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# Analysis of 'count-to-ten' fetal movement charts: a prospective cohort study

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**Objective** We aimed to describe patterns of maternally perceived fetal movement (FM) counts in normal third-trimester pregnancies and present associations between published limits of decreased fetal movement (DFM) and FM patterns in the total population.

**Design** Prospective cohort study.

**Setting** Norway, in 2005–2007 and 2007–2009.

**Population** The total population of women with singleton pregnancies.

**Methods** Using a 'count-to-ten' approach, women counted FMs daily from pregnancy week 28 until delivery. Data on maternal characteristics and birth outcomes were obtained from the Medical Birth Registry of Norway and hospital records. We measured the observed mean counting time and used chi-square and Mann–Whitney *U*-tests to examine differences between normal pregnancies and pregnancies with suboptimal outcomes.

**Main outcome measures** Fetal movements in normal pregnancies and in pregnancies ending in a small-for-gestational-age baby, preterm birth or non-elective caesarean section.

**Results** A total of 1786 women were included. The mean time to perceive ten movements was approximately 10 minutes in normal pregnancies, with a <2-minute increase in the mean towards term. Fixed limits for DFMs had low predictive values. Overall, the mean counting time in pregnancies with suboptimal outcomes did not differ markedly from normal pregnancies.

**Conclusions** This study does not support the notion that FM counts decrease at term in normal pregnancies. A standard approach to FM counting, applying the currently best-founded definition of DFM, was not useful as a screening tool for at-risk pregnancies in this population. Further research is needed to improve measurements of DFM.

**Keywords** Decreased fetal movement, fetal movements, kick counting.

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## Introduction

Most mothers-to-be are aware of how their babies move and intuitively interpret decreased fetal movement (DFM) as an alarming sign. Maternal concern for DFM is a frequent cause for unscheduled antenatal consultations, occurring in approximately 10% of third-trimester pregnancies.[1,2] Although existing guidelines recommend that pregnant women should be informed about the need to contact healthcare professionals when they notice DFM,[3–5] they are given ambiguous information on what to expect about fetal activity,[6] and the variation in obstetric practice is substantial.[1,7,8] One widespread view, both among lay and professional contributors, is that DFM is normal as the pregnancy approaches term.[6] However, the supporting evidence is limited,[9–15] and uncertainties still remain as to what constitutes normal FM patterns.

Furthermore, what constitutes a clinically important change in the maternal perception of FM is unknown, undermining FM counting as a means to prospectively identify pregnancies at risk of adverse outcomes.[16] Currently, the best-founded definition of DFM comes from the study by Moore and Piacquadio, who defined DFM as maternal perception of less than ten movements within 2 hours (hereafter referred to as the '2-hours alarm'),[16] which is approximately five standard deviations from the mean counting time in normal pregnancies.[17] More recently, Kuwata et al.[11] proposed DFM as the maternal perception of less than ten movements within 25 and 35 minutes before and after 37 weeks of gestation, respectively (hereafter referred to as the '25/35-minute alarm'), approximating the 90th percentile in normal pregnancies.

The suggested pathophysiological mechanism for DFM includes reduced uteroplacental blood flow and fetal hypoxia,[18] and DFM is associated with placental pathologies,[19] and with severe pregnancy outcomes, including preterm birth, fetal growth restriction and death.[20–23] FM counting, as a daily systematic record of the woman's perception of her baby's movement, has therefore been proposed as a screening tool in antenatal care. Focused counting, i.e. the mother concentrates on fetal movements, preferably lying down, is the only method that is known to accurately reflect fetal gross and limb movements.[16,24,25] The most common method is that the mother records the time needed to perceive ten movements.[11,13,17,26] If FM counting is to be performed, this method followed by the '2-hours alarm' for DFM, is currently recommended by the American Academy of Pediatrics, the American Congress of Obstetricians and Gynecologists, the Society of Obstetricians and Gynaecologists in Canada and the Australian and New Zealand Stillbirth Alliance.[3,27,28]

Despite such recommendations, and the growing interest in the use of formal FM counting (kick counting) to reduce antepartum stillbirth, there is a paucity in published research, and conclusive evidence to support or refute formal FM counting is lacking.[22] Regardless of the debate over the effect of formal FM counting, self-screening by mothers continues and needs to be better informed. Indeed, when DFM concerns so many, even a small improvement in the interpretation of FM may well have a substantial impact on antenatal care.

A refined version of the 'count-to-ten' method has in recent years been introduced and tested in Norway, and provides the opportunity to examine patterns of FM in an unselected population.[1,2,29] In this study we aimed to: (i) describe FM patterns in normal third-trimester pregnancies, based on the refined counting method, and (ii) present associations between published definitions of DFM and FM patterns in a total population.

