BJOG An International Journal of Obstetrics and Gynaecology

# Put your weight behind it—Effect of body mass index on the active second stage of labour: A retrospective cohort study

Tilde Broch Østborg[1,2] | Ragnar Kvie Sande[1,2] | Jørg Kessler[2] | Christian Tappert[3] | Phillip von Brandis[1] | Torbjørn Moe Eggebø[1,4,5]

[1]Department of Obstetrics and Gynaecology, Stavanger University Hospital, Stavanger, Norway

[2]Department of Clinical Science, Medical Faculty, University of Bergen, Bergen, Norway

[3]Department of Obstetrics and Gynaecology, Trondheim University Hospital (St Olavs Hospital), Trondheim, Norway

[4]Centre for Fetal Medicine, Trondheim University Hospital (St Olavs Hospital), Trondheim, Norway

[5]Department of Clinical and Molecular Medicine, Norwegian University of Science and Technology, Trondheim, Norway

**Correspondence**
Tilde Broch Østborg, Department of Obstetrics and Gynaecology, Stavanger University Hospital, Postboks 8100, N-4068 Stavanger, Norway.
Email: tilde.broch.ostborg@sus.no

**Funding information**
There was no specific funding for the study. All authors have salaried positions in their respective university hospitals.

**Abstract**

**Objective:** To explore the duration of the active phase of the second stage of labour in relation to maternal pre-pregnant body mass index (BMI).

**Design:** Retrospective cohort study.

**Setting:** Labour wards of three Norwegian university hospitals, 2012–2019.

**Population:** Nulliparous and parous women without previous caesarean section with a live singleton fetus in cephalic presentation and spontaneous onset of labour, corresponding to the Ten Group Classification System (TGCS) group 1 and 3.

**Methods:** Women were stratified to BMI groups according to WHO classification, and estimated median duration of the active phase of the second stage of labour was calculated using survival analyses. Caesarean sections and operative vaginal deliveries during the active phase were censored.

**Main outcome measures:** Estimated median duration of the active phase of second stage of labour.

**Results:** In all, 47 942 women were included in the survival analyses. Increasing BMI was associated with shorter estimated median duration of the active second stage in both TGCS groups. In TGCS group 1, the estimated median durations (interquartile range) were 44 (26–75), 43 (25–71), 39 (22–70), 33 (18–63), 34 (19–54) and 29 (16–56) minutes in BMI groups 1–6, respectively. In TGCS group 3, the corresponding values were 11 (6–19), 10 (6–17), 10 (6–16), 9 (5–15), 8 (5–13) and 7 (4–11) minutes. Increasing BMI remained associated with shorter estimated median duration in analyses stratified by oxytocin augmentation and epidural analgesia.

**Conclusion:** Increasing BMI was associated with shorter estimated median duration of the active second stage of labour.

**KEYWORDS**
birth, body mass index, caesarean, delivery, labour, obesity, overweight, second stage, underweight

# 1 | INTRODUCTION

According to the World Health Organization (WHO) in 2016, 37% of women in the USA, 29% in the UK, 21% in France and 23% in Norway were obese,[1] and rates of obesity are rising throughout the world.[2–4] In Norway, 51% of the population was classified as overweight in 2019.[5] Obesity in pregnancy is associated with gestational diabetes, pre-eclampsia, miscarriage, birth defects, macrosomia, preterm delivery and stillbirth.[6–11] Obesity also poses challenges in safe delivery of the fetus, as cardiotocographic monitoring is impaired[12] and the risk of operative delivery is increased.[13–17] However, a recent study found that nulliparous low-risk normal weight women were more likely to require obstetric intervention or care than otherwise healthy multiparous women with body mass index (BMI) >35.[18] Furthermore, a recent study did not find any difference in neonatal outcome for women undergoing trial of labour compared with planned caesarean section in this group.[19]

Outcomes in labouring women are known to depend on parity, spontaneous or induced onset, previous caesarean section, fetal lie, multiple pregnancy and gestational age. To obtain comparable groups for these variables, the Ten-Group Classification System (TGCS) provides a useful framework.[20–22]

Labour is divided into a latent phase and an active phase, and the active phase is differentiated into the first, second and third stage. The second stage is defined from the a fully effaced cervix until the birth of the child. The second stage is divided into a passive phase and an active phase when the mother performs active expulsive effort.

Studies have shown that obesity is associated with slow progress in the latent phase,[23] and slow progress and arrested labour during the first stage of labour.[23–25] The duration of the second stage of labour and BMI has been investigated in a few previous studies, with conflicting findings. One study found no significant difference in duration,[26] but another study found shorter second stage in obese women.[27] A recent study found longer second stages in obese women; however, that study did not employ survival analyses[28] and neither of those studies differentiated between second stage and active second stage.

The precise moment when the woman reaches full dilation is unknown, and the diagnosis is first made upon vaginal examination, which may occur sometime after full dilation. Therefore, the true length of the passive second stage is not known with certainty. However, the start and end of active second stage can be recorded with certainty, as expulsive efforts and the birth of the child are objectively observable events.

