

**PAPER****ANTHROPOLOGY**

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## Skeletal Indicators of Pregnancy and Parturition: A Historical Review

**ABSTRACT:** Over a century of scientific literature has documented the research and analysis relating to the possible skeletal evidence of pregnancy, parturition, and childcare, yet today, there still exists variation in methodology and interpretation. Historical perspective facilitates understanding of the growth and development of the theories and research currently available to the forensic science community. Review of the relevant literature clearly indicates that specific skeletal alterations are not exclusively connected to obstetrical events. Although parturition and related events have been shown to leave various alterations on bone, the research record also demonstrates that other factors can contribute to the same or similar changes. Additionally, such alterations can often be found in nulliparous women and men and are frequently absent in parous and multiparous women. This literature review calls for the continued exploration of skeletal alterations for determining parity status in human skeletal remains.

**KEYWORDS:** forensic science, forensic anthropology, parturition, parity status, pelvis, skeletal alterations, childbirth indicators

For decades, forensic anthropologists and forensic scientists in related disciplines have discussed the possible effects of pregnancy and parturition on the human skeleton. The topic is important for medical reasons but also for its potential to determine the pregnancy/parturition experience of female skeletal remains and to use this information to assist identification and address other forensic issues. Despite an extensive published literature on the topic focusing on several areas of skeletal alteration, opinion and practice remain varied. However, the extent to which skeletal evidence continues to be used to interpret parity status in forensic casework is obscure. Over the years, research has reported on the preauricular sulcus, separation of the pubic symphysis, osteitis condensans ilii, osteitis pubis, pubic pitting, bone density loss, and extension of the pubic tubercle. Given the broad scope of this research, it is useful to examine and compare variations of the published evidence and survey current knowledge to critically assess whether skeletal alterations can be linked to pregnancy/parturition. Historical perspective is required to understand the development of thought and interpretation, as well as to examine the actual scientific evidence.

### Literature Review

In 1909 and 1911, the London anatomist D.E. Derry (1874–1961) (1,2) called attention to the “sulcus preauricularis” of the ilium as an indicator of female sex, possibly linked with pregnancy. Derry noted previous work by the anatomists Zaaizer (3,4), Löhr (5), and Virchow (6). These authors, along with Aeby (7), had detected human variation in anatomical features of the pelvis, although much of their discussion and interpretation became mired in racial theories of the time. Working with skeletons of ancient Egyptians in Cairo,

Derry (2) noted that the preauricular sulcus was more common and more strongly expressed in female skeletons than in those of men. Like his predecessors, Derry noted that the sulcus was the site of attachment of the sacroiliac ligaments. He suggested that rather than being a racial marker, the sulcus appeared to be a female trait, likely associated with pregnancy, a connection suggested earlier by Aeby (7). Derry noted that during pregnancy, there occurred “some softening of the ligaments, which permits of freer movement than might otherwise be possible” (2, p. 19) that could lead to the development of the preauricular sulcus.

The suggestion that some skeletal variation in the pelvis might be associated with pregnancy and parturition caught the attention of anatomist Todd (1885–1938) (8). Todd had been instrumental in assembling the Hamann-Todd collection in Cleveland Ohio. Focusing on age changes in the pubic bone at the area of the pubic symphysis, he noted in 1921 the difficulty of addressing the parity factor in skeletal collections, “it is always difficult and in most cases impossible to obtain statements regarding children from or in relation to those females who ultimately find their way into our skeletal series” (8, p. 39). Todd added “I do not believe that pregnancy and child-birth leave any permanent stamp upon the skeleton” (8, p. 40).

Interest in this topic continued into the 1920s (9) and 1930s. In 1933, Boland (10,11) noted that although rare, “delivery can produce separation of the symphysis pubis” (11, p. 522), and this can involve “infection, hemorrhage, and laceration of the ligaments” (11, p. 518). Abramson et al. (12) added in 1934 that relaxation of the pelvic joints was normal in pregnancy and likely stimulated by hormones. Thorp and Fray (13) noted that in their 1938 study of 78 cases of pregnancy and labor, 44% indicated a widening of the symphysis pubis an average of 5 mm. Rare complete separation was discussed much later (1996) by Kowalk et al. (14) who suggested that progesterone and relaxin were factors. Alicioglu et al. noted in 2008 (15) that symphysis pubis distance can narrow with advancing age (no association with parity). Putschar (1904–1987)

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(16) also presented evidence in 1931 of anatomical variations in the pelvis and discussed the possible influence of pregnancy and parturition.

