RAE2026

Analysis of 3D and 4D Body Surfaces for Design of Sport-Specific Activewear

Prof. Yick Kit-lun

SFT PolyU – UoA38

11.2025

Contents

Title: Analysis of 3D and 4D Body Surfaces for Designing Sport-Specific Activewear

Descriptor

Following a pilot study of dentist bra design in 2020, this research is supported by grants from Innovation and Technology Fund (ITF), General Research Fund (GRF) and Sports Science and Research Funding Scheme (SRFS), totaling HK$5 million (2021-2025). The project integrates 4D scanning technology to add a time-based dimension, addressing the extent of body movement for sport-specific activewear design that conforms to human anatomy by analyzing the dynamic deformation of the body surface during exercise. This approach equips designers with precise material properties and appropriate compression for target support, significantly enhancing the prediction for tailored, sports-specific support and performance across various sports.

By applying 4D dynamic body mapping and biomechanical analysis, the project has formulated data-driven activewear solutions that address the unique needs of different athletic populations. This innovation enables the creation of running leggings and sports bras that precisely accommodate movement patterns, muscle oscillations, breast kinematics, and growth variations, ensuring optimal support and comfort for elite athletes, recreational athletes and adolescent girls.

This work has resulted in publications in 16 peer-reviewed journals and conferences, garnered awards at international conferences, including the Outstanding Research Paper Award at TBIS 2024 in Korea and the Best Paper Award at ICTEAA 2024 in Italy. Over 600 custom-fitted sports bras for elite racket sports athletes were used during the 2024 Paris Summer Olympics and the 2025 National Games. A collection of tailored sports bra designs for cycling, softball, hockey, and tennis, incorporating fashion into 3D and 4D breast shape analysis, was showcased in a Paris exhibition in June 2024. The study has been shared through educational workshops at the Hong Kong Sports Institute and interactive sessions in secondary schools, fostering dialogue between researchers, practitioners, and the public on the importance of science-based sportswear design.

Prof. YICK Kit-lun

Prof. Yick specialises in ergonomic design to improve human well-being, focusing on patient clothing, activewear and footwear. She integrates 3D anthropometry, biomechanical analysis and material science to enhance comfort and functionality, particularly for vulnerable populations. Her research involves developing advanced manikin systems for bra evaluation (MCO1) and applying 4D motion analysis to optimise sports bra fit and support for elite athletes (the current MCO3), translating biomechanical data into improved movement and power efficiency. She has also established robust methods to predict pressure distribution and combine foot biomechanics and dynamic anthropometry to design custom orthotic insoles for diabetic patients (MCO2).

Prof. Yick's role in research projects is characterised by her ability to define design criteria, propose material innovations and develop prototypes that address sports, rehabilitation, and personalized care needs. She maintains scientific rigor by establishing objective assessment frameworks to evaluate prototype performance. In addition to government funding, her collaborative network includes the Hong Kong Intimate Apparel Industries' Association, Hong Kong Sports Institute, activewear brands, global testing and certification firms, healthcare institutions, NGOs, and the Laboratory for Artificial Intelligence in Design under InnoHK. These partnerships reflect her commitment to interdisciplinary collaboration, ensuring that her work contributes to both academic advancement and practical benefits for industry and society.

Prof. YICK Kit-lun

Multi-disciplinary Research

Co-investigators

DR. YU ANNIE
Assistant Professor, PolyU

Apparel Ergonomic Designer

DR. SUN YUE
Lecturer, Zhejiang Sci-Tech University

Biomechanical Engineer

PROF. YIP JOANNE,
Professor, PolyU

Materials Scientist

Supporting & Collaborating Partners

Hong Kong Intimate Apparel Industries' Association 香港內衣業聯會 HKIATA

AiDLab Laboratory for Artificial Intelligence in Design 人工智能設計研究所

HONG KONG SPORTS INSTITUTE 香港體育學院

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Dr. Yu, applies ergonomic principles to activewear design, leading the integration of 3D and 4D scanning data to create functional, supportive designs tailored to athletes' movement and performance needs.

Dr. Sun, a biomechanical engineer, conducts biomechanical modeling and analyses human movement and mechanics, providing essential data to optimise activewear design for improved support and comfort.

Prof. Yip, a material scientist, develops innovative material structures for activewear, focusing on aesthetics, structural integrity, and optimal body support to enhance both garment performance and user experience.

Research Questions

Activewear design and evaluation primarily rely on 3D body shape analysis. However, the human body is a complex structure formed by various tissues, which undergoes continuous changes in shape, volume and behavior during physical activities. The scientific understanding of body motion and 4D body surface deformations during different sports remains limited. Understanding the biomechanics of the human body in relation to body position, planes of motion and body support is crucial for designing activewear that accommodates the unique characteristics and needs of individuals in each sport. The research questions of this project are as follows:

a) How does the human body deform during various physical activities and high-impact exercises?

b) What are the areas of high stress and strain within the body soft tissue during sports, and how can activewear design reduce these factors?

c) Can changes in body surface and deformations be scientifically quantified, predicted and validated using finite element modelling or motion capturing techniques?

d) Can the results of 3D and 4D body surface changes and deformations be used to design activewear corresponding to individual sports for optimal fit and support?

Research Outputs

- During physical activities, significant changes occur in body shape geometry, with deformations of soft tissues. Activewear design must account for varying fit, support and compression needs across motion planes and postures, influenced by age, body geometry, sizes and the type and intensity of the activity.
- Understanding body region-specific stress and strain enables new insights in activewear design and material selection, reducing excessive stress by offering targeted support and compression in critical areas, thus providing precise protection against high stresses and impact forces during sports.
- Body surface changes and deformations can be scientifically quantified and validated by using finite element modeling and motion capturing techniques. A nonlinear, multi-component dynamic finite element model has been developed to provide a clear picture of the breast biomechanical behavior during motion.
- 3D and 4D body surface data help determine geometric features, hyper-elastic parameters and regional movements of the human body. A series of sport-specific activewear has been designed for a tailored fit and support, catering to specific sports and individual athlete needs

Research findings were published in 16 journals and conferences from 2022 to 2025. Custom-fitted sports bras, designed for elite athletes on tennis, squash and badminton teams, are intended for use during the 2024 Paris Summer Olympics. More tailored sports bra designs integrating fashion with 3D and 4D breast shape analysis are set to be further showcased at a Paris exhibition in June 2024, highlighting PolyU's research strength and creativity. Collaborations have included research on supportive bra designs for female dentists, featured in an interview with Dental Tribune (Germany), contract research on running-specific leggings and seminars with leading lingerie and sportswear companies as well as engagements with the Hong Kong Intimate Apparel Industries' Association. Knowledge transfer efforts continued with workshops at the Hong Kong Sports Institute and interactive sessions at secondary schools, aiming to educate and engage younger audiences.

Research Outputs

This research is supported by local government funds & the Sports Science and Research Funding Scheme ***(HK$6M)***

	Category	Details
01	**Journal Papers**	• **Yick KL,** Keung YC, Yu A, Wong KH, Hui KT, Yip J. (2022). Sports bra pressure: Effect on body skin temperature and wear comfort. *International Journal of Environmental Research and Public Health*, 19, 15765 • Chan, MK, Li PL, **Yick KL,** Yip J, Ng, SP. (2024). Exploration of textile–silicone composites and materials for personal impact-resistant protection. *Materials,* 17, 1439. • Chen J, Sun Y, Liu QL, Yip J, **Yick KL.** (2024). Construction of multi-component finite element model to predict biomechanical behaviour of breasts during running and quantification of the stiffness impact of internal structure. *Biomechanical & Modelling in Mechanobiology,* 23, 1679–1694. • Kwan MY, Tu YF, **Yick KL,** Yip J, Li NW, Yu A, Lo K-W. (2024). Enhancing force absorption, stress–strain and thermal properties of weft-knitted inlay spacer fabric structures for apparel applications. *Polymers,* 16(21), 3031. • Liu Q, **Yick KL**, Sun Y, Yip J. (2024) Ultra-dense motion capture: An exploratory full-automatic approach for dense tracking of breast motion in 4D. *PLOS ONE* 19(2), e0299040. • Kwan MY, **Yick KL**, Yip J, Li NW, Yu A, Lo KW. (2024). Breast geometry and sports bra design study for adolescent girls. *Journal of Fiber Bioengineering and Informatics*. 17(4), 233-243 • Chen J, Zhong Z, Sun Y, Yip J, **Yick KL**. (2025). Dynamic simulation of breast behaviour during different activities based on finite element modelling of multiple components of breast. *Scientific Reports,* 15, 3659 • Chen J, Keung YC, Sun Y, Yip J, **Yick KL**. (accepted). Exploration of breast motion under different activities and intensities. *Journal of Engineered Fibers and Fabrics*.

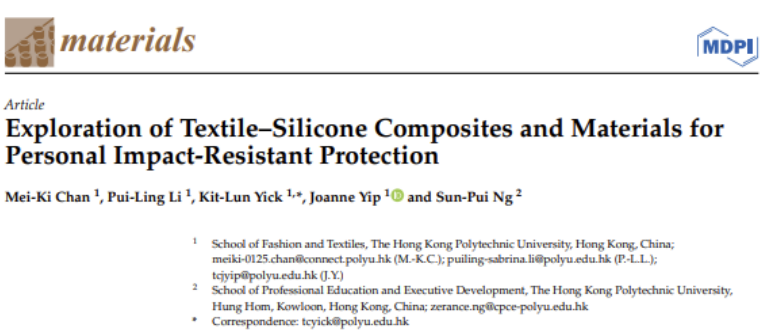
Research Outputs

	Category	Details
02	**Conference Papers**	• Keung YC, **Yick KL,** Yip J, Yu A. (2023). Ergonomic design of badminton-specific sports bras for athletes. The 92nd Textile Institute World Conference 2023, Jul 3–6, 2023, University of Huddersfield, Huddersfield, UK. • Keung YC, **Yick KL.** (2024). Exploring the impact of body shape on bra fit: integrating 3D body scanning and traditional patternmaking methods. International Conference on Textile Engineering and Applied Arts, Aug 22–23, 2024, Rome, Italy. • Chen J, Sun Y, Yip J, **Yick KL.** (2024). Optimizing 3D shape parameters of sports bra pads in motion by finite element dynamic modelling with inverse problem solution. International Conference on Textile Engineering and Applied Arts, Aug 22–23, 2024, Rome, Italy. • Zhong Z, Kwan MY, **Yick KL.** (2024). Novel seamless sports bra designs for adolescent girls. The Symposium on Sports Science & Technology 2024, Hong Kong. • Kwan MY, **Yick KL,** Yip J, Li NW, Yu A, Lo KW. (2024). Breast anthropometry measurements of Chinese adolescent girls for sports bra design. 17th Textile Bioengineering and Informatics Symposium (TBIS), 2024, Daegu, Korea. • Zhang LY, Zhou X, **Yick KL.** (2024). Impact of bra usage on upper body measurements and biomechanical performance in tennis athletes. The Symposium on Sports Science & Technology 2024, Hong Kong. • Chan MK, **Yick KL,** Yip J, Ng SP. (2024). Breast protective equipment usage and perception among female contact sports players. The Symposium on Sports Science & Technology 2024, Hong Kong. • Liu Q, Zhang LY, Xiao Q, **Yick KL.** (2024). Quantifying breast regional deformation during fast walking with 4D scanning. The Symposium on Sports Science & Technology 2024, Hong Kong.

Research Outputs

	Category	Details
03	**Patents**	• 能適應胸型變化、一體成型的無縫運動內衣 China Patent filed on 5 November 2024 • 運動文胸 China Patent filed on 18 June 2025
04	**Designs**	• Sport-specific leggings • Sport-specific sports bras

Research Outputs | 01 Journal Papers



materials

MDPI

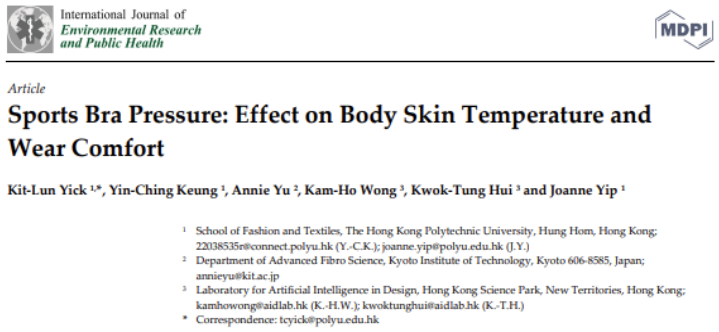
Article

Exploration of Textile–Silicone Composites and Materials for Personal Impact-Resistant Protection

Mei-Ki Chan [1], Pui-Ling Li [1], Kit-Lun Yick [1,*], Joanne Yip [1] and Sun-Pui Ng [2]

[1] School of Fashion and Textiles, The Hong Kong Polytechnic University, Hong Kong, China; meiki-0125.chan@connect.polyu.hk (M.-K.C.); puiling-sabrina.li@polyu.edu.hk (P.-L.L.); tcjyip@polyu.edu.hk (J.Y.)
[2] School of Professional Education and Executive Development, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China; zerance.ng@cpce-polyu.edu.hk
* Correspondence: tcyick@polyu.edu.hk

Chan, MK, Li PL, Yick KL, Yip J, Ng, SP. (2024). Exploration of Textile–Silicone Composites and Materials for Personal Impact-Resistant Protection. *Materials*, 17, 1439.