Obese women have an increased risk for several adverse outcomes;[17] the awareness of this may influence the attitude of the birth attendant, which in turn may affect both the birth experience and delivery outcome.[29] Clinical experience indicates that obese women may have a shorter active second stage, and we believe this information could result in a more positive approach to delivery in both the birth attendant and the women themselves. We wanted to explore the duration of the active second stage in TGCS groups 1 and 3 differentiated into BMI groups.

# 2 | METHODS

We performed a retrospective cohort study in women who delivered at Stavanger University Hospital, Haukeland University Hospital, Bergen and Trondheim University Hospital in Norway between 2012 and 2019. Data were collected and stored in the hospital's electronic birth journals (Natus-CSAM).

In all, 109 989 women with a gestational age ≥22 weeks delivered at the hospitals during the study period. Women with a singleton pregnancy, cephalic presentation, spontaneous onset of labour, pregnancy length ≥37 weeks and without previous caesarean section were included in the study population. The women were differentiated into nulliparous (TGCS 1) and parous women (TGCS 3) and stratified into BMI groups according to WHO classification.[17] Pre-pregnant BMI <18.5 was categorised as underweight, BMI 18.5–24.9 as normal weight, BMI 25.0–29.9 as overweight, BMI 30.0–34.9 as obesity class 1, BMI 35.0–39.9 as obesity class 2 and BMI ≥40.0 as obesity class 3. The main outcome measure was estimated median duration of the active second stage of labour.

The start of the first stage of labour was defined according to the former WHO classification during the study period as an effaced cervix, regular contractions and 4-cm dilation.[30,31] The second stage was defined when the woman had a fully dilated cervix, and the active second stage was defined as the time from active expulsive effort started until the delivery of the fetus.

Labour progress during the first stage of labour was monitored in accordance with the WHO recommendations before 2018,[32] with an alert line (1 cm cervical dilation/hour) and an action line displaced at 4 hours.[33,34] According to the national guidelines, augmentation with oxytocin during the first stage could only be started if the action line was crossed, and after amniotomy.[31] Zhang's guideline was used in the first stage of labour at Stavanger University Hospital in 2015 and 2016.[35] During the second stage, oxytocin augmentation could be started at the discretion of the birth attendant when the contractions were considered insufficient. Also in accordance with national guidelines, the duration of the second stage was not recommended to exceed 3 hours and an operative delivery should be considered both in nulliparous and parous women after 60 minutes of active pushing.[31]

Oxytocin was administered as an intravenous infusion of 5 mU/minute, with dose increments of 2.5 mU every 15 minute to a maximum of 30 mU/minute, until progress of labour or regular contractions at a rate of 3–5/10 minute was achieved. A low-dose mobile epidural analgesia (bupivacaine or ropivacaine combined with fentanyl) was the first choice for pain relief.

## 2.1 | Statistical analyses

Median duration of the second stage of labour and interquartile ranges were estimated using survival analyses. Caesarean sections and operative vaginal deliveries during the active phase were censored. Women with a caesarean section in the first stage of labour were left censored and women with an active phase of second stage ≥120 minutes were right-censored and not included in the survival analyses. We considered oxytocin augmentation and epidural analgesia to be mediators, and stratified the analyses of estimated median duration in women with and without epidural analgesia, and with and without oxytocin augmentation.

One minus survival plots were created from Cox regression analyses and stratified into BMI groups. TGCS group 1 and 3 were analysed separately.

We calculated the unadjusted hazard ratio (HR) as an estimate of relative risk of delivery using Cox regression analyses. The normal weight group with BMI of 18.5–24.9 kg/m$^2$ was used as the reference group. We also performed analyses adjusted for maternal age. The assumptions of proportional hazards for the Cox regression analyses were checked using log minus log plots. Statistical analyses were performed with IBM SPSS statistics for Windows v.26.0 (IBM Corp.).

## 3 | RESULTS

During the study period, 68 963 women in TGCS 1 and 3 gave birth in the three hospitals. We excluded 18 192 women with missing BMI, leaving 50 711 women available for analysis, 23 516 in TGCS group 1 and 27 255 in TGCS group 3. The study population and selections into the survival analyses are presented as a flow chart (Figure 1). Maternal, labour and fetal characteristics are presented in Tables 1 and 2.

Increasing BMI was associated with shorter estimated median duration of the active phase of second stage in both TGCS groups. In TGCS group 1, the estimated median durations (interquartile range) were 44 (26–75), 43 (25–71), 39 (22–70), 33 (18–63), 34 (19–54) and 29 (16–56) minutes in BMI groups 1–6, respectively (Table 3). In TGCS group 3, the corresponding values were 11 (6–19), 10 (6–17), 10 (6–16), 9 (5–15), 8 (5–13) and 7 (4–11) minutes (Table 4). Figure 2 shows the probability of delivery in accordance with duration of the active phase illustrated as one minus survival plots. Tables 3 and 4 show the estimated median durations stratified into women with and without epidural analgesia, and in women with and without oxytocin augmentation. Increasing BMI was associated with shorter estimated median duration in both TGCS groups in the stratified analyses as well.

The overall estimated median duration was 40 (95% CI 39.2–40.8) minutes in women with missing BMI information versus 42 (95% CI 41.5–42.5) minutes in women with known BMI in TGCS group 1. Corresponding values in group 3 were 11 (95% CI 10.9–11.1) versus 10 (95% CI 9.9–10.1) minutes.