In 1956, Wells (17) called attention to "osteitis condensans ilii" a condition detected radiologically that is rarely discussed in the subsequent anthropological literature. Wells noted "a fairly uniform triangular area of increased density in the lower portion of the iliac bone, adjacent to, but not involving the sacroiliac joint" (17, p. 1141). She studied 67 cases of women between the ages of 25 and 65 years with this condition noting that 80% had a record of previous pregnancy. The remaining 20% had no record of pregnancy. A poor association was found with the evidence of urinary tract infection or low back pain. Much later, Kurihara et al. (18) and Brogdon (19) reported the condition almost entirely in parous women, but Kurihara et al. suggested that the condition likely disappears with advancing age because it was not common in older women. In 2010, Mitra (20) reported that pregnancy and osteitis condensans ilii are not clearly correlated because the condition can also be found in nulliparas and men.

Also in 1956, Wiltse and Frantz (21) noted that nonsupportive osteitis pubis was commonly found in men but can occur in women as well. Their research suggested that infection likely caused "spotty resorption" (21, p. 512) of the symphysis pubis with associated notching and moderate widening. Historically, this publication is important in offering an explanation of how morphological pelvic changes similar to those with suggested association with parturition can occur in men, as well as in nonparous women.

Similarly, in 1974, Harris and Murray (22) published data on osteitis pubis. They reported a higher frequency in male athletes than in other men. Radiographs revealed reactive sclerosis in those with the condition. They suggested that repeated minor trauma was the primary influencing factor. They noted that the condition is seen in men following operations on the bladder and prostate as well as treatment from urinary tract infection. They suggested that in men, instability at the symphysis may relate to joint laxity producing "subchondral reactive sclerosis" (22, p. 212). In a separate 1974 article, Harris (23) described pubic lesions in cases of women with multiple pregnancies but also with histories of infection. He noted the similarity of the lesions with those of male athletes.

In 1957, Stewart (24) (1901–1997), concerned about factors influencing age estimation, called attention to anatomical variation in the female pubis in the form of dorsal pitting and the likely influence of pregnancy. Stewart felt that Todd (8) had been too negative on the pregnancy factor, noting that most women represented in the Todd collection likely had no children "for otherwise there would have been children to claim the bodies" (24, p. 16). Stewart noted the scientific literature of the time supporting the notion of "relaxation of the joints of the pelvis during pregnancy" (24, p. 17). He also made the important observation that obstetrical care likely differed markedly between ancient and modern times, possibly explaining the differences seen in female pelvises from those contexts. Stewart found it reasonable that "frequent pregnancies associated with lack of prenatal care traumatize the pubic symphysis over and over again, with resultant bony degenerative changes" (24, p. 17).

Stewart's Smithsonian colleague J. Lawrence Angel (1915–1986) recognized the forensic appeal of being able to associate pelvic skeletal changes with the life events of pregnancy and parturition. Trained in anatomy and a pioneer in the newly developing field of paleodemography, Angel (25) suggested in 1969 that not only skeletal alterations, namely pits around the pubic symphysis, were produced by pregnancy/parturition but that these alterations could be quantified to estimate the number of childbirths. Although there

was no scientific evidence to suggest such calculations were possible, Angel found the possibility of calculating fertility from skeletal remains too tempting to resist. Citing the Putschar (16) and Stewart (24) articles, Angel provided a detailed description of the anatomical structures involved and introduced a system of alteration quantification allowing the calculation of the number of births and thus fertility. As evidence for this system, Angel revealed eight pubic bones of American women of known parity (ages 19–74). One woman with only two documented births showed extensive deep pitting on the posterior surface, which in his system would suggest many more births. In regard to this individual, Angel noted she "clearly has had more actual births than stated or else is pathological" (25, p. 436).