## Methods

### Data collection

The material includes FM charts from two different studies on mothers with singleton pregnancies in Norway (see the flow chart in Figure 1): both are part of the international collaboration Fetal Movement Intervention Assessment (FEMINA).[1] The population of pregnant Norwegian women is fairly homogenous, with overall low rates of perinatal morbidity and mortality. The two studies were designed to facilitate the later combined analyses of FM charts: they both recruited from total populations; and the counting protocol was similar in both studies, including the information about fetal activity provided to the mothers, and the instructions on how to use and interpret the FM chart. Women were approached during the routine ultrasound assessment in pregnancy weeks 17–19, and were invited to count FM daily from week 28 until delivery. In Norway, almost all pregnant women adhere to the public antenatal care programme. Information from the Medical Birth Registry of Norway (MBRN) was available from both studies, making demographic and outcome measures comparable.

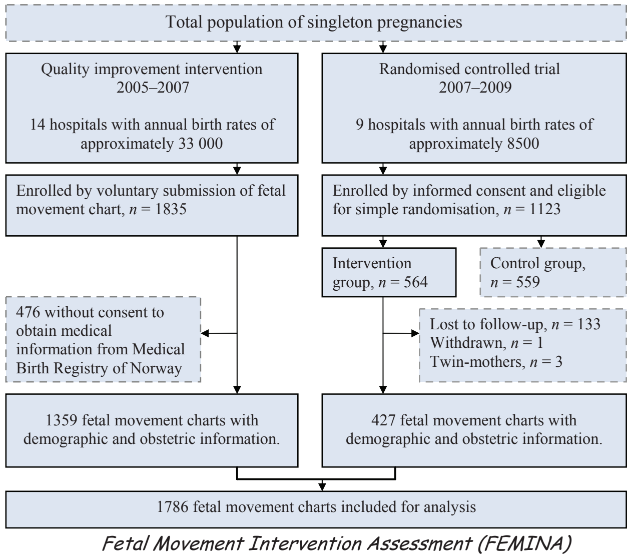


**Figure 1.** Flow chart for data collection.

The first study, a quality improvement intervention, provided mothers with the novel FM chart presented as an optional tool for support in pregnancy and an opportunity to contribute to research on FM (Appendix S1).[2,29] Mothers were encouraged to submit the FM chart to the study group after the birth, and to give their consent so that additional demographic and obstetric information could be obtained from the MBRN. Only charts with such consent were included in further analyses. The second study, a multicentre randomised controlled trial (RCT) (www.clinicaltrials.gov/ct2/results?term=NCT00513942), aimed to measure the effect of FM counting on expectant mothers.[30] Participants were randomly assigned to perform FM counting or receive standard care. Only women in the intervention group counted FMs and were included in this analysis. The baseline characteristics did not differ between the intervention and control groups, and for the purpose of this study the intervention group represents a population-based prospective cohort. Demographic and obstetric information was obtained from hospital records postpartum.

 

### Fetal movement counting and recording

Although the counting protocol was based on the traditional 'count-to-ten' method,[13] some important adjustments were introduced. To improve the accuracy of the counting observations, mothers were specifically advised to start to count FMs when they perceived the first movement, as a sign that their baby was awake, and then record the number of minutes required to perceive the additional nine. To enhance feasibility, mothers were encouraged to select a 2-hours period during the day when they knew their baby was usually active, and it was suitable for them to spend the time, preferably lying down, to focus on FMs. Furthermore, to reduce variability, they were encouraged to count within the same period every day. Women were instructed that all movements counted as kicks, rolling movements counted as one kick only and that hiccups should be disregarded.[1] The counting time was marked in the box with the corresponding 5-minute interval in the chart. If mothers did not perceive ten movements within 2 hours, it was recorded as '>2 hours' in the first half of the intervention study, whereas the exact number of minutes was reported later.[1]

### Definitions

We used a strict definition of a normal pregnancy: a non-smoking mother, with a pre-pregnancy body mass index (BMI) < 28, with an uncomplicated pregnancy ending in a normal, vaginal term delivery of a baby with Apgar score $\geq 7_{5\ \text{minutes}}$ and adjusted birthweight between the 10th and 90th percentile.[31] Pregnancy complications were defined as those known to affect fetal growth (including medication) according to current Norwegian guidelines, which are generally consistent with the UK's 2003 National Institute for Health and Clinical Excellence (NICE) guidelines for routine antenatal care for healthy pregnant women.[4,5] Birthweight for gestational age was adjusted for fetal gender and maternal height, weight and parity,[31] and babies below the 10th percentile were classified as small for gestational age (SGA). We defined suboptimal pregnancy outcomes as one or more of the following: (i) SGA; (ii) SGA with impaired health, i.e. transferred to neonatal intensive care or with a neonatal diagnosis of cerebral depression or respiratory distress; (iii) preterm birth ($28^{+0}$–$36^{+6}$ weeks); or (iv) non-elective caesarean section. Non-elective implies that the intervention was decided upon within the last 8 hours prior to delivery, and includes acute and emergency cases.[32] We also assessed FM in pregnancies in which the mother was overweight (BMI ≥ 28).