The unadjusted calculated HR as an estimate of relative risk of delivery increased with increasing BMI. The HR was 0.94 (95% CI 0.88–1.01) for the underweight group compared with normal weight women in TGCS group 1. The HR was 1.07 (95% CI 1.03–1.12) for the overweight group compared with normal weight women, and 1.23 (95% CI 1.15–1.31), 1.36 (95% CI 1.20–1.54) and 1.48 (95% CI 1.19–1.1) for obesity classes 1–3, respectively. Corresponding HR in TGCS group 3 was HR 0.92 (95% CI 0.86–0.98) for the underweight group, 1.09 (95% CI 1.05–1.12) for the overweight group and 1.19 (95% CI 1.13–1.25), 1.28 (95% CI 1.16–1.41) and 1.45 (95% CI 1.25–1.69) for obesity classes 1–3. Maternal age did not show a confounding effect in adjusted analyses.

## 4 | DISCUSSION

We found that higher BMI was associated with shorter estimated median duration of the active second stage in labour, in both TGCS group 1 and 3. In TGCS group 1, the estimated median duration was 14 minutes shorter in women with obesity class 3 than in normal weight women, and in TGCS group 3 the corresponding difference was 3 minutes. The association between higher BMI and estimated duration remained similar when stratifying women into groups with and without epidural analgesia and oxytocin augmentation.

A strength of the study was that the population was large, and that the women were included from three university hospitals over a period of 8 years. The second stage was managed according to the same national guidelines and the data were collected in the same structured electronic birth journal across all participating hospitals. The use of survival analyses reduces the risk of error due to operative delivery.

Only pre-pregnant BMI was recorded, not the BMI at the time of delivery. Information about pre-pregnant BMI was missing in 26% of cases. Overweight or obese women might be less inclined to give information about their weight to caregivers, but the missing data may also be due to lack of entry into the electronic birth journal. However, when analysing the overall estimated duration of the active second stage in the women with missing BMI, there were only small differences from the population available for analysis. Although Norwegian hospitals adhere to the national guidelines, exceptions may have occurred in the management of individual women, either intentionally or unintentionally. Another source of bias is that a greater proportion of women in high BMI groups were delivered by caesarean before reaching the second stage. However, more than 85% of nulliparous women in all BMI groups did reach the active second stage. Furthermore, the caesarean section rate was similar in obesity groups 1–3, and the bias may therefore only partly explain the differences in estimated duration of the active second stage.

Several previous studies have reported slower cervical dilation and increased duration of the first stage of labour in overweight and obese women.[23–25,36,37] Analysing mean or median duration of labour carries a risk of error, as all operative deliveries shorten the duration. Ellekjaer et al. investigated nulliparous women in a Danish cohort and found
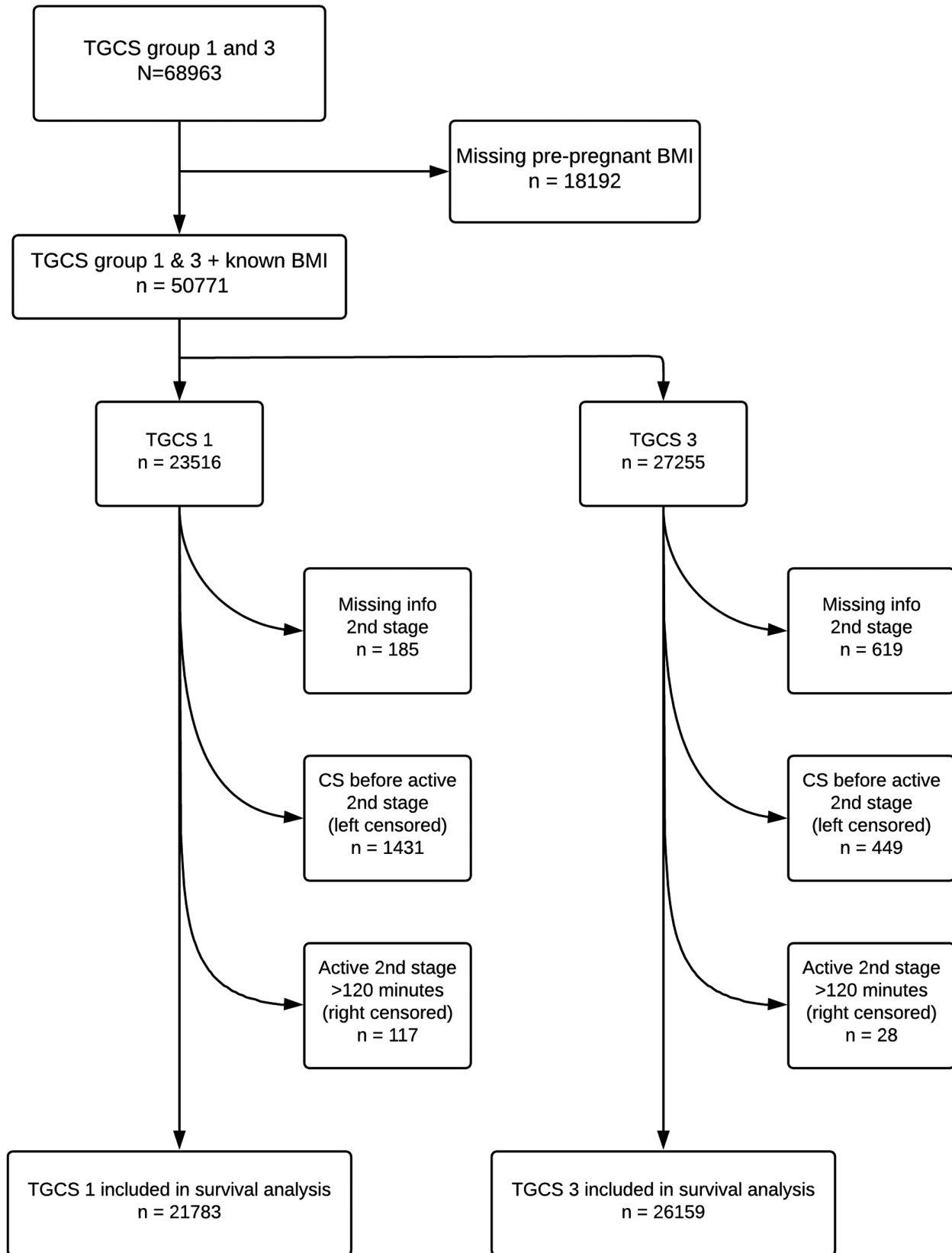
**FIGURE 1** Flow chart illustrating the study population and women included in the survival analyses

