Mainstream Adoption of Smart Gymwear for Injury Prevention

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MAJOR RESEARCH PROJECT

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Abstract

This research begins with a simple but familiar moment: being in the gym, unsure if what you're doing is right. Many people train alone, relying on memory, social media, or guesswork to guide their movements. Often, feedback comes too late, after discomfort, strain, or injury has already appeared. While fitness technology has become more common, most tools still focus on tracking performance rather than helping people move safely in the moment.

This project explores how smart gymwear could shift that experience. It asks what would happen if clothing itself could quietly support the body by detecting changes in movement, responding to fatigue, and offering guidance before injury occurs. Positioned at the intersection of fashion, technology, and everyday fitness culture, the research focuses on how smart textiles might move from experimental concepts into something people would wear.

Using a qualitative, design-led approach, the study draws on interviews with gym-goers and experts, gym observation, and co-design sessions. These methods reveal that injury is rarely caused by a single mistake, but by small, unnoticed shifts in movement, especially under fatigue. At the same time, adoption is shaped less by technology itself and more by how it feels: comfort, trust, simplicity, and whether it blends into everyday gym routines.

In response, the project proposes a different direction for smart gymwear, one that prioritizes subtle guidance over constant monitoring, and prevention over performance tracking. This direction is explored through the design of a smart arm sleeve prototype, developed as a lightweight, familiar entry point into smart textiles. Rather than replacing existing gymwear, it works alongside it, offering real-time, intuitive feedback without disrupting the workout experience.

Ultimately, this research suggests that the future of smart gymwear is about creating a quieter form of support, one that helps people feel more aware, more confident, and less alone in their training.

Acknowledgement

This project has been such a meaningful and rewarding journey, and I feel incredibly grateful for all the support that carried me through it. I would like to sincerely thank my supervisor, Helen, for her guidance, patience, and constant encouragement. Her support made this entire process feel both manageable and inspiring.

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To my parents, thank you for your endless love and belief in me. It gave me the confidence to keep going. And finally, to my partner, Kamran, thank you for being my rock, my strength, and my calm through everything. I truly couldn't have done this without you.

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Glossary

Accelerometer

A sensor that measures changes in movement, speed, and direction, used in wearable and textile systems.

Bioelectrodes

Sensors embedded in textiles that detect electrical signals from the body, such as heart activity.

Calories Burned

A measure of energy expenditure tracked by wearable fitness technologies.

Conductive Yarn

Textile fibers that allow electrical signals to pass through fabric structures.

Electrocardiogram (ECG)

A measurement of the heart's electrical activity captured through wearable or textile-based sensors.

Fatigue

A physical state where muscle performance declines, often leading to reduced movement quality and increased injury risk.

Gyroscope

A sensor that tracks rotational movement and orientation of the body.

Heart Rate (HR)

The number of heart beats per minute, used to monitor exercise intensity.

Heart Rate Variability (HRV)

The variation in time between heartbeats, used to assess recovery and stress.

Inertial Measurement Unit (IMU)

A combined sensor system (accelerometer + gyroscope) used to track motion and body orientation.

Joint Angle

The degree of movement at a joint, used to analyze posture and exercise technique.

Kinetic Energy Harvesting

The process of generating electrical energy from body movement in smart textile systems.

Load

The amount of weight or resistance used during strength training exercises.

Machine Learning

Computational methods used to analyze movement and sensor data to detect patterns or predict outcomes.

Movement Patterns

The way the body moves during exercise, including coordination, posture, and repetition.

Passive Clothing

Clothing that does nothing beyond its basic function.

Piezoelectric Textiles

Textile materials that generate electrical energy when stretched or compressed.

Pressure Sensor

A sensor that measures force or load applied to a specific area of the body.

Repetition (Rep)

One complete execution of an exercise movement.

Respiration Rate

The number of breaths taken per minute during rest or exercise.

Set

A group of repetitions performed consecutively.

Step Count

The number of steps taken, commonly tracked by wearable devices.

Strain Sensor

A sensor that detects stretching or deformation in fabric to monitor body movement.

Thermoelectric Energy

Energy generated from body heat differences, explored as a power source for smart textiles.

VO_2 Max (Maximal Oxygen Uptake)

A measure of the maximum amount of oxygen the body can use during intense exercise.

CHAPTER 1: INTRODUCTION

1.1 Background & Context

Over the past decade, gyms have evolved from functional training environments into spaces deeply embedded within everyday lifestyle culture. Fitness is no longer understood solely through structured routines or athletic performance, but as part of a broader pursuit of identity, wellbeing, and long-term health. This shift has transformed how gym spaces, practices, and products are perceived, positioning fitness as a continuous lifestyle practice rather than an isolated activity.

Within this context, gymwear has taken on an expanded role. Once designed primarily for durability and movement, apparel is now expected to align with aesthetic expression, comfort, and technological innovation. The rise of data-driven fitness culture, fueled by smartwatches and fitness trackers, has further reinforced expectations that clothing and accessories should actively contribute to the training experience. As a result, gymwear increasingly sits at the intersection of fashion, technology, and wellness.

Parallel to these developments, smart textile technologies have emerged as a growing area of interest within both academic research and the apparel industry. By embedding sensing and responsive capabilities directly into fabrics, smart textiles offer new possibilities for garments that interact with the body in more intimate and continuous ways. For designers, this represents a shift from clothing as a passive layer to clothing as an interface that mediates between the body, movement, and digital systems.

Positioned within this evolving landscape, this Major Research Project explores the role of smart textiles in contemporary gymwear. It situates smart gymwear within broader cultural, technological, and industry shifts, establishing the foundation for examining how such technologies might shape the future of fitness apparel.

1.2 Problem Statement

Despite the evolution of gym culture and the increasing sophistication of fitness technologies, injury prevention remains a persistent challenge within strength training environments. Many gym-goers train independently, without consistent access to professional supervision, and are required to make moment-to-moment decisions about load, form, and fatigue related to their activity. As a result, many gym-goers overexert, have improper technique and accumulated strain which leads to musculoskeletal injuries.

While personal trainers and physiotherapists play a central role in promoting safe and effective movement, access to their support is often constrained by cost, time limitations, and availability (Brenna Bath 2016). As a result, many individuals seek guidance from social media demonstrations, generic workout applications, or self-directed assessment, despite these sources offering little to no real-time, individualized feedback during exercise. Recent research suggests that people are more likely to accept and follow exercise guidance based on how visually appealing a social media influencer appears, rather than on verified professional expertise (Julia Durau 2022). Within online fitness spaces, this dynamic can lead individuals to place considerable trust in influencers who appear confident or physically fit, even in the absence of formal training or corrective supervision. The absence of immediate, personalized guidance at this stage creates a critical gap that emerges precisely at the point where the risk of improper technique and injury is highest.

Although wearable fitness devices are now widely used, their primary function remains the quantification of activity rather than the improvement of movement quality. Metrics such as heart rate, calories burned, and step count offer retrospective data, but provide little actionable insight into posture, technique, or physical strain as it occurs. Consequently, there is a disconnect between the volume of fitness data available to users and its ability to meaningfully support safer training behaviors.

Smart textiles present a potential pathway to address this problem by enabling garments to sense and respond to the body in real time. However, despite their promise, such technologies remain

largely absent from mainstream gymwear. Issues surrounding comfort, cost, data privacy, usability, and consumer trust continue to impede adoption.

This research addresses this gap by investigating how smart textiles can be meaningfully and ethically integrated into gymwear to support injury prevention. Rather than focusing solely on technical feasibility, the study examines user expectations, industry constraints, and ethical considerations that shape adoption. In doing so, it seeks to identify strategic opportunities for gymwear brands to move beyond performance tracking toward preventative, human-centered fitness solutions.

1.3 Research Aim

This Major Research Project aims to investigate how smart textiles might be positioned within mainstream gymwear as a preventative support system rather than a performance-tracking tool. The project is guided by a strategic design perspective, focusing on how design decisions, industry structures, and user values influence the integration of emerging textile technologies into everyday fitness apparel.

Rather than seeking to produce a finished garment, the research concentrates on understanding the conditions under which smart gymwear could be meaningfully adopted. It examines how gym-goers interpret feedback, how professionals approach injury prevention, and how brands navigate technological, ethical, and commercial considerations. These perspectives are explored through qualitative methods including interviews, gym shadowing, and co-design activities.

By integrating these observations, the project hopes to identify design principles and strategic approaches that will guide future development in the gymwear industry. This research contributes to ongoing conversations about human-centered technology and preventative health by providing recommendations for the proper implementation of smart textile technologies into gymwear.

1.4 Research Questions

This research is guided by the following primary question:

1.4.1 Primary Research Question

RQ1: How might smart textiles be integrated into mainstream gymwear to support injury prevention and safer training practices?

1.4.2 Secondary Research Questions

To support this inquiry, the following sub-questions were developed:

RQ2: What are gym-goers' experiences, needs, and concerns regarding current wearable fitness technologies?

RQ3: How do industry and health professionals perceive the potential of smart textiles in gymwear?

RQ4: What barriers and opportunities exist for mainstream adoption of smart gymwear?

RQ5: How can design and strategic approaches support ethical and user-centered integration of smart textiles within the gymwear industry?

1.5 Method Overview

This study used a qualitative, design-led approach to investigate perceptions, experiences, and expectations surrounding smart gymwear. Data was collected through a combination of end-user interviews, expert interviews, gym shadowing, and co-design exercises. These methods were selected to capture both personal and professional insights related to injury prevention, wearable technologies, and smart textiles.

End-user interviews were conducted with gym-goers aged 18 to 50+, representing a range of fitness levels and training backgrounds. These interviews sought to better understand participants' training habits, motivations, and concerns related to injury risk and technology use.

Expert interviews included professionals from fitness training, healthcare, textile engineering, software engineering, and the gymwear industry, offering technical, clinical, and industry-specific perspectives. Gym shadowing was also employed to observe real-time training behaviors and identify patterns related to fatigue, form, and interactions with existing fitness technologies.

The data generated through these methods was thematically analyzed to identify recurring patterns and key themes. These insights were synthesized through clustering and affinity mapping to establish clear relationships across user needs, behaviors, and challenges.

Building on this analysis, a set of design implications was developed to guide the direction of the project. These implications informed the creation of a smart arm sleeve as a strategic product concept, which was explored through a low-fidelity prototype. The prototype was then used within co-design sessions to refine concepts and validate underlying assumptions through user interaction and feedback.

The insights generated through this iterative process extended beyond design development to inform broader strategic outcomes. These included the development of a Value Proposition Canvas (VPC) and a Flourishing Business Canvas (FBC), which translated user needs and system-level considerations into a structured value and business model. The process concludes with a set of strategic recommendations and a future roadmap, outlining pathways for integrating smart textiles into mainstream gymwear.