### Data handling and statistical analyses

We used SPSS v17.0 (SPSS Inc., Chicago, IL, USA) and R (v2.11.1 for WINDOWS) for statistical analyses, and PS POWER and SAMPLE SIZE CALCULATION for power estimates.[33] The 5-minute intervals in the FM charts were recoded to their respective midpoints, e.g. the 6–10-minute interval was assigned to 8 minutes. We recoded all observations exceeding 2 hours to 123 minutes. The justification is that 85% of such observations were recorded only as '>2 hours' in the FM charts, rather than giving an exact number of minutes. Mothers were instructed to increase vigilance, repeat counting sessions or to contact antenatal care services if they did not perceive ten movements within 2 hours. Furthermore, counting observations beyond 2 hours could be unreliable because they might not represent focused counting, and could also be perceived as statistical outliers. We measured compliance concerning counting starting with the first observation from each woman. The Mann–Whitney *U*-test was used to examine differences in mean counting time between independent groups: (i) between normal pregnancies and the different outcome groups and the overweight group; (ii) by fetal gender and primiparity; and (iii) between women below or over the 25th percentile for compliance. We used the chi-square test to explore the relationship between having '2-hours alarms' and the different outcomes and maternal and fetal characteristics mentioned above. We divided third-trimester pregnancy into three time periods (according to the number of completed weeks of pregnancy): 28–31, 32–36 and 37 weeks until delivery, and we used the Friedman test for repeated measures to analyse variance. We applied the '2-hours alarm' from the study by Moore and Piacquadio,[17] and the '25/35-minute alarm' from the study by Kuwata et al.,[11] and calculated their sensitivity, specificity, and positive and negative predictive values (PPV/NPV) for the selected outcomes. Our material represents a convenience sample with the power to identify an odds ratio (OR) of 2.3 for an association between SGA and the '2-hours alarm' limit, and an OR of 1.5 for the '25/35-minute alarm' limit.

## Results

Characteristics of the 1786 mothers and babies, in total and by risk group, are listed in Table 1. All babies were liveborn, although one preterm baby died within the first week of birth. The total study sample included more primiparous women, fewer smokers, and less preterm and low birthweight babies (<2500 g) than the total pregnant population in Norway (2007 used as reference, data not shown).[32] No substance abuse was reported.

In the 582 (33%) normal pregnancies included, the observed mean time to perceive ten movements approximated 10 minutes (SD 9 minutes) throughout pregnancy (Figure 2). The mean counting time was unrelated to gender ($P = 0.413$) and parity ($P = 0.126$), and differed by <2 minutes over the three time periods in the third trimester (9.43, 9.16 and 10.88 minutes, respectively; $P < 0.001$).

**Table 1.** Characteristics of mothers and babies, in total and by risk group ($n$ = 1786)

| | Of total | Maternal age, years | Primiparous | Infant sex, boys | Gestational age at birth, days* | Maternal smoking last trimester | Maternal BMI ≥ 28 (kg/m$^2$) |
|---|---|---|---|---|---|---|---|
| | *n* (%) | Mean (SD) | *n* (%) | *n* (%) | Mean (SD) | *n* (%) | *n* (%) |
| Study sample | 1786 (100) | 31 (4.6) | 810 (45) | 912 (51) | 280 (11.1) | 146 (8) | 284 (16) |
| Normal pregnancies | 582 (33) | 31 (4.2) | 240 (41) | 294 (51) | 281 (12.1) | – | – |
| SGA | 222 (12) | 31 (4.9) | 105 (47) | 121 (55) | 280 (12.1) | 18 (8) | 40 (18) |
| SGA with impaired health** | 39 (2) | 31 (4.3) | 25 (64) | 24 (62) | 271 (17.2) | 1 (3) | 9 (23) |
| Preterm*** | 72 (4) | 32 (5.1) | 35 (49) | 39 (54) | 248 (9.3) | | 10 (14) |
| Non-elective caesarean section | 153 (9) | 31 (4.8) | 101 (66) | 78 (51) | 277 (17.5) | 18 (12) | 32 (21) |

*Gestational age is based on ultrasound assessment in 97% of the cases.
**Small for gestational age and transferred to neonatal intensive care or with a diagnosis of cerebral depression or respiratory distress.
***Among the preterm births, 27 (38%) had iatrogenic delivery onset.