International Journal of Environmental Research and Public Health

MDPI

Article

Sports Bra Pressure: Effect on Body Skin Temperature and Wear Comfort

Kit-Lun Yick [1,*], Yin-Ching Keung [1], Annie Yu [2], Kam-Ho Wong [3], Kwok-Tung Hui [3] and Joanne Yip [1]

[1] School of Fashion and Textiles, The Hong Kong Polytechnic University, Hung Hom, Hong Kong; 22038535r@connect.polyu.hk (Y.-C.K.); joanne.yip@polyu.edu.hk (J.Y.)
[2] Department of Advanced Fibro Science, Kyoto Institute of Technology, Kyoto 606-8585, Japan; annieyu@kit.ac.jp
[3] Laboratory for Artificial Intelligence in Design, Hong Kong Science Park, New Territories, Hong Kong; kamhowong@aidlab.hk (K.-H.W.); kwoktunghui@aidlab.hk (K.-T.H.)
* Correspondence: tcyick@polyu.edu.hk

Yick KL, Keung YC, Yu A, Wong KH, Hui KT, Yip J. (2022). Sports bra pressure: effect on body skin temperature and wear comfort. *International Journal of Environmental Research and Public Health*, 19, 15765.

Original article

JOURNAL OF ENGINEERED FIBERS AND FABRICS

Exploration of breast motion under different activities and intensities

Journal of Engineered Fibers and Fabrics
Volume 20: 1–11

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Jiazhen Chen[1], Yin ChingDoris Keung[1], Yue Sun[2], Joanne Yip[1] and Kit-Lun Yick[1]

Chen J, Keung YC, Sun Y, Yip J, Yick KL. (2025). Exploration of breast motion under different activities and intensities. *Journal of Engineered Fibers and Fabrics*. 20:1-11.

[Article]

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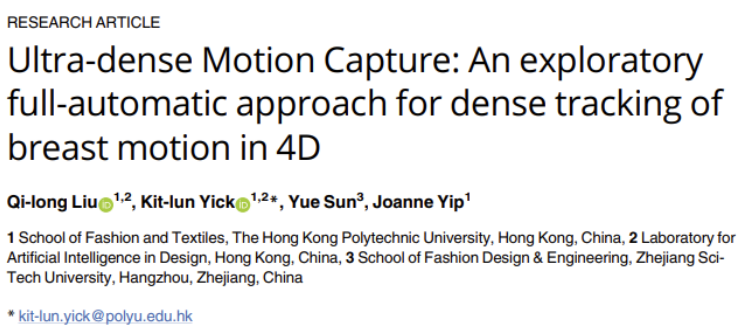
Chen J, Sun Y, Liu QL, Yip J & Yick KL. (2024). Construction of multi-component finite element model to predict biomechanical behaviour of breasts during running and quantification of the stiffness impact of internal structure. *Biomechanics and Modeling in Mechanobiology*, 23. 1679-1694.

Research Outputs | 01 Journal Papers



RESEARCH ARTICLE

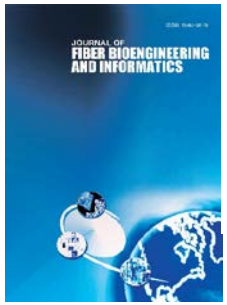
Ultra-dense Motion Capture: An exploratory full-automatic approach for dense tracking of breast motion in 4D

Qi-long Liu[1,2], **Kit-lun Yick**[1,2]*, **Yue Sun**[3], **Joanne Yip**[1]

1 School of Fashion and Textiles, The Hong Kong Polytechnic University, Hong Kong, China, **2** Laboratory for Artificial Intelligence in Design, Hong Kong, China, **3** School of Fashion Design & Engineering, Zhejiang Sci-Tech University, Hangzhou, Zhejiang, China

* kit-lun.yick@polyu.edu.hk

Liu Ql, Yick Kl, Sun Y, Yip J (2024) Ultra-dense Motion Capture: An exploratory full-automatic approach for dense tracking of breast motion in 4D. *PLOS ONE* 19(2): e0299040.



Breast Geometry and Sports Bra Design Study for Adolescent Girls

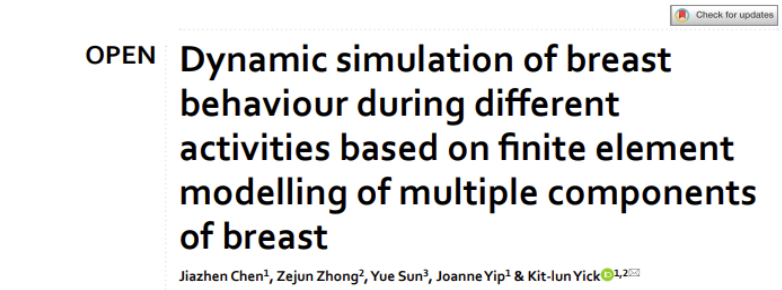
Mei-Ying Kwan, Kit-Lun Yick, Joanne Yip, Nga Wun Li, Annie Yu & Ka-Wai Lo

DOI: 10.3993/jfbim01572

Journal of Fiber Bioengineering & Informatics, 17 (2024), pp. 233-243.

Published online: 2024-12

Kwan MY, Yick KL, Yip, J, Li NW, Yu A, Lo KW. (2024). Breast Geometry and Sports Bra Design Study for Adolescent Girls. *Journal of Fiber Bioengineering and Informatics*. 17 (4). 233-243.



scientific reports

OPEN

Dynamic simulation of breast behaviour during different activities based on finite element modelling of multiple components of breast

Jiazhen Chen[1], Zejun Zhong[2], Yue Sun[3], Joanne Yip[1] & Kit-lun Yick[1,2]

Chen, J., Zhong, Z., Sun, Y. Yip J, Yick KL. (2025). Dynamic simulation of breast behaviour during different activities based on finite element modelling of multiple components of breast. *Scientific Reports*. 15, 3659.

Enhancing Force Absorption, Stress–Strain and Thermal Properties of Weft-Knitted Inlay Spacer Fabric Structures for Apparel Applications

by Mei-Ying Kwan [1], Yi-Fan Tu [1], Kit-Lun Yick [1,*], Joanne Yip [1], Nga Wun Li [2], Annie Yu [1] and Ka-Wai Lo [1]

[1] School of Fashion and Textiles, The Hong Kong Polytechnic University, Hong Kong, China
[2] Faculty of Design, Architecture and Building, University of Technology Sydney, Sydney, NSW 2007, Australia
* Author to whom correspondence should be addressed.

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Kwan MY, Tu YF, Yick KL, Yip J, Li NW, Yu A, Lo KW. (2024). Enhancing Force Absorption, Stress–Strain and Thermal Properties of Weft-Knitted Inlay Spacer Fabric Structures for Apparel Applications. *Polymers*. 2024; 16(21):3031.

Research Outputs | 02 Conference Papers

The 92nd Textile Institute World Conference 2023

The 92nd Textile Institute World Conference 2023, University of Huddersfield, Huddersfield, UK

ERGONOMIC DESIGN OF BADMINTON-SPECIFIC SPORTS BRAS FOR ATHLETES

Yin-Ching Keung[1], Kit-Lun Yick[1]
[1] *School of Fashion and Textiles, The Hong Kong Polytechnic University, Hong Kong, China*

Presenting author E-mail: 22038535r@connect.polyu.hk; Corresponding author email: tcyick@polyu.edu.hk

Today, sports bra designs for an elite level of sport with consideration of vigorous body motion, posture changes and prolonged wearing are largely neglected. Bra discomfort, displacement and fit problems negatively affect sporting performance. This study therefore aims to offer a new scientific approach that precisely identifies breast and bra displacements from movements during badminton sport.

Keung, Y.C., Yick, K.L., Yu, A. & Yip, J. (2023). Ergonomic design of badminton-specific sports bras for athletes. The 92nd TIWC 2023, July 3-6, 2023, University of Huddersfield, Huddersfield, UK.

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International Conference on Textile Engineering and Applied Arts

Paper title:

Optimizing 3D Shape Parameters of Sports Bra Pads in Motion by Finite Element Dynamic Modelling with Inverse Problem Solution

Abstract:

The design of sports bras poses a considerable challenge due to the difficulty in accurately predicting the wearing result after computer-aided design (CAD). It needs repeated physical try-on or virtual try-on to obtain a comfortable pressure range during motion. Specifically in the context of running, the exact support area and force exerted on the breasts remain unclear. Consequently, obtaining an effective method to design the sports bra pads shape becomes particularly challenging. This predicament hinders the successful creation and production of sports bras that cater to women's health needs.

Chen, J., Sun, Y., Yip, J. & Yick, K.L. (2024). Optimizing 3D shape parameters of sports bra pads in motion by finite element dynamic modelling with inverse problem solution. International Conference on Textile Engineering and Applied Arts, Aug 22-23, 2024, Rome, Italy.

Exploring the Impact of Body Shape on Bra Fit: Integrating 3D Body Scanning and Traditional Patternmaking Methods

Yin-Ching Keung, Kit-Lun Yick

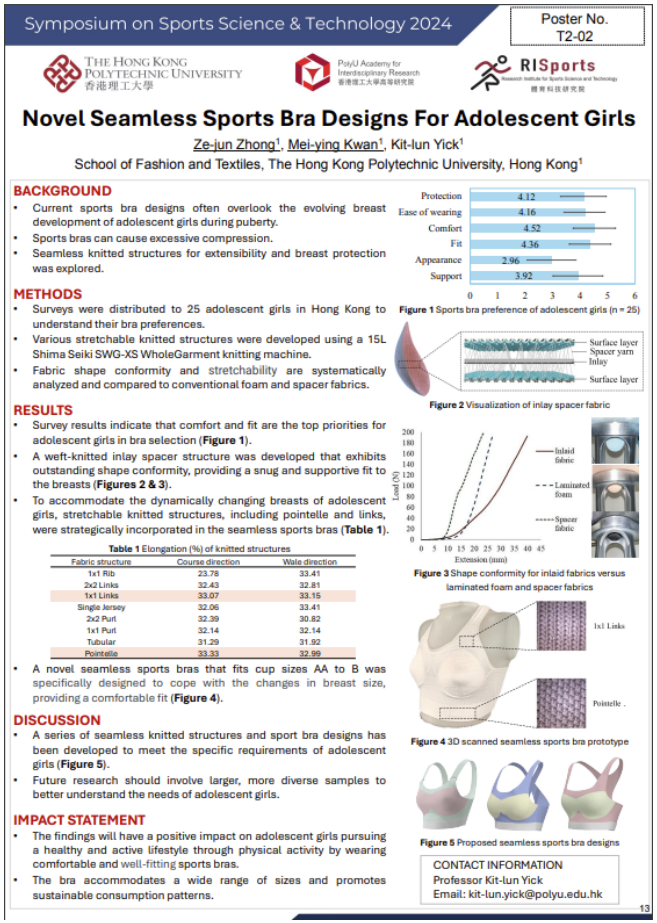
***Abstract*—The issue of bra fitting has persisted throughout history, despite advancements in molded bra cups. To gain a deeper understanding of the interaction between the breast and bra pattern, this study combines the art of traditional bra patternmaking with 3D body scanning technology. By employing a 2D bra pattern drafting method and analyzing the effect of body shape on the desired bra cup shape, the study focuses on the differentiation of the lower cup among bras designed for flat and round body shape breasts. The results shed uniqueness of every individual. The interplay between body shape and breast shape is a crucial factor to consider in bra design, as it directly influences the fit, support, and the comfort of the garment.

Understanding and appreciating the diversity in breast shape is essential in bra design. As the breast tissues are mounted on the rib cage, it is important to recognize that the shape of the rib cage directly impacts the distribution of the breast tissues [8].