The overall research and design process, from initial investigation to strategic outcomes, is summarized in Figure 1.

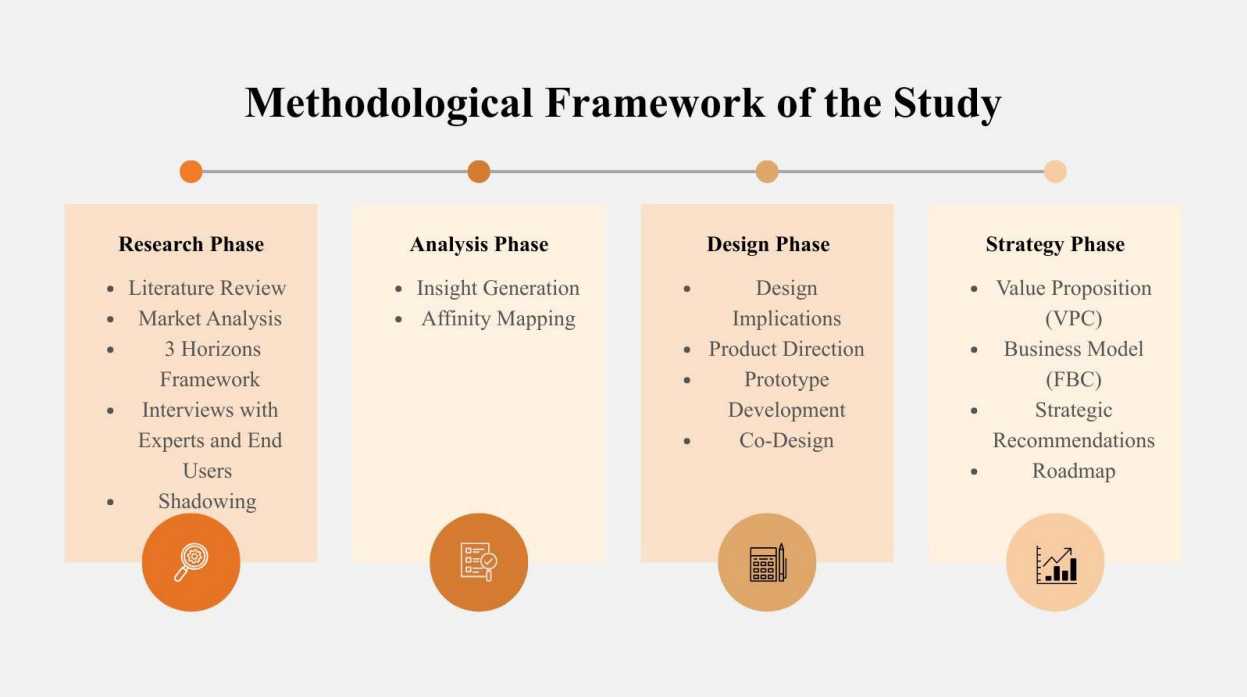

Figure 1 Methodology Overview

1.6 Scope and Limitations

This study focuses on Canadian gym-goers who predominantly participate in strength training and general fitness activities in commercial gym environments. The study used a small, intentionally selected sample of four end users and a small number of experts in fitness, healthcare, technology, and textiles. As an exploratory qualitative study, the findings aim to provide depth of insight rather than statistical generalizability across all gym demographics.

The scope of the study is limited to perspectives and experiences with injury prevention, wearable technology, and smart fabrics in the context of popular gymwear in Canada. While previous research on smart textiles in elite sports and professional athletic training is referenced to provide a larger context, these areas are not the primary focus of the study, which is on everyday gym participation rather than high-performance sports.

This project is not intended to create or test a fully functional smart textile system. Prototyping was restricted to low-fidelity exploration designed to aid concept creation and discussion rather than technical validation. Furthermore, the study was done within a specific timeframe, and data

collection relied on participant self-reporting, which could be influenced by recall bias. Access to people and resources also influenced the size and scope of empirical research.

Within these limits, the study provides useful qualitative insights into consumer demands, industry views, and strategic considerations for smart gymwear adoption in Canada.

1.7 Significance of the Study

This research is significant in its ability to support the gymwear industry in integrating smart textile technologies in ways that are both seamless and commercially viable. By positioning injury prevention as a meaningful driver of product value, the study encourages brands to recognize safety and long-term wellbeing as central considerations in gymwear design.

By examining user behavior, expectations, and attitudes toward smart textiles, the research helps industry stakeholders align innovation with real consumer needs. In doing so, it offers guidance for brands seeking to succeed within the growing smart textile market while building trust, usability, and lasting relevance.

CHAPTER 2: LITERATURE REVIEW

2.1 Gym Culture & Fitness Trends

2.1.1 From Performance to Lifestyle-Oriented Fitness

For much of its history, fitness was framed narrowly around physical performance and appearance. In recent years, however, the fitness industry has undergone a significant cultural transformation, evolving from a niche lifestyle pursuit into a widely accepted and embedded part of everyday life. Fitness is now increasingly understood as part of a broader wellness ecosystem. This shift is reflected in the growing emphasis on personalized health practices, community engagement, and holistic wellbeing experiences that extend beyond the gym floor. According to McKinsey's *Future of Wellness* research, younger generations are key drivers of this change, integrating fitness into daily wellness routines rather than treating it as an occasional or isolated activity (Company 2025). This signals a fundamental shift in how fitness is understood, positioning it as a way of life rather than a single physical activity.

2.1.2 Generational Redefinition of Wellness

Research conducted by McKinsey involving more than 9,000 consumers across multiple countries further illustrates this cultural redefinition. Millennials and Generation Z, in particular, view wellness as a core component of personal identity, placing exercise alongside nutrition, sleep, and mental health (Co 2025). Within this framework, exercise is no longer perceived as a separate goal but as an integral part of overall health. This shift is also reflected in changing gym environments, where strength training, functional movement, and holistic workout formats are increasingly prioritized, while traditional, equipment-centered routines are becoming less dominant. Although these findings reflect global trends, similar patterns are evident within the Canadian fitness landscape, where participation continues to grow in gyms that align with lifestyle-oriented health practices.

2.1.3 Growth of the Wellness and Fitness Market

The expansion of the wellness market further reinforces this cultural shift. Consumers are increasingly investing in health-related services and products, extending beyond traditional gym memberships to include digital coaching platform add-ons such as Strava and the EvolveYou app, wearable technologies like the Apple Watch and other fitness trackers, structured fitness classes including F45 and Orangetheory, community-based initiatives, and curated diet plans (Institute 2025). Together, these spending patterns reflect a broader societal shift toward preventative and long-term health behaviors, with fitness positioned as a central component of everyday life.

From a business perspective, this growth is reflected in the scale of the fitness economy itself. The Canadian fitness industry is valued between $4.3 and $5.4 billion, encompassing gyms, equipment, and digital fitness platforms, with approximately 21% of Canadian adults holding a gym membership. These intersecting trends signal a wellness market that prioritizes sustained engagement, everyday integration, and personalized approaches to health support.

2.1.4 Strength, Longevity, and Changing Body Ideals

This evolving understanding of fitness has also reshaped cultural attitudes toward strength and physical capability. As Joanna Strober, Chief Executive of Midi Health, observes, “There’s been a shift in realizing that skinny, as you get older, rather than being strong, is detrimental.” This perspective has been further reinforced by Peter Attia’s 2023 book *Outlive*, which brought muscle and strength into mainstream discussions of longevity by reframing fitness not as aesthetic performance, but as a tool for extending quality of life. As a result, physical strength has increasingly taken on symbolic value, with toned arms functioning as both a marker of discipline and a contemporary status symbol (Chaker 2025).

2.1.5 Community, Social Connection, and Gym Participation

Alongside these cultural and market shifts, social connection and communal experience are becoming more influential in shaping exercise participation alongside physical outcomes. People increasingly see fitness centers more as communities than places to work out alone; there, they

meet new people and build bonds through common physical activities. Group workouts, strength-training courses, and community fitness challenges have become increasingly popular among younger generations who seek inspiration, accountability, and a sense of community in their exercise programs (Mills 2024).

2.1.6 Implications for Fitness Technologies and Gymwear

These cultural changes have important implications for how individuals interact with fitness technologies and apparel. Workouts are no longer isolated routines but are embedded within broader lifestyle practices that encompass mental wellbeing, social connection, and long-term health maintenance. As a result, gymwear and related technologies are expected to evolve in response to these changing behaviors. This context provides an important foundation for the present research, as it highlights opportunities for smart gymwear to integrate seamlessly into everyday fitness practices and support safer, more sustainable training behaviors.

2.2 Wearables & Consumer Fitness Technology

Wearable fitness technologies, including smartwatches, heart rate monitors, and activity trackers, have become common tools for personal health and fitness monitoring. Most consumer-facing devices allow users to track metrics such as heart rate, step count, calories burned, sleep quality, and workout intensity (O'Donnell 2025), (Alger 2024). These technologies are typically promoted as ways to improve motivation, accountability, and performance, which has contributed to their widespread adoption among recreational gym-goers looking for structure and measurable feedback in their routines.

The growing presence of wearables is not limited to consumer fitness alone. Medical and health institutions have also begun to recognize their role in supporting health monitoring. The Cleveland Clinic notes that heart rate monitors can help individuals better understand exercise intensity and cardiovascular load, enabling users to adjust their training more effectively (Clinic 2024). Similarly, GE Healthcare highlights the increasing clinical relevance of wearable ECG devices, particularly in the monitoring of heart rhythm irregularities (Handzel 2022). Together, these examples show how wearable technologies are gradually moving beyond lifestyle tracking and into health-related and preventative contexts.

Market research further reflects this shift. Deloitte's *Connectivity and Mobile Trends Survey* report steady growth in smart device usage, alongside high levels of consumer trust in wearable technologies for health and fitness tracking. This pattern points to a broader cultural move toward data-driven fitness, where individuals increasingly rely on digital metrics to inform how they train, recover, and evaluate progress (Jana Arbanas 2023).

Despite their popularity, current wearable technologies have notable limitations. Many consumer devices rely on watches and mobile phones, which can lead to inconsistent or inaccurate readings depending on movement type, sweat levels, and device placement (Handzel 2022). Research published in digital health literature also suggests that while wearables are effective at measuring activity levels, they struggle to capture more complex aspects of movement, such as posture, exercise technique, and muscular engagement (Raphael A. Fraser 2025).

Beyond accuracy, wearable devices often present users with large volumes of numerical data that are difficult to interpret in practical terms. Metrics such as heart rate variability, VO_2 max, and recovery scores are frequently displayed without sufficient context or guidance, limiting their usefulness for improving movement quality or reducing injury risk (O'Donnell 2025). As a result, users may gain insight into how hard they are training, without clearly understanding how well they are moving.

