

Morphological Classification of Female Abdominal-Hip and Crotch Regions for Menstrual Pants Design

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Abstract

Existing menstrual pants often suffer from poor fit, which can cause side leakage. While research on female lower-body is crucial for structural design, studies on abdominal and crotch morphology remain insufficient. This study therefore aims to analyze and classify the morphology of women's abdominal-hip and crotch regions. Anthropometric data were collected from 143 female subjects aged 18-50 years wearing size L menstrual pants. Factor analysis identified four key factors: circumference, crotch length, width, and crotch depth. Cluster analysis classified abdominal-hip morphologies into three types (flat abdomen-flat hip, thick abdomen-flat hip, slender abdomen-prominent hip) based on abdominal-hip difference and hip protrusion degree; and crotch morphologies into three types (H-shaped medium crotch, A-shaped short crotch, V-shaped long crotch) based on the crotch width-length index. The bottom crotch points were categorized into anterior type (51.75%) and posterior type (48.25%). These findings provide an anthropometric basis for the structural design of differentiated menstrual pants.

Keywords: Menstrual Pants; Crotch Width; Anthropometry; Body Shape Classification; Structural Research

1 Introduction

With the rapid development of the women's health industry, menstrual pants, as a new type of hygiene product, show explosive growth in market size [1]. A typical menstrual pant consists of a waist, abdomen, and hip area, and a crotch area. The waist-abdomen-hip area is mainly composed of elastic panel, mostly made of non-woven fabric. Elastic bands are set around the waist edge to fit the body. The crotch area consists of a liquid-permeable topsheet, a distribution layer for rapid liquid diffusion, an absorbent core, a leak-proof barrier layer, and barrier cuffs.

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Its main functions are to absorb menstrual blood, reduce leakage, and provide a comfortable, well-fitting wearing experience [2].

However, surveys find that over 80% of women experience side leakage during menstruation, with the proportion of lateral-posterior leakage reaching 87.14%. Furthermore, nearly half of such leakage results from insufficient fit between the crotch structure of menstrual pants and the human body [3-6]. The current national standard for menstrual pants is primarily based on hip circumference and uses the maximum waist circumference as a sizing reference. Meanwhile, most brands in the market provide weight recommendations in addition to the hip circumference sizes specified in the national standard, as a reference for purchasing. Taking size L as an example: the national standard specifies a hip circumference of 85-105 cm and a maximum waist circumference of 105 cm, while market guidelines suggest a weight range of 45-70 kg. As these sizing systems are primarily based on hip measurements rather than crotch measurements, they may contribute to inadequate fit in the crotch area of menstrual pants. Additionally, surveys reveal that menstrual pants also have issues with poor fit around the abdomen and hips. Against this backdrop, research focuses on the morphology of women's abdominal-hip and crotch regions. Hualei Chen collects data on the hip-crotch region from 98 women aged 20-28 years. Through analysis, she selects the hip protrusion angle as the clustering index and classifies the hip-crotch morphology of women during menstruation into 3 types [7]. Xia Yan randomly selects 200 female college students, extracts hip data using a 3D scanner, and obtains 4 types of gluteal region curves through clustering [8]. Kaixuan Liu et al. select 116 young women aged 20-30 years, extract 14 lower-limb anthropometric dimensions using 3D scanning, and classify lower-body morphologies into 3 categories based on the hip-waist difference [9]. Wu W selected 179 young women, obtained 85 lower body anthropometric data, chose the abdomen-hip differential of the second principal component as a key indicator, and classified the lower body into 9 types [10]. While the above studies explore the characteristics of women's lower-body shapes, current research primarily focuses on hip morphology and waist-hip differences, with insufficient attention to abdominal morphology. Only a limited number of studies have addressed abdominal morphology. For instance, Yijia Yan selected 165 Chinese women aged 50-59 years, obtained 23 characteristic parameters of abdominal convexity via 3D scanning, screened 133 samples with abdominal convexity, summarized five main morphological parameters, and classified abdominal morphology into four types [11]. Although this study provides an important reference for classifying abdominal morphology, its subjects were middle-aged and elderly women, whose age range differs from that of the main consumer group for menstrual pants. Thus, research on abdominal morphology among users of menstrual pants remains insufficient.

Furthermore, because the thighs and hips obstruct the crotch curve, existing menstrual pants are mostly modified versions of ordinary underwear. They focus on local adjustments such as lengthening the crotch panel and optimizing crotch width. But they lack research based on the morphological characteristics of the human crotch [12-17]. Moreover, menstrual pants, unlike regular underwear, must be able to absorb menstrual blood. Therefore, it is necessary to clarify the crotch morphology and the position of the vaginal opening. Based on this, this study uses custom measurement items for crotch length and width. This study combines a Martin measuring instrument and 3D scanning technology, with SPSS analysis software. It systematically analyzes and classifies the morphological characteristics of women's abdominal-hip and crotch regions. The goal is to provide a reference for the fit design of menstrual pants.