Keung, Y.C. & Yick, K.L. (2024). Exploring the impact of body shape on bra fit: integrating 3D body scanning and traditional patternmaking methods. International Conference on Textile Engineering and Applied Arts, Aug 22-23, 2024, Rome, Italy.

Research Outputs | 02 Conference Papers

Symposium on Sports Science & Technology 2024



Symposium on Sports Science & Technology 2024

Poster No. T2-02

THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學 | PolyU Academy for Interdisciplinary Research | RISports

Novel Seamless Sports Bra Designs For Adolescent Girls

Ze-jun Zhong[1], Mei-ying Kwan[1], Kit-lun Yick[1]

School of Fashion and Textiles, The Hong Kong Polytechnic University, Hong Kong[1]

BACKGROUND

- Current sports bra designs often overlook the evolving breast development of adolescent girls during puberty.
- Sports bras can cause excessive compression.
- Seamless knitted structures for extensibility and breast protection was explored.

METHODS

- Surveys were distributed to 25 adolescent girls in Hong Kong to understand their bra preferences.
- Various stretchable knitted structures were developed using a 15L Shima Seiki SWG-XS WholeGarment knitting machine.
- Fabric shape conformity and stretchability are systematically analyzed and compared to conventional foam and spacer fabrics.

RESULTS

- Survey results indicate that comfort and fit are the top priorities for adolescent girls in bra selection (**Figure 1**).
- A weft-knitted inlay spacer structure was developed that exhibits outstanding shape conformity, providing a snug and supportive fit to the breasts (**Figures 2 & 3**).
- To accommodate the dynamically changing breasts of adolescent girls, stretchable knitted structures, including pointelle and links, were strategically incorporated in the seamless sports bras (**Table 1**).

Table 1 Elongation (%) of knitted structures

Fabric structure	Course direction	Wale direction
1x1 Rib	23.78	33.41
2x2 Links	32.43	32.81
1x1 Links	33.07	33.15
Single Jersey	32.06	33.41
2x2 Purl	32.39	30.82
1x1 Purl	32.14	32.14
Tubular	31.29	31.92
Pointelle	33.33	32.99

- A novel seamless sports bras that fits cup sizes AA to B was specifically designed to cope with the changes in breast size, providing a comfortable fit (**Figure 4**).

DISCUSSION

- A series of seamless knitted structures and sport bra designs has been developed to meet the specific requirements of adolescent girls (**Figure 5**).
- Future research should involve larger, more diverse samples to better understand the needs of adolescent girls.

IMPACT STATEMENT

- The findings will have a positive impact on adolescent girls pursuing a healthy and active lifestyle through physical activity by wearing comfortable and well-fitting sports bras.
- The bra accommodates a wide range of sizes and promotes sustainable consumption patterns.

Figure 1 Sports bra preference of adolescent girls (n = 25)

Figure 2 Visualization of inlay spacer fabric

Figure 3 Shape conformity for inlaid fabrics versus laminated foam and spacer fabrics

Figure 4 3D scanned seamless sports bra prototype

Figure 5 Proposed seamless sports bra designs

CONTACT INFORMATION
Professor Kit-lun Yick
Email: kit-lun.yick@polyu.edu.hk

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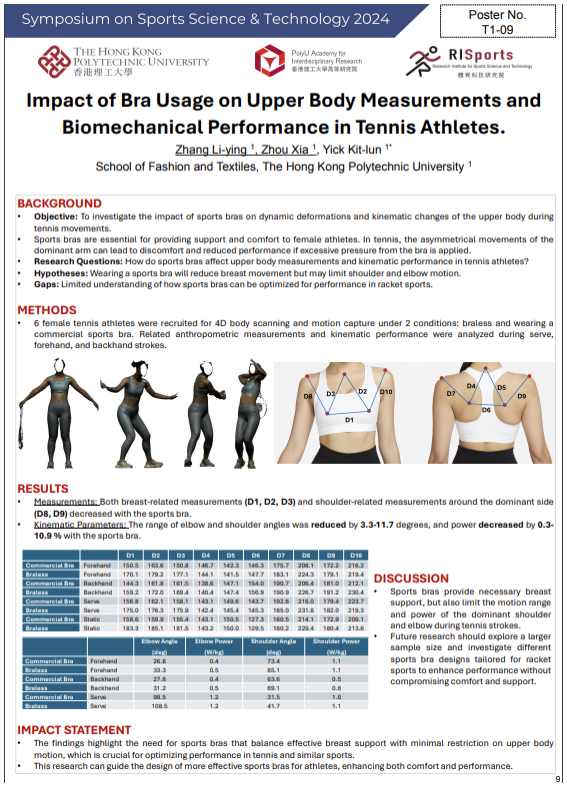
Zhong Z, Kwan MY, Yick KL. (2024). Novel Seamless Sports Bra Designs for Adolescent Girls. The Symposium on Sports Science & Technology, Hong Kong.

Research Outputs | 02 Conference Papers

Journal Papers | Conference Papers | Patents | Designs

Symposium on Sports Science & Technology 2024



Symposium on Sports Science & Technology 2024

Poster No. T1-09

The Hong Kong Polytechnic University 香港理工大學 | PolyU Academy for Interdisciplinary Research 香港理工大學高等研究院 | RISports Research Institute for Sports Science and Technology 體育科技研究院

Impact of Bra Usage on Upper Body Measurements and Biomechanical Performance in Tennis Athletes.

Zhang Li-ying [1], Zhou Xia [1], Yick Kit-lun [1*]

School of Fashion and Textiles, The Hong Kong Polytechnic University [1]

BACKGROUND

- **Objective:** To investigate the impact of sports bras on dynamic deformations and kinematic changes of the upper body during tennis movements.
- Sports bras are essential for providing support and comfort to female athletes. In tennis, the asymmetrical movements of the dominant arm can lead to discomfort and reduced performance if excessive pressure from the bra is applied.
- **Research Question:** How do sports bras affect upper body measurements and kinematic performance in tennis athletes?
- **Hypotheses:** Wearing a sports bra will reduce breast movement but may limit shoulder and elbow motion.
- **Gaps:** Limited understanding of how sports bras can be optimized for performance in racket sports.

METHODS

- 6 female tennis athletes were recruited for 4D body scanning and motion capture under 2 conditions: braless and wearing a commercial sports bra. Related anthropometric measurements and kinematic performance were analyzed during serve, forehand, and backhand strokes.

RESULTS

- Measurements: Both breast-related measurements **(D1, D2, D3)** and shoulder-related measurements around the dominant side **(D8, D9)** decreased with the sports bra.
- Kinematic Parameters: The range of elbow and shoulder angles was **reduced** by **3.3-11.7** degrees, and power **decreased** by **0.3-10.9 %** with the sports bra.

		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Commercial Bra	Forehand	150.5	163.6	150.8	146.7	142.3	146.3	175.7	208.1	172.2	216.2
Braless	Forehand	170.1	179.2	177.1	144.1	141.5	147.7	183.1	224.3	179.1	219.4
Commercial Bra	Backhand	144.3	161.8	161.5	138.6	147.1	154.0	190.7	206.4	181.0	212.1
Braless	Backhand	159.2	172.0	169.4	140.4	147.4	156.9	190.9	226.7	191.2	230.4
Commercial Bra	Serve	156.8	162.1	158.1	143.1	149.6	143.7	192.6	216.0	179.4	223.7
Braless	Serve	175.0	176.3	175.9	142.4	145.4	145.3	185.0	231.8	182.0	219.3
Commercial Bra	Static	158.6	159.9	155.4	143.1	150.5	127.3	180.5	214.1	172.9	209.1
Braless	Static	183.3	185.1	181.5	143.2	150.0	129.5	180.2	229.4	180.4	213.6

		Elbow Angle (deg)	Elbow Power (W/kg)	Shoulder Angle (deg)	Shoulder Power (W/kg)
Commercial Bra	Forehand	26.8	0.4	73.4	1.1
Braless	Forehand	33.3	0.5	85.1	1.1
Commercial Bra	Backhand	27.8	0.4	63.6	0.5
Braless	Backhand	31.2	0.5	69.1	0.6
Commercial Bra	Serve	99.5	1.2	31.5	1.0
Braless	Serve	108.5	1.2	41.7	1.1

DISCUSSION

- Sports bras provide necessary breast support, but also limit the motion range and power of the dominant shoulder and elbow during tennis strokes.
- Future research should explore a larger sample size and investigate different sports bra designs tailored for racket sports to enhance performance without compromising comfort and support.

IMPACT STATEMENT

- The findings highlight the need for sports bras that balance effective breast support with minimal restriction on upper body motion, which is crucial for optimizing performance in tennis and similar sports.
- This research can guide the design of more effective sports bras for athletes, enhancing both comfort and performance.

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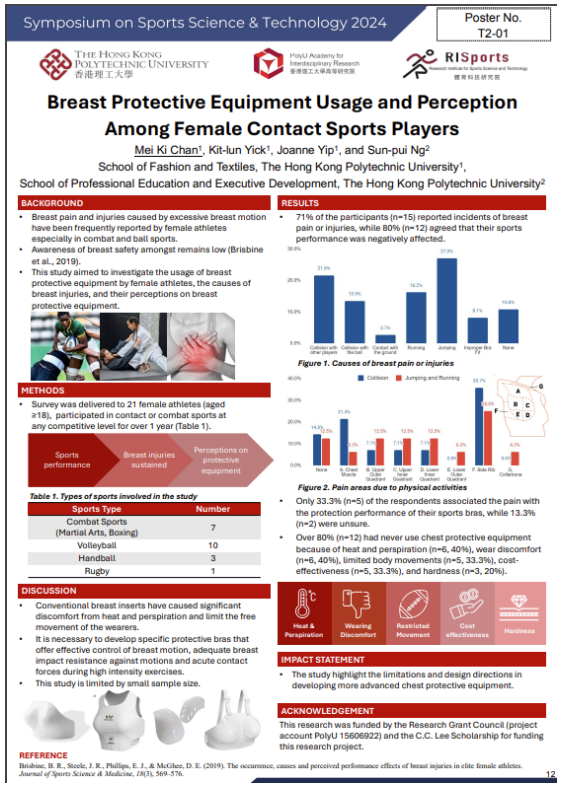

Symposium on Sports Science & Technology 2024

Poster No. T2-01

The Hong Kong Polytechnic University 香港理工大學 | PolyU Academy for Interdisciplinary Research 香港理工大學高等研究院 | RISports Research Institute for Sports Science and Technology 體育科技研究院

Breast Protective Equipment Usage and Perception Among Female Contact Sports Players

Mei Ki Chan[1], Kit-lun Yick[1], Joanne Yip[1], and Sun-pui Ng[2]

School of Fashion and Textiles, The Hong Kong Polytechnic University[1],

School of Professional Education and Executive Development, The Hong Kong Polytechnic University[2]

BACKGROUND

- Breast pain and injuries caused by excessive breast motion have been frequently reported by female athletes especially in combat and ball sports.
- Awareness of breast safety amongst remains low (Brisbine et al., 2019).
- This study aimed to investigate the usage of breast protective equipment by female athletes, the causes of breast injuries, and their perceptions on breast protective equipment.

METHODS

- Survey was delivered to 21 female athletes (aged ≥18), participated in contact or combat sports at any competitive level for over 1 year (Table 1).

Sports performance → Breast injuries sustained → Perceptions on protective equipment

Table 1. Types of sports involved in the study

Sports Type	Number
Combat Sports (Martial Arts, Boxing)	7
Volleyball	10
Handball	3
Rugby	1

RESULTS

- 71% of the participants (n=15) reported incidents of breast pain or injuries, while 80% (n=12) agreed that their sports performance was negatively affected.

Figure 1. Causes of breast pain or injuries

Figure 2. Pain areas due to physical activities

- Only 33.3% (n=5) of the respondents associated the pain with the protection performance of their sports bras, while 13.3% (n=2) were unsure.
- Over 80% (n=12) had never use chest protective equipment because of heat and perspiration (n=6, 40%), wear discomfort (n=6, 40%), limited body movements (n=5, 33.3%), cost-effectiveness (n=5, 33.3%), and hardness (n=3, 20%).

Heat & Perspiration | Wearing Discomfort | Restricted Movement | Cost effectiveness | Hardness

DISCUSSION

- Conventional breast inserts have caused significant discomfort from heat and perspiration and limit the free movement of the wearers.
- It is necessary to develop specific protective bras that offer effective control of breast motion, adequate breast impact resistance against motions and acute contact forces during high intensity exercises.
- This study is limited by small sample size.