Although the scientific evidence for the association of pelvic skeletal changes with parturition remained weak, the system proposed by Angel was attractive to anthropologists. In 1970, Gejvall (26) presented an analysis of an archeologically recovered skeleton "The Fisherman from Barum-mother of several children!" Gejvall cited the Putschar (16) article as the evidence for the association between childbirth and pelvic changes. He sent photographs of the pelvic alterations noted on the Barum skeleton to Angel at the Smithsonian who estimated between 10 and 12 births. This interpretation complicated the earlier impression that the skeleton was that of a man!

Like Angel (25), Hungarian paleodemographers Acsádi and Nemeskéri stretched the available science to suggest in 1970 "that female fertility can be estimated from the micro-anatomical changes of the female pelvis due to full-term pregnancies. These possibilities have opened up new vistas in paleodemographic research" (27, p. 98). Similar to Angel's work (25), they produced a five-stage classification system based on Putschar's (16) and Stewart's (24) published comments suggesting sequentially the number of pregnancies ranging from 1 to 2 to over 9.

The same year, Stewart (28) injected academic caution into the growing discussion on the correlation of pelvic alterations, specifically to the area of the pubic symphysis, and parturition. He noted that his earlier reports had focused not on parturition but on pathological alterations in relation to age changes in women. He suggested that pubic bones of females can show alterations "that are probably scars attributable to the trauma of parturition" (28, p. 132), concentrated on the dorsal surface. He also noted that modern samples from the Terry collection curated at the Smithsonian revealed "fewer scars of parturition" (28, p. 132) than in Eskimos reinforcing his earlier statement that population differences may reflect obstetric practice. He noted that nine specimens of known parity he had examined revealed that "some women can bear children with a minimum of scarring, or even without any scarring" (28, p. 133). Stewart felt that although extreme examples "seem clearly indicative of parturition...probably it will never be possible to associate accurately the degree of scarring with the true number of complete pregnancies" (28, p. 133), a position he maintained in 1972 (29).

Also in 1970, Atkinson and West (30) suggested that despite adequate calcium intake, lactation produces a loss of skeletal calcium, another likely influence on bone changes. This point was later reinforced by Goldsmith and Johnston (31) and Mensforth and Lovejoy (32). Mensforth and Lovejoy additionally suggested that the presence of unremodeled porotic hyperostosis of the cranial vault, especially in women during their child-bearing years, could be further evidence of bone mineral loss, namely iron and calcium, because of pregnancy. In 1990, Kent et al. (33) suggested that human lactation could lead to reduction in bone density, especially at trabecular bone sites. However, Goldsmith and Johnston (31)

also found a correlation between high bone mineralization and certain types of oral contraceptives. This type of birth control as a whole has a higher user rate in industrialized countries than in non-industrialized countries: "17% vs. 6%" (34, p. 60) showing a possible cultural factor related to bone mineralization that could offset the bone density effects of lactation.

Despite Stewart's (28) cautionary statements, in 1971, Angel continued his influential calibration of supposed pubic evidence of childbirth. His observations included "an unusual spike formation of the pubic tubercle" (35, p. 43) and "enough pubic roughening and pectin sharpness to indicate a good number of pregnancies" (35, p. 48). His case descriptions of individuals from the archeological Lerna site in Greece included such examples as "severe enough exostoses and eroded areas on the pubic bones next to the symphyses to indicate many pregnancies, perhaps nine" (35, p. 54). Angel presented a detailed account of how he thought pregnancy and parturition produced alterations. This account generally described the tearing and stretching of ligaments producing anterior exostoses, posterior pits, and areas of erosion. To Angel, the severity of the alterations directly related to the number of children born.

In 1973, Gilbert and McKern (36) published their study of age changes in female pubic bones based on a large documented modern collection. Following Stewart's (24,28,29) lead, they also discussed pregnancy and childbirth as factors influencing morphology, but departing from the work of Angel (25,35), they suggested that it was not possible to determine the number of pregnancies.