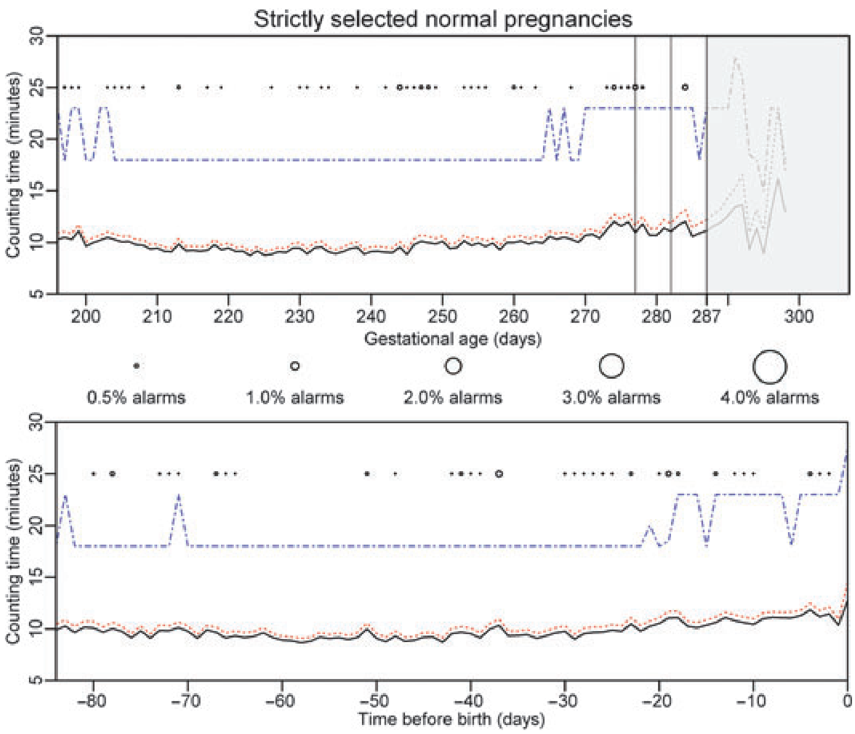


**Figure 2.** Mean time (in minutes) to perceive ten fetal movements in normal pregnancies, by gestational age and by time before birth (in days); $n$ = 582. Black solid line, observed arithmetic mean; red dotted line, observed arithmetic mean plus one standard error; blue dashed line, 90th percentile. The circles represent the daily percentage of '2-hours alarms'. The vertical lines indicate the 25th, 50th and 75th percentiles for gestational age at birth. The shaded grey area represents fetal movement after 287 days of pregnancy.

The total numbers of counting observations are presented in Figure S1. The '2-hours alarm' occurred in 4% of the pregnancies, and was only significantly associated with overweight mothers ($P$ = 0.003), and not with any of the suboptimal pregnancy outcomes listed. The sensitivity was low, with only 5% for the composite measure of suboptimal outcomes, and with specificity reaching 96% (Table 2). The daily percentages of '2-hours alarms' within the different groups are presented in Figures 2–4 and S2. Although the sensitivity for the '25/35-min alarm' increased to 44%,

 

**Table 2.** Previously published definitions of decreased fetal movements applied to an unselected population of 1786 singleton pregnancies

| Study | DFM definition, count-to-ten method | Pregnancy outcome | | Any early alarm* | Any late alarm* | Any alarm* | Pregnancy | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *n* | *n* | *n* | *N* | S | Sp | PPV | NPV |
| Moore and Piacquadio[17] | <10 movements within 2 hours | Total study sample | 1786 | 53 | 34 | 70 | | | | |
| | | SGA | 222 | 9 | 4 | 10 | 5 | 96 | 14 | 88 |
| | | SGA and impaired health*** | 39 | 1 | 0 | 1 | 3 | 96 | 1 | 98 |
| | | Preterm, spontaneous delivery onset | 45 | 5 | | | 11 | 97 | 9 | 98 |
| | | Preterm, iatrogenic delivery onset | 27 | 0 | | | – | – | – | – |
| | | Non-elective CS | 153 | 6 | 3 | 8 | 5 | 96 | 11 | 92 |
| | | All outcome groups | 398 | 16 | 6 | 19 | 5 | 96 | 27 | 78 |
| Kuwata et al[11] | <10 movements within 25/35 minutes before and after pregnancy week 37 respectively | Total study sample | 1786 | 714 | 226 | 740 | | | | |
| | | SGA | 222 | 93 | 35 | 95 | 43 | 59 | 13 | 88 |
| | | SGA and impaired health** | 39 | 13 | 8 | 15 | 39 | 59 | 2 | 98 |
| | | Preterm, spontaneous delivery onset | 45 | 20 | | | 44 | 60 | 3 | 98 |
| | | Preterm, iatrogenic delivery onset | 27 | 9 | | | 33 | 60 | 1 | 98 |
| | | Non-elective CS | 153 | 65 | 24 | 68 | 44 | 59 | 9 | 92 |
| | | All outcome groups | 398 | 172 | 54 | 176 | 44 | 60 | 24 | 79 |