The widespread adoption of wearables therefore highlights both the value and the limitations of current fitness technologies. While these devices have normalized data-driven approaches to training, they also expose gaps in how movement, form, and bodily awareness are monitored and supported. This creates space for more embodied and context-aware solutions, such as smart textile systems. Unlike external wearables, smart textiles remain in continuous contact with the body, which opens opportunities for more precise movement tracking and real-time feedback to be integrated directly into gymwear.

2.3 Smart Textiles in Fitness and Gymwear Context

Smart textiles refer to fabrics that integrate electronic and sensing components to extend the traditional role of clothing beyond protection and aesthetics. Asis and Sweta Patnaik's book Fibers to Smart Textiles illustrates how elements such as conductive yarns, embedded sensors,

microcontrollers, and communication modules can be integrated directly into textile structures, enabling garments to sense, process, and transmit information related to the wearer's body or environment. Unlike conventional wearable devices that function as external attachments, smart textiles operate through continuous physical contact with the body, making them particularly suitable for physiological and biomechanical monitoring during movement.

The construction of smart textile systems typically involves layered components, including a base fabric, conductive pathways, sensing elements, data transmission units, and power mechanisms. Conductive pathways enable electrical signals to pass through the fabric while maintaining flexibility and comfort. Preserving the mechanical properties of textiles is critical, as increased stiffness or weight can negatively affect wearability and user acceptance, especially in gymwear where freedom of movement is essential (Asis Patnaik 2020).

Smart textiles are commonly categorized based on their level of functionality. Passive smart textiles can sense external or bodily stimuli, such as temperature or strain, without responding to these changes. Active smart textiles can both sense and react, for example by regulating heat or altering material properties. More advanced adaptive systems integrate sensing, data processing, and actuation to dynamically respond to user needs, demonstrating progression from simple data collection toward interactive textile systems (Asis Patnaik 2020).

Sensor integration can occur at different stages of textile development. In practice, industry research shows that sensors do not always need to be fully embedded into fabrics; instead, they can be modularly attached using flexible interconnects, offering alternative design approaches where full textile integration is not feasible (Datatex n.d). Within fitness and movement contexts, textile-based sensing technologies commonly include strain sensors to capture posture and movement, pressure sensors to monitor load distribution, bioelectrodes for physiological signals, and inertial measurement units (IMUs) to track motion patterns (Kai Yang 2024) . Together, these sensing methods allow garments to collect biomechanical and physiological data continuously, in ways that wrist-worn devices often struggle to achieve during dynamic exercise.

Evidence from sports science and performance research suggests that this approach is already technically viable. One well-documented example is the Hexoskin smart shirt, which integrates

textile-based ECG, respiratory, and accelerometer sensors into a compression garment. Laboratory validation studies comparing Hexoskin outputs with clinical reference systems during rest and cycling exercises reported strong agreement for heart rate and breathing measurements, demonstrating that textile-embedded sensors can capture physiological data accurately and in real time without limiting movement (Cara M Smith 2020).

This feasibility is further supported by a scoping review of smart shirts that examined more than 40 studies involving both athletic and clinical populations. The review found consistent evidence that fabric-integrated sensors can reliably monitor heart rate, respiration, and activity levels during movement, reinforcing the potential of smart garments for continuous monitoring in active settings (Hamzeh Khundaqji 2020).

More recent research has begun to move beyond basic physiological tracking toward capturing movement itself. Emerging systems such as VersaPants use textile-integrated capacitive sensing channels within loose-fitting garments to capture lower-body motion and joint angles across every day and exercise-based activities, such as walking, sitting, and squatting. Validation studies indicate that these systems can reliably map movement patterns when combined with machine-learning models (Deniz Kasap 2025). Similarly, the MoCaPose system explored motion capture using stretchable garments embedded with capacitive sensors, translating fabric deformation into joint angle data. When validated against optical motion capture systems, the results showed strong tracking accuracy, pointing to the growing potential of garment-based sensing as an alternative to external motion-tracking technologies (Bo Zhou 2025).

Despite these advances, energy supply remains a critical challenge in smart textile design. Traditional batteries can limit wearability due to bulk, rigidity, and frequent charging requirements (Asis Patnaik 2020). In response, research has increasingly explored self-powered textile systems capable of harvesting energy from body motion, heat, or environmental sources. Advances in triboelectric and piezoelectric textiles enable mechanical energy generated during movement to be converted into electrical power, supporting longer-term and more autonomous sensing systems (Direct 2025). Additional research highlights thermoelectric, photovoltaic, and kinetic energy harvesting mechanisms as promising pathways for reducing reliance on external batteries in next-generation smart apparel (Gabel 2025).

While smart textile technologies demonstrate strong technical potential, considerations around everyday wear remain important for their transition into mainstream gymwear. Existing research notes that factors such as washability and long-term durability can affect sensor performance over time, particularly when garments are exposed to repeated laundering (Asis Patnaik 2020). Even with these limitations, smart gymwear represents a potential pathway for extending advanced sensing capabilities into more accessible, everyday fitness contexts, a possibility that informs the direction of the present research.

2.3.1 Three Horizons Framework

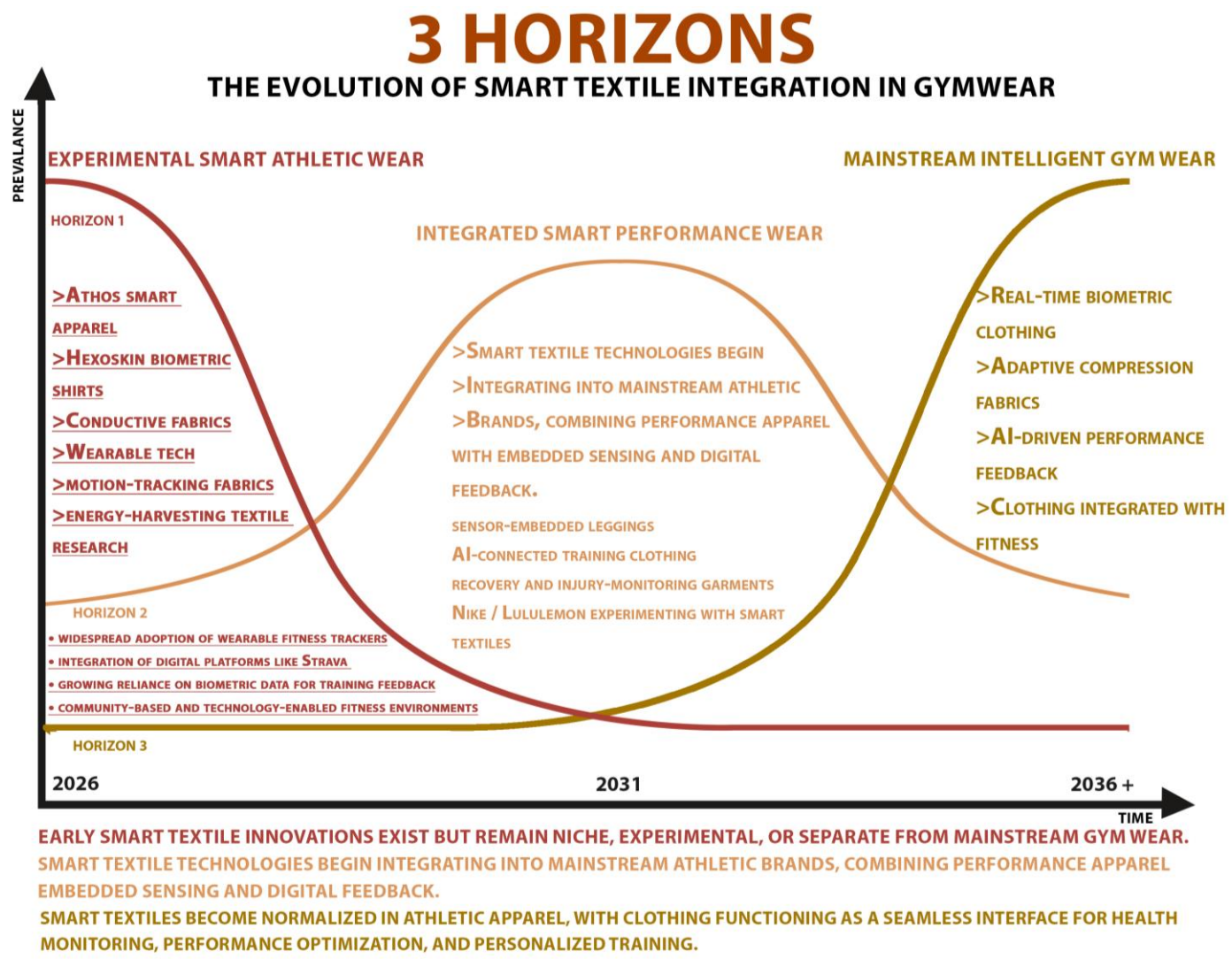

Figure 2 Three Horizons Framework

In simple terms, the Three Horizons framework, developed by Bill Sharpe, is a way to look at change from a broader, systems-level perspective. It allows this research to take an “aerial view” of how smart gymwear is evolving over time.

All the shifts discussed earlier can be positioned within this framework, helping to understand what exists today, what is emerging, and what may transition into the future.

Here, Horizon 1 reflects the present, where gymwear remains largely passive, and wearable technologies exist separately. Horizon 2 captures what is emerging, where smart textiles begin integrating into apparel. Horizon 3 represents a future state, where intelligent gymwear becomes seamless and embedded into everyday fitness.

Using this framework, the research traces a trajectory from present to future, showing that smart gymwear evolves gradually rather than through sudden disruption.

2.4 Data Privacy, Ethics, and User Trust in Wearable Technologies

As smart gymwear becomes more closely integrated into everyday fitness routines, questions around data privacy, ethical use, and user trust become increasingly important. Unlike traditional fitness devices that can be removed after use, smart gymwear is worn directly on the body and often for extended periods of time. As a result, these garments are capable of continuously collecting sensitive personal data, including movement patterns, heart rate, muscle activity, and, in some cases, location-based information. Research within digital health literature highlights that this level of continuous data collection raises concerns related to informed consent, data ownership, and the long-term storage of personal health information (Schmidt 2025).

Several studies indicate that many users remain unaware of how their data is processed, stored, or shared once collected. For example, research published in *Frontiers in Digital Health* suggests that transparency in data practices remains limited, with users frequently agreeing to privacy policies without fully understanding how their information may be used or distributed (Radanliev 2025). This lack of clarity can undermine trust and discourage long-term engagement with smart gymwear technologies. In addition, scholars note that constant data capture can blur the line between self-monitoring and surveillance, particularly when data is accessed by brands,

platforms, or third-party providers rather than remaining under the direct control of the user (Schmidt 2025).

