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Conference Abstract

Female Cycling Movement: How to Construct Biomechanical Digital-Twins

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Abstract:

Cycling witnesses an increasing number of women breaking barriers and inspiring change. Despite these advancements, there remains significant work to achieve full equality and recognition for women cyclists. Key gender gaps persist in:

- **Ergonomics and performance optimization:** The cycling industry largely focuses on tacit and explicit knowledge on male physiology, neglecting the distinct needs of female cyclists. This results in equipment and training regimens that may not be optimal for women's bodies, potentially leading to discomfort and sub-optimal performance.
- **Understanding and preventing injuries:** Research has primarily focused on male cyclists, leaving significant knowledge gaps on prevalence and specific types of injuries in women due to cycling. This lack of understanding hinders the development of appropriate prevention strategies, treatment protocols and performance optimization in elite athletes and recreants.
- **Inclusive design:** From bicycle design to infrastructure development, the industry often overlooks the specific needs and preferences of female cyclists. This creates an environment where women might feel less safe, comfortable, or catered to, potentially perpetuating the existing participation gap.

The biomechanics of women exercising significantly differ from those of men, starting with notable distinctions in skeletal anatomy. Women typically have a wider pelvic region, shorter legs, and an increased femoral angle from hip to knee. Additionally, women generally exhibit greater joint mobility and more flexible ligaments compared to men. Beyond skeletal differences, there are substantial disparities between female and male skeletal muscles, including variations in energy metabolism, fiber type composition, and contractile speed. Additionally, fat storage patterns differ significantly, shifting the center of gravity's location, with women primarily storing fat subcutaneously in the breasts, buttocks, and thighs, while men tend to accumulate visceral fat within the abdomen.

These differences have profound implications for performance, injury risk, and equipment needs. Despite their significance, current biomechanical models often fall short. Many models treat females as scaled-down versions of males, leading to inaccurate assessments and overlooking the unique needs of female athletes. This oversimplification hinders the development of appropriate equipment, limits our understanding of female athletic performance, and potentially contributes to an increased risk of injuries for women in sports.

We aim to analyze specific kinematics and dynamics of female cyclist using 4D movement measurements (3D+time) combined with medical imaging and numerical simulations to achieve accurate biomechanical human models. The research will provide valuable insights into the biomechanics of females both athletes as well as non-athletes presenting with even larger variance in body sizes.

In this paper we outline our scientific methodology that we will use to that end: combining 4D body scanning, medical imaging and numerical simulations to acquire next generation biomechanical models.

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