group (BMI <18.5 kg/m$^2$) was derived from 1,486 measurements of 208 subjects. The normal weight group (BMI 18.5-24.99 kg/m$^2$) was derived from 4,756 measurements of 661 subjects, and the overweight and obese group (BMI ≥25.0 kg/m$^2$) was derived from 1,281 measurements of 169 subjects. The FH growth curve of each group was presented as a smoothed function of the 10th, 50th and 90th percentiles lines between 20 and 40 weeks. It showed differences between three groups including FH at the 10th, 50th and 90th percentiles and increasing rate of FH in every week. The FH growth curve of the underweight group was below the normal weight, about 0.5-0.8 cm. The overweight and obese groups were higher than the normal weight, around 0.6-0.8 cm. An obvious difference was observed after GA >30-32 weeks (Figure 4.1). The difference might be due to many factors such as abdominal subcutaneous fat thickness, fetal size, fetal weight, gestational weight gain, parity, and maternal age. Moreover, FH growth curve derived from normal weight group was similar to Jirawan FH growth curve which derived from all populations.[16] The differences among the three groups of BMI and all populations are summarized in Table 4.2.

It demonstrated that the FH growth curves of these women differed. In monitoring and screening abnormal intrauterine growth among underweight, overweight and obese pregnant women, fundal height growth curves specifically developed for such women should be applied. This may reduce the over- or under-investigation as a consequence of an inappropriate application of the FH growth curve for a normal population.

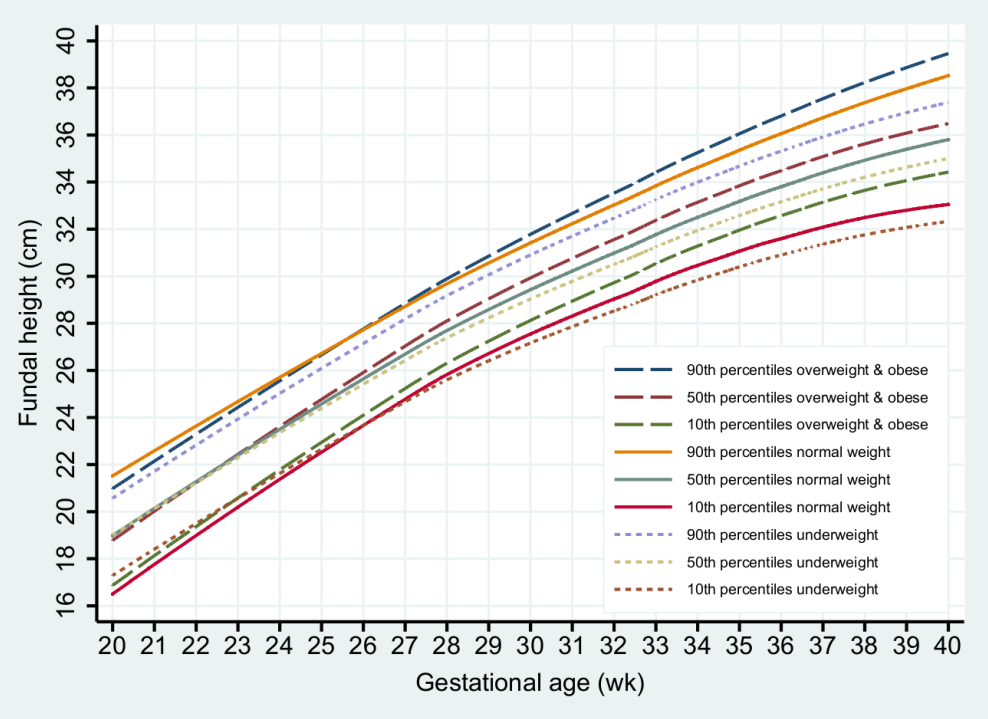



**Figure 4.1** Specific fundal height growth curves for underweight, normal weight, overweight and obese pregnant women in upper northern Thailand[14]

**Table 4.2** Fundal height in centimeters, growth rate of fundal height per week and quadratic equation to derive FH growth curve between all populations and 3 groups of BMI