Ethical concerns are further complicated by the growing use of performance analytics within the fitness industry. As data generated through smart gymwear is increasingly positioned as valuable for commercial, performance, or research purposes, questions arise regarding power dynamics between users, brands, and technology providers (Sengupta 2026). Research suggests that when individuals feel their personal data is being monetized or exploited without clear benefit or control, trust in wearable technologies decreases significantly (Radanliev 2025).

Within digital health and human-centered design research, user autonomy is consistently identified as a core ethical principle in the development of wearable technologies. (C. L. V. Sivakumar 2024) emphasizes that users should retain meaningful control over what data is collected, how it is interpreted, and who can access it, including the ability to opt out of data collection, remove personal data, and understand how algorithms generate feedback from sensor inputs.

These considerations are particularly relevant for smart gymwear, given its intimate and embodied nature. For smart gymwear to be trusted and adopted within everyday fitness environments, ethical design principles and transparent data practices must be treated as foundational rather than secondary features.

2.5 Injury Prevention in Recreational Fitness

Injury is common in recreational gym training, particularly in environments where individuals train independently without professional guidance. Many gym-goers rely on self-taught techniques, social media demonstrations, or informal advice, increasing the likelihood of movement errors and unsafe loading patterns. Research consistently shows high rates of musculoskeletal injury in recreational fitness, with a systematic review reporting a mean injury prevalence of approximately 32.8% and identifying the shoulder, lower back, and knee as the most frequently affected areas during resistance and strength-based training (Fábio Dominski 2021).

Observational studies of everyday gym participation reflect similar patterns, with high levels of training-related pain reported during commonly performed compound movements such as squats, deadlifts, bench presses, and dips. Upper-body pain is reported most frequently, followed by discomfort in the lower back and knees, suggesting that widely practiced lifts may elevate injury risk when technique is inconsistent or unsupported (Maria A. Bernstorff 2023).

Beyond exercise selection, fatigue and recovery play a significant role in how injuries develop over time. While extreme overtraining is relatively uncommon among recreational gym-goers, repeated training sessions without adequate rest can gradually reduce movement quality. As fatigue accumulates, technique often becomes less stable, increasing stress on joints and surrounding tissues during strength training (Bell 2024). These subtle changes are not always obvious to the individual, particularly during unsupervised workouts.

Biomechanical research helps explain how this process unfolds. Studies using wearable inertial sensors have shown that movement patterns can shift as fatigue builds within a single training session. Variables such as repetition timing, joint positioning, and movement symmetry often change during exercises like squats and deadlifts, altering how load is distributed across the body. These changes are associated with increased injury risk, particularly when they go unnoticed over repeated sessions (Gleadhill 2019).

For this reason, wearable sensing technologies have increasingly been explored as tools to support injury prevention through real-time feedback. Research suggests that motion sensors can capture key aspects of movement, including joint angles, repetition speed, and asymmetry, offering insights that may help identify technique breakdown before injury occurs (Ryan T. Li 2015). While much of this research has focused on athletic or rehabilitation settings, the underlying principles are highly relevant to recreational gym environments, where objective feedback on movement quality is largely absent.

Many injuries in recreational fitness are not the result of single events, but rather the outcome of repeated technique errors, accumulated fatigue, and unstructured training loads, showing the value of systems that help people stay aware of how they move during everyday training.

2.6 Research Gap and Chapter Summary

This chapter has brought together literature on evolving gym culture, consumer fitness technologies, smart textiles, ethics, and injury patterns in recreational fitness. While wearable devices are now widely used, existing research suggests they remain largely focused on tracking activity and performance, offering limited support for understanding movement quality or reducing injury risk during training.

Smart textile technologies, by contrast, have shown strong potential in healthcare, research, and elite sports contexts through their ability to capture physiological and biomechanical data. However, there is still limited research exploring how these capabilities can be translated into smart gymwear for everyday gym-goers, particularly in environments where training is often unsupervised, and real-time feedback is lacking. Ethical considerations around data privacy, transparency, and user trust further shape this gap, especially when sensing systems are worn directly on the body.

Responding to these gaps, this research shifts attention toward injury prevention through smart gymwear. Focusing on everyday gym-goers in Canada, the study examines how smart textiles can be integrated into mainstream fitness apparel in ways that are practical, ethical, and aligned with real training behaviors, drawing on qualitative methods such as interviews, gym shadowing, and co-design.

CHAPTER 3: METHODOLOGY

3.1 Research Approach

This study uses an exploratory qualitative, design-led research approach to explore the integration of smart textiles into conventional gym-wear for the purpose of injury prevention among Canadian gym-goers. A qualitative methodology was selected to focus on understanding experiences, perceptions, behaviors, and expectations rather than measuring numerical outcomes or testing predefined hypotheses. This approach gives a richer understanding of how people train, manage injury risks, and relate to emerging technologies in everyday gym settings.

The research is grounded in a human-centered design framework, which means the gym-goers and their lived experiences are at the heart of the process. Fitness routines vary significantly depending on age, physical capability, and training goals, making direct engagement with users essential. Alongside gym-goers, industry professionals were also included to give practical and technical perspectives. Bringing these voices together helped balance empathy with feasibility and ensured that the research remained connected to real-world industry contexts.

Design was used not only as an end outcome but as a way of thinking and investigating. A multi-method qualitative research design supported this approach, combining end-user interviews, expert interviews, gym shadowing, and co-design activities. Using multiple methods made it possible to view the topic from different angles and strengthen the reliability of the findings through comparison and overlap.

The research followed a sequential and iterative structure, where each stage informed the next. Initial interviews with gym-goers focused on training routines, injury experiences, and attitudes toward fitness technology. In parallel, expert interviews with professionals from textile engineering, wearable technology, and fitness-related fields offered insight into material capabilities, design constraints, and market realities. Gym shadowing and observational research then provided a closer look at real training behaviors, revealing movement patterns and injury-prevention practices that are often difficult to express in interviews alone.

Insights from these stages were brought together to inform the development of a low-fidelity prototype. Rather than representing a finished product, the prototype served as a discussion tool

during co-design sessions. Engaging with a tangible concept encouraged participants to reflect more deeply on their needs, imagine future possibilities, and suggest meaningful improvements for smart gymwear.

Overall, this research approach supports a layered understanding of user needs, technological possibilities, and industry considerations. By combining human-centered research with design-led thinking, the study produces grounded insights that can inform both academic discussion and practical direction for gymwear brands exploring smart textile integration.

3.2 Participants

This study involved two main participant groups: recreational gym-goers (end users) and industry experts. Including both groups allowed the research to capture user experiences alongside professional perspectives, supporting a more holistic understanding of smart gymwear adoption.

Four gym-goers participated in the study. Participants were selected using purposive sampling, as they met specific inclusion criteria relevant to the research goals.

All participants were:

- Regular gym attendees who go to the gym at least 3 times per week
- Between the ages of 18-55+
- Engaged in strength training or mixed fitness routines
- Based in Canada

This group included individuals that had different fitness goals, levels of experience and prior injury histories. This diversity made it possible to explore different ways of training behaviors, pain points, and attitudes toward fitness technology. Participants were recruited through personal networks and gym communities.

In addition to end users, expert participants were recruited from relevant professional fields, including:

- Textile engineering
- Software engineering
- Gym-wear industry professional
- Healthcare professional
- Fitness coaching

Experts were selected based on their professional experience, industry involvement, and expertise in smart textiles or athletic apparel. They provided insights into:

- Technical feasibility
- Industry constraints
- Market readiness
- Design considerations

Expert participants were recruited through professional networks and referrals

3.3 Rationale for Participant Selection

The combination of end users and experts enabled data triangulation, strengthening the validity of findings. While gym-goers shared lived experiences and unmet needs, experts contextualized these insights within technological and industry realities. This dual perspective ensured that recommendations emerging from the research were both user-centered and commercially viable.

All participants provided informed consent prior to participation. Pseudonyms were used throughout the study to protect participants' identities.

3.4 Data Collection Methods

Data was collected using four primary qualitative methods: semi-structured interviews with end-users and experts, gym shadowing, and prototype engagement in a co-design session. These

methods were selected to capture both verbal insights and observed behaviors, providing a holistic understanding of user needs and experiences.

3.4.1 Semi-Structured Interviews

Semi-structured interviews were conducted with both end users and expert participants. This format made it possible for guided discussion while also giving participants the freedom to talk about their own experiences and points of view. Interview questions focused on:

- Gym routines and training habits
- Past injury experiences
- Awareness and use of fitness technology
- Attitudes toward smart gymwear

Each interview lasted approximately 45 to 60 minutes and was conducted either in person or online, depending on participant's availability. With the participant's consent, interviews were audio-recorded and later transcribed for analysis.

3.4.2 Gym Shadowing and Observation

Observational research was conducted by shadowing one end-user during their regular gym session. This participant had previously participated in an interview and volunteered for observation, facilitating a deeper examination of their reported behaviors in a real-world context. This method helped to understand their behaviors and practices, including:

- Exercise selection
- Movement patterns
- Rest periods
- Informal injury prevention strategies

Field notes were taken throughout the session to document observations. This method provided contextual insight into behaviors that participants may not have consciously articulated during interviews.

3.4.3 Co-Design Sessions and Prototype Development

After the initial ideas were generated, a co-design session was conducted. Participants were invited to engage with a design concept and provide feedback. A low-fidelity prototype was

created as a research tool to support the session and to better understand how participants behaved and interacted.

The prototype was a knitted stretchable sleeve with a sensor built into the forearm area near the elbow. The sensor was built into the fabric structure to make it more comfortable and easier to wear. The prototype's goal was not to make a working product, but to:

- Visualize smart textile concepts
- Prompt discussion
- Encourage critique and idea generation

Activities during the session included:

- Discussing pain points in current gym-wear
- Brainstorming features for smart gym-wear
- Interacting with and reflecting on the prototype

Participants' interaction with the prototype yielded insights into comfort, usability, and perceived value. The feedback gathered during these interactions informed subsequent design decisions. The session encouraged participants to actively contribute to design directions rather than remain as passive respondents.

3.5 Data Analysis

Data analysis followed a thematic analysis approach. Interview transcripts, observation notes, and co-design feedback were reviewed multiple times to identify recurring patterns and themes.

The process included:

1. Familiarization with data
2. Open coding to identify key ideas
3. Grouping codes into broader themes
4. Refining themes through comparison

This process allowed insights to emerge organically rather than being forced into predefined categories. The resulting themes were synthesized to inform design implications and industry recommendations. Co-design sessions were then used to validate these insights, findings, and

recommendations, ensuring they resonated with participants' experiences and accurately reflected their needs and perspectives.