IMPACT STATEMENT

- The study highlight the limitations and design directions in developing more advanced chest protective equipment.

ACKNOWLEDGEMENT

This research was funded by the Research Grant Council (project account PolyU 15606922) and the C.C. Lee Scholarship for funding this research project.

REFERENCE

Brisbine, B. R., Steele, J. R., Phillips, E. J., & McGhee, D. E. (2019). The occurrence, causes and perceived performance effects of breast injuries in elite female athletes. *Journal of Sports Science & Medicine, 18*(3), 569–576.

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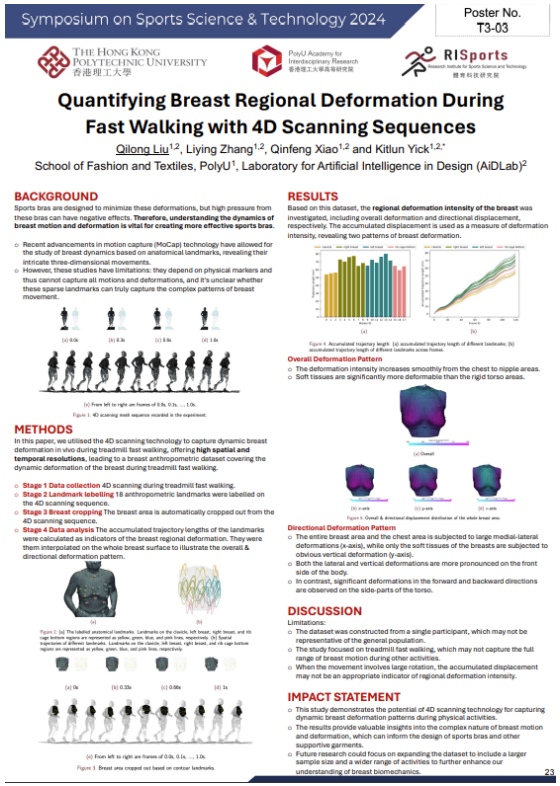

Symposium on Sports Science & Technology 2024

Poster No. T3-03

The Hong Kong Polytechnic University 香港理工大學 | PolyU Academy for Interdisciplinary Research 香港理工大學高等研究院 | RISports Research Institute for Sports Science and Technology 體育科技研究院

Quantifying Breast Regional Deformation During Fast Walking with 4D Scanning Sequences

Qilong Liu[1,2], Liying Zhang[1,2], Qinfeng Xiao[1,2] and Kitlun Yick[1,2,*]

School of Fashion and Textiles, PolyU[1], Laboratory for Artificial Intelligence in Design (AiDLab)[2]

BACKGROUND

Sports bras are designed to minimize these deformations, but high pressure from these bras can have negative effects. **Therefore, understanding the dynamics of breast motion and deformation is vital for creating more effective sports bras.**

- Recent advancements in motion capture (MoCap) technology have allowed for the study of breast dynamics based on anatomical landmarks, revealing their intricate three-dimensional movements.
- However, these studies have limitations: they depend on physical markers and thus cannot capture all motions and deformations, and it's unclear whether these sparse landmarks can truly capture the complex patterns of breast movement.

METHODS

In this paper, we utilised the 4D scanning technology to capture dynamic breast deformation in vivo during treadmill fast walking, offering **high spatial and temporal resolutions**, leading to a breast anthropometric dataset covering the dynamic deformation of the breast during treadmill fast walking.

- **Stage 1 Data collection** 4D scanning during treadmill fast walking.
- **Stage 2 Landmark labelling** 18 anthropometric landmarks were labelled on the 4D scanning sequence.
- **Stage 3 Breast cropping** The breast area is automatically cropped out from the 4D scanning sequence.
- **Stage 4 Data analysis** The accumulated trajectory lengths of the landmarks were calculated as indicators of the breast regional deformation. They were then interpolated on the whole breast surface to illustrate the overall & directional deformation pattern.

RESULTS

Based on this dataset, the **regional deformation intensity of the breast** was investigated, including overall deformation and directional displacement, respectively. The accumulated displacement is used as a measure of deformation intensity, revealing two patterns of breast deformation.

Overall Deformation Pattern

- The deformation intensity increases smoothly from the chest to nipple areas.
- Soft tissues are significantly more deformable than the rigid torso areas.

Directional Deformation Pattern

- The entire breast area and the chest area is subjected to large medial-lateral deformations (x-axis), while only the soft tissues of the breasts are subjected to obvious vertical deformation (y-axis).
- Both the lateral and vertical deformations are more pronounced on the front side of the body.
- In contrast, significant deformations in the forward and backward directions are observed on the side-parts of the torso.

DISCUSSION

Limitations:

- The dataset was constructed from a single participant, which may not be representative of the general population.
- The study focused on treadmill fast walking, which may not capture the full range of breast motion during other activities.
- When the movement involves large rotation, the accumulated displacement may not be an appropriate indicator of regional deformation intensity.

IMPACT STATEMENT

- This study demonstrates the potential of 4D scanning technology for capturing dynamic breast deformation patterns during physical activities.
- The results provide valuable insights into the complex nature of breast motion and deformation, which can inform the design of sports bras and other supportive garments.
- Future research could focus on expanding the dataset to include a larger sample size and a wider range of activities to further enhance our understanding of breast biomechanics.

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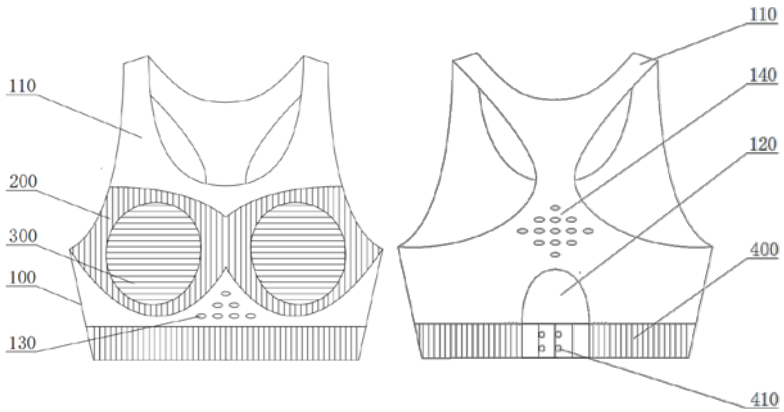
Zhang LY, Zhou X, Yick KL. (2024). Impact of Bra Usage on Upper Body Measurements and Biomechanical Performance in Tennis Athletes. The Symposium on Sports Science & Technology 2024, Hong Kong.

Chan MK, Yick KL, Yip J, Ng SP. (2024). Breast Protective Equipment Usage and Perception Among Female Contact Sports Players. The Symposium on Sports Science & Technology 2024, Hong Kong.

Liu Q, Zhang LY, Xiao Q, Yick KL. (2024) Quantifying Breast Regional Deformation During Fast Walking With 4D Scanning. The Symposium on Sports Science & Technology 2024, Hong Kong.

Research Outputs | 03 Patents

A design patent entitled: An inlaid seamless one-size-fits-more sports bra design 能適應胸型變化、一體成型的無縫運動內衣, filed on 5 November 2024 (China).



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发文日：
2024 年 11 月 05 日

申请号或专利号：202411218992.5　　发文序号：202410310084840 0

申请人或专利权人：香港理工大学

发明创造名称：能适应胸型变化、一体成型的无缝运动内衣

发明专利申请初步审查合格通知书

上述专利申请，经初步审查，符合专利法实施细则第 50 条的规定。
根据专利法第 34 条的规定，专利申请自申请日起满十八个月即行公布。
初步审查合格的上述发明专利申请是以：
2024 年 9 月 2 日提交的说明书摘要
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Research Outputs | 03 Patents

運動文胸, filed on 18 June 2025 (China).

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发文日：
2025 年 06 月 18 日

申请号：202521251365.1　　发文序号：2025061801396820

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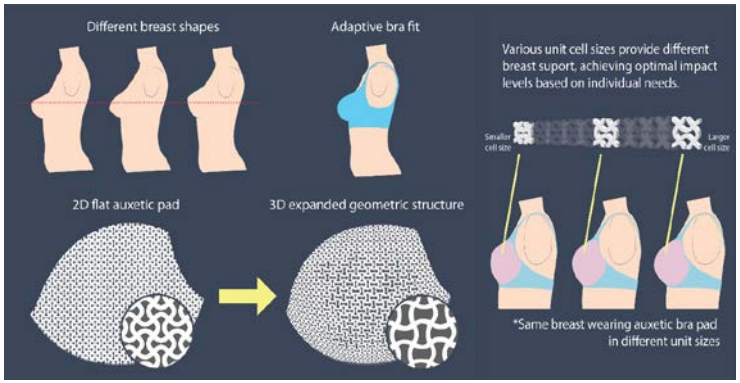
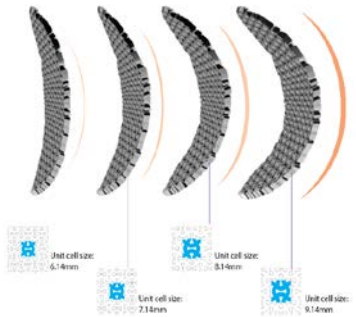
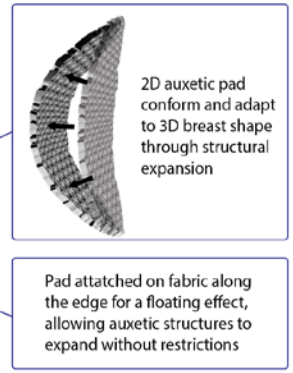




Outer view

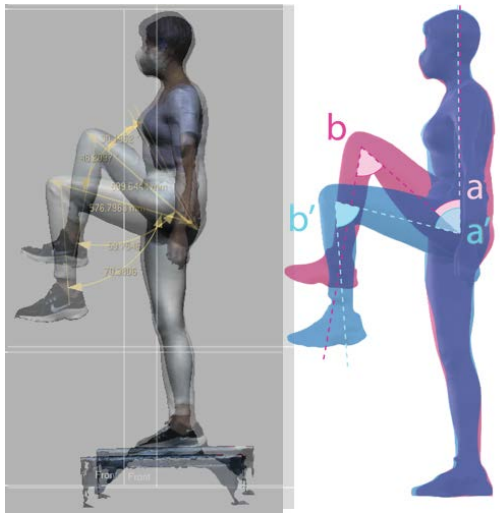
Inner view



Research Outputs | 04 Sport-Specific Leggings

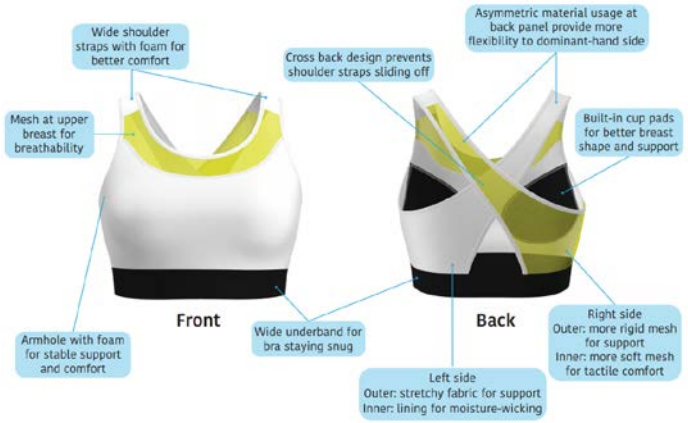
Journal Papers | Conference Papers | Patents | **Designs**

Engineered with advanced 3D and 4D scanning, **running-specific leggings** are designed to accommodate the dynamic movement and muscle expansion of the lower limbs, including quadriceps, gluteus maximus and hamstrings during movements. This ensures a supportive, flexible fit that enhances performance and comfort by adapting to the runner's natural motion.

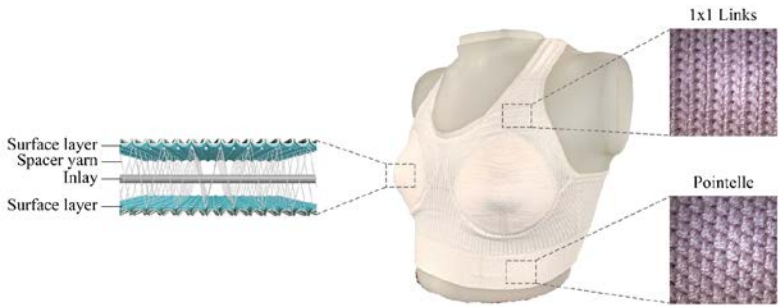


Research Outputs | 04 Sport-Specific Sports Bras

Sports bra designs tailored for **elite athletes in racket sports teams**, including badminton, tennis and squash, facilitating upper body movement, particularly of the arms and shoulders. Given the asymmetrical nature of these sports, the incorporation of wide shoulder straps with **specialised designs for left-handed or right-handed players** enhances performance.



