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Textbook typologies: Challenging the myth of the perfect obstetric pelvis

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Abstract

Medical education's treatment of obstetric-related anatomy exemplifies historical sex bias in medical curricula. Foundational obstetric and midwifery textbooks teach that clinical pelvimetry and the Caldwell–Moloy classification system are used to assess the pelvic capacity of a pregnant patient. We describe the history of these techniques—ostensibly developed to manage arrested labors—and offer the following criticisms. The sample on which these techniques were developed betrays the bias of the authors and does not represent the sample needed to address their interest in obstetric outcomes. Caldwell and Moloy wrote as though the size and shape of the bony pelvis are the primary causes of "difficult birth"; today we know differently, yet books still present their work as relevant. The human obstetric pelvis varies in complex ways that are healthy and normal such that neither individual clinical pelvimetric dimensions nor the artificial typologies developed from these measurements can be clearly correlated with obstetric outcomes. We critique the continued inclusion of clinical pelvimetry and the Caldwell–Moloy classification system in biomedical curricula for the racism that was inherent in the development of these techniques and that has clinical consequences today. We call for textbooks, curricula, and clinical practices to abandon these outdated, racist techniques. In their place, we call for a truly evidence-based practice of obstetrics and midwifery, one based on an understanding of the complexity and variability of the physiology of pregnancy and birth. Instead of using false typologies that lack evidence, this change would empower both pregnant people and practitioners.

KEYWORDS

childbirth, evidence-based practice, health sciences education, midwifery, medical racism

1 | INTRODUCTION

Anatomical sciences have a complex history with the study of non-male anatomy. Young, White,[1] male individuals are often used as the baseline normal human form in human anatomy atlases (Lawrence & Bendixen, 1992; Parker et al., 2017), which leaves humans who lack those identities, including female and intersex individuals, seeming aberrant or even pathological in comparison. In healthcare settings, this male bias can lead to negative clinical consequences for female and intersex patients (Hamberg, 2008). This situation may be compounded for Black patients who also experience the intersectional consequences of sexism and racism in healthcare settings (Scott et al., 2019; Vedam et al., 2019). One example of how culturally circumscribed misunderstanding and propaganda about anatomy pervades health sciences education and clinical practice is the myth of pelvic typologies. In the current article, we describe the definition and usage of a typological classification of the obstetric pelvis; the history and critique of the construction of these classifications, which are rooted in racism; and the pervasive clinical implications of using these outdated and racist constructs.

1.1 | Language matters

People who have or can give birth are often categorized as female, women, or mothers in scientific literature. Here we use the term obstetric body, which refers to the body of someone who has or can give birth; this category includes some females, some women, some mothers, some people who are intersex, some trans men, some people who are gender diverse, and some people who do not identify as mothers. We acknowledge the complex relationship between the "culturally contextualized social and structural experiences" that form gender and the "biological characteristics generally related to reproductive anatomy or physiology" that form sex (DuBois & Shattuck-Heidorn, 2021, p. 3). In recognition of how difficult it is to separate the concepts of gender and sex when researching humans, we will refer to these entangled concepts as gender/sex, following the example of DuBois and Shattuck-Heidorn (2021). In the past, scientists falsely assumed that a gender/sex binary existed between male/man and female/woman, which led to the exclusion of intersex, transgender, and gender diverse individuals from scientific studies (DuBois & Shattuck-Heidorn, 2021).

Within this article, we discuss past studies that did not acknowledge these gender/sex issues. These studies examined patients who were or had been pregnant (called women, mothers, or female by the study authors) and skeletonized bones where the sex was either known from the soft tissue anatomy or was estimated using forensic anthropology techniques (in both cases, called female or male by the study authors). Most forensic anthropology/bioarchaeology sex estimation techniques allow for only three options: male, female, or unknown (see Buikstra & Ubelaker, 1994) and there exist no standardized methods for identifying intersex individuals or estimating a person's gender from skeletal remains (Bethard & VanSickle, 2020; DuBois & Shattuck-Heidorn, 2021). Since all sex estimation techniques are based on a model with only two sexes, estimating sex from skeletal remains reinforces a gender/sex binary. To avoid obscuring the meaning and biases of these past authors, we generally use female and male to describe their samples. We hope our readers understand these terms in the context they were originally used—that is, by people who did not consider gender/sex diversity, and therefore may have purposefully excluded or unknowingly included intersex, transgender, or gender-diverse individuals in their studies.

2 | THE TEXTBOOK OBSTETRIC PELVIS

Widely used textbooks on obstetrics and midwifery present clinical pelvimetry and the Caldwell–Moloy classification system of pelvic types as clinically relevant for understanding fetopelvic disproportion (King et al., 2019; Williams et al., 2018). Fetopelvic disproportion may occur when the obstetric pelvis is too small to accommodate the fetus during labor (i.e., inadequate pelvis capacity), leading to ineffective labor (e.g., arrested labor, failure to progress, failure to descend) and includes complications such as shoulder dystocia and obstructed labor (Williams et al., 2018).

2.1 | Clinical pelvimetry

Clinical pelvimetry is a method for measuring the bony pelvis of a living person to evaluate the capacity of the pelvic cavity (King et al., 2019). Textbooks present clinical pelvimetry as being useful for identifying fetopelvic disproportion in pregnant people. The measurements focus on the size of the bony pelvis at the three planes relevant to birth: the inlet, midplane, and outlet. Typical measurements included in clinical pelvimetry are shown in Figure 1 and defined in Table 1.