no difference in the total length of active labour.[38] However, they also found that caesarean sections were performed earlier in labour for overweight and obese women and

concluded that this may have influenced their results. Not attempting to correct for operative interventions could lead to the false conclusion that labour is shorter in obese women.

**TABLE 1** Maternal, labour and newborn characteristics in TGCS group 1

|  | Underweight | Normal weight | Overweight | Obesity class 1 | Obesity class 2 | Obesity class 3 |
|---|---|---|---|---|---|---|
| n = 23 516 | 1169 (5.0) | 16 039 (68.2%) | 4454 (18.9) | 1368 (5.8) | 360 (1.5) | 126 (0.5) |
| Maternal age | 27.2 (4.5) | 28.7 (4.4) | 28.6 (4.7) | 28.5 (4.7) | 27.9 (4.5) | 28.2 (4.9) |
| Birthweight, g | 3330 (426) | 3480 (426) | 3576 (438) | 3583 (465) | 3606 (476) | 3604 (472) |
| Caucasian | 726 (62.1) | 11 943 (74.5) | 3621 (81.3) | 1166 (85.2) | 317 (88.1) | 105 (83.3) |
| Oxytocin augmentation | 384 (32.8) | 5978 (37.3) | 1857 (41.7) | 583 (42.6) | 162 (45.0) | 64 (50.8) |
| Epidural analgesia | 551 (47.1) | 8152 (50.8) | 2603 (58.4) | 882 (64.5) | 253 (70.3) | 100 (79.4) |
| Spontaneous delivery | 840 (71.9) | 11 287 (70.4) | 2966 (66.6) | 909 (66.4) | 250 (69.4) | 85 (67.5) |
| Instrumental delivery | 274 (23.4) | 3664 (22.8) | 1032 (23.2) | 289 (21.1) | 61 (16.9) | 25 (19.8) |
| Intrapartum CS | 55 (4.7) | 1088 (6.8) | 456 (10.2) | 170 (12.4) | 49 (13.6) | 16 (12.7) |
| CS active 2nd stage | 9 (0.8) | 255 (1.6) | 95 (2.1) | 33 (2.4) | 10 (2.8) | 1 (0.8) |

*Note:* Values are mean (standard deviation) or *n* (%).

Abbreviations: BMI, body mass index; CS, caesarean section; TGCS, Ten Group Classification System.

**TABLE 2** Maternal, labour and newborn characteristics in TGCS group 3

|  | Underweight | Normal weight | Overweight | Obesity class 1 | Obesity class 2 | Obesity class 3 |
|---|---|---|---|---|---|---|
| n = 27 255 | 1129 (4.1%) | 17 617 (64.6%) | 5927 (21.7) | 1910 (7.0%) | 490 (1.8%) | 182 (0.7%) |
| Maternal age | 30.5 (4.4) | 31.7 (4.3) | 31.7 (4.5) | 31.3 (4.7) | 31.3 (4.9) | 31.3 (4.9) |
| Birthweight, g | 3446 (432) | 3622 (442) | 3719 (455) | 3761 (492) | 3766 (442) | 3802 (494) |
| Caucasian | 835 (74.0) | 14 053 (79.8) | 4674 (78.9) | 1584 (82.9) | 408 (83.3) | 162 (89.0) |
| Oxytocin augmentation | 55 (4.9) | 1141 (6.5) | 460 (7.8) | 201 (10.5) | 57 (11.6) | 27 (14.8) |
| Epidural analgesia | 227 (20.1) | 3782 (21.5) | 1400 (23.6) | 607 (31.8) | 179 (36.5) | 96 (52.7) |
| Spontaneous delivery | 1090 (96.5) | 16 792 (95.3) | 5616 (94.8) | 1787 (93.6) | 457 (93.3) | 170 (93.4) |
| Instrumental delivery | 25 (2.2) | 537 (3.0) | 184 (3.1) | 58 (3.0) | 18 (3.7) | 5 (2.7) |
| Intrapartum CS | 14 (1.2) | 288 (1.6) | 127 (2.1) | 65 (3.4) | 15 (3.1) | 7 (3.8) |
| CS active 2nd stage | 1 (0.1) | 44 (0.2) | 14 (0.2) | 6 (0.3) | 2 (0.4) | 0 (0) |

*Note:* Values are mean (standard deviation) or *n* (%).