Subsequently (1974, 1975), Houghton (37,38) provided further discussion of possible pelvic skeletal evidence of pregnancy distinguishing two forms of the preauricular sulcus: the groove of ligament (GL) and the groove of pregnancy (GP). He suggested that only a sulcus consisting of a series of pits, the GP, could be found exclusively in women. Houghton's work along with that of Angel (25) and Acsádi and Nemeskéri (27) influenced Ullrich (39,40) to estimate fertility using a comprehensive analysis of changes on the anterior pubis, posterior pubis, preauricular sulcus area of the ilium, and a corresponding area on the sacrum.

Despite the contradictory statements and turmoil in the published literature, in 1976, Ashworth et al. (41) offered a reasoned interpretation in their study of Peruvian mummies. They noted that "scars of parturition" are aspects of the inflammatory disorder "osteitis pubis," discussed earlier (21–23). Although this condition is clinically known more commonly in men, they suggested that it can result in women associated with trauma linked to delivery or walking during pregnancy.

Also in 1976, Putschar (42) clarified his earlier, frequently quoted comments (16) regarding anatomical changes associated with pregnancy. These changes included "resorption and remodeling of the posterior margin of the pubic facette and of the adjacent posterior pubic cortex" (42, p. 591). He also called attention to the retropubic eminence as a key feature.

In 1978, Holt (43) reported on his study of 68 female pelvises from the Hamann-Todd collection in Cleveland which had associated medical records providing information regarding parturition. In this key study, Holt found that about 38% of females with no birth history displayed trace to extensive pitting. About 13% of those with a history of parity displayed trace to small alterations. Those women with alterations but with no record of birth displayed a high incidence of pathological conditions and obesity. Based on this research, Holt concluded that scarring can occur for "a multiplicity of reasons" (43, p. 94) other than parturition. Also in 1978, a general text by El-Najjar and McWilliams (44) reviewed the literature and suggested that a correlation with pregnancy was logical but not

proven. El-Najjar and McWilliams also commented that "no doubt in time appropriate studies will be made which will clarify the question" (44, p. 82).

Such clarification and a major advance were recorded in 1979 with the publication of a study by Suchey et al. (45) on 486 modern American female pubic bones with documented parity. Although they found a correlation of dorsal pitting with the number of full-term pregnancies, it was not strong. They discovered that 17 nulliparous women had medium to large dorsal pits and 22 women with one to five full-term pregnancies displayed no dorsal pits. They also detected an age effect with the expression of pits increasing with age.

Also in 1979, Kelley (46) conducted new research utilizing the Hamann-Todd collection. Attempting to improve on the Holt study (43), he used only women associated with medical records providing definite evidence of parity. In a sample of 198 women, he examined dorsal pubic pitting, the preauricular groove, and the interosseous groove posterior to the auricular area. He found that the combined use of the three traits gave the highest correlation with parity but noted that age was a factor, likely obliterating evidence through remodeling and related changes, a point later (2009) emphasized by Braz (47). No traits or combination of traits were completely diagnostic. These findings were consistent with Stewart's summarizing statement in his influential 1979 text "signs of childbearing sometimes, but not always appear...on the dorsal side of the symphysis pubis...and in the preauricular grooves or sulci of the ilia" (48, p. 107).

In 1980, Bergfelder and Herrmann (49) published important research conducted on 49 pairs of documented female pubic bones with data on births and miscarriages. They found no correlation of the number of births with anterior exostoses and rim protrusion. Pubic bones of those with multiple births displayed rim recession and "tuberculum pubicum formed a slim, conical erection" (49, p. 612). On the posterior pubis, cavity size increased with the number of births. As others had noted before, some changes were found in childless women, and conversely, no changes were detected in some women with multiple births. They also cited age as a factor and argued pelvis structure was important.

The following year, Dee (50) published a radiological study of pelvic bones of 100 men and 200 women. This study documented the female association of the preauricular sulcus and found a slight form present in 65 men. In men, the groove appeared different than found in women, associated with a buttress of bone in some specially shaped pelvic bones. The same year, Brothwell (51), influenced by Houghton (37), suggested an association between the preauricular sulcus and pregnancy/childbirth.