Textbooks present different methods for obtaining these measurements and using them clinically to assess obstetric pelvic capacity. Direct measurement generally requires an internal view of the pelvic cavity. In the past, radiographs were used to take these measurements, but the potential danger to the fetus from X-ray radiation prevents their use today (King et al., 2019). Instead, direct clinical pelvimetry is obtained via magnetic resonance imaging (MRI), which involves less radiation. MRI may identify those at risk for dysfunctional labor (e.g., those with a breech position) but cannot accurately predict which patients will require cesarean delivery; this limits the value of obstetric MRI in clinical practice (Zaretsky et al., 2005), though its use may be justified for research purposes (Handa et al., 2009;

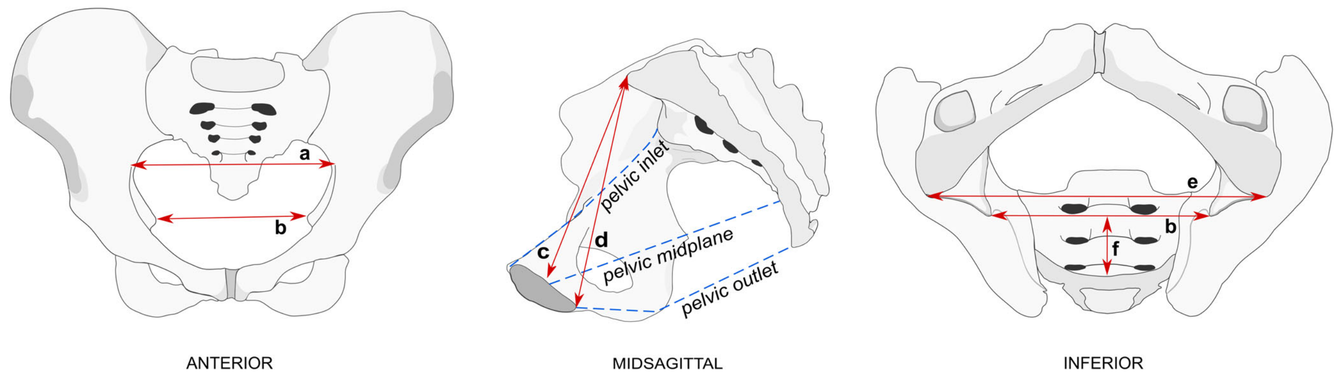

FIGURE 1 An obstetric pelvis in anterior, midsagittal, and inferior views. Pelvimetry labels include the maximum transverse pelvic inlet diameter (a), the interspinous breadth (b), the obstetrical conjugate (c), the diagonal conjugate (d), the intertuberous breadth (e), and the posterior sagittal diameter (f). On the midsagittal view, the pelvic inlet, midplane, and outlet are also labeled. Image courtesy of Jess Beck

TABLE 1 Pelvimetry of the contracted pelvis[a]

Region	Dimension	Definition	Typical	Contracted
Inlet	Obstetrical conjugate (Figure 1c)	Minimum distance between sacral promontory and pubic symphysis	10.5 cm	<10 cm
	Maximum transverse pelvic inlet diameter (Figure 1a)	Maximum distance between opposite arcuate lines; measured in a frontal plane	13 cm	<12 cm
	Diagonal conjugate (Figure 1d)	Distance between sacral promontory and lower border of pubic symphysis; measured manually	Obstetrical conjugate + 1.5 cm	<11.5 cm
Midplane	Interspinous breadth (Figure 1b)	Distance between ischial spines	10.5 cm	<8 cm
	Posterior sagittal diameter (Figure 1f)	Minimum distance between the interspinous line and the junction of S4–S5 sacral vertebrae	5 cm	NA
	Interspinous breadth + posterior sagittal diameter	Sum of these two measurements	15.5 cm	<13.5 cm
Outlet	Intertuberous breadth (Figure 1e)	Distance between the most posterior points of the ischial tuberosities; measured in a frontal plane	Not given	<8 cm

[a]Based on Williams et al. (2018). The values listed as typical were sometimes but not always referred to as averages.

Spörri et al., 2002). Today, many clinical textbooks recommend using a more accessible manual method of indirectly assessing pelvic capacity that requires no imaging (King et al., 2019). The obstetrical conjugate (Figure 1c) is the narrowest anteroposterior dimension the fetus passes through during childbirth and as such is the pelvic dimension purported to be most clinically relevant to obstetrics. The obstetrical conjugate is measured as the minimum distance between the sacral promontory and the posterior (internal) surface of the pubic symphysis, which makes it impossible to obtain manually (King et al., 2019; Moore & Dalley, 2018; Williams et al., 2018). The diagonal conjugate (Table 1d) is measured from the sacral promontory to the inferior aspect of the pubic symphysis, purportedly approximating the obstetrical conjugate. It has the advantage of being measured manually by palpating the sacral promontory through the vagina while the base of the hand rests against the inferior aspect of the pubic symphysis, thus requiring no clinical imaging.

2.2 | Caldwell–Moloy classification system

The pelvic typology based on these measurements and seen in most textbooks today was developed by two

TABLE 2 Textbook version of Caldwell–Moloy classification system[a]

Type	Inlet shape	Frequency	Birth outcome
Gynecoid (female)	Circular	40–50%	Favorable; occiput anterior delivery
Anthropoid (ape)	Sagittally long oval	25%	Favorable; occiput posterior delivery
Android (male)	Heart	20%	Fetopelvic disproportion; deep arrest within the pelvic cavity
Platypelloid (flat)	Sagittally short oval	2–5%	Fetopelvic disproportion; requires transverse facing fetal head for vaginal birth

[a]Based on Reece & Barbieri (2010) and Williams et al. (2018).

physicians, Drs William Edgar Caldwell and Howard Carman Moloy, in the 1930s (Caldwell & Moloy, 1933, 1938). Using some of the clinical pelvimetric dimensions from Table 1, the Caldwell–Moloy classification system defines four primary types of female bony pelvis and links each with a different birth outcome (Table 2).

Descriptions of the Caldwell–Moloy classification system vary across recent textbooks. For example, some include additional information such as details about the anterior and posterior spaces of the pelvic cavity or features of the midplane and outlet (Edmonds, 2018; King et al., 2019; Posner et al., 2013; Williams et al., 2018). However, they all include the original and most commonly used definition—pelvic inlet shape based on the relationship between the anteroposterior and transverse pelvic inlet diameters—and most include information on frequency of types within a population and the birth outcomes associated with each type (Table 2). What is missing from these textbooks and from Caldwell and Moloy's original study is evidence demonstrating a correlation between pelvic inlet size and shape and particular birth outcomes; in fact, such evidence remains elusive today.