S, sensitivity; Sp, specificity; PPV, positive predictive value; NPV, negative predictive value.
*Early alarm (<37 weeks of gestation), late alarm (≥ 37 weeks of gestation), any alarm (throughout pregnancy).
**Small for gestational age and transferred to neonatal intensive care unit or with a diagnosis of cerebral depression or respiratory distress.

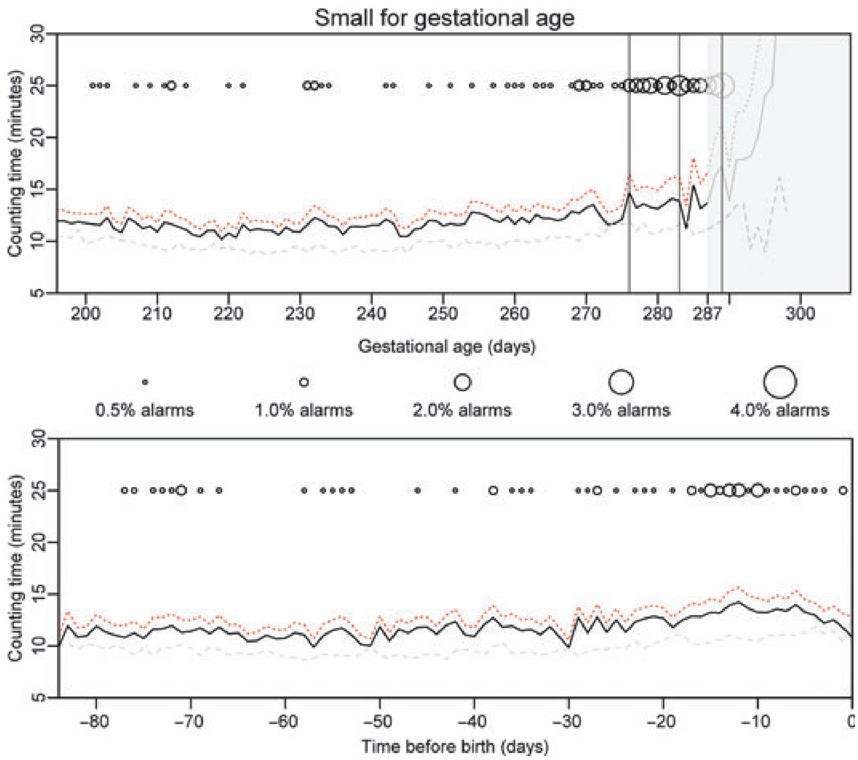


**Figure 3.** Mean time (in minutes) to perceive ten fetal movements in pregnancies with small-for-gestational-age babies, by gestational age and by time before birth (in days); *n* = 222. Black solid line, observed arithmetic mean; red dotted line, observed arithmetic mean plus one standard error; grey stippled line, observed arithmetic mean in normal pregnancies. The circles represent the daily percentage of '2-hours alarms'. The vertical lines indicate the 25th, 50th and 75th percentiles for gestational age at birth. The shaded grey area represents fetal movements after 287 days of pregnancy.