Also in 1981, a Michigan State University doctoral dissertation by Dunlap provided perspective on the preauricular sulcus from a study of the ilia from 67 women and 30 men. Research on this dissecting room sample of known parity suggested that although "well-developed sulci are virtually always associated with female ilia, their absence does not necessarily indicate male" (52, p. 82). He found no relation of the bony changes to the number of pregnancies. Like others, he noted the absence of indicators in some women (including some with a history of parity) and robust evidence of change in some women with no history of pregnancy but acknowledged the possibility of unreported pregnancy. He suggested that factors influencing sulci formation included obstetrical events but also lumbosacral anomalies and sciatic notch angle, sources of sacroiliac instability.

In 1983, Owsley and Bradtmiller (53) continued to use pelvic changes to assess parity in demographic studies of archeologically recovered samples. They suggested that pubic pitting, a preauricular



sulcus, and Schmorl's nodes provided "tentative evidence of previous pregnancies" (53, p. 335). They noted that the Schmorl's nodes held the weakest correlation, but they added that other factors relating to Schmorl's nodes, such as osteoarthritis and vertebral trauma, were not present. Given these findings, they suggested that the stress of pregnancy could be linked to the presence of the nodes.

In 1984, Işcan and Derrick suggested that sex differences in the sacroiliac joint were related to childbirth reflecting a mix of growth adaptation and "functional reaction" (54, p. 97).

In research summarized in a 1986 dissertation at Simon Fraser University, Andersen (55) revisited the Hamann-Todd collection examining pelvic alterations in a sample of 151 women with parity records and 87 men. In regard to dorsal pitting, she found no distinction between nulliparous and multiparous women with rare occurrence in men. These results suggested that "dorsal pubic pitting does not indicate a history of childbirthing events" (55, p. 165). The different manifestations of the preauricular sulcus recognized by Houghton (37,38) also did not demonstrate a relationship with parity. In regard to the interosseous groove, Andersen reported more pitting in women than in men but not a strong association with parity. Andersen concluded that "pelvic scarring cannot predict parity" (55, p. 180) and that pelvic instability from various possible causes likely was the key factor. Her later (1988) abstract (56) discussing this research cited influencing factors in addition to childbirth as occupation, obesity, habitual squatting, and trauma.

Also in 1986, Gamble et al. (57) pointed out that a variety of pathological conditions can affect pubic morphology, including congenital anomalies, infections, inflammatory disease, metabolic and degenerative disease, tumors, and trauma. This perspective was later emphasized by Resnick (58), Judd (59), and Pfeiffer (60). Literature at that time was summarized by Krogman and Işcan (61) and Steele and Bramblett (62). The former text (1986) suggested in regard to pregnancy and parturition that alterations on the dorsal pubic surface and the preauricular sulcus were the "best indicators" (61, p. 259) but the number of children cannot be estimated.

In a 1987 article reporting on their analysis of a historic sample from Philadelphia, Angel et al. (63) did not attempt to quantitate the number of births as Angel (25,35) had carried out previously. They did, however, suggest that increased numbers of births could be detected through observations of skeletal alterations discussed in his earlier publications. In 1988 and 1990, Tague (64,65) emphasized the role of estrogen in pubic bone and ilium resorption through the study of other mammals.

A 1989 dissertation at University College London by Cox (66) and a later journal article (67) introduced new data from Cox's study of 94 women of known parity status originating in the collections of Christ Church, Spitalfields, in London. In her dissertation, after examination of a number of anatomical features discussed in the literature cited earlier, she suggested that "preauricular sulcus and sacral scarring are independent of obstetric events and although the small numbers of females with more than one pubic pit or an extended pubic tubercle had born children, the absence of these features is associated with both parous and nulliparous females" (66, p. 2). She found that alterations were associated with larger pelvises (66,68). In her dissertation, she presented the hypothesis that "if parturition scars relate to obstetric events, the smaller pelvis would be more severely scarred than the larger pelvis" (66, p. 295). However, her data revealed that large pelvises actually exhibited more scarring in the form of a preauricular sulcus, pubic pitting, and sacral scarring. This suggested that these forms of scarring may in fact be caused by something other than parturition. She also reported that multiple pits and extended pubic tubercle (her grade 3 extreme category) were only found in parous women

but the sample sizes were <10. In her later (2000) summary article, Cox (69) emphasized the value of examination of the pubic tubercle extension.