The textbooks' straightforward description of the four pelvic types obscures the methodologically flawed and racist foundations of such classifications. It also reinforces that *manual* clinical pelvimetry is useful because of its relationship to the Caldwell–Moloy classification system, which in turn is presented (inaccurately) as a useful method for identifying fetopelvic disproportion in healthy individuals. Fetopelvic disproportion rarely occurs in healthy individuals; inadequate pelvis capacity is more often the result of pathologies caused by malnutrition (Dolea & AbouZahr, 2003). For example, vitamin D deficiencies lead to osteomalacia and rickets that may contract and malform the pelvis to reduce the capacity for vaginal birth (King et al., 2019; Walrath, 2003; Williams et al., 2018). Textbooks mention these facts, yet fail to acknowledge that the Caldwell–Moloy system was developed to assess the pelvis shape in *healthy* individuals, not individuals with nutritional pathologies (Caldwell & Moloy, 1933, 1938). Textbooks incorrectly present clinical pelvimetry as an evidence-based methodology to approximate pelvic type in healthy individuals based on the Caldwell–Moloy system, and then incorrectly imply that knowing the pelvic type provides useful information about the clinical likelihood of fetopelvic disproportion in otherwise healthy individuals. This uncritical presentation of clinical pelvimetry and the Caldwell–Moloy classification system results in health practitioners who expect fetopelvic disproportion to be common and who recommend unnecessary interventions, including cesarean sections, to mitigate this perceived health concern. We argue that the manner in which clinical pelvimetry is applied to nonpathological individuals to predict adverse birth outcomes is not evidence-based. We do not claim that pelvic measurements are never useful in obstetrics, just that they are not useful and may be actively harmful in this particular clinical application. In the following sections, we describe the history of how the Caldwell–Moloy classification system was developed based on clinical pelvimetry, its use in health sciences curricula, and the implications that its continued usage has for patient care and health inequities.

3 | THE PROBLEMS OF PREDICTING PREGNANCY OUTCOMES USING PELVIC MORPHOLOGY

3.1 | Problem 1: Sample bias and methodological flaws

Caldwell and Moloy (1933, 1938) cherrypicked data to build a classification system that divided obstetric pelves into four types. First, they obtained measurements of skeletonized female pelves to define their types, regardless of whether those pelves had experienced childbirth. They then obtained radiographs of patients who had records of a difficult childbirth, measuring their pelves to link pelvimetrics with their experienced birth outcomes. Later researchers added proxy manual measurements, like the diagonal conjugate, to the classification system because they allowed pelvis assessment to occur without expensive and potentially harmful imaging. Here, we describe the data and measurements that went into the original Caldwell–Moloy classification system as well as the proxy measurements developed after the original studies. We critique these studies for using a sample that supported the authors' confirmation biases about birth, for treating measurements in living persons as the same as the static values measured on the deceased, and for assigning a causal relationship to two measurements without accounting for normal human variation.

A history of measuring skeletonized bony pelves already existed when Caldwell and Moloy started their work (Caldwell & Moloy, 1933, 1938). Inspired by the concept of measuring the pelvis, they decided to develop a method that would guide physicians toward the best intervention during a difficult labor. They stated that their clinical experiences made it "apparent that certain pelvic abnormalities [were] not adequately described in obstetrical texts" so they wanted to quantify and record the supposed abnormalities that "increased the difficulty of operative delivery [i.e., vaginal birth assisted by the use of forceps or surgical birth]" (Caldwell & Moloy, 1938, p. 1). Using a quantitative biomedical approach, they developed a method that classified the bony obstetric pelvis into types, and then based on their experience as obstetricians, they associated each type with potential risks during labor (Caldwell & Moloy, 1933). Caldwell and Moloy suggested the shape of the pelvic inlet affected the frequency of particular birth difficulties, which they defined based on the use of surgical birth (i.e., cesarean section) or forceps (Caldwell & Moloy, 1938). They posited that knowing the shape of the inlet before the start of labor could help determine which interventions might be necessary during labor.

Caldwell and Moloy (1933, 1938) examined two kinds of data for their studies: skeletonized bony pelves and radiographs of living patients. They initially developed their model from skeletonized pelves from multiple sources in New York, NY; Washington, DC; and Cleveland, OH. However, they established the frequency of each pelvic type based on the skeletal remains from "Professor Todd's fine collection of sexed pelves at Western Reserve University" (Caldwell & Moloy, 1938, p. 8); today we know these skeletons as the Hamann-Todd Human Osteological Collection currently located at the Cleveland Museum of Natural History. This collection includes over 3,000 human skeletons that were primarily sourced from unclaimed bodies at local morgues (Kern, 2006). The records for these individuals often included their sex, weight, age, race, and cause of death (Kern, 2006). In general, race was listed as "white" or "negro"; here, we will use the terminology White or Black, respectively, to refer to these race assignments (following Mack & Palfrey, 2020). Caldwell and Moloy (1938) studied 268 rearticulated female pelves of 147 White and 121 Black individuals from the known-sex Hamann–Todd Human Osteological Collection. Although some of these skeletons may have had information about the number of children the individual had, it is unlikely that the records included information on the experience of childbirth. Despite not knowing whether the people represented by these bones had experienced childbirth, let alone a difficult or complicated childbirth, Caldwell and Moloy postulated how each pelvic type would fare during labor. These projected expectations were highly speculative since pertinent information about the people in the skeletal sample was lacking.

More directly, Caldwell and Moloy (1933, 1938) linked the pelvic types in their model with potential birth interventions using radiographic (roentologic) images of the pelvic inlet and outlet taken in stereoscopic view. These images were obtained from 500 patients who had given birth via either surgical birth or forceps-assisted vaginal birth, which is how Caldwell and Moloy identified difficult births (Caldwell & Moloy, 1938). To assess how fetal head remodeling in the pelvic cavity affected their predictions, Caldwell and Moloy also obtained radiographs of pregnant patients during labor, but they did not state how many patients were involved or how well their predictions matched their observations. These studies were completed in the early days of radiology, and the danger to the fetus from X-rays was not yet known.