Abbreviations: BMI, body mass index; CS, caesarean section; TGCS, Ten Group Classification System.

**TABLE 3** Estimated median duration of active pushing phase in minutes (interquartile range) in TGCS group 1

|  | n | Overall | Epidural − | Epidural + | Oxytocin − | Oxytocin + |
|---|---|---|---|---|---|---|
| BMI <18.5 Underweight | 1102 | 44 (26–75) | 37 (22–63) | 55 (32–84) | 34 (22–54) | 76 (51–98) |
| BMI 18.5–24.9 Normal weight | 14 997 | 43 (25–71) | 35 (21–58) | 54 (31–84) | 34 (20–53) | 68 (43–98) |
| BMI 25–29.9 Overweight | 4042 | 39 (22–70) | 30 (17–54) | 49 (26–82) | 29 (17–48) | 65 (37–97) |
| BMI 30–34.9 Obesity class 1 | 1214 | 33 (18–63) | 24 (14–44) | 43 (22–78) | 25 (15–44) | 61 (30–93) |
| BMI 35–39.9 Obesity class 2 | 319 | 34 (19–54) | 25 (18–48) | 39 (21–63) | 25 (17–45) | 46 (30–80) |
| BMI ≥49 Obesity class 3 | 109 | 29 (16–56) | 19 (15–37) | 32 (17–56) | 21 (15–38) | 38 (19–77) |

Abbreviations: BMI, body mass index; TGCS, Ten Group Classification System.

Labour duration can be studied with survival methods with censoring of operative deliveries, as previously suggested by Vahratian et al.[39] In this way, the risk of this type of error is reduced.

**TABLE 4** Estimated median duration of active pushing phase in minutes (interquartile range) in TGCS group 3

|  | n | Overall | Epidural − | Epidural + | Oxytocin − | Oxytocin + |
|---|---|---|---|---|---|---|
| BMI <18.5 Underweight | 1076 | 11 (6–19) | 10 (6–17) | 15 (9–28) | 11 (6–18) | 41 (20–74) |
| BMI 18.5–24.9 Normal weight | 16 975 | 10 (6–17) | 10 (6–15) | 14 (8–25) | 10 (6–16) | 25 (13–55) |
| BMI 25–29.9 Overweight | 5668 | 10 (6–16) | 9 (5–14) | 12 (8–22) | 9 (5–15) | 19 (10–42) |
| BMI 30–34.9 Obesity Class 1 | 1808 | 9 (5–15) | 8 (5–13) | 11 (7–20) | 8 (5–14) | 16 (8–32) |
| BMI 35–39.9 Obesity class 2 | 460 | 8 (5–13) | 8 (4–12) | 9 (5–15) | 8 (4–12) | 15 (8–51) |
| BMI ≥49 Obesity class 3 | 172 | 7 (4–11) | 7 (4–10) | 7 (4–13) | 7 (4–11) | 6 (4–17) |

Abbreviations: BMI, body mass index; TGCS, Ten Group Classification System.
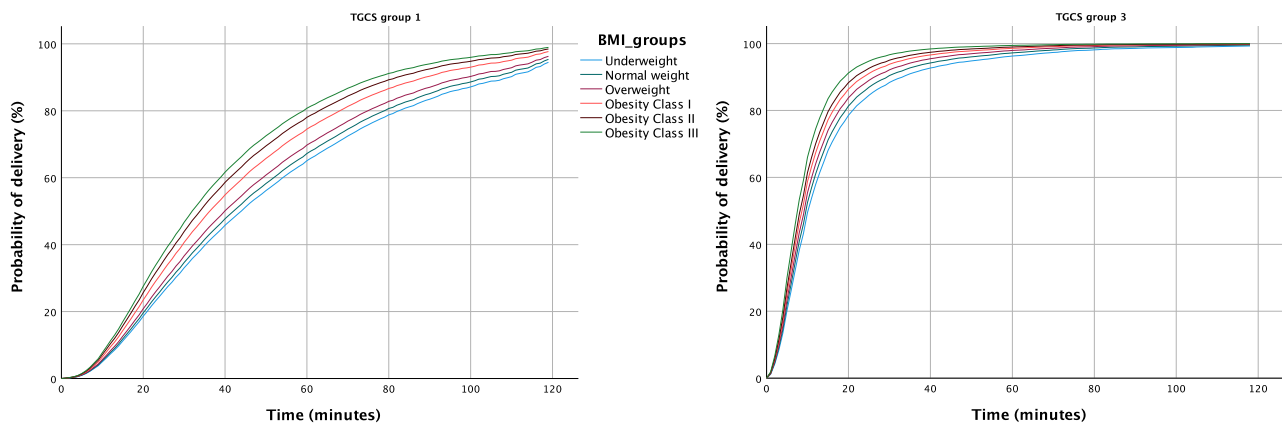


**FIGURE 2** One-minus survival plots showing probability of delivery during active pushing phase differentiated into BMI groups. TGCS 1 (left) and TGCS 3 (right)

The second stage of labour has been the subject of fewer studies. One study reports no difference of duration in the second stage with increasing BMI,[26] and one study found that the second stage was prolonged with increasing BMI in multiparous women, but not in nulliparous women.[36] Carlhäll et al.[27] studied a large, contemporary Swedish cohort. They found that the estimated duration of the active phase of labour increased significantly with increasing BMI using survival analyses. As a secondary finding, they reported a shorter median duration of the second stage in obese women. However, survival methods were not employed in the analysis of the second stage, and they did not differentiate between the passive and active second stage.