Novel seamless sports bra designs with tailored, stretchable knitted structures to offer a snug and supportive fit for adolescent girls.



Tailored sports bra designs for cycling, hockey, softball, and tennis meticulously account for the range of body movements, postures, and region-specific stress and strain, utilizing advanced 3D and 4D scanning techniques.

Research Field & Key References

Research Field

Research Context & Intellectual Positioning

- Human body dynamics significantly affect body measurements, making dynamic body surface analysis vital for optimal garment fit. *(1–2)*
- Despite increasing demands for fit, comfort and support in activewear, scientific understanding of design and material parameters for improved fit, comfort and protection against injuries during sports is lacking. The body's complex shape, regional movements and soft tissue deformations, which varies with the type of physical activity, present significant challenges for anatomically engineered activewear design.

Design Limitations

- Due to the lack of suitable technology and research design, significant challenges persist regarding body surface changes during natural continuous movement and trunk movements related to various sports modalities. *(3–4)*
- Conventional 3D body scanning systems, which capture only static postures, inadequately characterise the pliable and diverse geometry of body and breast tissue, as they fail to account for its dynamic deformability. *(4–5)*
- Insufficient dynamic 4D data hampers activewear design, as traditional 3D body scanning and motion capture systems cannot measure continuous body shape changes during motion.

Key References

1. Sohn MH & Bye E. (2014). Exploratory study on developing a body measurement method using motion capture. *Clothing & Text Res J*, 32(3), 170–185.
2. Wu Y, Li Y, Liu AM, Xiao F, Wang YZ, Hu F, Gu DY. (2016). Effect of active arm swing to local dynamic stability during walking. *Human Movement Science*, 45, 102–109.
3. Herr H & Popovic M. (2008). Angular momentum in human walking. *J of Exp Biology*, 211, 467–81.
4. McGhee DE, Steele JR. (2020). Biomechanics of breast support for active women. *The Amer Coll of Sports Med.* 48(3), 99–109.
5. Chi L, Kennon R. (2006). Body scanning of dynamic posture. *Int. J Clothing Sci & Tech*, 18(3), 166–78.

Research Field & Key References

Research Field

Methodological Constraints

- Motion capture systems offer limited spatial resolution and surface geometry information, and they require a large number of body landmarks for motion analysis, which is time consuming. *(1, 4, 6–7)*

Original Contribution

- This study uses 4D scanning technology to capture 3D point clouds of the human body surface at high frame rates to better understand the dynamic surface changes, regional deformations, skin stretching and geometric changes of the human body, as well as to advance the design and development of sports-specific sportswear. *(8–9)*

Key References

1. Sohn MH & Bye E. (2014). Exploratory study on developing a body measurement method using motion capture. *Clothing & Text Res J*, 32(3), 170–185.
2. Wu Y, Li Y, Liu AM, Xiao F, Wang YZ, Hu F, Gu DY. (2016). Effect of active arm swing to local dynamic stability during walking. *Human Movement Science*, 45, 102–109.
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5. Chi L, Kennon R. (2006). Body scanning of dynamic posture. *Int. J Clothing Sci & Tech*, 18(3), 166–78.
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Research Methods, Prototypes & Materials

Sports-Specific Activewear Design Protocol

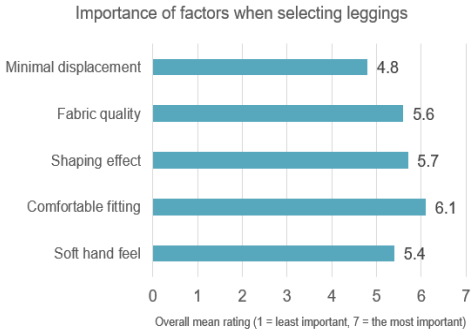
WORKFLOW

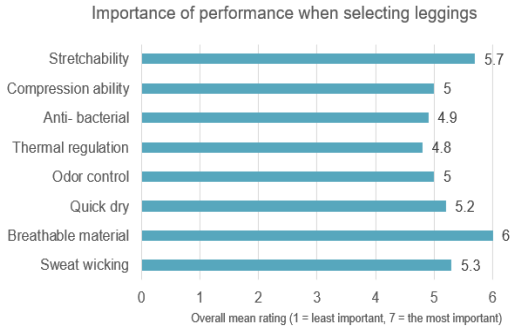
01 Needs Analysis	02 Motion Analysis	03 3D & 4D Body Scanning	04 Material & Activewear Design
• Questionnaire and interview	• Unique movement dynamics and biomechanical demands during sports activities	• Skin surface changes and region-specific deformations of body at dynamic situations	• Design of key features and engineered material structures for tailored fit, comfort and support in each sports • Formulation of numerical simulation models to optimise biomechanical alignment and support for targeted sports

Research Methods, Prototypes & Materials

Needs Analysis | Motion Analysis | 3D & 4D Body Scanning | Material & Activewear Design

Surveys and interviews were conducted to understand the specific needs of athletes and wearers, in areas of support, style preferences, issues of fit, motion and the preferred design features across different sports activities. The design features of commercially available sports bras and leggings were systematically compared and analysed.

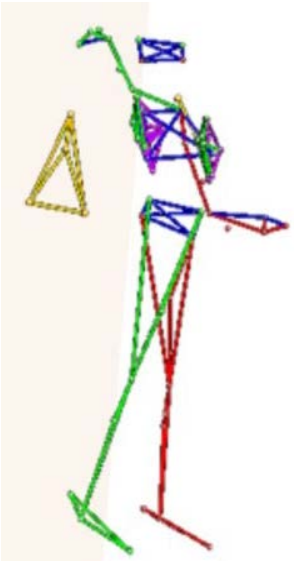


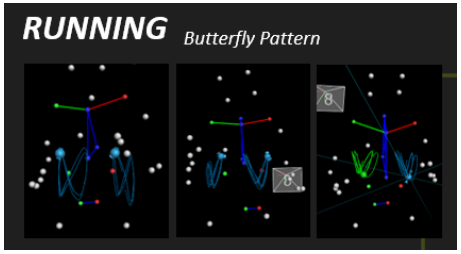


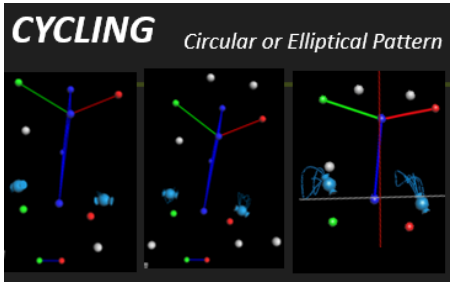
Research Methods, Prototypes & Materials

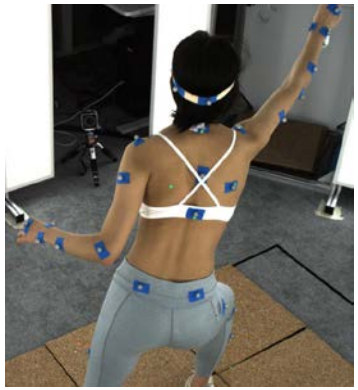
Motion capture analysis enables precise characterisation of unique movement dynamics and biomechanical demands during sports activities, providing valuable insights for improving athletic performance, injury prevention and activewear design.

Distinct differences in **nipple displacements** between running and cycling.



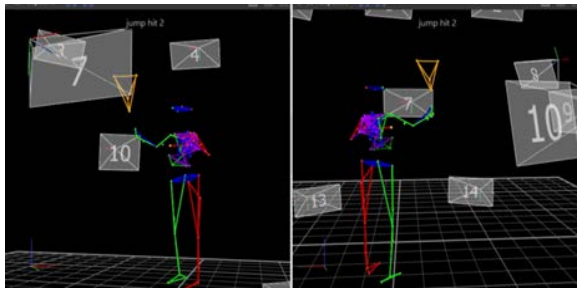




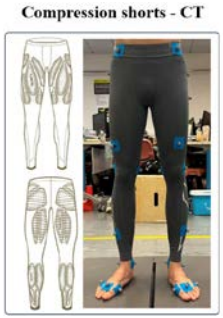


Tennis motion (video)

Squash motion (video)



Badminton (jump smash) video link

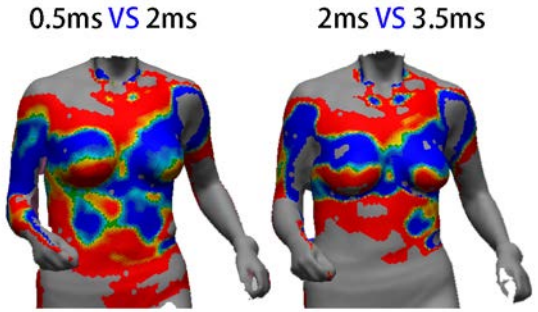


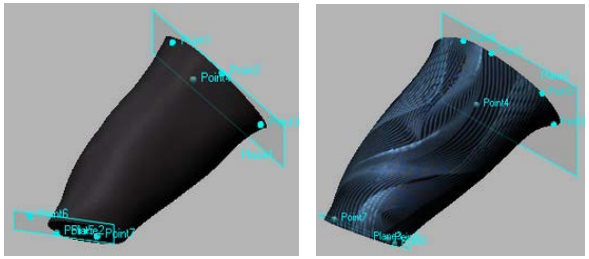
Jumping

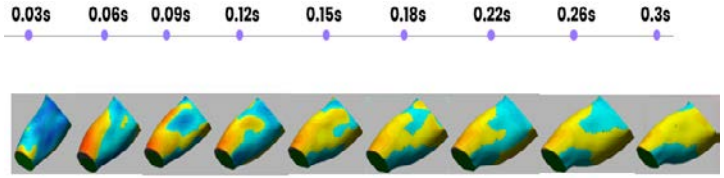
Research Methods, Prototypes & Materials

Needs Analysis | Motion Analysis | 3D & 4D Body Scanning | Material & Activewear Design

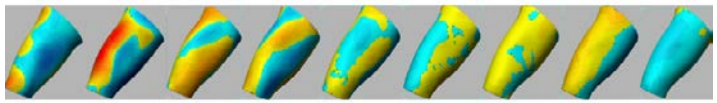
4D scanning, combined with time-based dimensional analysis, offers valuable insights into the dynamic deformation of the body surface during running. It yields crucial information for identifying specific body regions that require compression and support to protect the underlying tissues and muscles, thereby helping preventing muscular oscillations and potential injuries, particularly in high-intensity and endurance sports, including marathon running.







Thigh region without leggings



Thigh region with a high-impact leggings

Related publications:

Liu Q, Yick KL, Sun Y, Yip J (2024) Ultra-dense Motion Capture: An exploratory full-automatic approach for dense tracking of breast motion in 4D. *PLOS ONE* 19(2): e0299040.

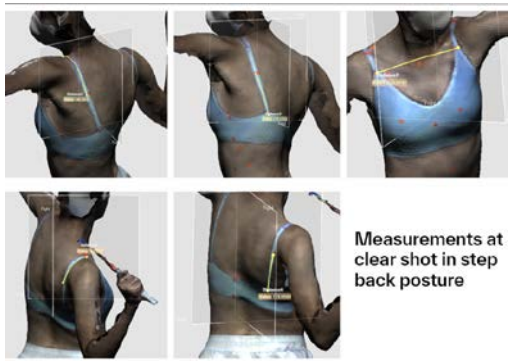
Liu Q, Zhang LY, Xiao Q, Yick KL. (2024) Quantifying Breast Regional Deformation During Fast Walking With 4D Scanning. The Symposium on Sports Science & Technology 2024, Hong Kong.

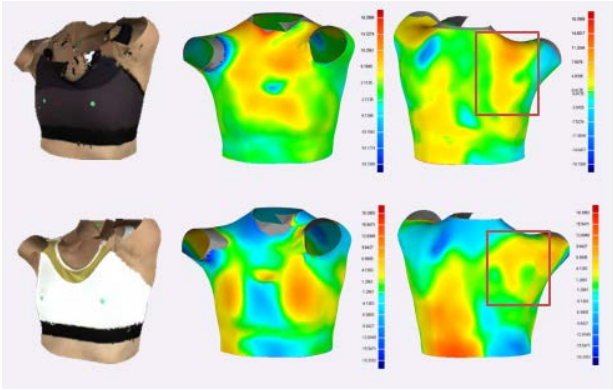
Research Methods, Prototypes & Materials

Needs Analysis | Motion Analysis | 3D & 4D Body Scanning | Material & Activewear Design

Through 3D and 4D scans, uneven stresses were identified at shoulder straps, between the front and the back and between the left and the right at various poses.