| Characteristics | All populations | Underweight (BMI 18.5-24.9 kg/m$^2$) | Normal weight (BMI <18.5 kg/m$^2$) | Overweight and obese (BMI ≥25.0 kg/m$^2$) |
|---|---|---|---|---|
| FH in cm at GA | | | | |
| 20 weeks | 19.1 ± 1.9 | 19.1 ± 1.7 | 19.1 ± 1.9 | 19.2 ± 2.0 |
| 30 weeks | 29.7 ± 1.7 | 29.1 ± 1.7 | 29.7 ± 1.6 | 30.5 ± 1.4 |
| 37 weeks | 34.9 ± 1.9 | 34.0 ± 2.0 | 34.9 ± 1.8 | 35.7 ± 1.7 |
| 40 weeks | 35.4 ± 2.4 | 34.5 ± 2.3 | 35.4 ± 2.3 | 36.2 ± 2.2 |
| Growth rate (cm/wk) | | | | |
| Average | 0.78 | 0.73 | 0.78 | 0.81 |
| 20-28 weeks | 0.96 | 0.89 | 0.96 | 0.99 |
| 29-36 weeks | 0.73 | 0.68 | 0.73 | 0.76 |
| 37-40 weeks | 0.13 | 0.13 | 0.13 | 0.13 |
| Quadratic equations | FH = -19.7882 + 2.438157 GA - 0.0262178 GA$^2$ | FH = – 19.04386 + 2.40662 GA - 0.026439 GA$^2$ | FH = – 19.61757 + 2.426414 GA - 0.0260198 GA$^2$ | FH = – 21.77403 + 2.552643 GA - 0.0272487 GA$^2$ |
| R-squared of equation | 0.85 | 0.84 | 0.86 | 0.87 |

Abbreviations: FH, fundal height in cm; GA, gestational age in week; GA$^2$, gestational age square; BMI, body mass index (kg/m$^2$)

For example, in the underweight group (Figure 4.2), when SFHGC derived from a normal population was applied, FH in centimeters below the 10th percentile line (size less than date) would be detected at 15.4%, and that above the 90th percentile line (size more than date) at 1.2% (Figure 4.2-A). When a specific FH growth curve for underweight group was applied, the FH in centimeters below the 10th percentile line would have been detected at 11.4% and that above the 90th percentile line would have been 5.8% (Figure 4.2-B), resulting in a 4.0% reduction of size less than date and a 4.6% increase of size more than date.

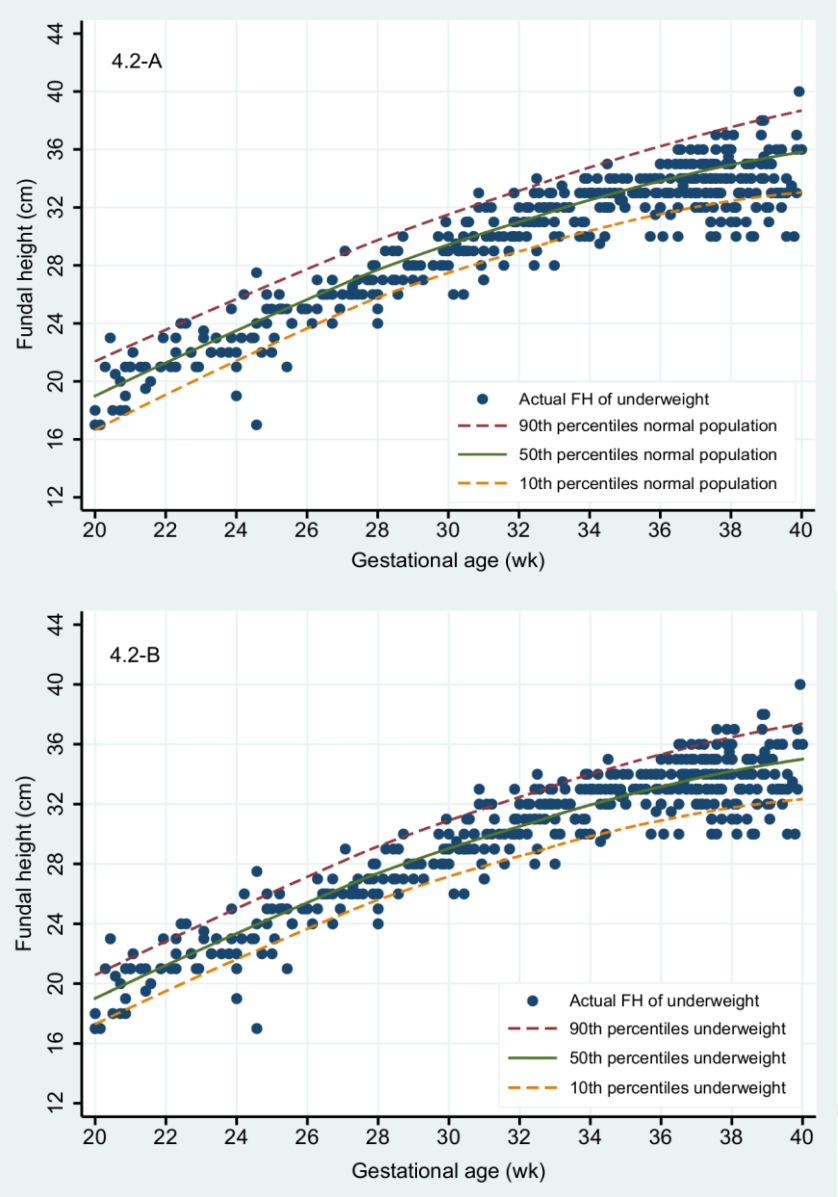
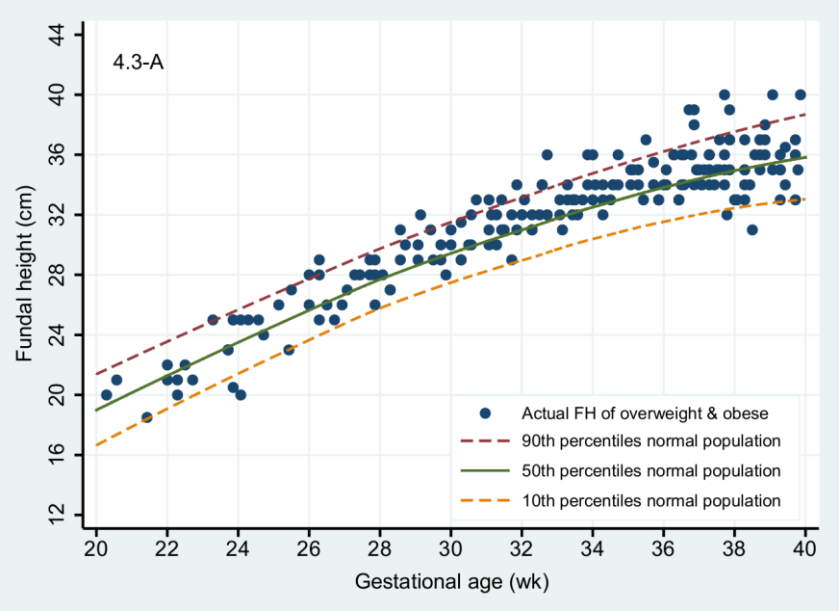





