Viewpoint: Are there valid concerns for completing a marathon at 39 weeks of pregnancy?

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RECENTLY, WIDESPREAD MEDIA attention has been given to Amber Danielle Miller, a 27-yr-old woman (163 cm tall), who, at 39 wk of pregnancy, gave birth following her completion of the Chicago Marathon on October 9, 2011 (17, 19, 21). She completed the Marathon in 6 h, 25 min, and 50 s (Fig. 1), which equates to a brisk walking pace of 14 min, 42 s/mile (~4.1 m/h or 6.6 km/h) for the full 26.2 mile (42.2 km) marathon distance. The coefficient of variation between her eight 5-km split times was 12% (73 s/miil). Eight hours after completing the marathon, she gave birth to a 7 lb, 13 oz. girl (Fig. 2).

In part, what spurred this attention was the public perception that completing a marathon late in pregnancy was either an amazing accomplishment or a dangerous endeavor with potentially harmful effects on the fetus. The Chicago Tribune website has fielded a barrage of criticism in response to this story; some readers accusing her of risking stillbirth and brain damage.

Thus the questions arise, to what extent does completing a marathon late (or anytime) during pregnancy in 6.5 h constitute a major accomplishment compared with nonpregnant individuals? To what extent is this dangerous for the mother and/or fetus? Given that she was healthy and was cleared medically to complete the race, we would argue that Amber’s long, brisk walk was probably “no big deal.”

Exercise before or during pregnancy has been reported to diminish the risk for gestational diabetes, hypertensive disorders, and abnormal weight gain, especially if the exercise intensity is >21.1 ml·kg⁻¹·min⁻¹ (6 METS)² (26). Completing a mile in 12 min or a general leisurely swim achieves this level of intensity. In recent reports, we suggested that energy expenditure during pregnancy can be 28 MET-h/wk,³ even up to 40 wk gestation (25, 26). Given that on race day she weighed 155 lb (70 kg, personal communication), Amber’s marathon energy expenditure equaled ~28 MET-h, or ~1,984 ± 89 kcal. This was determined by using the American College of Sports Medicine Equation for walking on level ground (the marathon was flat) and substituting the 3.5 ml O₂·kg⁻¹·min⁻¹ resting component with 4.4 ml O₂·kg⁻¹·min⁻¹ during pregnancy (3); thus oxygen consumption probably equaled ~15.3 ml O₂·kg⁻¹·min⁻¹ (4.4 METS).⁴ The error in the prediction equation for energy expenditure of brisk walking is ~3.4 kcal/mile (4) or 89 kcal for the entire marathon. As such, she achieved the target weekly energy expenditure in 1 day (26). A single session expending >1,200 kcal has been shown to improve insulin sensitivity ~60% (12).

As noted, the question is whether completing a marathon close to date of delivery is appropriate for a healthy pregnant woman? Several newspapers reported mixed responses from physicians (17, 19). For the developing fetus, a potential risk is an abnormal fetal heart rate response (<110 or >160 beats/min). However, fetal heart rate abnormality is unlikely when the maternal heart rate is below 90% of maximum (20). Runners who complete a marathon 2 h faster than Amber have an average heart rate that is 82–84% of maximum (10, 15, 22). This suggests that Amber’s average heart rate was substantially less than 84% of maximum. Nonetheless, the guideline to limit heart rates to ≤90% of maximal is problematic, as only six second trimester pregnant athletes were evaluated. Another problematic issue is that the fetal heart rate response to strenuous maternal exercise is not a predictor of fetal distress (8). Thus monitoring fetal heart rates during exercise is questionable at best.

With increasing exercise intensity and duration, uterine blood flow also can decrease progressively by as much as 50% (11, 20). Nonetheless, several mechanisms act to preserve fetal oxygen consumption even during exhaustive exercise (11). At strenuous exercise intensities (above the exercise intensity at which carbon dioxide production increases more rapidly than oxygen consumption) total uterine and umbilical oxygen delivery and oxygen consumption are minimally affected (7). Amber’s marathon was not of high intensity, nor was it exhaustive. Her average pace was a brisk walk, representing a metabolic rate of 4.4 METS, which is only moderate intensity. Neither was it exhaustive, as the major fuel source at moderate exercise intensity is from the supply of fat stores (2), not muscle glycogen, thus prolonging the onset of a substantial drop in running pace. During prolonged exercise ~10% the energy expenditure comes from glucose, and 70% comes from intramuscular triglycerides and plasma free fatty acids (18). With prolonged exercise, blood glucose levels may drop; however, glucose ingestion throughout exercise prevents this (1), and blood glucose levels are maintained during a marathon (5).