Epidural analgesia and oxytocin augmentation influence duration of labour, and it is debated how to manage these variables when investigating labour duration. A previous study found an increased duration of the active second stage in women with epidural analgesia,[40] and this is in accordance with our findings. We considered oxytocin and epidural analgesia to be mediators rather than confounders.

The associations between maternal age, epidural analgesia and oxytocin augmentation on BMI and the duration of the active second stage are illustrated in a directed acyclic graph (Figure 3). Maternal age is the only confounder with effect on both the independent and dependent variables. The causal associations are different for epidural analgesia and oxytocin augmentation.

High BMI may be associated with higher frequencies of epidural analgesia. Slow progress is an indication of oxytocin augmentation but this may also lead to shorter active second stage. Therefore, we stratified our analyses into groups with and without epidural analgesia and oxytocin augmentation and found similar associations in the stratified analyses (Tables 3 and 4).

The external validity of our results may be a matter for discussion. Norway, like the other Scandinavian countries, has a low caesarean section rate. However, to minimise this potential bias, we used survival methods. Furthermore, the mean BMI in Norway is lower than in USA and UK, but is similar to that in Germany, France and Italy.[1] The majority
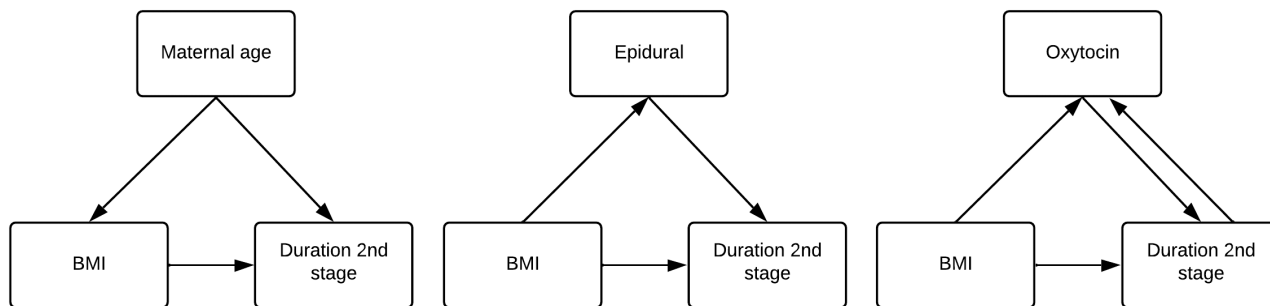
**FIGURE 3** Directed acyclic graph (DAG) illustrating how maternal age, epidural analgesia and oxytocin augmentation may be associated with BMI and the active second stage of labour

of women in our study were Caucasian (Tables 1 and 2), and another study found that black women had a shorter second stage than did women of other ethnicities.[41]

The causal mechanisms of shorter active second stage in overweight and obese women remain unclear and difficult to determine. The shorter active second stage may be related to increased abdominal pressure with increasing BMI,[42] or perhaps increased strength when pushing.[43] One study found that adults with a history of obesity from adolescence tend to have a wider bony pelvis in adulthood,[44] which could facilitate the expulsion of the fetus. Another possible mechanism is that the increased abdominal pressure and infiltration of fat in the muscular pelvic floor may decrease its strength and resistance.[45] Yet another hypothesis could be that the presence of fat in the birth canal of obese women may delay the urge to bear down, thereby postponing active pushing until the head is lower in the maternal pelvis, which in turn may shorten the active second stage.

The information given upon overweight and obese women throughout their pregnancy often has negative connotations. The finding that they have shorter times of bearing down when they reach the active second stage may provide a small, but significant positive counterweight, both for the patient and the clinician.

Regardless of the causal mechanism, upon bearing down, the woman and her birth attendant can be motivated by evidence that her active second stage is likely to be shorter than that in normal weight women, and that the risk of emergency caesarean section in this stage is low, and similar to lower BMI groups (Tables 1 and 2). As decision making by the clinician is influenced by perceived risk,[29] disseminating the results of this study may reduce unnecessary interventions for overweight and obese women.

In conclusion, we found that increasing BMI was associated with shorter estimated median duration of the active second stage of labour.

## CONFLICT OF INTERESTS
None declared. Completed disclosure of interest forms are available to view online as supporting information.

## AUTHOR CONTRIBUTIONS
TBØ initiated the study and took part in writing of the protocol, statistical analyses and writing of the manuscript. RKS took part in writing of the protocol and writing of the manuscript. JK was responsible for data collection at Haukeland University Hospital and took part in writing of the manuscript. CT was responsible for data collection at Trondheim University Hospital and took part in writing of the manuscript. PvB was responsible for data collection at Stavanger University Hospital and took part in writing of the manuscript. TME took part in writing of the protocol, writing of the manuscript and the statistical analyses. All authors approved the final version and accepted responsibility for the paper as published.