Caldwell and Moloy sampled patients with a history of difficult labor, identified the patients' pelvic shapes, and concluded that the two must be causally related, thus engineering a classically circular argument. The radiologic data on which their pelvic typology was based primarily examined people who experienced obstetric difficulties during labor; this post hoc approach likely biased them toward believing that subtle anatomic variations could be classified as problematic. They did not identify pelvis shape variation among individuals known to have easy childbirths and, therefore, could not say whether any (or all) of their pelvic types related to a lack of difficulties during childbirth. Without studying pelvic inlet shape in uncomplicated labors, there is a gap in understanding: it is not clear that any of the constructed categories of pelvic shape are actually more likely to be associated with poor outcomes than with unremarkable labor. Despite these troubling limitations, Caldwell and Moloy published their suggestions for using pelvic shape to predict difficulties during childbirth. Unfortunately, these suggestions have shaped categorical "function-follows-form" attitudes about pelvic types for nearly a century.

The X-ray measurements Caldwell and Moloy (1933, 1938) obtained during labor do not accurately reflect the dynamic changes to pelvic cavity shape that occur during labor. Caldwell and Moloy (1933, 1938) described in great detail the very precise position of the patient during X-rays, and imply that measurements taken on these radiographs are the same as the measurements they took on dry skeletal remains to establish and define their pelvic types. However, in a living person, pregnancy hormones relax the ligaments at the sacroiliac and sacrococcygeal joints as well as the fibrocartilaginous pubic symphysis to expand the pelvic cavity during labor. Different labor positions further change the dimensions of the pelvic cavity; for example, when a laboring person moves into a hands-and-knees position (called a Gaskin Maneuver), the obstetrical conjugate increases by up to 10 mm, and the sagittal measurement of the pelvic outlet increases by up to 20 mm (Borell & Fernstrom, 1957). Computational models have shown that when a pregnant person holds a squatting position most pelvic measurements, including those used by Caldwell and Moloy, increase (Hemmerich et al., 2019; Siccardi et al., 2021). Thus, measurements of pelvic size obtained on immobile skeletonized pelves and by X-rays, even X-rays taken during labor, may differ from the actual dimensions once the laboring person is away from the X-ray machine. Caldwell and Moloy assumed static pelvic shape when designing their model, but the more recent evidence is clear: obstetric pelvis dimensions are not static so it would be difficult to accurately place them within a typology like the one still being used today.

When physicians realized that X-raying pregnant people exposed the fetus to dangerous levels of radiation, recommendations shifted to using manual methods, like the diagonal conjugate, as a way to approximate the anteroposterior dimensions of the pelvic inlet without requiring imaging. However, research has shown that the diagonal conjugate does not correlate directly with obstetrical conjugate, the smallest anteroposterior distance the fetus needs to negotiate during childbirth (Kaltreider, 1951). Whereas most textbooks today repeat that diagonal conjugate is 1.5–2 cm longer than the obstetrical conjugate, Kaltreider (1951) measured pelvic dimensions on 1,133 patient X-rays and reported the difference between the two conjugates varied from 0.2 to 2.5 cm. Although the "subtract 2 cm" rule may work for some patients, it is clearly an inaccurate assessment of the minimal anteroposterior dimension of the pelvic cavity in others. Given the range of variation present in humans for the relationship between the obstetric and diagonal conjugates, this is not a technique that should be widely applied, yet none of the cited textbooks describe this discrepancy. Direct measurement of the pelvis to identify fetopelvic disproportion would require medical imaging, which is rarely recommended for healthy patients. Today, medical imaging is reserved for assessing the obstetric pelvis for abnormalities in the case of planned "high-risk" deliveries. For example, MRI has been applied to patients with breech presentations as a way to evaluate the possibility of vaginal delivery (Hoffmann et al., 2016; Klemt et al., 2019), though most breech presentations are managed by cesarean section (Committee on Obstetric Practice, 2018).

The evidence described here suggests that the variation in human pelvis dimensions and the resulting shape cannot be described in a typological model of static anatomy as it varies considerably even during labor and parturition. Linking simple linear measurements with birth difficulties also ignores the multifactorial causes of poor birth outcomes that we explore in the next section.

3.2 | Problem 2: Difficult births are difficult to define

Caldwell and Moloy's stated goal was to develop a method that allowed obstetricians to identify patients for whom birth would be difficult due to the normal shape of their bony pelvis and then use that knowledge to intervene appropriately (Caldwell & Moloy, 1933, 1938). Today we know that contracted pelves that lead to fetopelvic disproportion are typically the result of nutritional pathologies, yet these were not the patients that Caldwell and Moloy sought to help. Instead, they sought to find interventions for patients whose pelvic morphology fit within normal human variation. Their premise assumed that normal variation of the human obstetric pelvis would lead to difficult births requiring clinical interventions, such as surgical birth or forceps. Their assumption effectively pathologizes the obstetric body and normalizes clinical interventions that may not be needed. Caldwell and Moloy considered difficult births to be ones in which surgical or forceps interventions were needed *because* of the obstetric pelvis size and shape. This view fails to account for the many other factors that lead to birthing difficulty, as well as the other ways in which birth difficulty can be defined. The size or shape of the pelvic outlet would most commonly be indicative of a difficult birth if it led to a prolonged second stage of labor, after the cervix is completely dilated and the pregnant person is pushing. Other common birth difficulties (e.g., arrest of dilatation, prolonged first stage of labor, hypertonic uterus, and occiput posterior fetal position) are associated with the uterus, cervix, or fetal position and therefore have little relation with bony morphology of the obstetric pelvis (Williams et al., 2018). Difficult birth may also refer to how well the laboring person is coping with a labor that is longer or more painful than expected (Murphy & Strong, 2018; Quine et al., 1993; Waldenström et al., 2004).

The existence of other causes of birth difficulty or an expansion of how birth difficulty is defined does not mean that pelvic shape and size does cannot contribute to birth difficulty. We argue, however, that the focus on the measurements used in clinical pelvimetry and the Caldwell–Moloy classification overestimates the impact of the bony pelvis on birth. A recent Cochrane review of five randomized control trials spanning 1962–2009 and including 1,159 pregnant people assessed the relationship between clinical pelvimetry and birth outcomes when the fetus is in a head-down presentation; they found that there was no difference in perinatal outcomes (e.g., perinatal mortality) among groups who received X-ray pelvimetry, manual pelvimetry, or no clinical pelvimetry at all (Pattinson et al., 2017). X-ray pelvimetry was predictive of surgical birth, a relationship the authors warned could be due to selection bias because by the time X-ray pelvimetry is ordered, clinicians' concerns about birth likely already exist. On the whole, the authors caution that there is insufficient high-quality evidence to conclude that "measuring the size of the woman's pelvis (pelvimetry) is beneficial and safe when the baby is in a head-down position" (Pattinson et al., 2017, p. 2).