Also in 1989, in a radiographic study of 190 women with known pregnancy history and 110 men, Spring et al. (70) found that the preauricular sulcus was specific for female sex but an "unreliable indicator of past pregnancy history" (70, p. 252). A small subsample of women had radiographs documented both before and after pregnancy; no change was detected. That same year, Saul and Saul (71) suggested that the preauricular sulcus and pubic pits could be interpreted as evidence of pregnancy.

In 1995, Schemmer et al. (72) reported on their clinical radiological study of the paraglenoid sulcus (a term they preferred to the preauricular sulcus) within a large sample of female patients. In 172 subjects, prevalence was about 14%. They noted that deep grooves were found only in parous women and that the grooves deepened with multiple pregnancies. However, despite the evidence that deep grooves were absent in nulliparas, they were only present in a small number of parous women, suggesting that there may be other causes. They also found an association of the grooves with osteitis condensans ilii. Although they suggested that pregnancy may be an important factor, they also noted the importance of obstetric care, genetics, and physical activity.

The contrasting results and recommendations in some of these and earlier studies were summarized and noted by Galloway (73) in 1995 who appropriately urged caution in forensic applications. She also noted the importance of considering cultural factors and temporal changes, which may affect skeletal morphology, specifically drops in birthrates, variation in birthing positions, and increased medical involvement, such as Cesarean sections. In a later article (1998), Galloway et al. (74) recognized body size as a complicating factor. Similar perspective was reported in general texts in 1999 and 2000 by Jurmain (75), Ubelaker (76), and White (77).

In 2003, Snodgrass and Galloway (78) reported on their study of pubic bones from 148 modern women with known parity status. In contrast to the research reported by Cox (66,67,69), they found that "elongation of the pubic tubercle shows no correlation with number of births, but instead is associated with the distance this feature is from the pubic symphysis" (78, p. 1226). They did find a correlation of pitting with parity, but recognized body mass was also a factor. In their view, even the pitting correlation "does not reach the level of accuracy needed for forensic applications at the level of the individual" (78, p. 1230). In 2008, Barker et al. (including Cox) (79) argued that the extended pubic tubercle was the only factor related to parity, although the above study (78) was not mentioned and no new evidence was presented.

## Discussion

The research and discussion summarized earlier suggest that pregnancy and parturition can produce skeletal alterations; however, conclusive evidence that these alterations can be diagnostic of parity status is lacking. The research reports on factors that contribute to these skeletal changes during pregnancy, parturition, and childcare including hormonal shifts, separation of the symphysis pubis, pelvic joint relaxation, general pelvis instability, trauma, and associated pathological conditions sustained during parturition, and lactation. Skeletal alterations connected to these factors may include various manifestations of the preauricular sulcus, osteitis condensans ilii, pubic pitting, trabecular bone loss and sclerosis, pelvic exostoses and erosions, and extension of the pubic tubercle.

However, the research suggests that the skeletal conditions mentioned above also can be produced by factors not related to

pregnancy, in some cases even in men. These factors include general age changes, urinary tract infection, repeated minor trauma, surgery, general joint laxity and pelvic instability, lumbosacral anomalies, variation in sciatic notch angle, occupation-related activity, obesity, habitual posture including squatting, congenital anomalies, metabolic and degenerative conditions, and general pelvic, and body size.

The published literature presents contradictory evidence and discussion relating to the issue of skeletal alterations and their association with childbirth. In this ongoing debate, research initially suggesting that certain features could be diagnostic of childbirth has been disputed by later contributions. Other studies provide evidence that a relation exists between skeletal change and obstetrical events but the resulting alterations are not entirely diagnostic. Moreover, conclusions regarding "parturition scarring" are made with varying degrees of scientific certainty. Although much of the research has been conducted using documented skeletal collections and scientific methods, many publications base their findings on conjecture with little scientific or empirical evidence to support their claims. While the historical perspective provided earlier is informative, a summary of the skeletal alterations suggested to be linked to parity status and the research challenging that association provides enhanced understanding of the topic's current status.