Findings: Length changes in shoulder straps ranged from -0.6% (lower back of the non-dominant side) to 4.6% (upper back of the dominant side). Asymmetry design of shoulder straps can effectively reduce arm restriction on the dominant side.





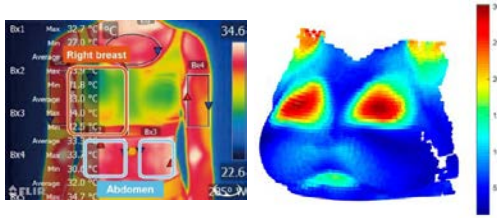
Related publications:

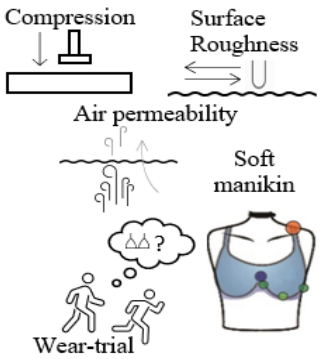
Zhang LY, Zhou X, Yick KL. (2024). Impact of Bra Usage on Upper Body Measurements and Biomechanical Performance in Tennis Athletes. The Symposium on Sports Science & Technology 2024, Hong Kong.

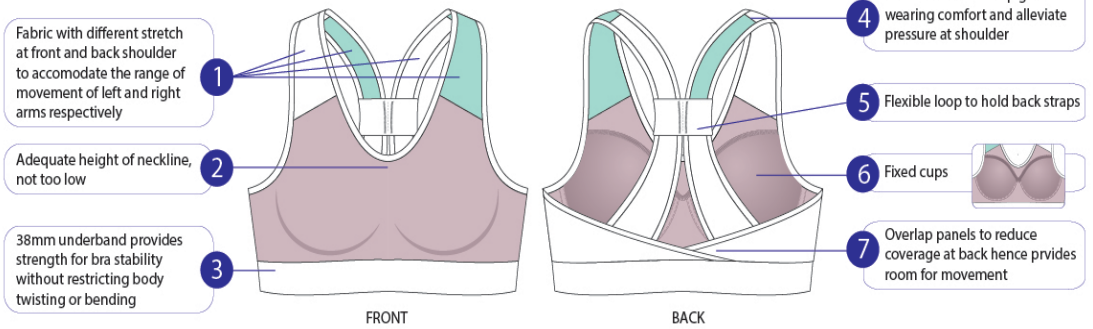
Research Methods, Prototypes & Materials

Design of Badminton-Specific Sports Bras (2022)

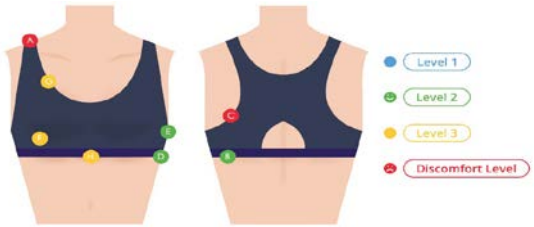
A **badminton-specific sports bra** was designed to improve stretch and flexibility at the shoulder and the back to allow free range of motion, less compression and comfort.

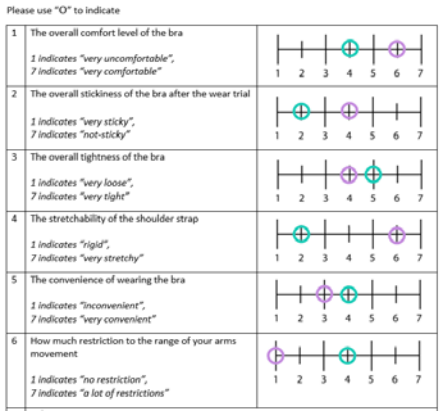






Analysis of fabric elasticity, thermal behaviour & bra pressure to improve wear comfort and free flexible movement of shoulders, arms and torso.





Bra A (Market sample)

Bra B (Prototype)

Related conference paper:

Keung, Y.C., Yick, K.L., Yu, A. & Yip, J. (2023). Ergonomic design of badminton-specific sports bras for athletes. The 92nd TIWC 2023, July 3-6, 2023, University of Huddersfield, Huddersfield, UK.

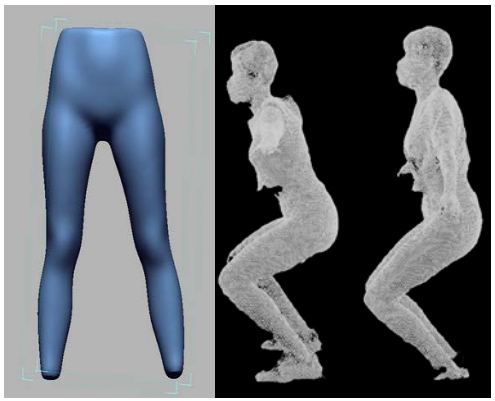
Research Methods, Prototypes & Materials

Design of Running-Specific Leggings (2023)

4D scans yield useful information about the geometry of the anatomical zones and the radius of the curvature of the body parts. Additionally, they inform the choice of fabrics, which is a critical prerequisite for precisely determining the garment-skin interface pressure and the contract conditions of compression garments in relation to different body parts and joints.

Fabric No.	Summer
Fabric 1 (2110252H1)	37% polyester + 37% nylon + 26% lycra (59" X 210 gsm; 0.4mm)
Fabric 2 (2110264H1)	37% polyester + 37% nylon + 26% lycra (59" X 210 gsm; 0.5mm)
Fabric 3 (2110262H1)	37% polyester + 37% nylon + 26% elastane (59" X 210 gsm; 0.45mm)
Fabric 4 (2110260H1)	37% polyester + 37% nylon + 26% elastane (59" X 210 gsm; 0.48mm)
Fabric 5 (2110253H1)	37% polyester + 37% nylon + 26% Roica (59" X 210 gsm; 0.39mm)
Fabric 6 (2110258H1)	37% polyester + 37% nylon + 26% Roica (59" X 210 gsm; 0.38mm)
Fabric 10 (2110256H1)	37% polyester + 36% nylon + 27% Roica (59" X 215 gsm; 0.42mm)
Fabric 11 (2110254H1)	37% polyester + 36% nylon + 27% Roica (59" X 215 gsm; 0.56mm)

Findings: A series of **running-specific leggings** have been custom-designed**,** offering unique support to protect the underlying tissues and muscles from excessive muscular oscillations during running.

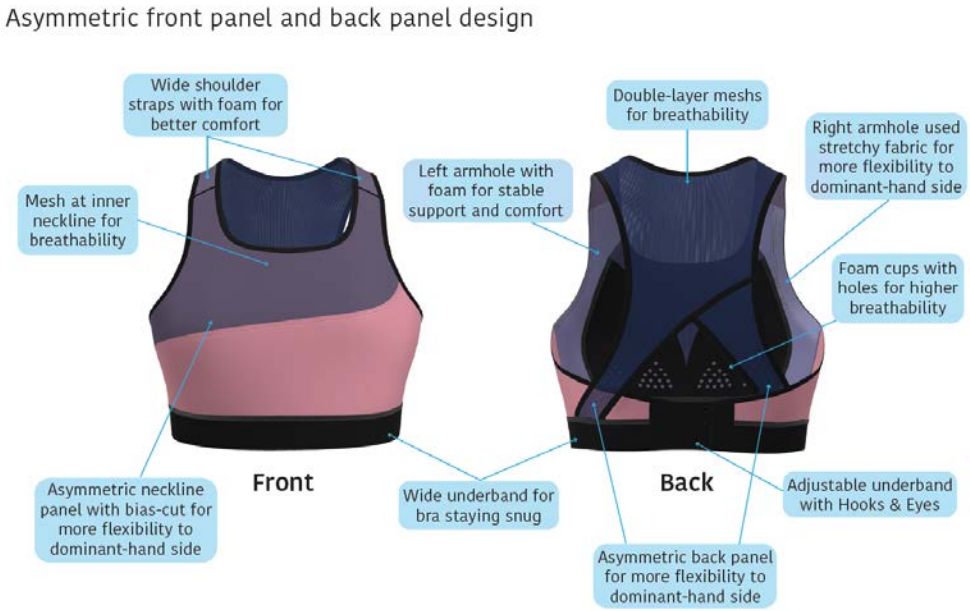


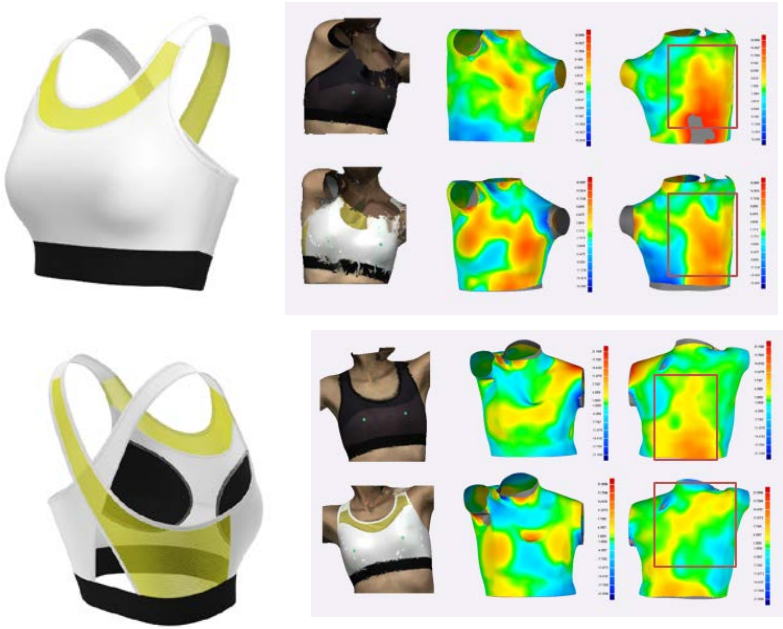
Research Methods, Prototypes & Materials

Needs Analysis | Motion Analysis | 3D & 4D Body Scanning | Material & Activewear Design

Design of Sports Bras for Elite Athletes (Racket Sports Teams) (2024)

Two sports bra designs have been tailored specifically for **elite athletes on racket sports teams**, ensuring unrestricted shoulder and arm movement on the dominant side while simultaneously providing improved support and fit on the non-dominant side to prevent the shoulder strap from slipping.



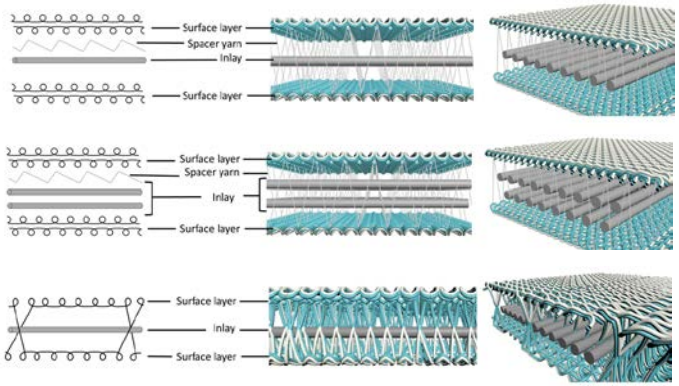


Related conference paper:
Zhang LY, Zhou X, Yick KL. (2024). Impact of Bra Usage on Upper Body Measurements and Biomechanical Performance in Tennis Athletes. The Symposium on Sports Science & Technology 2024, Hong Kong.

Stresses on the right side of the back and shoulder during backswing were relieved by the custom-designed sports bras.

Research Methods, Prototypes & Materials

Design of Seamless Sports Bras for Adolescent Girls (2024/25)



Stretchable inlaid fabric has been developed to offer a realistic 3D effect for bra cups. This design ensures adequate support, along with enhanced air and moisture permeability.

Sports bras were anatomically designed for adolescent girls with flexible bra cups and supportive fit by using spacer knitting techniques and inlay yarns.

It accommodates growth and size changes during adolescence and provide suitable breast protection.

Related publications:

Kwan MY, Yick KL, Yip J, Li NW, Yu A and Lo KW. (2024). Breast Geometry and Sports Bra Design Study for Adolescent Girls. *Journal of Fiber Bioengineering and Informatics*. 17 (4). 233-243.