Caldwell and Moloy's concerns focused on the type of labor arrest recorded for the patients for whom they had radiographs (Caldwell & Moloy, 1933, 1938). Labor arrest has multiple causes that are not necessarily explained by the shape of the obstetric pelvis and that were not addressed in Caldwell and Moloy's studies. Shoulder dystocia, a form of fetopelvic disproportion, is one of the most common sources of obstetric malpractice litigation (Mavroforou et al., 2005). Clinical pelvimetry is still recommended as a way to predict and prevent shoulder dystocia (Hill & Cohen, 2016), even though fetal weight affects shoulder dystocia risk more than the anatomy of the obstetric pelvis (Ouzounian, 2016). Since clinical pelvimetry cannot accurately predict shoulder dystocia (Schmitz, 2015), clinicians may be using clinical pelvimetry either based on a false understanding of its effectiveness or as a means to preempt litigation. More broadly, the link between normal pelvic inlet variation and birth outcomes is tenuous due to lack of evidence, especially given the many factors involved in the complex biocultural process of birth (Davis-Floyd, 1994; Liese et al., 2021; Rutherford et al., 2019).

Caldwell and Moloy (1933, 1938) used their limited dataset to identify four pelvic types based on the size and shape of the pelvic inlet; this typology is still in use today. Under their system, a pelvis could be a combination of types, based on separate assessments of the anterior and posterior parts of the pelvic inlet (divided at the maximum transverse inlet diameter), however this is not presented in all textbooks. Caldwell and Moloy also stated that the pelvic inlet did not correspond to the shape of the pelvic outlet, which could also vary. Therefore, to use their model as originally described, a practitioner would need to know the anterior and posterior inlet shape, which requires imaging, and the subpubic angle (anterior outlet) morphology, which can be palpated. Caldwell and Moloy (1933) predicted the following outcomes for their primary four pelvic types: Birth was most dangerous through an android pelvis as it requires the fetal head to enter the pelvic inlet at an angle; they recommended surgical birth if this shape was identified prior to labor. Birth through a platypelloid pelvis would require the fetal head to remain laterally rotated throughout its passage, which may require forceps. Birth through anthropoid or gynecoid pelves both require the fetal head to enter the pelvic inlet through the longest dimension (sagittally for anthropoid or transversely for gynecoid) and then rotate as it travels toward the outlet; these forms were not considered dangerous unless they were contracted (i.e., unusually small due to a pathology) or the fetus was unusually large. These assessments were inferred from skeletal remains and observations of pelvis shape in patients who had previously had difficult labors, calling into question their relevance to obstetric practice today.

Even when using the broad definition that successful birth outcomes are those that avoid maternal and infant mortality, there are still logical flaws with relating Caldwell and Moloy's classification system to difficulties in labor. Failure to progress and failure to descend are clinical causes of labor arrest that refer to the cessation of cervix dilation or failure of fetal descent, both of which are required for vaginal birth (King et al., 2019; Williams et al., 2018). Today, midwifery students learn the "Four Ps of Labor and Birth": passenger (fetus/es), passage (pelvic cavity, uterus, and vagina), powers (uterine contractions), and psychology (pregnant person's psyche). This list is taught to better determine underlying causes of labor arrest and to identify interventions to support physiological birth (King et al., 2019). The four Ps are modifiable through labor-management techniques including strategic use of position changes, ambulation, familiar birth setting, doulas, and support people. Antepartum health, support systems during labor, and postpartum care greatly influence maternal and infant mortality rates (Greenwood et al., 2020). Degrees of maternal autonomy and support in labor ultimately change the dimensions of the pelvic cavity and influence labor arrest and the clinical consequences of that diagnosis (King et al., 2019; Williams et al., 2018). Nevertheless, the codification of adequate versus inadequate pelvic types based on clinical pelvimetry provides a fabricated objectivity to the obstetric discourse surrounding causes of labor arrest.

Another limitation of the Caldwell-Moloy classification system is that it was based on experiences of hospital births from the first half of the 20th century from the perspective of White male obstetricians. Therefore, the births that Caldwell and Moloy defined as difficult may have been difficult simply because of actions taken in the hospital setting. Patients were likely in lithotomy (supine) position to allow the obstetrician a better view. Recall that a person laboring on hands and knees may increase their obstetrical conjugate by up to 10 mm compared with the supine position (Borell & Fernstrom, 1957). MRI studies have also shown the dimensions of the pelvic outlet become wider in the squatting and kneeling positions (Gupta et al., 2017). In an upright position, gravity can facilitate fetal descent and efficient uterine contractions.

Some of Caldwell and Moloy's patients may have also been in twilight sleep, which involves an analgesic cocktail usually containing morphine to induce unconsciousness and immobility (Haultain & Swift, 1916). Because this procedure prevented the pregnant patient from engaging with the birth, it typically made labor dependent on interventions like forceps (Jolly, 2010; Mandy et al., 1952). If patients are too drugged to participate in labor, they may be unable to aid fetal descent by pushing during contractions, which has implications for powers, one of the four Ps. Forceps delivery was common by this time (Walrath, 2003) and has been associated with increased rates of maternal mortality in the early 1900s (Loudon, 1992). Even today, forceps use is associated with high maternal and fetal morbidity, as forceps may damage the adult's visceral organs, harm the fetus, or lead to infection (Patel & Murphy, 2004). Caldwell and Moloy explicitly omitted the rachitic pelvis (the result of childhood rickets) from their study, focusing instead on normal variation in pelvic shape unrelated to pathology. However, their ideas about contracted pelves making childbirth difficult were likely influenced by the real difficulties observed in patients with pathologically contracted pelves. At that time, interventions like vitamin D supplementation and surgical birth were less widely available and less safe (Walrath, 2003), which highlighted contracted pelves as a major problem of childbirth that obstetricians needed to solve.

