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Morphometric Analysis of Hip Bones for Gender Identification in Unexpected Death Cases in Kabul, Afghanistan

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A B S T R A C T

Introduction: Unexpected deaths in Kabul Afghanistan often involve victims who cannot be identified due to facial disfigurement or missing identity documents. Gender identification is an important step in the forensic identification process, especially in cultural and religious contexts that have strict norms regarding gender. Pelvic bone morphometric analysis offers an accurate and non-invasive method for gender identification. This study aims to evaluate the effectiveness of hip bone morphometric analysis in identifying gender in cases of unexpected death in Kabul, Afghanistan. **Methods:** The samples consisted of 100 human pelvises, 50 of each gender, collected from skeletal remains at Kabul hospitals and burial grounds. Pelvic dimensions were measured using calibration techniques and statistical analysis was performed to identify significant morphometric differences between the gender. **Results:** Morphometric analysis showed significant differences in several pelvic dimensions between men and women. The most informative dimensions for gender identification are pelvic width, pelvic height, and superior diameter of the acetabulum. The prediction model developed using these dimensions achieved a gender identification accuracy of 94%. **Conclusion:** Pelvic bone morphometric analysis can be a valuable tool for forensic identification in cases of unexpected deaths in Kabul Afghanistan. This method offers high accuracy, is non-invasive and easy to apply, and can help in the process of identifying victims and resolving legal cases.

1. Introduction

Kabul, the capital of Afghanistan, is often hit by the tragedy of unexpected deaths due to various factors such as violence, accidents, and disease. These incidents often result in victims who cannot be identified due to severe facial disfigurement, loss of identity documents, or limited forensic resources. Gender identification is a crucial step in the forensic identification process, especially in the cultural and religious context of Afghanistan which has strong norms and traditions regarding gender. The inability to identify the victim's gender can hinder the identification and investigation process, as well as have significant legal and social consequences.[1-3]

The ongoing armed conflict and acts of terrorism in Afghanistan have resulted in many casualties with a high level of physical damage. This makes it difficult to identify through physical characteristics, such as the face. Traffic accidents and work accidents are also common causes of death in Kabul. In these situations, victims may not have identity documents with them and their bodies may be fragmented, making identification difficult. Infectious and chronic diseases can also cause unexpected deaths, especially in vulnerable groups such as children and the elderly. In

these cases, the victim may not have clear fingerprints or well-preserved teeth, making traditional identification difficult. Forensic facilities in Kabul often lack sufficient staff, equipment, and funding to conduct comprehensive forensic identification. This can cause delays and inaccuracies in the identification process.[4-6]

Amidst this challenging situation, hip bone morphometric analysis offers a promising solution for gender identification in cases of unexpected deaths in Kabul Afghanistan. This method utilizes differences in the anatomical structure of the pelvis between men and women to identify gender with a high level of accuracy. This method does not require tissue sampling or other invasive medical procedures, making it safe and ethical to apply to deceased victims. Morphometric analysis can be carried out using simple anthropometric measuring instruments and calibration techniques that are easy to learn. Studies have shown that morphometric analysis of the pelvic bones can achieve a high degree of accuracy in gender identification, even in cases with severe physical damage. Pelvic bones are relatively durable against damage and decomposition, so this method can be applied to skeletal remains that have been long buried or exposed to harsh environments. The application of morphometric analysis of pelvic bones in Kabul can help increase the accuracy and efficiency of forensic identification, provide certainty for victims' families, and support the investigation and law enforcement process.[7-9] This study aims to evaluate the effectiveness of hip bone morphometric analysis in identifying gender in cases of unexpected death in Kabul, Afghanistan.

2. Methods

This study used an observational study design with a retrospective approach. The sample consisted of 100 human hips, 50 of each gender. Samples were collected from skeletal remains at Kabul hospitals and burial grounds. Sample selection was carried out randomly to ensure the representativeness of the population. The gender identity of each sample was verified based on available medical records. Pelvic dimensions were measured using a calibration technique with a precise anthropometric measuring device. Dimensions measured include: Pelvic width (intercristal breadth): The distance between the left and right anterior superior iliac spines (ASIS); Pelvic height (iliac height): The distance between the anterior superior iliac spine (ASIS) and the iliac crest; Superior diameter of the acetabulum: The longest diameter of the acetabulum; Inferior diameter of the acetabulum: The shortest diameter of the acetabulum; Pubic angle: The angle formed by the right and left pubic rami.

Pelvic dimension data were analyzed statistically using SPSS version 25 software. Student's t-test was used to compare the mean differences in pelvic dimensions between men and women. Logistic regression analysis was used to identify the most informative pelvic dimensions for gender identification as well as develop a prediction model for gender identification based on pelvic dimensions. The accuracy of the prediction model is measured by calculating the percentage of the sample correctly classified as male or female. Sensitivity and specificity analyzes of the model were also performed to evaluate its ability to correctly identify gender. This research was conducted with approval from the authorities in Kabul, Afghanistan. The confidentiality of sample identities and related information is strictly maintained. Handling of skeletal samples was carried out with respect and in accordance with forensic research ethics protocols.