## ETHICAL APPROVAL
The study was carried out in accordance with the Declaration of Helsinki and was approved by the regional ethics committee in western Norway (REK 2020/109526).

## DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

## ORCID
*Tilde Broch Østborg* https://orcid.org/0000-0003-3600-0283
*Torbjørn Moe Eggebø* https://orcid.org/0000-0002-3162-9595

## REFERENCES
1. World Health Organization. Prevalence of obesity among adults, BMI >= 30. 2021 [cited 2021 Nov 18]. Available from: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/prevalence-of-obesity-among-adults-bmi-=-30-(age-standardized-estimate)-(-)
2. Agha M, Agha R. The rising prevalence of obesity: part B-public health policy solutions. Int J Surg Oncol (N Y). 2017;2(7):e19.
3. Agha M, Agha R. The rising prevalence of obesity: part A: impact on public health. Int J Surg Oncol (N Y). 2017;2(7):e17.
4. Koethe JR, Jenkins CA, Lau B, Shepherd BE, Justice AC, Tate JP, et al. Rising obesity prevalence and weight gain among adults starting antiretroviral therapy in the United States and Canada. AIDS Res Hum Retroviruses. 2016;32(1):50–8.
5. Eurostat. Overweight population map. 2021 [cited 2021 Nov 18]. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Overweight_population_map_July_2021_V2.png
6. Kominiarek MA, Chauhan SP. Obesity before, during, and after pregnancy: a review and comparison of five National Guidelines. Am J Perinatol. 2016;33(5):433–41.

7. Kominiarek MA, Peaceman AM. Gestational weight gain. Am J Obstet Gynecol. 2017;217(6):642–51.

8. Marchi J, Berg M, Dencker A, Olander EK, Begley C. Risks associated with obesity in pregnancy, for the mother and baby: a systematic review of reviews. Obes Rev. 2015;16(8):621–38.

9. Baer RJ, Chambers BD, Coleman-Phox K, Flowers E, Fuchs JD, Oltman SP, et al. Risk of early birth by body mass index in a propensity score-matched sample: a retrospective cohort study. BJOG. 2022. https://doi.org/10.1111/1471-0528.17120

10. Santos S, Voerman E, Amiano P, Barros H, Beilin LJ, Bergström A, et al. Impact of maternal body mass index and gestational weight gain on pregnancy complications: an individual participant data meta-analysis of European, North American and Australian cohorts. BJOG. 2019;126(8):984–95.

11. Lindegren L, Stuart A, Herbst A, Källén K. Stillbirth or neonatal death before 45 post-menstrual weeks in relation to gestational duration in pregnancies at 39 weeks of gestation or beyond: the impact of parity and body mass index. A national cohort study. BJOG. 2022;129(5):761–8.

12. Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and cost. Am J Clin Nutr. 2000;71(5 Suppl):1242S–8S.

13. Kominiarek MA, Vanveldhuisen P, Hibbard J, Landy H, Haberman S, Learman L, et al. The maternal body mass index: a strong association with delivery route. Am J Obstet Gynecol. 2010;203(3):264 e1–7.

14. Seligman LC, Duncan BB, Branchtein L, Gaio DS, Mengue SS, Schmidt MI. Obesity and gestational weight gain: cesarean delivery and labor complications. Rev Saude Publica. 2006;40(3):457–65.

15. Weiss JL, Malone FD, Emig D, Ball RH, Nyberg DA, Comstock CH, et al. Obesity, obstetric complications and cesarean delivery rate–a population-based screening study. Am J Obstet Gynecol. 2004;190(4):1091–7.

16. Yesilcicek Calik K, Korkmaz Yildiz N, Erkaya R. Effects of gestational weight gain and body mass index on obstetric outcome. Saudi J Biol Sci. 2018;25(6):1085–9.

17. Dalbye R, Gunnes N, Blix E, Zhang J, Eggebø T, Nistov Tokheim L, et al. Maternal body mass index and risk of obstetric, maternal and neonatal outcomes: a cohort study of nulliparous women with spontaneous onset of labor. Acta Obstet Gynecol Scand. 2021;100(3):521–30.

18. Hollowell J, Pillas D, Rowe R, Linsell L, Knight M, Brocklehurst P. The impact of maternal obesity on intrapartum outcomes in otherwise low risk women: secondary analysis of the birthplace national prospective cohort study. BJOG. 2014;121(3):343–55.

19. Tzadikevitch-Geffen K, Melamed N, Aviram A, Sprague AE, Maxwell C, Barrett J, et al. Neonatal outcome by planned mode of delivery in women with a body mass index of 35 or more: a retrospective cohort study. BJOG. 2021;128(5):900–6.

20. Robson MS. The 10-Group Classification System-a new way of thinking. Am J Obstet Gynecol. 2018;219(1):1–4.

21. Rossen J, Lucovnik M, Eggebo TM, Tul N, Murphy M, Vistad I, et al. A method to assess obstetric outcomes using the 10-Group Classification System: a quantitative descriptive study. BMJ Open. 2017;7(7):e016192.