Yet the typology Caldwell and Moloy developed implied that normal obstetric pelvis variation includes imperfect forms that are not functional during childbirth and therefore require additional assistance or intervention from obstetricians. This ideology prioritizes and idealizes obstetric pelvis shape over provider management and structural issues that likely have a greater effect on maternal and infant mortality and may reinforce worse outcomes for some patients.

3.3 | Problem 3: Obstetric pelvis variation is normal and complex

Caldwell and Moloy and the obstetric literature that reference them reinforce the notion that static and simplistic pelvic categories illustrate sufficient nuance of several dynamic biological processes. This notion involves pathologizing the normal variation of pelvic shape found in healthy obstetric bodies. The Caldwell–Moloy classification system primes clinicians to expect people with particular pelvic shapes to be more likely to have poor birth outcomes even when they are otherwise healthy. It focuses on the differences between individuals, while ignoring the areas of overlap. Delprete (2017) studied the skeletonized pelves of 378 adult individuals from three identified skeletal collections, a sample comprising similar numbers of males and females of comparable ages. She found that the most common inlet shape for both sexes was android, the same shape Caldwell and Moloy described as most dangerous and that textbooks list as being present in only 20% of obstetric pelves (Table 2). Delprete's methods involved defining pelvic types based on a ratio of the anteroposterior pelvic inlet diameter and the transverse pelvic inlet diameter, linking dimensions of the pelvis with pelvic types while also applying the typology to males. This study shows considerable overlap between males and females and provides important context for understanding the degree of individual difference in the bony pelvis across a more diverse study sample. It also shows that the pelvic type Caldwell and Moloy thought was most dangerous may be the most common, which further illustrates how their classification system pathologizes normal anatomy.

Pelvis shape has changed over human history and varied in response to ecological factors like diet and climate (Wells et al., 2012). In their review of variation across populations, Wells et al. (2012) found that the emergence of agriculture may have decreased maternal stature, which in turn limited the dimensions of the pelvic cavity, while increasing fetal size. In *Williams Obstetrics*, Thoms (1937) is cited as saying that people with small pelves birth small babies (Williams et al., 2018). More recently, Kurki (2007) showed that small (but not short) females have larger midplanes and outlets than those with larger body masses. Together, these studies suggest that body size variation affects pelvic cavity dimensions but that very small-bodied populations have adaptations to accommodate childbirth through reduction of fetus size and expansion of the midplane and outlet. If Wells et al.'s (2012) hypothesis is correct that childbirth became more difficult after the emergence of agriculture because of secular changes to stature and body mass, those difficulties should have also been present in the skeletal collection that Caldwell and Moloy used to develop their classification. This interpretation also suggests that population-level adaptations may develop over time, rendering a one-size-fits-all-populations typology even less useful. Since nutrition, healthcare access, interventions and medicines, and activity types have changed in the U.S. since the 1920s and vary widely across populations now, even if Caldwell and Moloy's typology was accurate at the time of its development, it may not accurately describe the U.S. birthing population today, due to continuing secular and demographic changes (e.g., Bogin, 2013; NCD Risk Factor Collaboration, 2016).

4 | THE PROBLEM OF RACISM IN THE CONSTRUCTION OF PELVIC TYPES AND IMPLICATIONS FOR HEALTH INEQUITIES

Human biological variation does not fit a model of biological race variation (Fuentes et al., 2019). However, early naturalists from the 18th and 19th centuries strongly believed that human biological variation naturally separated humans into clearly defined races that determined behavior and that could be ranked (Blakey, 1999; Caspari, 2003; Marks, 2009; Roberts, 2012; Watkins, 2012). Unsurprisingly, the White researchers placed their own race at the top of the hierarchy and used their ranking to justify the genocide, sterilization, and enslavement of non-White races (Blakey, 1999; Caspari, 2003; Marks, 2009; Roberts, 2012; Watkins, 2012). Stereotypes developed that linked fertility and sexuality with being animalistic, and these behaviors were considered more common in non-White races, especially those from Africa (Cooper Owens, 2018; Schiebinger, 1993). These concepts became embedded in social, medical, political, and economic structures that forged the disparities in maternal health outcomes that are still experienced today (Cooper Owens, 2018; D.-A. Davis, 2019; Scott et al., 2019; Vedam et al., 2019).

The biological race concept—that races are naturally existing biologically quantifiable categories that determine behavior and can be ranked—was a mainstream belief in European and American academic and clinical circles well before and during the time that Caldwell and Moloy developed their typology (Roberts, 2012). Early anthropologists sought to identify race-defining features of the skeleton and use them to reify the idea that biology determines behavior and ability (Blakey, 1999; Caspari, 2003). After the cranium, the pelvis was considered the second-best skeletal element for identifying race (Garson, 1881). Researchers rarely agreed on the number of races or the traits that should be used to define them (Blakey, 1999; Caspari, 2003; Roberts, 2012); some even noted that the pelvis divided skeletons into different categories than the cranium (Pruner-Bey, 1864; Verneau, 1875).

Turner (1885) was one of the first scholars to describe what he perceived as racial differences in bony pelvis shape. Although he described the small amount of previous research on the subject, he considered most of it not objective enough to be useful. For example, some of the authors he cited only compared two races or had no way to quantify differences between races (Turner, 1885). One of these early classification systems defined four types of pelvic inlet shapes (oval, round, four-sided, and wedge) but was not consistent in defining these types or assigning them to pelves. Some of these earlier researchers developed a pelvic inlet index: $100 \times$ conjugate diameter $\div$ transverse diameter (Turner, 1885).

Turner (1885) believed that the inconsistencies in earlier classifications were because earlier authors examined female pelves, which he thought were more similar across races because of the constraints of childbirth; therefore, he assumed that the true pelvis form for each race would be better identified using the male pelvis (Caldwell & Moloy, 1938). He used the pelvic inlet index to define his three pelvic types: dolichopellic (deep pelvis), platypellic (flat pelvis), and mesatipellic ("middle pelvis" or intermediate between deep and flat; Table 3). Using the existing literature and his own observations of bony pelvis remains from across the globe, he assigned a pelvic type to each race. Although this racial typology was developed from male pelves, he also studied females in each racial group, finding that females were typically more platypellic (having a lower index) than males of the same group and that no females were dolichopellic (Turner, 1885). Turner explicitly described the dolichopellic type—which he associated with many African and Polynesian races—as similar to that of anthropoid apes, reinforcing racist assumptions that non-White races were more biologically primitive and therefore more similar to nonhuman apes than White people.