Kwan MY, Tu YF, Yick KL, Yip J, Li NW, Yu A, Lo KW. (2024). Enhancing Force Absorption, Stress–Strain and Thermal Properties of Weft-Knitted Inlay Spacer Fabric Structures for Apparel Applications. *Polymers*,16, 3031.

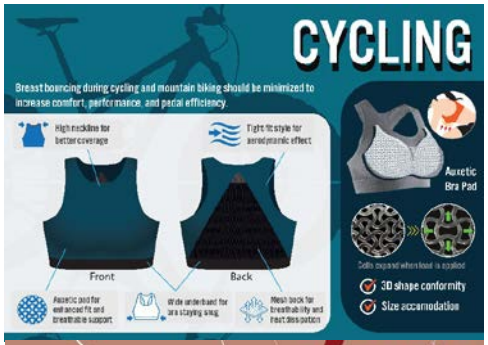
Zhong Z, Kwan MY, Yick KL. (2024). Novel Seamless Sports Bra Designs for Adolescent Girls. The Symposium on Sports Science & Technology, Hong Kong.

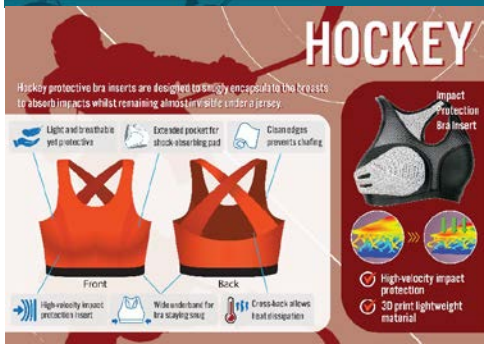
能適應胸型變化、一體成型的無縫運動內衣 (2024112189925) China Patent filed on 5th November 2024

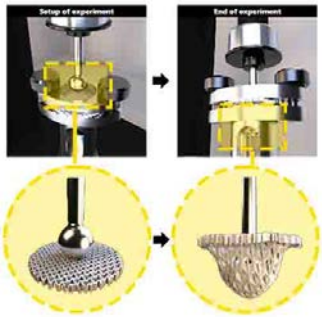
Research Methods, Prototypes & Materials

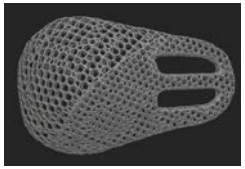
Needs Analysis | Motion Analysis | 3D & 4D Body Scanning | Material & Activewear Design

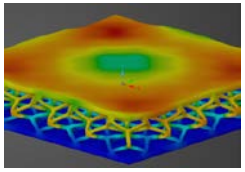
Design of Sports Bras for Cycling and Hockey (2024/25)

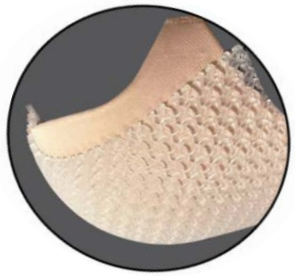




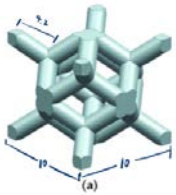








Findings: Bra pads with auxetic structures offer excellent shape-forming behaviour, allowing for a flexible fit and support in various body orientations, such as forward-leaning during cycling.



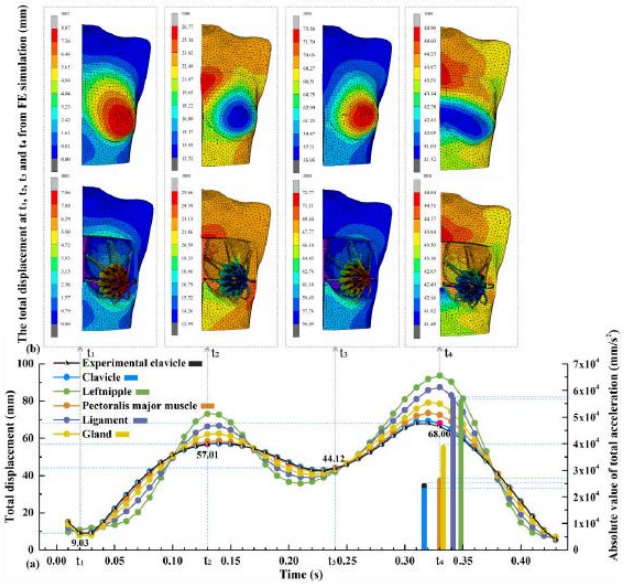
Silicone-textile composites, combined with lattice structures, provide excellent cushioning and protection against high-impact forces encountered in sports like hockey.

Related publications:

Chan MK, Li PL, Yick KL, Yip J, Ng SP (2024). Exploration of textile-silicone composites and materials for personal impact-resistant protection. *Materials*, 17, 1439.

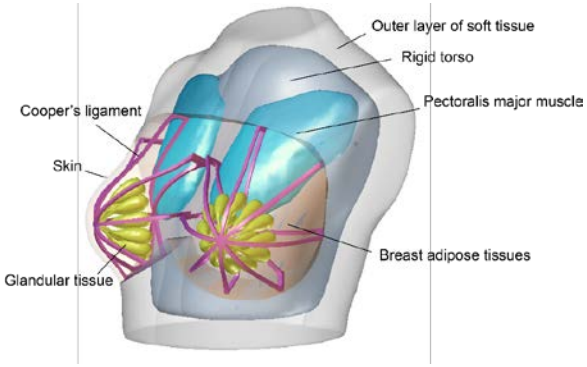
Research Methods, Prototypes & Materials

Design of Sports Bras based on Biomechanical Simulations (2024/25)



Findings:

- 4D scans capturing dynamic surface changes of the body provide clarity on soft tissues and boundaries during movement, effectively validating FE simulated models.
- The stress experienced by the breast components, in ascending order of magnitude, affects the **glandular tissues**, pectoralis major muscle, adipose tissues and ligaments.



Related journal paper:

Chen J, Sun Y, Liu QL, Yip J & Yick KL. (2024). Construction of multi-component finite element model to predict biomechanical behaviour of breasts during running and quantification of the stiffness impact of internal structure. *Biomechanics and Modeling in Mechanobiology*, 23. 1679-1694.

Chen, J., Zhong, Z., Sun, Y. Yip J, Yick KL. (2025). Dynamic simulation of breast behaviour during different activities based on finite element modelling of multiple components of breast. *Scientific Reports*. 15, 3659.

Chen J, Keung YC, Sun Y, Yip J, Yick KL. (2025). Exploration of breast motion under different activities and intensities. *Journal of Engineered Fibers and Fabrics*. 20:1-11.

Research Outcomes, Findings & Further Research

Research Outcomes:

The proposed 3D and 4D scanning techniques for body surface analysis can successfully visualise major changes in body shape and deformations that occur during various physical activities and high-impact exercises. These techniques provide valuable information on body region-specific stress and strain, enabling new insights into activewear design and material developments with targeted support, compression and protection to wearers.

Findings:

The multi-component dynamic finite element models provides a clear picture of body and breast behavior across various sports. The proposed approach also provides a scientific and practical guideline to enhance the activewear design process, empowering designers to create custom designs that address the needs and muscle control requirements corresponding to individual sports.

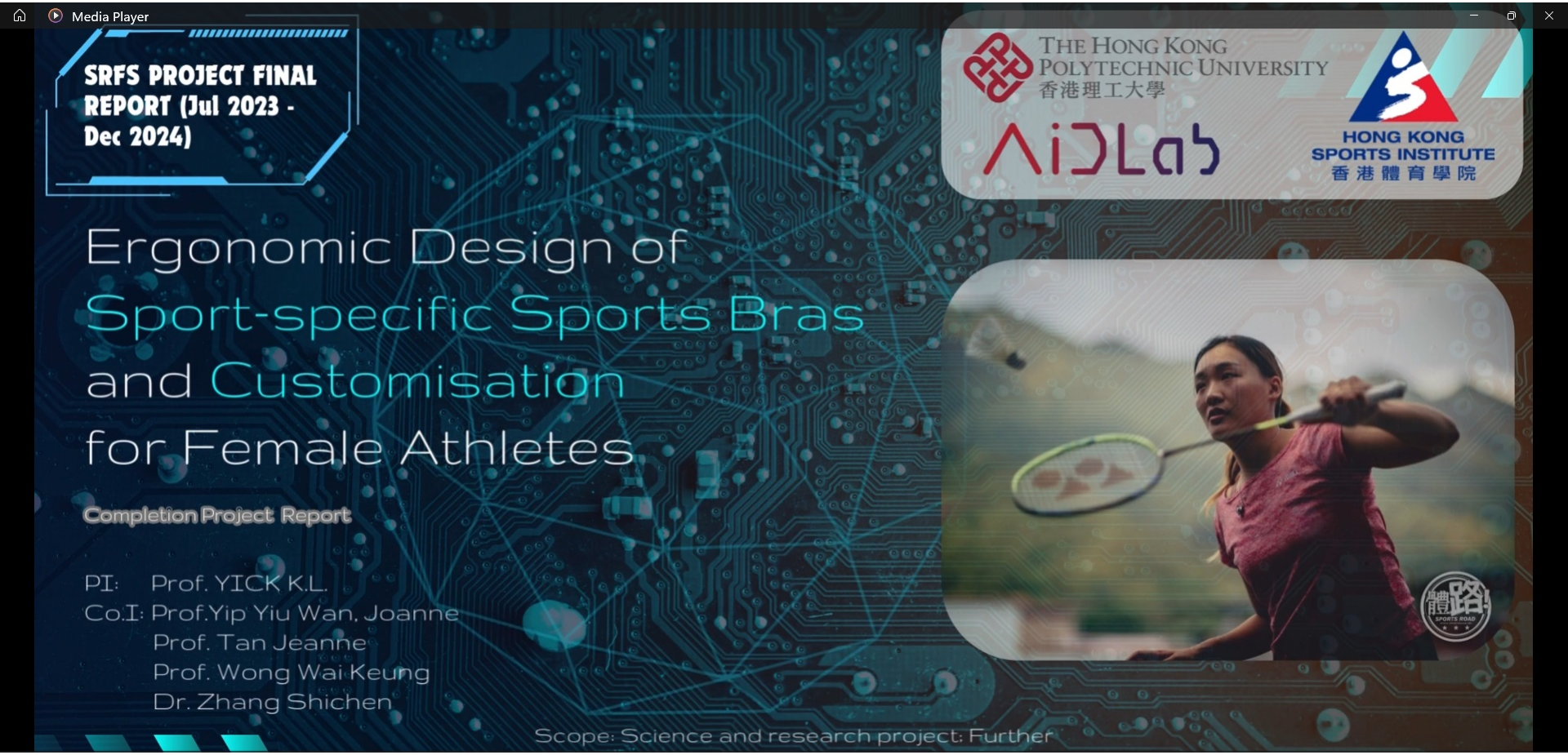
Further Research:

Future research will delve deeply into specific breast sizes, particularly focusing on larger-breasted females, and will further categorise breast shapes to design personalised sports bras. By analysing breast motion trajectories and boundaries during physical activities, tailored solutions that enhance support, comfort and performance for each breast type will be addressed.

Research Dissemination

	Category	Details
01	Video	Video of customised sports bra designs for elite athletes of racket sports teams
02	Exhibition	'Flying High' exhibition in Paris, France, 2024. https://www.polyu.edu.hk/rio/event-calendar/
03	Media Report	A collaborative project with the German Academy of Dental Ergonomics (AGEZ) and an interview report in the Dental Tribune
04	Contract Research	A contract research of running-specific legging design ***(HK$416,000).***
05	Awards	Outstanding Research Paper Award & Outstanding Presentation Award (TBIS 2024) Best Paper Award (ICTEAA 2024)
06	Education Workshops	• Educational workshops and fit assessments for elite athletes at the Hong Kong Sport Institute • Education workshops for adolescent girls in secondary schools, Shenzhen University and the Junior Researcher Mentoring Programme
07	Appendix	• Feedback from elite athletes and testimonials from schoolgirls • Presentations at the Symposium on Sports Science & Technology • NIKE visits of Hong Kong office and US R&D team • PolyU Alumni Sports and Wellness Day

Research Dissemination / *01 Video*



HKSI Sport Bras Design.mp4

Research Dissemination | 02 Exhibition

‘Flying High’ exhibition in Paris, France

Sport-specific sports bra designs for cycling, softball, hockey and tennis were developed to provide targeted support, compression and protection to wearers.