¹ This article is the topic of an Editorial Focus by Peter Wagner (23).
² A MET is a metabolic equivalent task. One MET is generally said to be equal the resting metabolic rate in a nonpregnant state, which is a resting, whole body, oxygen consumption of 3.5 ml O₂·kg⁻¹·min⁻¹ (with a slight variability between individuals).
³ 228 MET-h/wk is equivalent to 1,600 kcal/wk in a 120-lb women and increases by 265 kcal for every 20 lb (9 kg) increase in the woman’s pre-pregnancy body weight.
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⁵ Oxygen consumption for walking on level ground in m; O₂·kg⁻¹·min⁻¹ = 0.1-speed in m/min + 4.4.
⁶ Amber drank approximately 200 ml of glucose/electrolyte/water mixture every 2 miles and ate a nutrient bar (~240 kcal) midway during the marathon. Two hours before the marathon began she ate a nutrient bar, two pieces of toast with peanut butter, and a banana. After the race, she ate a turkey sandwich, salad, some fruit, and ice cream (personal communication).
Another potential risk for the fetus is that regular exercise training could result in a small for gestational age (SGA) infant. Usually a consequence of compromised intrauterine development, a SGA infant is considered at risk of perinatal morbidity and mortality. Among infants born of mothers who exercised regularly, weight did not differ significantly, compared with infants born to nonexercising women (6). Amber’s newborn was of normal weight for her gestational age.

A third potential fetal risk is exercise-generated heat stress. Although extreme overheating (not directly linked to exercise) can result in neural tube defects (14), the absolute risk is low (0.6%) (14) and is only of potential risk during the first trimester. Moderate exercise does not increase core temperature to a dangerous level. For Amber, heat production can be calculated to be ~7.3 kcal/min or ~2817 kcal of total heat for the marathon.6 The Chicago ambient temperature was cool at the start of the race (57°F, 14°C, 72% humidity, calm wind), which increased to 78°F (26°C) at the finish. The humidity was lower (39% humidity) however, and a light wind was present (~5–10 miles/h) by the time Amber finished. Therefore, she probably could dissipate the heat she produced. According to the Central Governor Model, when core body temperature reaches critical levels, metabolic rate decreases as a safety mechanism to reduce heat production and prevent catastrophic failure of homeostasis (13, 16).7 Thus a pregnant mother who self-selects a pace of rapid walk or slow run is unlikely to overheat in these environmental conditions.

A final potential exercise risk during pregnancy is the participant’s cardiac status. The incidence of cardiac arrest in women during marathons is minute, 0.16 per 100,000 people (95% CI = 0.07 to 0.31 per 100,000). The incidence of cardiac death from marathon running is also small, at 0.63 per 100,000 (9), which is many times less than the Centers of Disease Control age-adjusted death rate for accidental deaths (deaths from unintentional injuries = 41 deaths per 100,000 people) (24). We are aware of no reason to suggest that the cardiac risks differ during pregnancy. In fact, the major pathology underlying cardiac arrest during marathons is hypertrophic.

6 Heat production is dependent on the individual’s body mass. Heat production in watts = weight in kg × speed in m/s × 4 J·kg⁻¹·m⁻¹·s⁻¹. Estimating Amber’s weight as 70.0 kg, the heat production = 70 kg × 1.82 m/s × 4 J·kg⁻¹·m⁻¹·s⁻¹ = 509.6 W or 509.6 J/s. Then, 509.6 J/s × 60 s = 30,576 J/min or 30.57 kJ/min. Given that 4.2 kJ = 1 kcal, then 7.3 kcal of heat is produced per minute.

7 The Central Governor Model of exercise regulation is a controversial model that explains how the whole body can prevent catastrophic physiological failure during exercise.

Fig. 1. Amber en route to a 6:25:50 marathon performance (weight at beginning of race = 70.0 kg). Photo reproduced with permission from MarathonFoto.

Fig. 2. Amber Miller holds her baby at Central DuPage Hospital in Winfield, IL. Miller felt contractions a few minutes after finishing the Chicago Marathon on October 9, 2011, and gave birth 8 h later to a daughter. Photo taken by husband and used with permission.
Fig. 3. Concerns of completing a marathon while pregnant, debunked. Completing a marathon in ~4 h and 30 min or better elucidates an average heart rate that is 82 to 84% of maximum (10, 15, 22). As such, fetal heart rate is unlikely to be abnormal when maternal heart rate is below 90% of maximum (20). Blood flow to the uterus and umbilical oxygen delivery is minimally affected below the ventilatory threshold (7). At this marathon pace or slower, the major fuel source is intramuscular triglycerides and plasma free fatty acids, not muscle glycogen (18). As such, hypoglycemia is unlikely (5). Exercise-generated heat stress is improbable with the incidence being miniscule (0.00016%) (9). Finally, women who exercise regularly while pregnant should not worry about having a small for gestational age infant, as their infant’s weight at birth is usually similar to the weight of infants born from women who do not exercise throughout their pregnancy (6). Figure created by Allison M. Straub.

cardiomyopathy. This occurs in younger individuals, suggesting a pathology that takes years to manifest itself (9).

In conclusion, in considering the scientific evidence on exercise during pregnancy while at the same time understanding the environmental conditions during Amber’s marathon, we suggest that this feat by walking briskly at 39 wk pregnant, was “no big deal” physiologically speaking (Fig. 3). On an individual basis, however, any woman considering completing a marathon should consult her physician before making that decision.

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In this article, the authors make no clinical or ethical recommendations on this woman’s (or any woman’s) ability to take part in physical activities during pregnancy.

Amber Danielle Miller previously gave permission to include photos and data pertaining to this Viewpoint.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

Author contributions: G.S.Z. conception and design of research; G.S.Z. analyzed data; G.S.Z. prepared figures; G.S.Z. drafted manuscript; G.S.Z. and L.D.L. edited and revised manuscript; G.S.Z. and L.D.L. approved final version of manuscript.

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