3.6 Ethical Considerations

Ethical approval was obtained prior to data collection. All participants provided informed consent before participating in the study. Participants were informed of:

- The purpose of the research
- Their right to withdraw
- How data would be used

All data was anonymized, and pseudonyms were used in reporting. Audio recordings and transcripts were stored securely and were only accessible to the researcher.

3.7 Limitations

This study has several limitations. The small sample size limits the generalizability of findings. As a qualitative study, the results reflect personal experiences rather than statistically representative data.

Additionally, shadowing was conducted with only one participant, which may not capture the full range of gym behaviors.

Despite these limitations, the study provides valuable exploratory insights that contribute to understanding smart gymwear adoption and injury prevention practices.

CHAPTER 4: FINDINGS & INSIGHTS

4.1 Overview of Findings

This chapter brings together insights that surfaced through conversations, observations, and collaborative sessions with gym-goers and industry experts. As stories were shared during interviews, patterns began to take shape across experiences about injury risk, fatigue, guidance, technology, and trust within everyday gym environments.

Instead of separating findings by method, the insights are woven together to reflect how behaviors, perceptions, and situational factors intersect in real life. Each theme unfolds through a narrative grounded in both participant and expert voices. Together, these themes illuminate not only what gym-goers do, but why they do it, revealing the motivations, assumptions, and psychological patterns that shape how people approach fitness, injury prevention, and technology in their daily routines.

Theme 1

Dependence on External Guidance as a Risk-Management Strategy

As participants spoke about their gym routines, a clear pattern began to surface. Many did not see themselves as the primary decision-makers in their own training. Instead, they described leaning on external sources such as personal trainers, fitness apps, or structured programs to shape what they did and how they performed their movements. This reliance did not come across as passivity, but rather as a deliberate and thoughtful strategy. During shadowing, for instance, one participant paused mid-exercise to recheck instructions and watch a demonstration before continuing.

Underlying this pattern was a shared sense of uncertainty. Participants frequently described form, technique, and exercise selection as areas where they felt underqualified, particularly when approaching compound lifts or unfamiliar movements. The hesitation they expressed was not rooted in a lack of motivation, but in an awareness of risk. Many framed independent decision-making as potentially unsafe, voicing concern that choosing incorrectly could result in strain or injury.

Professionals echoed these observations from their own perspectives. One expert noted that recreational gym-goers often lack foundational movement education, a gap that encourages them to rely on structured direction. In this light, outsourcing decisions was not framed as convenience, but as a protective response to environments perceived as technically demanding.

Insight

External guidance functions as a form of risk management. Rather than striving for complete autonomy, recreational gym-goers often prioritize reassurance, correctness, and safety. Guidance is less about receiving instructions and more about gaining confirmation that what they are doing is safe enough to continue.

Quotes

End User A:

"I don't really decide my workouts myself. If someone gives me a plan, I'll follow it because I don't trust that I know enough to do it properly."

Fitness Coach Expert:

"Most injuries I see happen when people try to self-program without understanding movement fundamentals. Guidance gives them confidence, not control."

Theme 2

Injury Awareness Emerges Only After Physical Disruption

Injury prevention was rarely something the participants described thinking about in advance. Instead, it entered their awareness only after something felt wrong. Before that point, soreness and fatigue were often interpreted as positive signals, signs that a workout had been effective rather than indications that something might need attention. Several participants spoke about pushing through discomfort without hesitation, only pausing to reconsider their routines once pain began to interfere with everyday tasks or prevented them from returning to the gym.

What stood out across accounts was how normalized these sensations were within their understanding of exercise. Discomfort was not immediately recognized as a warning sign. It was instead folded into expectations about what progress should feel like. Professionals described observing the same pattern from their side of practice. Experts noted that many recreational gym-goers have limited awareness of cumulative strain or early injury indicators, which makes it

difficult for them to recognize subtle warning signs. Without that knowledge, individuals often continue training until symptoms become unavoidable. From this perspective, the issue is not negligence but timing. Attention is typically triggered only when discomfort crosses a threshold that can no longer be ignored.

Insight

Injury prevention is not naturally integrated into everyday gym behavior. Instead, pain functions as the primary signal that prompts awareness, reflection, and behavioral change, meaning that prevention often begins only after disruption has already occurred.

Quotes

End User C:

"I didn't really think about injury until my knee started hurting properly. Before that, I thought soreness just meant I was working hard."

Healthcare Professional:

"By the time people feel pain, the damage is often already there. Prevention isn't intuitive unless something forces attention."

Theme 3

Fatigue Creates an Invisible Threshold for Injury Risk

During gym shadowing, a gradual shift in movement quality became visible as the observed participant progressed through their workout. Early sets were controlled and stable, but as fatigue accumulated, posture began to deteriorate, weight distribution became uneven, and compensatory movements appeared, particularly during compound exercises. These changes unfolded subtly, without immediate acknowledgment from the participant, making them easy to overlook in real time.

This pattern became especially revealing because the same individual had been interviewed beforehand. In the interview, they spoke confidently about their ability to maintain proper form even when tired, describing themselves as attentive to technique and consistent in their execution. Yet during observation, their performance told a different story. As exertion increased, their posture declined, and movement patterns became less stable, highlighting a clear gap between perceived ability and actual performance. The discrepancy did not appear

intentional; rather, it reflected how difficult it can be for individuals to accurately monitor their own biomechanics while physically engaged and fatigued.

Although only one participant was shadowed, their experience echoed what other interviewees described retrospectively. Many participants acknowledged that fatigue affects their form but noted that they usually realize this only after completing a workout. In the moment, they tend to feel capable and in control, even when their movement quality suggests otherwise. Experts identified this perceptual gap as a key contributor to injury risk, emphasizing that fatigue subtly alters mechanics in ways that are often imperceptible to the person experiencing them.

Insight

Fatigue creates a hidden threshold of vulnerability in which gym-goers feel capable while their movement quality quietly declines. Because this shift often goes unnoticed in real time, individuals may continue training under conditions that increase their risk of strain or injury.

Quotes

End User B:

"I usually realize my form was bad only after I'm done. In the moment, I feel fine and just keep going."

Fitness Coach Expert:

"People don't get injured when they're fresh. They get injured when fatigue creeps in and their body starts compensating without them noticing."

Theme 4

Comfort and Social Perception Shape Smart Gymwear Adoption

As participants imagined what it would be like to wear technology-integrated gym clothing, their responses consistently returned to one central idea: it had to feel like ordinary activewear. Across interviews, individuals emphasized that any garment intended for workouts should blend seamlessly into their existing routines, both physically and socially. They described wanting clothing that moved naturally with their bodies, without stiffness, bulk, or unfamiliar sensations that might interrupt their focus during exercise.

Equally important was how the garment appeared to others. Participants expressed hesitation about visible technological elements, explaining that anything that looked noticeably different

from standard gym attire could attract attention in shared fitness spaces. For them, the concern was not only physical comfort but social comfort. Clothing that stood out risked making them feel self-conscious, which in turn could distract from their workout. In this sense, acceptance was tied not just to functionality, but to whether the technology could remain discreet and unobtrusive.

Experts in the gymwear field described seeing the same pattern in practice. From their perspective, many wearable fitness technologies fail not because of poor functionality, but because they disrupt the user's sensory or social experience. When a garment feels unusual, restrictive, or visibly technical, users often abandon it regardless of its potential benefits.

Insight

Adoption of smart gymwear is shaped primarily by embodied comfort and social discretion rather than technological novelty. For users, the ideal wearable is one that does not feel like technology at all; but instead disappears into the experience of exercising.

Quotes

End User D:

"If it doesn't feel like normal gym clothes, I wouldn't wear it. I don't want to feel like I'm wearing a gadget."

Gymwear Industry Expert:

"The moment a garment feels different from regular activewear, adoption drops. Comfort is non-negotiable."

Theme 5

Users Prioritize Understanding Over Quantification

As participants described their experiences with fitness technologies, many focused less on what was being measured and more on how the information was presented to them. Numerical dashboards, performance graphs, and detailed metrics were frequently discussed as features they encountered but did not consistently use. Several participants explained that although they initially explored these data displays, they gradually paid less attention to them when the information felt difficult to interpret or disconnected from their immediate workout experience.

Across interviews, it became evident that the challenge was not the presence of data itself, but the absence of clear explanation. When metrics were presented without contextual guidance, participants often reported difficulty understanding what the information meant or how it related to their training decisions. In contrast, forms of feedback that translated information into clear, actionable direction were described as easier to engage with and more useful during workouts. This preference also helped explain why many participants expressed greater trust in trainers or structured gym environments, where feedback is personalized, immediate, and explained in relation to their specific movements. Similarly, community-based gym settings were described as spaces where individuals could ask questions, observe others, and make sense of guidance more easily than when interpreting numerical outputs alone.

Experts working with wearable technologies described similar observations from their professional experience. They noted that while measurement accuracy is technically important, users' ability to interpret and apply information plays a larger role in sustained engagement.

Insight

For recreational gym-goers, the usefulness of fitness technology is closely tied to how understandable it is. Rather than prioritizing large quantities of detailed metrics, users tend to value information that is clear, interpretable, and directly relevant to their activity, which helps explain their preference for guidance sources that provide personalized and contextualized feedback.

Quotes

End User B:

"I don't really care about all the numbers. Half the time I don't even know what they mean."

Software Engineer Expert:

"Users don't want data dumps. They want systems that tell them what matters and why."

Theme 6

Privacy Concerns Shape Trust and Willingness to Engage

As conversations turned toward data and monitoring, participants began to express concerns that extended beyond physical use and into digital trust. Questions about where their information would go, who could access it, and how it might be used surfaced consistently across interviews.

Continuous tracking and cloud-based storage were described as sources of uncertainty because they suggested that personal data might leave the user's control. These concerns were not framed as technical objections but as issues of transparency and reassurance, with participants indicating they would feel more comfortable engaging with systems whose data practices were clearly explained.

Experts described encountering similar reactions in practice and pointed to technical design choices that can shape user trust. The software engineer expert explained that systems which store processing on the user's device, rather than sending data to external servers, can reduce perceived risk because information never leaves the device. He noted that some companies already implement forms of local processing or anonymization, illustrating how system architecture itself can function as a trust-building mechanism.

Insight

Privacy functions as a foundational condition for trust in smart fitness technologies. Rather than being treated as an added feature, transparent data practices shape whether users feel comfortable engaging with a system at all.

Quotes

End User A:

"I don't like the idea of my workout data being stored somewhere without me really knowing what happens to it."

Software Engineer Expert:

"Once users feel their data is being exploited, they disengage completely, no matter how good the product is."