Caldwell and Moloy (1933, 1938) referred to Turner and other early researchers of pelvic shape when developing their typology. They perpetuated Turner's categories by linking them to their own: dolichopellic became anthropoid (making the link to apes even more explicit)

TABLE 3 Turner (1885) pelvic typology

Turner's type	Inlet shape	Pelvic inlet index[a]	"Races" Turner associated with this type[b]
Dolichopellic	Sagittally long and transversely narrow	>95	Australians Bushmen Hottentots Kaffirs Andamans New Zealanders? Polynesians generally? Malays Aïnos?
Platypellic	Transversely wide and sagittally short	<90	British French Germans Europeans generally Ganache? Esquimaux? Laplanders? Chinese, Mongolians generally, American Indians
Mesatipellic	Intermediate between dolichopellic and platypellic	90–95	Negroes Tasmanians New Caledonians Melanesians generally?

[a]Pelvic inlet index = 100 × conjugate diameter ÷ transverse diameter.
[b]The races are listed exactly as they appear in Turner (1885, p. 141) to show the biases inherent in his classification.

or android (since the pelvic inlet index does not distinguish long-oval and wedge-shaped inlets), platypellic became platypelloid, and mesatipellic became gynecoid. When describing their own pelvic types, Caldwell and Moloy specified how each pelvic type related to different races, citing Turner and their own observations of the Hamann–Todd Human Osteological Collection. From their assessment of 268 female pelves from this collection, they concluded that in their sample of White females (n = 147), 41.4% were gynecoid, 32.5% android, 23.5% anthropoid, and 2.6% platypelloid. In contrast, in the sample of Black females (n = 121), 42.1% were gynecoid, 15.7% android, 40.5% anthropoid, and 1.7% platypelloid. Turner (1885) suggested that his dolichopellic type was more often found in "the lower races", by which he meant non-Europeans. Although Caldwell and Moloy (1933, 1938) identified the anthropoid pelvis in both White and Black females, it was nearly twice as common in Black females, reinforcing Turner's claim that this type was found mostly in the so-called "lower races". Caldwell and Moloy (1933) overvalued the platypelloid pelvis type, which is very rare and resembles a pathologically constricted pelvis that likely would compromise childbirth. Yet Caldwell and Moloy (1933, p. 490) described this type as being least similar to "lower mammals", making it the opposite of the anthropoid form. Although rare overall, it was over 1.5 times more common in White females than in Black females in their study (2.6% vs. 1.7%, respectively) (Caldwell & Moloy, 1938). They described this type, which some of their peers claimed was only present in individuals who experienced nutritional deficiencies in childhood, as being "ultrahuman" and cited a study that reported it in "robust women" with no evidence of rickets to support their belief that it was the ideal and not pathological (Caldwell & Moloy, 1933, p. 481).

This racist classification has implications for the stereotypes about differences in the childbirth process. According to Cooper Owens (2018, p. 110), citing Breeden (1980), "Eighteenth-century anthropologists and anatomists formed these type of ideologies because they believed that 'African women's alleged extraordinary ease in parturition seemed to indicate pelvises more capacious than European women's... (this was also assumed to be true of apes and other quadrupeds)'." The racist underpinnings of the Caldwell–Moloy classification system contribute to false ideas about sex and population variation that are not supported by evidence. Caldwell and Moloy's typology, but not their data, suggested that transversely wide pelvic inlets are more common in White females, an idea that fueled the persistent assumption that childbirth was easier and less painful for Black women (Cooper Owens, 2018; McMillan Cottom, 2019). Further, by linking Black women to a more animalistic form, they are distanced from an ideal "feminine" form ascribed to Whiteness (A. W. Davis et al., 2018; Deliovsky, 2008). These interpretations continue to have implications for maternal healthcare and health inequality in the United States. For example, when compared with non-Hispanic White women, Black women are given fewer epidurals during labor (Glance et al., 2007). Black women also report more pain during labor, birth, and the postpartum period, yet are prescribed fewer pain medications (Badreldin et al., 2019; Johnson et al., 2019). Studies based on the premise of a biological reality of race tend to reify these assumptions; for example, Greenberg et al. (2006) found that Black patients had the shortest duration of the second stage of labor and recommended a "multifactorial redefinition of labor curves" on the basis of race. The notion of racial differences in childbirth duration has implications for the rising rates of surgical births among Black patients: surgical births are recommended based on the duration of the second stage of labor, which in Black patients is expected to be short relative to White patients (Rutherford et al., 2019).

Another key factor affecting the shape and size of a person's pelvic cavity is microevolutionary differences between human populations over time. Betti (2017) suggests this difference is the result of genetic drift (i.e., random changes), not selection for a particular pelvis type. Her work shows that female pelvis shape varies across and within human populations and that there is no prescribed ideal pelvis form and certainly not one that can definitively be assigned to an entire group of humans or even a discrete sex. Instead, human populations can have variations in particular biologically based features, like pelvis shape, without fitting into discrete racial categories like the ones used by Caldwell and Moloy and other researchers of their time. Even though broad differences in pelvis shape exist across geographic regions, these differences are not rooted in biological race (Handa et al., 2008).

5 | CURRENT CURRICULA CREDIBILITY

It is unclear how often clinical pelvimetry and the Caldwell–Moloy classification system are used clinically. We have shown that the clinical pelvimetry suggested by many current textbooks requires medical imaging to measure accurately, which is expensive and carries risks. Therefore, clinicians are likely only referring healthy pregnant patients for imaging-based pelvimetry if they are using MRI to assess the pelvis before attempting a vaginal breech birth. However, aspiring maternity care providers are still taught manual pelvimetry and how to assess the pelvis as "adequate" or otherwise. The records of these methods are documented in admission and progress notes of laboring patients, despite no evidence that clinical pelvimetry is related to perinatal outcomes (Pattinson et al., 2017). *Varney's Midwifery* says that clinical pelvimetry "is classically done when an initial vaginal examination is performed during pregnancy and/or during the course of labor" (King et al., 2019, p. 749). We argue that these exams are unnecessary because using measurements to predict birth outcomes is not evidence-based. Further, these exams reinforce the imposition of digital penetration of the vagina, sometimes without consent, as an appropriate clinical procedure to be performed on a laboring person to make a determination of their birthing capacity as defined by the biomedical hegemony (Tillman, 2020).