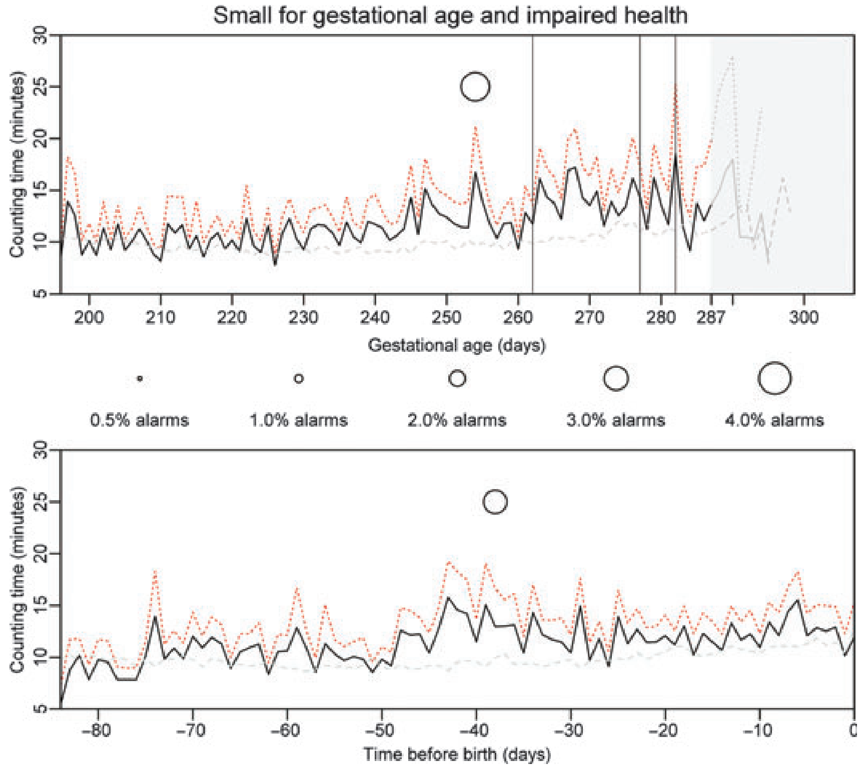


**Figure 4.** Mean time (in minutes) to perceive ten fetal movements in pregnancies with small-for-gestational-age babies with impaired health (transfer to neonatal intensive care unit or neonatal diagnosis of cerebral depression or respiratory distress), by gestational age and by time before birth (in days); $n = 39$. Black solid line, observed arithmetic mean; red dotted line, observed arithmetic mean plus one standard error; grey stippled line, observed arithmetic mean in normal pregnancies. The circles represent the daily percentage of '2-hours alarms'. The vertical lines indicate the 25th, 50th and 75th percentile for gestational age at birth. The shaded grey area represents fetal movements after 287 days of pregnancy.

it was at the cost of specificity, as this alarm occurred in 41% of pregnancies (Table 2). Although the positive predictive values for the two definitions were more comparable, they were low for both. This remained consistent for all subgroups (Table 2). Both alarms had higher sensitivity in the preterm compared with the term period in all subgroups: declining from 2 to 11% in the preterm period to 0–2% in the term period for the '2-hours alarm', and from 33–44% to 14–21% for the '25/35-minute alarm'. Among women who had recorded the exact number of minutes when the counting time exceeded 2 hours, the median counting time was 152 minutes. However, these represent only 15% of such observations, and variation was large.

The FM curve in SGA pregnancies (Figure 3) remained higher than the FM curve in normal pregnancies throughout gestation, although only reaching a significant difference in mean counting time in the preterm period ($P = 0.004$), not in the term period ($P = 0.370$). When mean counting time was measured against remaining time to birth, the FM curve showed a modest decline. A significantly higher counting time occurred in the term period only in the subgroup of SGA babies with impaired health ($P = 0.033$) (Figure 4). A mother being overweight was associated with a higher mean counting time throughout pregnancy ($P < 0.001$; Figure S2), whereas the mean counting time in pregnancies ending in a non-elective caesarean section did not differ significantly from normal pregnancies either in the preterm period ($P = 0.051$) or in the term period ($P = 0.086$) (FM curves not presented). The same applied to pregnancies ending in preterm birth ($P = 0.124$), unrelated to whether delivery onset was spontaneous or iatrogenic.

Maternal compliance with daily counting was high, both overall and in subgroups, (median of 97%), except for a marked decrease in the last days before delivery. We found no significant difference in compliance in the term period between women with normal pregnancies and any of the outcome groups. Although women with the lowest compliance (<25th percentile) had higher mean counting times than the rest ($P < 0.001$), compliance also remained high (median 66%) in this group, and the difference in counting times was <2 minutes. Compliance among women who experienced '2-hours alarms' was not different from women without such alarms ($P = 0.670$).

 

## Discussion

We found the mean time to count ten movements to be <10 minutes in a normal pregnancy, with a statistically significant, although miniscule, increase in the mean towards term. Thus, we refute the widely accepted understanding that it is normal for the mother to perceive DFM in late pregnancy. The two definitions we assessed using fixed limits for DFM performed poorly as screening in our sample, and the FM curves in pregnancies with suboptimal outcomes did not differ substantially from normal pregnancies (Appendix S2).

The strengths of this study include a large sample of pregnancies, with generally complete and standardised demographic and obstetric information. This enabled us to study FM in a substantial number of strictly selected normal pregnancies. Except for slightly more primiparous women being included in the study on quality improvement intervention study, the two data sets did not differ significantly on key variables. Overall, compliance with counting was very good, falling into the higher end of the 55–97% range reported in previous studies.[15,17,34]

Compared with the total pregnant population, the study sample is likely to be biased towards healthier pregnancies. FM counting could also be more appealing to mothers with active babies, as they are reassured about their babies' well-being within a short time. For these reasons, the mean counting time could be underestimated.