Theme 7

Smart Gymwear Is Framed as Supportive Rather Than Supervisory

When participants imagined interacting with smart gymwear, they consistently described wanting it to feel encouraging rather than evaluative. Instead of systems that monitored them in a strict or corrective way, they spoke about preferring guidance that worked quietly in the background, offering suggestions without interrupting their flow. The idea of constant surveillance was widely rejected, not because participants opposed feedback, but because they

associated overly directive systems with pressure or judgment. What they described instead was a form of assistance that respected their pace, adapted to their goals, and allowed them to remain in control of their workout experience.

Across interviews, this distinction between support and supervision appeared repeatedly. Participants framed ideal feedback as something that would feel collaborative rather than authoritative, helping them adjust without drawing attention to mistakes. Subtlety was especially important, as many emphasized that they wanted feedback to blend into their routine rather than dominate it. In this sense, the emotional tone of interaction mattered as much as the function itself.

Experts highlighted the same dynamic from a design perspective, noting that tone strongly influences whether users continue engaging with a system over time. They explained that when feedback feels punitive or overly corrective, users are more likely to disengage, whereas supportive feedback encourages trust and sustained use.

Insight

Gym-goers tend to conceptualize smart gymwear not as a supervising authority but as a supportive assistant. Engagement is shaped not only by what feedback is delivered, but by how that feedback feels when received.

Quotes

End User C:

"I wouldn't want it to judge me. I'd want it to help me quietly."

Software Engineer Expert:

"If the system feels punitive, users shut down. Supportive feedback keeps them engaged."

Theme 8

Smart Textiles Remain Conceptually Distant from Everyday Fitness

When participants spoke about smart textiles, their tone often shifted to a mix of curiosity and uncertainty. Many found the idea intriguing, yet they described it as something that felt removed from their everyday experience. Instead of picturing these garments as part of their own gym routines, they often associated them with futuristic products or niche gear intended for athletes or

specialized environments. This framing made the concept feel distant from their personal routines, even when they expressed interest in the technology itself.

Because of this perception, participants found it difficult to imagine smart textiles as something they would naturally wear as part of their regular gym clothing. Rather than seeing them as an extension of familiar activewear, they tended to view them as advanced tools designed for specific purposes. Experts echoed this observation, explaining that smart textiles are still most presented in high-performance sports or healthcare contexts. This limited exposure shapes expectations and can lead people to question whether such garments would be practical, durable, or useful in everyday fitness settings.

Insight

Barriers to adoption stem primarily from familiarity and perception rather than technological readiness. Even when smart textile systems are functionally viable, limited exposure can make them feel unfamiliar or inaccessible, slowing their acceptance in everyday fitness.

Quotes

End User B:

"I want to see results before adopting it."

Textile Engineer Expert:

"The technology is there, but consumers don't really understand it yet. That gap slows everything down."

4.2 Summary of Findings

What became evident through these findings is that gym-goers experience injury risk, fatigue, guidance, comfort, and trust not simply as technical concerns, but as lived and emotional dimensions of their routines. Insights from conversations, observations, and expert perspectives all point to fitness as something shaped as much by perception, confidence, and reassurance as by physical performance.

These themes lay the groundwork for what follows, informing the design implications, prototype development, and strategic directions.

CHAPTER 5: DESIGN DEVELOPMENT & PROTOTYPING OF SMART GYMWEAR

5.1 Design Implications

Derived from the key insights in Chapter 4, the following design implications outline the key standards, principles, and requirements that should guide future design decisions when integrating smart textiles into mainstream fitness apparel. These considerations ensure that recommendations and design suggestions for gymwear align closely with user needs, comfort, and real-world gym use.

5.1.1 Design for Guided Support Rather Than Autonomy

Gym-goers tend to prefer structured guidance and reassurance instead of having to analyze data on their own. Because of this, smart gymwear should function as a supportive training aid rather than a fully independent analytics tool. It should provide subtle, real-time guidance during exercises that helps users stay on track without requiring constant attention or effort to interpret feedback. Signals should gently indicate when movements are correct or need adjustment, reducing mental strain during training.

5.1.2 Prioritize Injury Prevention Through Early Detection

Participants generally took a reactive approach to injury prevention, usually paying attention only after discomfort appeared. This highlights the importance of focusing on early warning signs such as fatigue-related form changes or uneven movement patterns. Smart textile systems should detect small biomechanical changes before they escalate into injury, shifting the experience from reactive correction to preventative awareness.

5.1.3 Design for Fatigue-Aware Feedback

Observational data showed that exercise form often deteriorates under fatigue, even when users perceive themselves as capable of continuing. Smart gymwear should therefore incorporate fatigue-aware sensing, so feedback can adjust dynamically as physical load accumulates.

Adaptive alerts can prompt rest, reduced intensity, or form correction when fatigue thresholds are reached, allowing the system to respond to the body's changing state during a workout.

5.1.4 Ensure Comfort, Flexibility, and Invisibility

Comfort and invisibility emerged as non-negotiable requirements for adoption. Smart gymwear must maintain the look, feel, and flexibility of conventional athletic apparel. There should be no hard parts, bulk, or visible hardware within the textile structure. Sensors and conductive elements should be fully embedded in the fabric. From a design perspective, this requires stretchable materials, seamless construction, and sensor placement that does not interfere with movement.

5.1.5 Translate Data into Intuitive Feedback

Participants reported frustration with complex dashboards and excessive metrics. Smart gymwear should therefore focus on communicating information clearly rather than presenting large amounts of data. Instead of detailed statistics, feedback can be delivered through simple signals such as vibration, color change, or brief prompts that can be understood instantly during exercise.

5.1.6 Design for Trust and Privacy Transparency

Concerns about data privacy strongly influenced willingness to engage with wearable technology. Smart gymwear should therefore integrate privacy into the design from the outset. This includes collecting only necessary data, storing processing locally when possible, and clearly communicating how information is used. Trust should be reinforced through transparent interaction rather than hidden processes.

5.1.7 Summary

Overall, these design implications show that successful smart gymwear must balance technological capability with comfort, clarity, and trust. The findings suggest that smart textiles should function as subtle systems that integrate smoothly into existing gym routines.

5.2 Strategic Product Direction: The Smart Arm Sleeve as an Entry Point for Smart Textile Adoption

Building on the design implications, a clear product direction emerges in the form of a smart gymwear arm sleeve. Rather than introducing fully integrated smart garments, this research proposes a more gradual approach through a complementary wearable that can be used alongside existing gymwear.

This direction is grounded in key findings from earlier stages of the research. Participants consistently emphasized the importance of comfort, familiarity, and minimal disruption to their routines. As a result, introducing smart textiles through a smaller, optional product reduces resistance and allows users to engage with the technology without requiring full commitment.

The arm sleeve offers a practical and accessible entry point. As a lightweight and flexible accessory, it can be easily worn and removed, while maintaining the look and feel of conventional activewear. Its smaller form also reduces complexity in terms of maintenance, durability, and integration of sensing components.

From a functional perspective, the sleeve is well-positioned to capture upper-body movement and provide real-time feedback without interfering with natural motion. This makes it particularly suitable for exercises such as bicep curls, where movement patterns are clearly defined but often performed incorrectly under fatigue.

Positioning the arm sleeve as a complementary layer rather than a replacement product also aligns with broader adoption challenges identified in the research. It allows users to experiment with smart textiles incrementally, lowering psychological and behavioral barriers while maintaining trust and comfort.

In this way, the smart arm sleeve functions not only as a design solution, but as a strategic entry point for introducing smart textile technologies into everyday fitness contexts.

5.3 Prototype Development

A low-fidelity prototype was developed to be tested within a co-design setting as a way to explore how smart textiles could support injury prevention and movement awareness in everyday gym contexts. The prototype took the form of a smart gymwear arm sleeve, created specifically to reflect the proposed product direction and business model strategy identified earlier in the research. It was designed as a simple exploratory artifact to examine how embedded sensing and real-time feedback might function within a wearable garment during exercise.