**Figure 4.2** Fundal height of underweight pregnant women as screened by different fundal height growth curves: (A) normal population FH growth curve; (B) specific FH growth curve for the underweight group.[14]

In the overweight and obese groups (Figure 4.3), when the normal population curve was applied, FH in centimeters above the 90th percentile line (size more than date) would be detected at 11.1% and that below the 10th percentile line (size less than date) at 3.0% (Figure 4.3-A). On the other hand, when specific FH growth curves for overweight and obese groups were applied, FH in centimeters above the 90th percentile line would have been detected at 9.0%, and that below the 10th percentile line would have been 9.0% (Figure 4.3-B). As a consequence, size more than date decreased 2.1% and size less than date increased 6.0%.



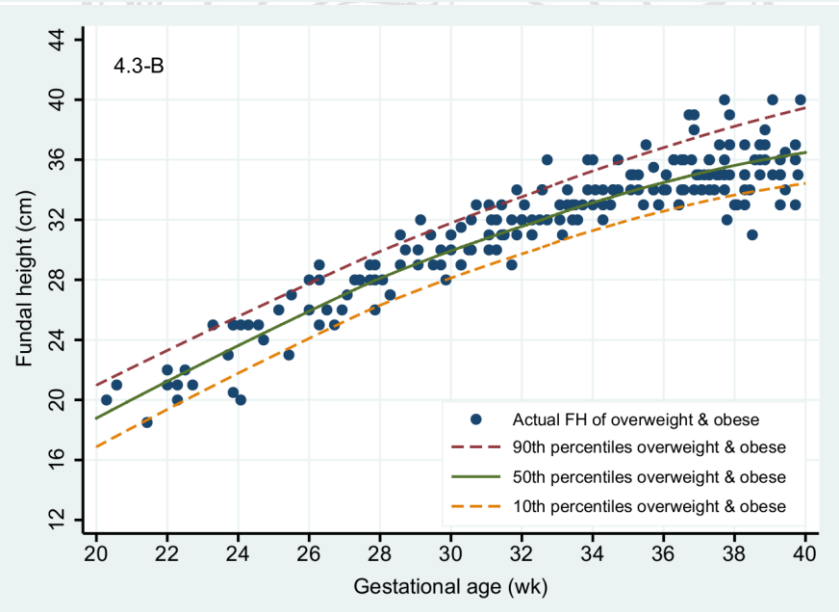






**Figure 4.3** Fundal height of overweight and obese pregnant women as screened by different fundal height growth curves: (A) normal population FH growth curve; (B) specific FH growth curve for overweight and obese groups.[14]

As mentioned above, it demonstrated that normal weight pregnant women could use a standard FH growth curve for Thai women based on normal populations as a screening tool. However, underweight, overweight, or obese pregnant women were recommended to use specific FH growth curves that were suitable to their prepregnancy BMI.

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