Another limitation is the small numbers from some subgroups, e.g. preterm babies and SGA babies with impaired health. We believe three factors may have contributed to an underestimation of the mean counting time in riskier pregnancies: (i) acute events leading to spontaneous or iatrogenic delivery could be missed because of the low number of counting observations in the final days prior to birth; (ii) risk groups had to be broadly defined because of the restricted obstetric information; and (iii) all observations exceeding 2 hours were recoded to 123 minutes.

### Fetal movements in normal pregnancies

We found the mean time to perceive ten movements to be shorter than the average of 20 minutes reported in earlier studies.[15,17,35] Our results are closer to the median of 10–14 minutes reported in a recent study, where mothers were also instructed to count at a time of the day when they knew that the baby was usually active.[11] Our study also had lower dispersion than in earlier studies, yet again was closer to the most recent study.

More importantly, we found FM to remain constant throughout gestation in normal pregnancies when measured during active periods (Figure 2). The <2 minutes increase in mean counting time was statistically significant at the population level, although it is likely of limited clinical usefulness within the concept of the 'count-to-ten' method for the individual woman. Previous studies have reported divergent results: (i) FMs decrease significantly from 32 weeks of gestation towards delivery;[10,11,13] (ii) FMs decrease, but not predictably, in each woman;[12] or (iii) FMs remain constant.[9,14,15] The most credible explanation for these divergences lies in the counting method. A distinctive feature with the refined 'count-to-ten' protocol is the proper recognition that periods of fetal quiescence vary during the day,[36] and lengthen during the third trimester.[37] Therefore, both intraday and gestational age variability are duly accounted for.

Furthermore, simultaneous, rolling movements are increasingly frequent towards term, and may be perceived differently than the more distinctive kicks earlier in the pregnancy.[15] In two much-cited studies reporting DFM towards term, mothers were instructed to decide on their own what constituted an FM,[10,13] probably introducing an upwards bias in the mean counting time. Unfocused counting can further add to this bias. The refined counting method accounted for these factors. However, the importance of the quality and force of FMs has been less studied, and may play a role.

Using the 'count-to-ten' method, two previous studies have specifically addressed whether FM patterns in normal pregnancies change over the course of the third trimester.[11,38] In support of our results, one study found no increase in the mean counting time, neither towards term nor approaching birth, provided that mothers counted in active periods and were aware that FMs might be perceived differently in late pregnancy.[38] In contrast, the other study concluded that DFM is normal as the pregnancy approaches term.[11] In this study, riskier pregnancies might have contributed to the reported DFM at term.

In general, FM curves in late pregnancy need careful interpretation. Maternal complaints of DFM may result in earlier spontaneous or iatrogenic delivery. The pregnancies that could have contributed to increased counting time in late pregnancy are then no longer included. This bias is amplified as gestation progresses. Only thriving babies will then normally be allowed to continue pregnancy, and the curve will no longer represent the natural history of FMs.

Although several attempts have been made to quantify normal FM, it is generally agreed that normal FM varies greatly, both in activity among different fetuses and among the mothers' ability to perceive FM. [39,40] The inter-fetal variation is reported to account for up to two-thirds of the total variation.[9,10,38] Thus, a wide range of patterns can be considered normal as long as FM does not drastically decrease or cease, implying that the 'one size fits all' rule will fail. Previously, the application of quantitative limits to identify DFM has rightly been disputed.[16]

Both the '2-hours alarm' from Moore and Piacquadio and the '25/35-min alarm' from Kuwata et al. failed for screening purposes when applied to our sample: the former for its very low sensitivity and the latter for its low specificity. The '2-hours alarm' failed to identify 95% of the cases it was intended for in our sample, implying a very low capacity to prevent morbidity and mortality. Our study supports previous reports that pregnancies in which the mothers consistently report regular fetal activity have low mortality and morbidity.[16] Whether the high specificity contributes additional reassurance is unsure, following the low prevalence of the conditions screened for and the low sensitivity. The '25/35-minute alarm', on the other hand, generated an unacceptably high false-positive rate, with the risk of increased maternal anxiety, overuse of healthcare services and unnecessary iatrogenic adverse effects.

The validity of any DFM definition for screening rests in its ability to identify compromised fetuses in time to prevent perinatal morbidity and mortality. To date the only RCT that has compared FM counting versus no FM counting reported lower mortality. The relative risks of stillbirths and avoidable stillbirths were 0.25 (95% CI 0.07–0.88) and 0.27 (95% CI 0.08–0.93), respectively.[41] These favourable results have later been overshadowed by the negative outcome of one large cluster-randomised RCT, where counting for all versus counting in riskier pregnancies was compared.[34] The latter study reported no difference between the groups, and is often cited as evidence against FM counting.[42] It has been suggested, however, that an increased awareness of FM among mothers in the control group may have distorted their results, as the overall stillbirth rate declined in the study period. Both RCTs have been criticised for substandard methodology.[16] Neither of them used focused counting and both applied alarm limits that were not intended for screening purposes.[16] Before any new attempt to measure the effect of FM counting is justified, a new validated definition of DFM is needed. Recognising that no quantitative definition of DFM has been shown to be superior to maternal common sense,[43] the focus should remain on any considerable changes in FM in an individual pregnancy.