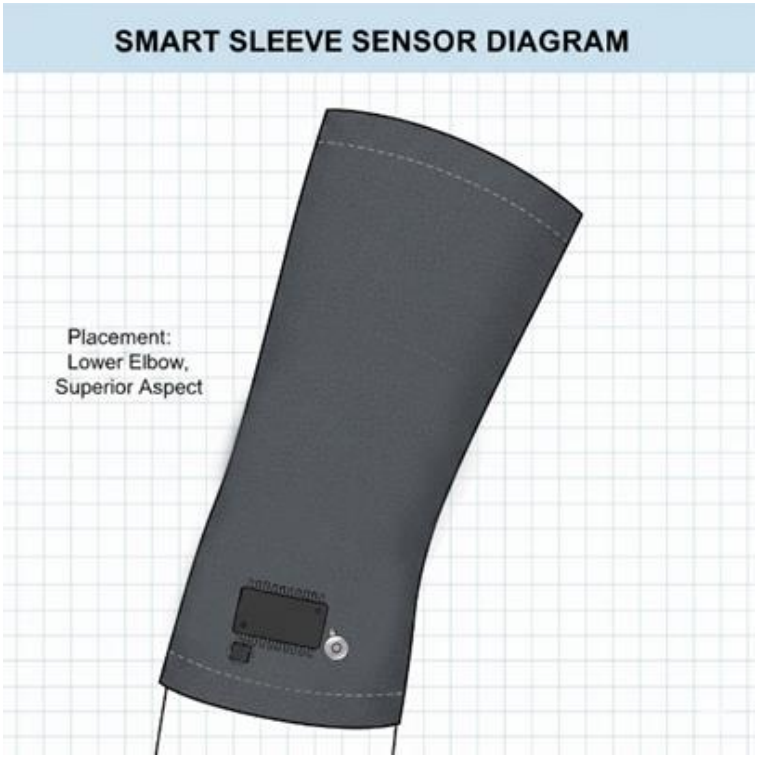

Figure 3 Prototype Draft

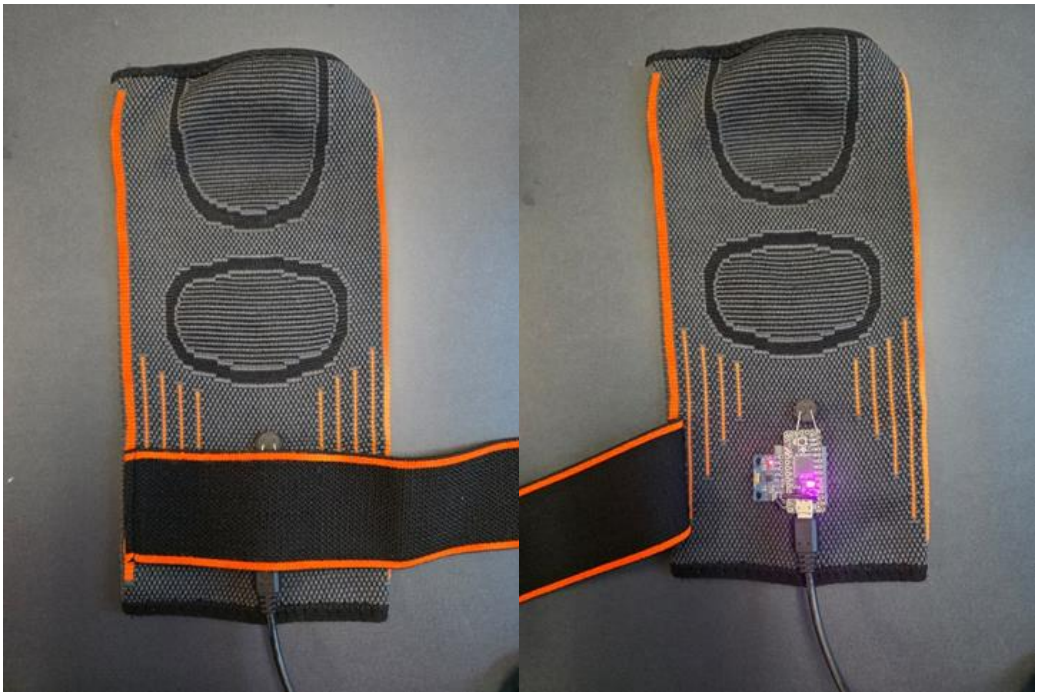

Figure 4 Low-Fidelity Prototype

5.3.1 Purpose of the Prototype

The prototype functioned as a research instrument to support exploration, reflection, and discussion. Its purpose was to test how sensing and feedback could be integrated into a wearable textile while maintaining comfort, simplicity, and usability, while also validating key insights identified in earlier research stages. Specifically, the prototype aimed to:

- explore the comfort and wearability of a sensor-embedded sleeve
- test the viability of auditory feedback as a subtle guidance mechanism
- examine how smart gymwear could support injury-aware movement without relying on screens or dashboards
- prompt participant feedback and future-oriented design suggestions during co-design sessions

5.3.2 Choice of Exercise: Bicep Curl

The prototype was programmed to detect movement during a bicep curl, selected deliberately for several reasons. Bicep curls are a common strength-training exercise performed by a wide range of gym-goers, making them familiar and easy to interpret during testing and discussion. Despite

their apparent simplicity, bicep curls are also associated with improper execution, excessive momentum, and increased risk of muscle strain or tendon injury, particularly when performed with poor form or under fatigue.

From a technical perspective, the exercise provided a clear and well-defined range of motion, allowing early exploration of movement thresholds without introducing excessive complexity. This made the bicep curl an appropriate starting point for an early-stage prototype intended to test sensing logic rather than full-system accuracy.

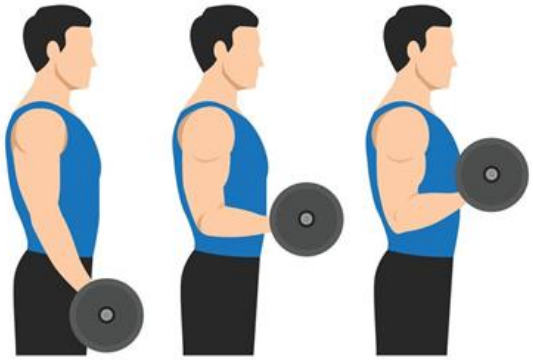

Figure 5 Bicep Curls Exercise Note. From Vecteezy (n.d.).

5.3.3 Prototype Configuration and Functionality

The prototype sleeve integrated an inertial measurement unit (IMU)**,** a microcontroller board, and a simple beeper for auditory feedback. The sensor was embedded within the sleeve just below the elbow, a placement chosen to capture arm movement while minimizing interference with joint articulation and user comfort.

The embedded software was programmed to detect arm acceleration and positional changes during the bicep curl movement. A predefined acceptable range of motion was established, approximating full arm extension (around 180 degrees) to controlled elbow flexion (approximately 45 degrees). When the movement fell within this expected range and was

performed at an appropriate speed, the system emitted a distinct auditory tone to indicate a correct repetition. When movement exceeded the defined thresholds, such as excessive speed, insufficient range of motion, or incorrect arm angle, the beeper produced a different tone to signal deviation from the expected movement pattern.

Importantly, the system relied solely on auditory feedback, avoiding screens or mobile interfaces. This design choice aligned with findings from Chapter 4, where participants expressed frustration with data-heavy dashboards and a preference for intuitive, low-effort feedback during workouts.

Figure 6 Live Measurements in Co-Design Session

5.3.4 Role of the Prototype in the Research

As a low-fidelity prototype, the sleeve was not intended for precision measurement or long-term use. Instead, it functioned as an interaction probe to support co-design conversations and elicit participant reflections. Engaging with a tangible artifact allowed participants to more clearly

articulate perceptions of comfort, usability, and potential value, informing later design and strategic considerations.

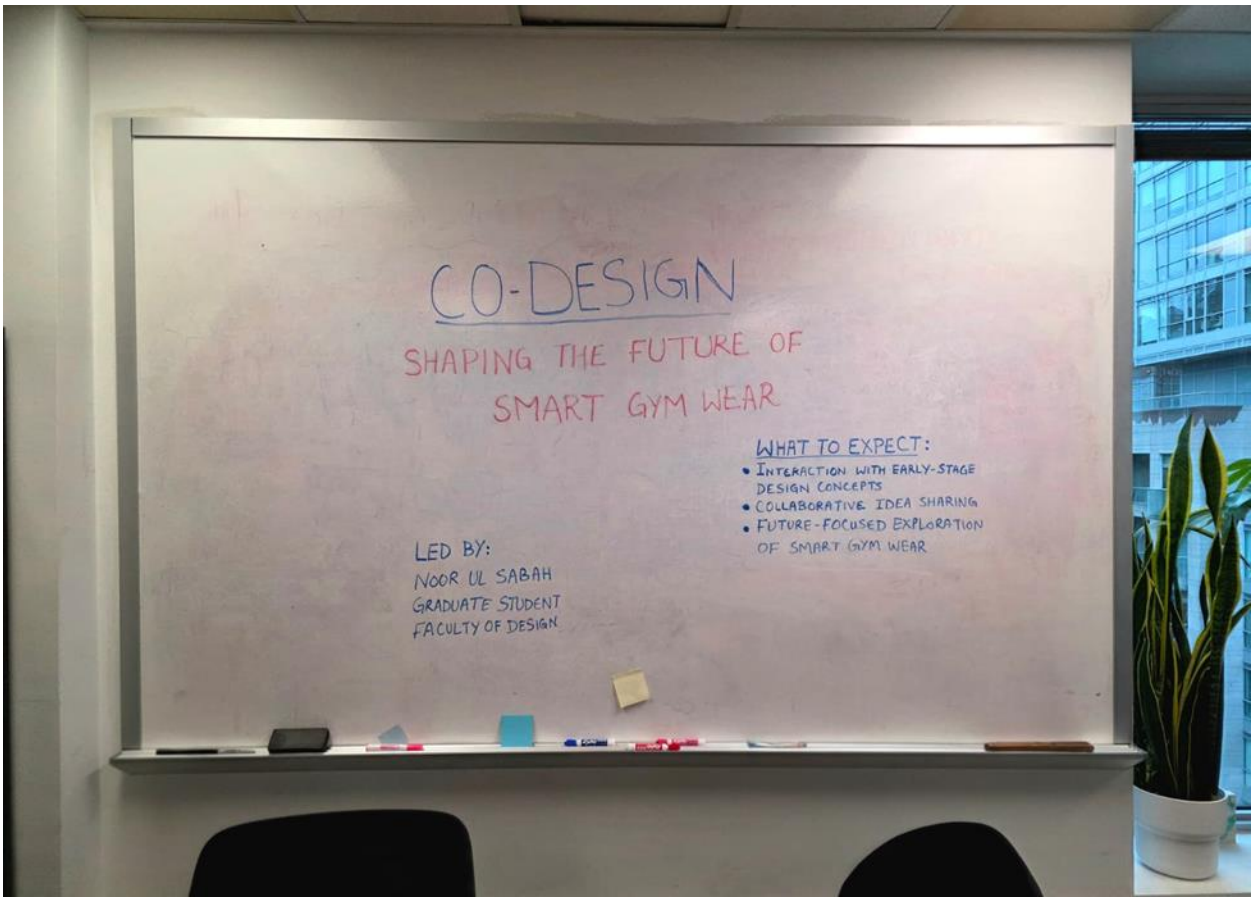

Figure 7 Co-Design Session

5.3.5 Reflections on Fidelity and Scope

Positioning the prototype as low fidelity allowed for flexibility and openness during co-design sessions. Limitations such as single-exercise functionality, basic feedback mechanisms, and non-optimized hardware were intentionally accepted to prioritize learning over performance. This approach ensured that the prototype remained a means of inquiry rather than a solution, aligning with the design-led research methodology underpinning this study.

5.4 Co-Design Outcomes

Co-design sessions were conducted with three recreational gym-goers following the development of the low-fidelity smart arm sleeve prototype. The sessions were designed to explore participant

reactions to the prototype, gather feedback on comfort and usability, and collaboratively envision how smart gymwear could better support injury prevention and workout effectiveness. Rather than evaluating technical accuracy, the co-design process focused on experience, perception, and future potential.

Participants interacted with the prototype, observed its behavior during movement, and engaged in guided discussion around feedback mechanisms, wearability, and trust. Several key outcomes emerged from these sessions.