The preauricular sulcus, although mentioned as a seemingly convincing indicator of parturition by Houghton (37,38), was demonstrated to be unreliable in determining parity status by Andersen in her 1986 dissertation (55). Dunlap (52) also concluded that this groove is a clear marker of the female sex but not of parturition. Although the preauricular sulcus has been discussed in this context since at least 1858 (7), research has suggested that it is diagnostic neither of childbirth nor of related events.

Similarly, the separation of the pubic symphysis was linked to parturition by Thorp and Fray (13), but other studies, such as by Alicioglu et al. (15), suggest that pubic symphysis distance can be altered with age. Although Boland (10,11) indicated that such a separation was directly associated with some pregnancies, it is rare and thus not associated with all pregnancies. It also is not clear how such separation contributes to alterations that can be recognized in skeletonized human remains recovered in forensic contexts.

Osteitis condensans ilii was also discussed as a possible indicator of parturition by Wells (17), but Mitra's study (20) shows that there are other causes for this condition. Although it may be present in some parous women, it cannot be considered diagnostic of parity status given its various etiological possibilities.

The same holds true for osteitis pubis, a condition considered to be connected to pregnancy by Ashworth et al. (41) but is shown much earlier to be extensively present in men by Wiltse and Frantz (21). Although Harris (23) suggested it may be found in pregnant women, Harris and Murray (22) found it to be very common among male athletes, and therefore, it does not offer conclusive evidence of pregnancy.

Pitting on the pubic bone has probably been the most widely discussed skeletal alteration in the forensic community in regard to possible skeletal evidence of parturition; however, this association also has been very widely disputed. Putschar (16), Stewart (24), and Angel (25) argued that this skeletal alteration could show evidence of childbearing. However, since these publications, research by Holt (43) and Suchey et al. (45) documented its unreliability. Ultimately, these analyses show that pubic pitting is not an accurate indicator of parturition.

The loss of bone density because of lactation (33) is another skeletal alteration considered for its relation to pregnancy/childcare. However, it was made clear by Goldsmith and Johnston (31) that

bone mineralization can be augmented by some oral contraceptives taken during or immediately after lactation. Of the studies related to this subject, none found that changes in bone density were completely diagnostic of lactation or other elements of childcare.

Cox (66,67,69), after studying other skeletal changes possibly linked to parturition, deemed the extension of the pubic tubercle to be the most reliable indicator of childbirth. Snodgrass and Galloway (78), however, questioned this argument and found that the extension was more likely linked to the morphology of the pelvis than to parturition.

Another area of study discussed in the literature and initially mentioned by Angel (25) is the estimation of the number of births based on the severity of parturition scars. However, this concept has been negated by Gilbert and McKern (36), Suchey et al. (45), Bergfelder and Herrmann (49), and Dunlap (52).

Despite the extensive literature discussing the subject, no feature has yet been found to be indisputably indicative of pregnancy, childbirth, or childcare. The scientific literature indicates that, of the skeletal alterations discussed in relation to pregnancy and parturition, none can be used definitively in a forensic context to indicate that pregnancy/parturition occurred or to estimate the number of childbirths. Although some skeletal alterations may be linked to obstetrical events, other factors are shown to often play an equally important role in the alteration formation. The numerous factors that lead to the skeletal changes discussed above add an element of difficulty in distinguishing between parturition and other etiological events or conditions and thus in determining an individual's parity status in a forensic setting. Moreover, variation between and within populations and over time, especially regarding obstetrical care, birth control methods, birth rate, birthing positions, and medical interference, further complicates the interpretation, suggesting that information linking skeletal alterations to pregnancy and parturition in any one study may not be more broadly applicable over different time periods or locations. Nevertheless, accurate predictive methodology could potentially be generated through research on remains of known parity status using an approach combining observation and measurement of key attributes including pelvic size and morphology with consideration to cultural and temporal factors.

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