22. Robson M, Murphy M, Byrne F. Quality assurance: the 10-Group Classification System (Robson classification), induction of labor, and cesarean delivery. Int J Gynaecol Obstet. 2015;131(Suppl 1):S23–7.

23. Vahratian A, Zhang J, Troendle JF, Savitz DA, Siega-Riz AM. Maternal prepregnancy overweight and obesity and the pattern of labor progression in term nulliparous women. Obstet Gynecol. 2004;104(5 Pt 1):943–51.

24. Hilliard AM, Chauhan SP, Zhao Y, Rankins NC. Effect of obesity on length of labor in nulliparous women. Am J Perinatol. 2012;29(2):127–32.

25. Verdiales M, Pacheco C, Cohen WR. The effect of maternal obesity on the course of labor. J Perinat Med. 2009;37(6):651–5.

26. Robinson BK, Mapp DC, Bloom SL, Rouse DJ, Spong CY, Varner MW, et al. Increasing maternal body mass index and characteristics of the second stage of labor. Obstet Gynecol. 2011;118(6):1309–13.

27. Carlhall S, Kallen K, Blomberg M. Maternal body mass index and duration of labor. Eur J Obstet Gynecol Reprod Biol. 2013;171(1):49–53.

28. Frolova AI, Raghuraman N, Stout MJ, Tuuli MG, Macones GA, Cahill AG. Obesity, second stage duration, and labor outcomes in nulliparous women. Am J Perinatol. 2021;38(4):342–9.

29. Healy S, Humphreys E, Kennedy C. Midwives' and obstetricians' perceptions of risk and its impact on clinical practice and decision-making in labour: an integrative review. Women Birth. 2016;29(2):107–16.

30. World Health Organization. Managing complications in pregnancy and childbirth: a guide for midwives and doctors. 2nd ed. Geneva: World Health Organization; 2017.

31. Norwegian Society of Obstetrics and Gynecology. Augmentation of labour. 2014 [cited 2021 Nov 18]. Available from: http://www.nfog.org/files/guidelines/34%20NGF%20Obst%20Augmentation%20of%20labour%20Eggebø.pdf

32. World Health Organization. WHO recommendations: intrapartum care for a positive childbirth experience. Geneva: World Health Organization; 2018 [cited 2021 Nov 18]. Available from: https://www.who.int/reproductivehealth/publications/intrapartum-care-guidelines/en/

33. Philpott RH, Castle WM. Cervicographs in the management of labour in primigravidae. II. The action line and treatment of abnormal labour. J Obstet Gynaecol Br Commonw. 1972;79(7):599–602.

34. Philpott RH, Castle WM. Cervicographs in the management of labour in primigravidae. I. The alert line for detecting abnormal labour. J Obstet Gynaecol Br Commonw. 1972;79(7):592–8.

35. Zhang J, Landy HJ, Branch DW, Burkman R, Haberman S, Gregory KD, et al. Contemporary patterns of spontaneous labor with normal neonatal outcomes. Obstet Gynecol. 2010;116:1281–7.

36. Kominiarek MA, Zhang J, Vanveldhuisen P, Troendle J, Beaver J, Hibbard JU. Contemporary labor patterns: the impact of maternal body mass index. Am J Obstet Gynecol. 2011;205(3):244 e1–8.

37. Norman SM, Tuuli MG, Odibo AO, Caughey AB, Roehl KA, Cahill AG. The effects of obesity on the first stage of labor. Obstet Gynecol. 2012;120(1):130–5.

38. Ellekjaer KL, Bergholt T, Lokkegaard E. Maternal obesity and its effect on labour duration in nulliparous women: a retrospective observational cohort study. BMC Pregnancy Childbirth. 2017;17(1):222.

39. Vahratian A, Zhang J, Troendle JF, Sciscione AC, Hoffman MK. Labor progression and risk of cesarean delivery in electively induced nulliparas. Obstet Gynecol. 2005;105(4):698–704.

40. Shmueli A, Salman L, Orbach-Zinger S, Aviram A, Hiersch L, Chen R, et al. The impact of epidural analgesia on the duration of the second stage of labor. Birth. 2018;45(4):377–84.

41. Greenberg MB, Cheng YW, Hopkins LM, Stotland NE, Bryant AS, Caughey AB. Are there ethnic differences in the length of labor? Am J Obstet Gynecol. 2006;195(3):743–8.

42. Lambert DM, Marceau S, Forse RA. Intra-abdominal pressure in the morbidly obese. Obes Surg. 2005;15(9):1225–32.

43. Tomlinson DJ, Erskine RM, Morse CI, Winwood K, Onambélé-Pearson G. The impact of obesity on skeletal muscle strength and structure through adolescence to old age. Biogerontology. 2016;17(3):467–83.

44. Novak JM, Bruzek J, Zamrazilova H, Vankova M, Hill M, Sedlak P. The relationship between adolescent obesity and pelvis dimensions in adulthood: a retrospective longitudinal study. PeerJ. 2020;8:e8951.

45. Pomian A, Lisik W, Kosieradzki M, Barcz E. Obesity and pelvic floor disorders: a review of the literature. Med Sci Monit. 2016;22:1880–6.

## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.