Date: 25 June – 1 July 2024
Time: Paris (GMT +2) 10:00 am – 7:00 pm
Location: 7 Rue Notre Dame des Victories, 75002 Paris, France

VIDEO

Research Dissemination | 03 Media Report & Bra design for Dentists

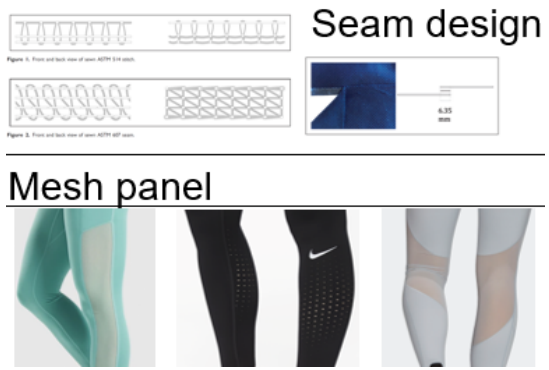
A collaborative research was established with the **German Academy of Dental Ergonomics (AGEZ)** to design and develop a supportive bra aimed at facilitating a healthy, neutral and balance working posture with optimal comfort and protection for female dentists. Apart from an international survey with more than **50 dental professionals**, the performance of the proposed bra designs made of various bra features and materials was assessed and compared.

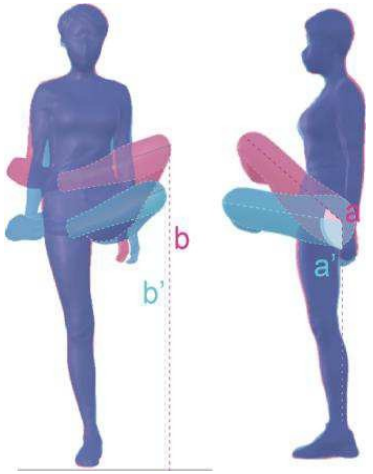
An interview was conducted and reported in **Dental Tribune** in Dec 2020 (in both German and English).

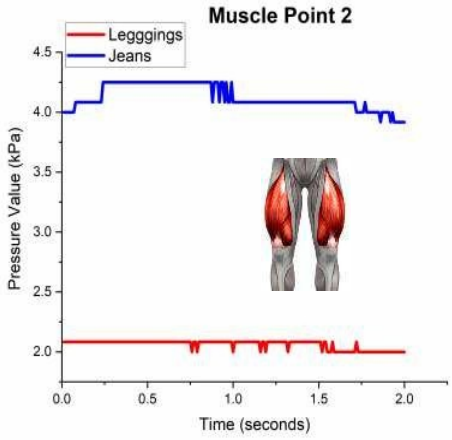
Interview Report:
https://www.dental-tribune.com/news/it-was-my-intention-to-break-this-taboo-researchers-_develop-ergonomic-bra-for-female-dentists/

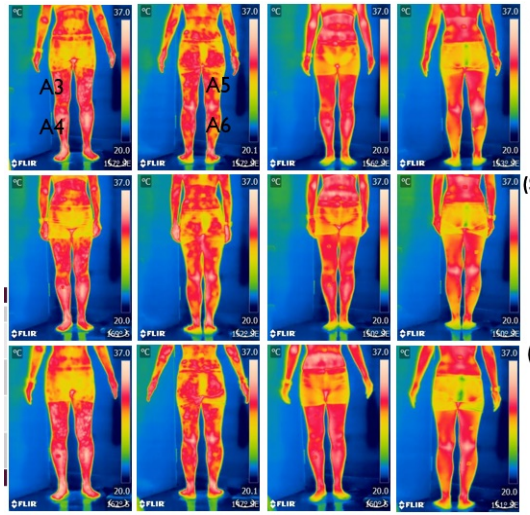
Research Dissemination | 04 Contract Research

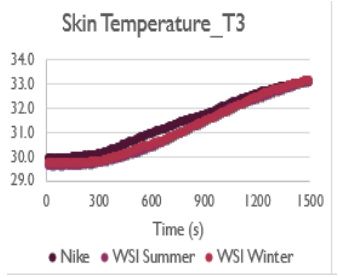
A contract research on the ergonomic design of running specific leggings with a new activewear brand was conducted in 2022.





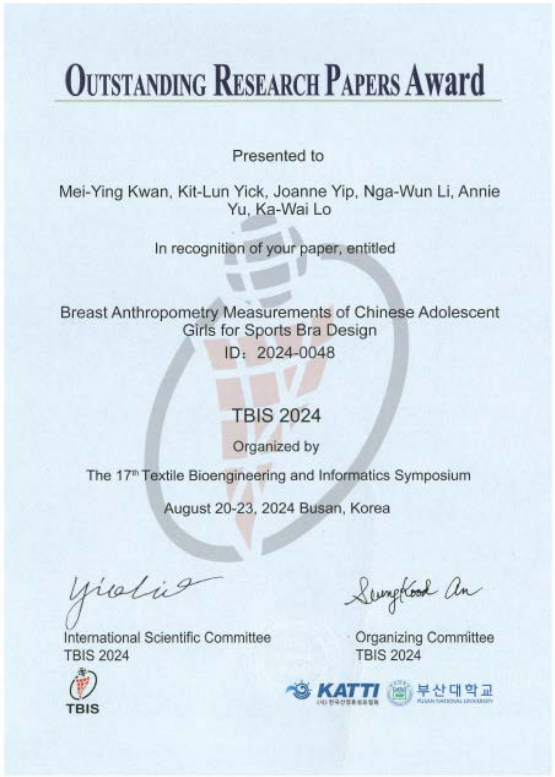






Research Dissemination | 05 Awards

Outstanding Research Paper Award and Outstanding Presentation Award at TBIS 2024 in Korea



OUTSTANDING RESEARCH PAPERS AWARD

Presented to

Mei-Ying Kwan, Kit-Lun Yick, Joanne Yip, Nga-Wun Li, Annie Yu, Ka-Wai Lo

In recognition of your paper, entitled

Breast Anthropometry Measurements of Chinese Adolescent Girls for Sports Bra Design
ID：2024-0048

TBIS 2024

Organized by

The 17th Textile Bioengineering and Informatics Symposium

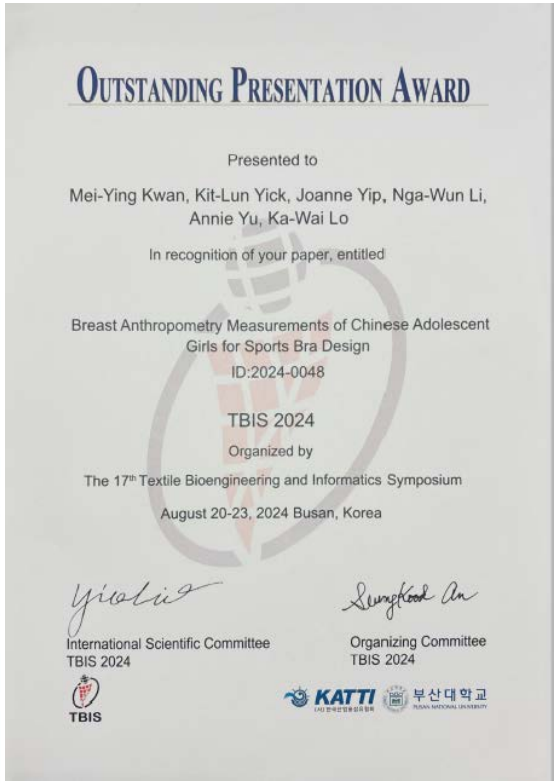
August 20-23, 2024 Busan, Korea

International Scientific Committee
TBIS 2024

Organizing Committee
TBIS 2024

TBIS

KATTI 부산대학교



OUTSTANDING PRESENTATION AWARD

Presented to

Mei-Ying Kwan, Kit-Lun Yick, Joanne Yip, Nga-Wun Li, Annie Yu, Ka-Wai Lo

In recognition of your paper, entitled

Breast Anthropometry Measurements of Chinese Adolescent Girls for Sports Bra Design
ID:2024-0048

TBIS 2024

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International Scientific Committee
TBIS 2024

Organizing Committee
TBIS 2024

TBIS

KATTI 부산대학교

Best Paper Award at ICTEAA 2024 in Italy

CERTIFICATE OF BEST PAPER AWARD

ICTEAA 2024: XVIII. International Conference on Textile Engineering and Applied Arts hereby certifies that the below mentioned paper has been selected as the best paper

Exploring the Impact of Body Shape on Bra Fit: Integrating 3D Body Scanning and Traditional Patternmaking Methods
Yin-Ching Keung, Kit-Lun Yick

ROME, ITALY

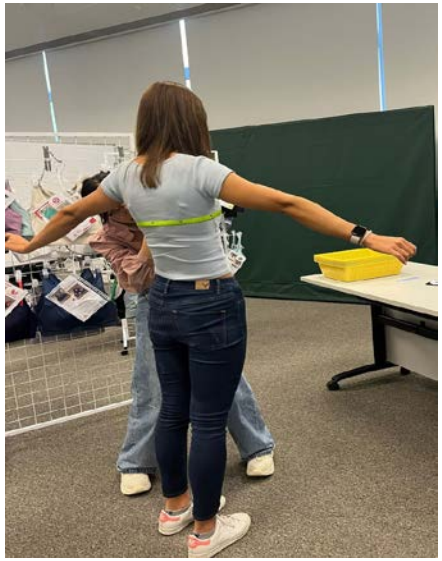
AUGUST 22-23, 2024

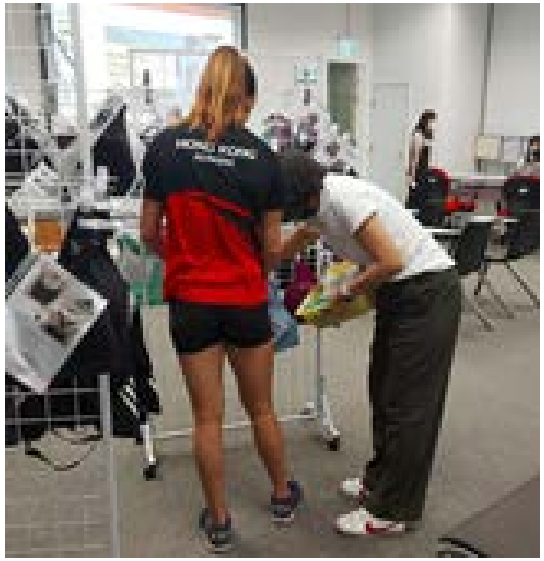
The Document Verification Service - Fast, Secure, Trusted Verify by https://waset.org/verification or by QR Code Reader Verify Code: 1505-4091-2466-1685

Research Dissemination | 06 Educational Workshops

An educational workshop for adolescent girls in **secondary schools** was conducted to impart essential knowledge on selecting a well-fitting bra. The workshop introduced methods of determining bra size and covered the features and functions of sports bras. After the workshop, 100% athletes agreed the workshop was helpful, and 59% of the bra fit problems or issues were solved.

Additionally, sports bra educational workshops were organised at the **Hong Kong Sports Institute** from July 2023 to October 2023. This workshop facilitated discussions on bra-related issues with a total of 40 elite athletes from various sports teams.



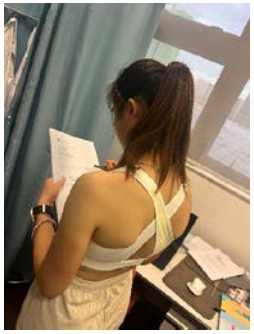


Research Dissemination | 07 Appendix

Feedback from elite athletes

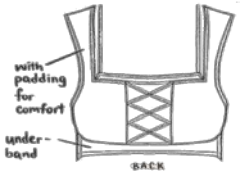
***Leung, Elite badminton athlete**: 'I noticed marked differences in my shoulder and right-back movements.'*

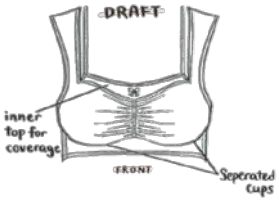
PARIS 2024



***Full project report** with feedback from elite athletes*

Feedback from schoolgirls





***Aimer, Secondary school student**: 'The project opened my eyes to the perfect fit of activewear, sparking my enthusiasm to move and exercise like never before! It is amazing to see how high-performance designs are driven by cutting-edge innovation and research.'*

Junior Research Mentoring Programme, Media Report

Research Dissemination | 07 Appendix

Presentations at Symposium on Sports Science & Technology

NIKE visits of Hong Kong office and US R&D team

PolyU Alumni Sports and Wellness Day