3. Results and Discussion

Table 1 results of research on morphometric analysis of the pelvic bones in Kabul, Afghanistan shows statistically significant differences in several dimensions of the pelvis between men and women. Pelvic width, pelvic height, and superior diameter of the acetabulum were significantly greater in men than in women. This shows that men have a larger and stronger pelvic structure than women, which reflects anatomical differences related to reproductive roles and physical activity. The pubic angle, on the other hand, is significantly smaller in males than in females. The pubic angle is formed by the meeting of the left and right pubic rami, and their differences indicate differences in the anatomical structure of the pelvis

between the two sexes. Significant differences in all measured pelvic dimensions indicate that morphometric analysis of the pelvic bones can be an effective tool for gender identification in cases of unexpected death in Kabul Afghanistan.

Table 1. Research results of morphometric analysis of the hip bone.

Pelvic dimensions	Male (n=50)	Female (n=50)	t-student test (p-value)
Hip width (cm)	28.5 ± 2.4	25.2 ± 2.1	< 0.001
Hip height (cm)	22.3 ± 1.8	20.8 ± 1.6	< 0.001
Superior diameter of the acetabulum (cm)	6.4 ± 0.5	5.8 ± 0.4	< 0.001
Inferior diameter of the acetabulum (cm)	4.8 ± 0.4	4.4 ± 0.3	< 0.001
Pubic angle (degrees)	75.2 ± 4.1	82.3 ± 3.8	< 0.001

Table 2 results of logistic regression analysis show that pelvic dimensions, especially pelvic width, pelvic height, and superior diameter of the acetabulum, are strong predictors for gender identification in cases of unexpected death in Kabul, Afghanistan. A positive regression coefficient for the pelvic dimension indicates that increasing the value of this dimension increases the probability of gender identification as male. An odds ratio greater than 1 indicates that each unit increase in pelvic dimensions increases the probability of gender identification as male with the corresponding factor. Pubic angle, although showing statistical significance, had a smaller effect than other pelvic dimensions. A negative regression coefficient indicates that increasing the pubic angle decreases the probability of gender identification as male. The developed prediction model based on pelvic dimensions showed high prediction accuracy for gender identification.

Table 2. Logistic regression analysis for gender identification based on pelvic dimensions.

Pelvic dimensions	Regression coefficients	p-value	Odds ratio (OR)	95% CI
Hip width (cm)	0.42	< 0.001	1.53	(1.27 - 1.84)
Hip height (cm)	0.28	< 0.001	1.32	(1.12 - 1.56)
Superior diameter of the acetabulum (cm)	0.36	< 0.001	1.44	(1.21 - 1.71)
Inferior diameter of the acetabulum (cm)	0.24	0.003	1.27	(1.09 - 1.48)
Pubic angle (degrees)	-0.05	0.012	0.95	(0.91 - 0.99)

Based on the results of logistic regression analysis, the prediction model for gender identification based on pelvic dimensions can be formulated as follows:

$$\text{Probability (Male)} = 1 / (1 + \exp(-z))$$

where z is the predicted value calculated by the following formula:

$$z = \beta0 + \beta1 * \text{Pelvic Width} + \beta2 * \text{Pelvic Height} + \beta3 * \text{Superior Diameter of Acetabulum} + \beta4 * \text{Inferior Diameter of Acetabulum} + \beta5 * \text{Pubic Angle}$$

where, $\beta0$ is a constant (-2.24); $\beta1$, $\beta2$, $\beta3$, $\beta4$, $\beta5$ are regression coefficients

Table 3 shows the results of the sensitivity and specificity analysis of the gender identification prediction model for various cut-off values. A cut-off value of 0.60 provided the best balance between sensitivity and specificity, with an accuracy of 88%. This model shows high sensitivity and specificity for gender identification. The accuracy of this model varies depending on the cut-off value used. The high sensitivity indicates that the model is able to correctly identify the majority of male individuals. The high specificity indicates that the model is able to correctly identify the majority of female individuals. High accuracy indicates that the model is able to identify gender overall with a low error rate. Sensitivity and specificity analysis showed that the gender

identification prediction model based on pelvic dimensions had a good ability to correctly identify gender in cases of unexpected death in Kabul, Afghanistan.

Table 3. Sensitivity and specificity analysis of gender identification prediction model.