Students across the health sciences may absorb pelvic shape classifications and clinical pelvimetry as presented in their general anatomy texts into their understanding of the body and carry that into clinical practice, remaining unaware of the important critiques we have outlined here. These assumptions reinforce stereotypes about failures of the female body and racist assumptions that contribute to discrepancies in pain management during pregnancy. The epistemologies of science developed during the European Age of Enlightenment and still used today established the idea that rigorous science requires quantification (Gould, 2008). In this case, while measurements of the pelvis may seem scientifically rigorous, they do not provide useful clinical information about the patient or support evidence-based practices (Pattinson et al., 2017). If clinicians are taught during training that there are reliably predictive typologies and methods for measuring the obstetric pelvis, they are likely to remember that information during clinical practice and consider it important and practicable, even if they cannot remember the specifics. In this manner, flawed information has the potential to shape obstetric iatrogenesis, i.e., injuries resulting from medical interventions (Liese et al., 2021).

Perhaps more concerning, clinical pelvimetry and the Caldwell–Moloy classification system are also found in both professional and lay resources, such as continuing education courses for obstetric nurses and providers that are accredited by professional organizations for licensure (Relias Obstetrics, 2021) and on expectant parent websites and blogs (Fischer, 2018; Seladi-Schulman, 2020; Spinning Babies, 2021). For example, one website states, "If you're pregnant or planning to become pregnant and have concerns about how your pelvis shape might affect childbirth, speak with your doctor. They can examine your pelvis to help get an idea of how it's structured" (Seladi-Schulman, 2020). Even though these ideas may not be applied in clinical practice, their pervasiveness in lay resources may occur because they are still presented in textbooks and repeated by clinicians when discussing birth with eager and anxious patients. The transition from obstetrics and midwifery textbooks to lay person resources codifies these ideas in the popular imagination, which means they may retain social meaning long after the textbooks quietly remove this content from their pages. As educators, we must remember that what we teach does not stop with our clinicians-in-training; it is also disseminated to the broader public through our students and their social and familial networks.

The concerns we have presented are not new; Walrath (2003) also thoroughly critiqued the existence and application of pelvic typologies. *Varney's Midwifery* will be adding a reference to Walrath (2003) to their upcoming 2022 edition (C. Klima, personal communication, July 7, Klima, 2021), an example of the truism that it takes nearly 20 years for evidence to be translated into practice (Morris et al., 2011). While the inclusion of the critique is a sign of progress, it should be noted that the typologies themselves will still be presented in the text.

5.1 | Call for change

By problematizing normal pelvic variation, the Caldwell–Moloy classification system of the bony pelvis contributes to the pathologizing of the obstetric body in clinical practice today. This system is still presented to clinicians-in-training and interpreted as fact by lay people. The evidence against its usefulness and accuracy and for its harm as a tool of White supremacy is strong, yet we continue to teach this system nearly a century after it was developed. Educational resources should not treat normal variation of the human body as artificially pathological, nor should they promote methods that are not supported by the evidence and that have the potential to do harm via unnecessary medical interventions. This is unacceptable.

Since Caldwell and Moloy developed their classification system, which included reinforcement of racist and sexist stereotypes, anthropology has grown as a discipline into one that thoroughly rejects the biological race concept (Fuentes et al., 2019). Even forensic anthropologists, who are often called on by the criminal justice system to identify race from the skeleton, reject the idea that race determination is possible or helpful (DiGangi & Bethard, 2021). Although anthropologists recommend abolishing the practice of ancestry estimation (which replaced but remains entangled with the concept of biological race), health science fields still have relics of early physical anthropology and its associated racist pseudoscience in their textbooks (Jaschik, 2017), in particular flawed references to pregnancy, labor, and childbirth. As anthropologists who are educators in health science contexts, we are uniquely positioned to recognize the dangers of typologizing the human body under a racial framework.

We therefore recommend that faculty instructors of courses that use these textbooks stop teaching the Caldwell–Moloy classification system of female pelvis shape. We call on textbook editors to go beyond the addition of critiques and instead fully remove the Caldwell–Moloy classification system from their books. Further, this material should be removed from any certification or board exam that might currently include it, and the item writers for these exams should exclude it moving forward. We call for educators who use resources that still refer to this typology to take the time to explain to their students why the typology does not accurately reflect human variation and how it is based on racist stereotypes. Further, we recommend that educators learn about and explain to students how racist hierarchies and assumptions in clinical obstetrics education and practice—even if ostensibly hidden—contribute to health inequalities to the disproportionate detriment of people of color, especially Black people, in the United States.

Instead of teaching pelvis typologies, we recommend that educators and textbook authors and editors focus on acknowledging that many pelvis shapes exist that lead to uncomplicated births resulting in both a healthy parent and neonate. Although it may be useful to describe some pelvic cavity dimensions when discussing a pathologically contracted pelvis, we could not find any scientific evidence of a relationship between clinical pelvimetry and particular birth outcomes. Healthy adults do not lack an appropriately sized and shaped pelvis for their body to function, including the function of childbirth if reproduction is their decision. These typologies form a structure that upholds the patriarchal racist medical hegemony supporting health disparities on the basis of flawed and racist evidence. These systems are so ingrained that providers rely on them as justification for perpetuating different standards of care to different populations. Thus, educators and clinicians are responsible for acknowledging the evidence (or lack thereof) that influences people's ideas about who is and is not capable of childbirth. Our dream is to have truly evidence-based educational materials that teach our students to empower pregnant people to trust their bodies and that are free of the influences of sexist and racist pseudoscience.

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ENDNOTE

[1] In reference to races, we choose to capitalize White to avoid "implicitly affirm(ing) Whiteness as the standard and norm" (Mack & Palfrey, 2020). We agree with Mack and Palfrey (2020) that "Keeping White lowercase ignores the way Whiteness functions in institutions and communities".

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