### Interpretation of fetal movement in riskier pregnancies

In acute causes of hypoxia (placental abruption, cord accidents) the intrauterine environment will quickly deteriorate, and lead to death or spontaneous or iatrogenic delivery. The ability of FM counting to predict this outcome is limited,[12] as such acute events are often preceded by reassuring FMs.[14] Yet, acute DFM may still lead to immediate intervention.

Monitoring FM potentially has great preventive value when placental insufficiency is long standing, as it allows for the early identification of compromised fetuses and for timely intervention. The most frequently reported association with DFM is SGA and fetal growth restriction.[16]

Although the FM curve for SGA babies remained higher than in normal pregnancies throughout gestation, the effect was modest. Maternal complaints of DFM in a pregnancy with poor fetal growth may result in some form of intervention, leaving the healthiest pregnancies for observation as gestation progresses. In support of this we found that SGA babies with impaired health had lower gestational ages compared with the remaining SGA babies. Contrary to expectation, the mean counting time for the SGA babies declined, even when measured against time before birth. Also, selection bias is plausible here, with high counting-time pregnancies being over-represented among the missing group at the end, although we were unable to find significant results to support this assumption.

By contrast, when we selected the subgroup of SGA babies with impaired health (Figure 4) we discerned a modest, although significantly higher, mean counting time in the term period. Thus, careful analyses at the appropriate subgroup levels may reveal relevant patterns that are hidden in more compound groups, implying that the mean counting time will often fail as a prudent measure of risk. This confirmed an earlier study where a marked reduction in FM was only present in the subgroup of babies with subsequent perinatal distress.[14]

Whereas parity, gestational age, being overweight or obese, and placental location are among factors that have been reported to reduce the maternal perception of FM, a recent review found the evidence for this to be conflicting, mainly related to small samples and inconsistent definitions.[24] It is also unknown whether the influence of these factors varies at different gestational ages.[24] We found overweight mothers to have higher mean counting times (Figure S2), and also to be the only group significantly associated with the '2-hours alarm'. In our sample, the effect of BMI on mean counting time was higher than the effect of gestation.

Women presenting with DFM in the preterm period have been shown to have an increased incidence of preterm birth.[44] We found that FM curves in pregnancies ending in non-elective caesarean section or preterm birth did not differ significantly from normal pregnancies. Possible explanations are again that acute events are often preceded by normal FM patterns, and that compound groups may hide patterns in relevant subgroups.

## Conclusion

The message to pregnant women should be that FM counts in normal pregnancies remain constant throughout gestation when measured during active periods. The currently best-founded definition of DFM—the '2-hours alarm'—performed poorly for screening purposes, indicating the need for further refinements. The focus must remain on what truly constitutes DFM in the individual pregnancy, and what patterns of FM are associated with fetal growth restriction and other adverse outcomes.

### Disclosure of interests

The authors declare that they have no competing interests.

### Contribution of authorship

All authors have contributed to this scientific work and approved the final version of the article. BAW: data analyses, interpretation of data, writing and finalising the article. ES: design of the studies, data collection, interpretation of data and revising the article. NG: data analyses, interpretation of data, presentation of figures, writing and revising the article. JVHT: design of the quality improvement study, data collection and revising the article. BSP: design of the quality improvement study and revising the article. VF: design of the studies and revising the article. JFF: design of the studies, data collection, analyses and interpretation of data, and revising the article.

### Details of ethical approval

Written informed consent was obtained from all participants. The Norwegian Data Inspectorate and The Regional Committees for Research Ethics approved both studies: Quality improvement intervention (24.10.2005, S-015195), and RCT (22.05.2007, S-07188a), www.ClinicalTrials.gov, no NCT00513942.

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## Supporting information

The following supplementary materials are available for this article:

**Figure S1.** Number of observations (counting sessions) presented by gestational age and by time before birth (in days).

**Figure S2.** Mean time (in minutes) to perceive ten fetal movements in pregnancies with pre-pregnancy maternal BMI ≥ 28, by gestational age and by time before birth (in days); $n = 284$.

**Appendix S1.** Fetal movement chart.

**Appendix S2.** Key messages.

Additional Supporting Information may be found in the online version of this article.

Please note: Wiley-Blackwell are not responsible for the content or functionality of any supporting information supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author. ■

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