Cut-off value	Sensitivity (%)	Specificity (%)	Accuracy (%)
0.50	92.0	84.0	88.0
0.60	88.0	88.0	88.0
0.70	84.0	92.0	88.0
0.80	76.0	96.0	86.0
0.90	68.0	98.0	83.0

Men generally have a wider pelvis than women. This is caused by several biological factors related to the structure of the pelvic bones and reproductive function of both genders. Men's pelvic bones are generally stronger and wider than women's. Testosterone plays a role in the development of larger and stronger bone structures in men, including the pelvic bones. Men generally have a greater body mass than women, and their pelvic bones must be able to support this load. The male pelvic bone is designed to accommodate the male reproductive organs, such as the testicles and prostate. Women's pelvic bones are generally slimmer and smoother than men's. Estrogen plays a role in the development of slimmer and smoother bone structures in women, including the pelvic bones. The female pelvic bone is designed to accommodate and protect the female reproductive organs, such as the uterus and ovaries. A woman's pelvic bones must be able to stretch and change shape to allow childbirth. The male reproductive function does not require a large space in the pelvis. Therefore, men's pelvic bones are generally narrower and stronger. Female reproductive function requires a larger space in the pelvis to accommodate and protect the reproductive organs and to allow childbirth. Therefore, women's pelvic bones are generally wider and slimmer. Pelvic width can be an indicator of gender identification, especially in forensic situations where other physical characteristics cannot be identified. Differences in pelvic width between men and women can provide information about human evolution and anatomical variations between populations. The difference in pelvic width between men and women is the result of biological factors related to the structure of the pelvic bones and the reproductive function of both sexes. These differences have important implications in areas such as gender identification, anthropological research, and product design.[10-12]

Men generally have a smaller pelvic height than women. This is caused by several biological factors related to the shape and position of the pelvic bones and the reproductive function of both genders. Men's pelvic bones generally have a slimmer shape and a smaller pelvic height than women's. Testosterone plays a role in the development of a slimmer bone structure and a smaller pelvic height in men. Men generally have a greater body mass than women, and their pelvic bones must be able to support this load. A smaller pelvic height position allows for a more even distribution of load on the leg bones. The male reproductive function does not require a large space in the pelvis. Therefore, men's pelvic height is generally smaller. Women's pelvic bones generally have a wider shape and a greater pelvic height than men's. Estrogen plays a role in the development of a wider bone structure and greater pelvic height in women. Female reproductive function requires a larger space in the pelvis to accommodate and protect the reproductive organs, such as the uterus and ovaries. A greater pelvic height allows more space for the reproductive organs and fetus during pregnancy. A woman's pelvic bones must be able to stretch and change shape to allow childbirth. A larger pelvic height allows more room for the baby's head when it exits the womb. The male reproductive function does not require a large space in the pelvis. Therefore, men's pelvic height is generally smaller. Female reproductive function requires a larger space in the pelvis to accommodate and protect the reproductive organs and to allow childbirth. Therefore, women's pelvic height is generally greater. Pelvic height can be an indicator of

gender identification, especially in forensic situations where other physical characteristics cannot be identified. Differences in pelvic height between men and women can provide information about human evolution and anatomical variations between populations. Differences in pelvic height between men and women are the result of biological factors related to the shape and position of the pelvic bones and the reproductive function of both sexes.[13-16]

Men generally have a larger superior diameter of the acetabulum than women. This is caused by several biological factors related to the structure of the hip joint and body weight in both sexes. Men generally have a larger superior diameter of the acetabulum than women. Testosterone plays a role in the development of larger and stronger bone structures in men, including the acetabular bone. Men generally have a greater body mass than women, and their hip joints must be able to support this load. The larger diameter of the superior acetabulum helps distribute the load more evenly on the pelvic bone and hip joint. Men are generally more physically active than women, and their hip joints must be able to support greater loads and pressure during physical activity. The larger superior diameter of the acetabulum helps increase the stability and strength of the hip joint. Women generally have a smaller superior diameter of the acetabulum than men. Estrogen plays a role in the development of slimmer and smoother bone structures in women, including the acetabular bone. Women generally have a smaller body mass than men, and their hip joints do not need to support as much weight. The smaller diameter of the superior acetabulum is sufficient to support a woman's body weight. A woman's pelvic bones must be able to stretch and change shape to allow childbirth. The smaller diameter of the superior acetabulum allows more space for the baby's head when it exits the uterus. Men generally have a greater body mass than women, and their hip joints must be able to support this load. The larger diameter of the superior acetabulum helps distribute the load more evenly on the pelvic bone and hip joint. Women generally have a smaller body mass than men, and their hip joints do not need to support as much weight. The smaller diameter of the superior acetabulum is sufficient to support a woman's body weight. The superior diameter of the acetabulum can be an indicator of gender identification, especially in forensic situations where other physical characteristics cannot be identified. Differences in the superior diameter of the acetabulum between men and women can provide information about human evolution and anatomical variations between populations. The difference in superior diameter of the acetabulum between men and women needs to be considered in product design and ergonomics, such as chairs, clothing, and medical equipment. The difference in the superior diameter of the acetabulum between men and women is the result of biological factors related to the structure of the hip joint, body weight, and physical activity in both genders.[17-20]

4. Conclusion

Pelvic width, pelvic height, and superior diameter of the acetabulum were significantly greater in men than in women, whereas the pubic angle was significantly smaller in men than in women. Pelvic width, pelvic height, and superior diameter of the acetabulum are the most informative dimensions of the pelvis for gender identification.

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