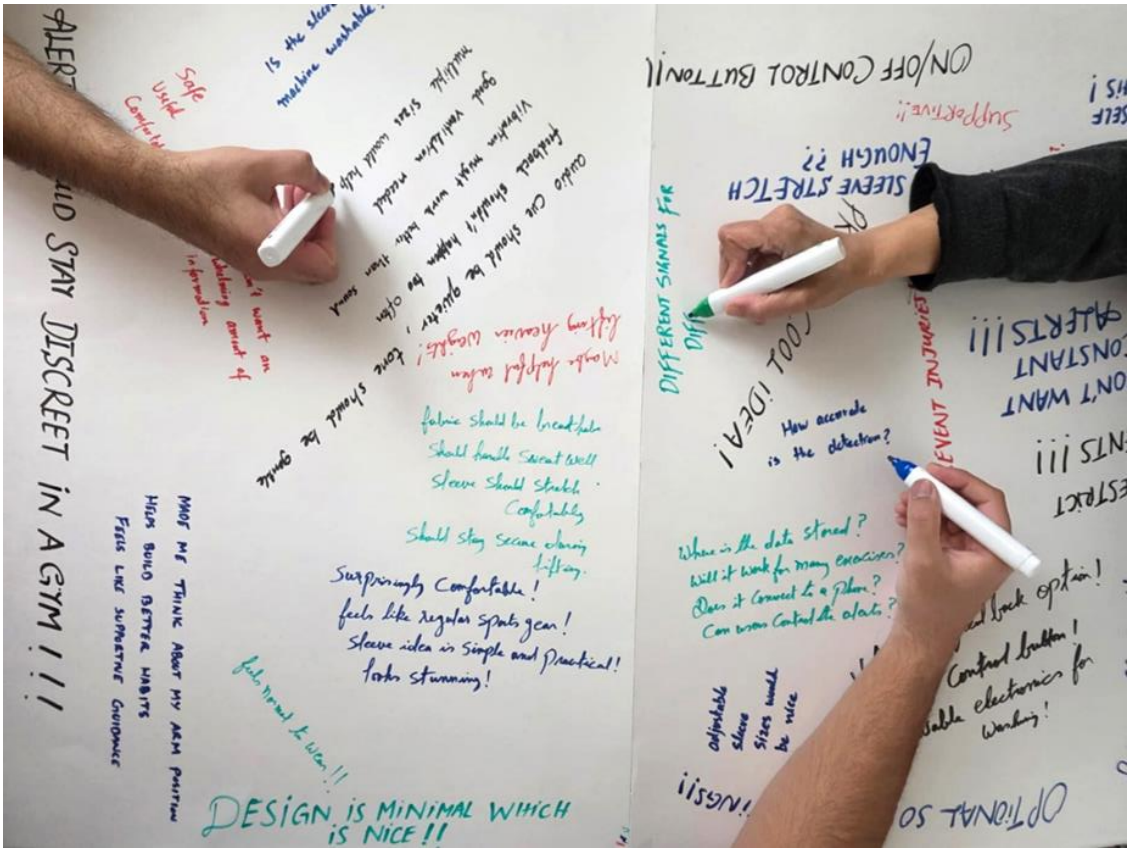

Figure 8 Capturing User Insights and Collaborative Ideation

5.4.1 Co-Design Outcome 1

Validation of the Arm Sleeve as an Acceptable Form Factor

Participants responded positively to the arm sleeve format, describing it as less intimidating and more practical than full smart garments. The ability to wear the sleeve over existing gymwear was frequently highlighted as a benefit, as it allowed experimentation without replacing familiar clothing.

Participants expressed that the sleeve felt lightweight and did not interfere with movement, reinforcing earlier findings around the importance of comfort and normalcy.

Figure 9 Feedback of Co-Design Participant

Participant feedback:

"I like that it's just a sleeve. It feels optional, not like I have to commit to a whole smart outfit." (End User 2)

This feedback validated the arm sleeve as a viable entry point for smart textile adoption, particularly for mainstream gym-goers who may be hesitant to engage with more complex wearable systems.

5.4.2 Co-Design Outcome 2

Auditory Feedback Was Understood but Required Refinement

Participants were able to understand the meaning of different beep tones after brief explanation, indicating that auditory feedback was an accessible and intuitive modality. However, they emphasized that the feedback was not yet subtle enough and would require refinement to function effectively in real workout environments.

Several participants noted that the sound needed to be quieter, less frequent, and more context-aware to avoid becoming distracting or stressful. Some suggested that alternative approaches, such as connecting feedback through earphones, using softer tones, or incorporating subtle visual indicators that might offer more discreet guidance during exercise.

Participants expressed concern that continuous or harsh sounds could create anxiety or embarrassment in shared gym spaces, reinforcing the importance of emotional comfort and discreet interaction.

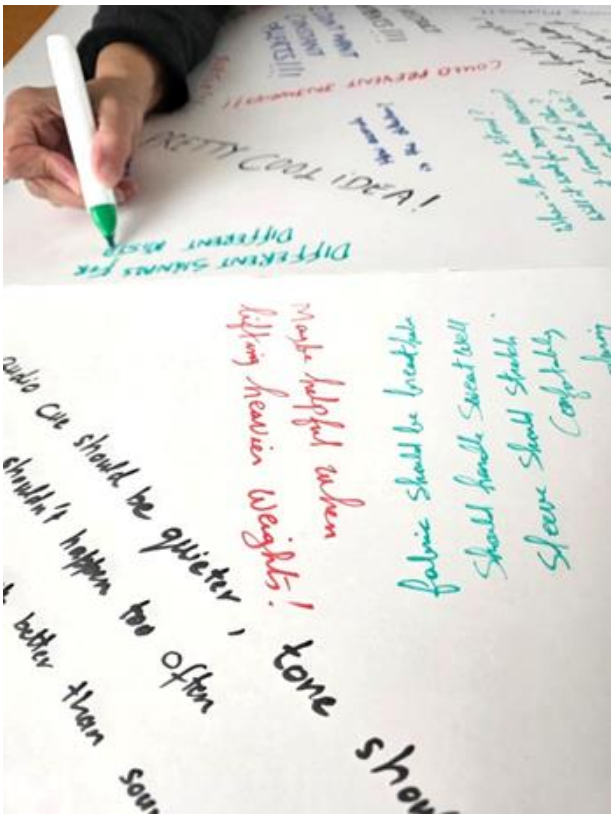

Figure 10 Co-Design Participant Writing Notes

Participant feedback:

"The sound makes sense, but I wouldn't want it to beep too loudly or too often. It should feel like a reminder, not an alarm." (End User 1)

This outcome suggests that while auditory feedback has potential, its tone, frequency, and timing must be carefully calibrated to maintain comfort and avoid unintended stress responses.

5.4.3 Co-Design Outcome 3

Desire for Feedback That Focuses on Safety Rather Than Performance

Participants consistently framed the value of the prototype in terms of injury prevention and reassurance, rather than performance tracking. When discussing potential future features, users prioritized knowing when their movement was unsafe or when fatigue might be affecting form, rather than optimizing repetitions or speed.

This reinforced findings from Chapter 4 that gym-goers value guidance and confidence over data-driven performance metrics.

Participant feedback:

"I don't need it to tell me how strong I am. I'd rather know if I'm doing something that could hurt me." (End User 3)

This outcome helped clarify that smart gymwear should be positioned as a supportive safety tool rather than a competitive performance tracker.

5.4.4 Co-Design Outcome 4

Feedback Encouraged Reflection

Participants noted that interacting with the prototype prompted them to reflect on their movement habits, even beyond the immediate moment of feedback. Users reported that they performed better when wearing the sleeve compared to performing the same movements without it. This suggests that smart gymwear may influence user behavior at a subconscious level,

encouraging improved performance and greater body awareness even when active feedback is not being directly attended to.

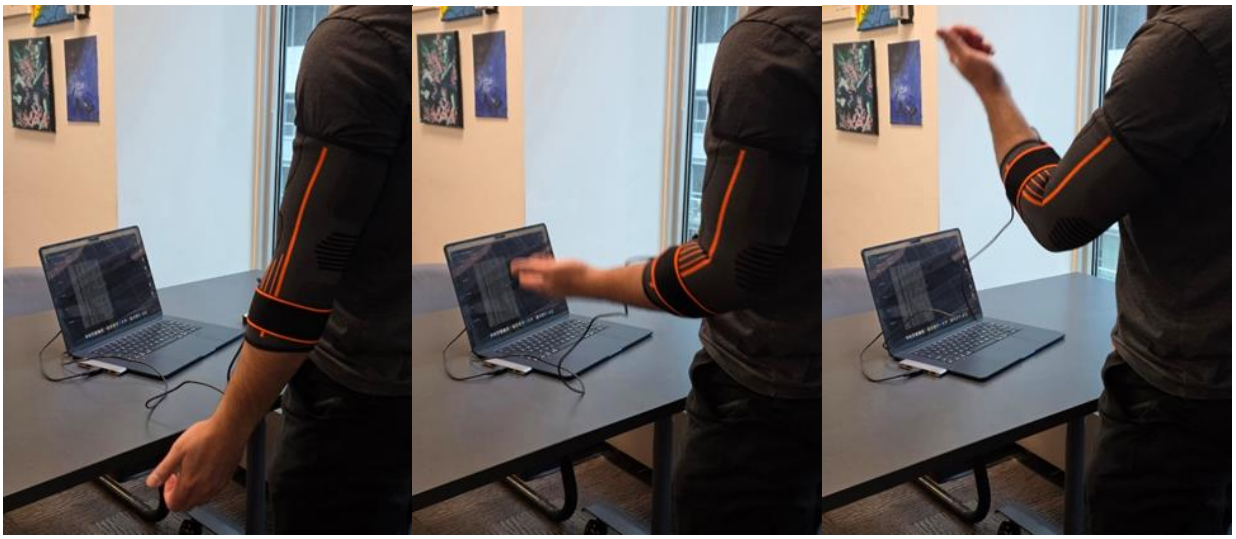

Figure 11 Participant Performing a Bicep Curl

Participant feedback:

"Even just knowing it's there makes me think more about how I'm moving." (End User 2)

This outcome highlights the potential of smart gymwear to support long-term habit formation.

5.4.5 Co-Design Outcome 5

Trust and Transparency Remained Central Concerns

Despite positive reactions to the prototype concept, participants raised questions about data handling, accuracy, and reliability. Users wanted clarity around what data was being collected and whether it would be stored or shared.

This reaffirmed earlier findings that trust, and privacy considerations remain critical, even at the exploratory stage.

Participant feedback:

"I'd want to know exactly what it's tracking and where that information goes." (End User 1)

5.5 Summary of Co-Design Outcomes

Overall, the co-design sessions showed that the arm sleeve is a promising and acceptable format for smart gymwear, while also revealing where refinement is needed. Participants were able to understand the auditory feedback, but they felt it needed to be more subtle and better suited to real workout settings so it would blend into their routines rather than stand out.

Across sessions, certain themes kept coming up. Comfort, discretion, and trust were consistently described as essential for adoption. Participants responded most positively to guidance that supported safe movement and awareness, rather than features focused on performance tracking. This reinforced the idea that the value of the product lies in reassurance and ease of use, not data intensity.

These sessions also helped clarify the broader direction of the project. The positive reaction to the sleeve as a wearable accessory supports its positioning as a complementary product that can fit naturally into existing gym wear habits. At the same time, feedback about subtle interaction confirmed that simplicity and unobtrusiveness should remain central priorities moving forward.

In this way, the co-design process did more than test a prototype; it helped validate the overall design approach and strategic direction. The responses suggest that the concept aligns well with real user expectations, supporting the feasibility of introducing smart textiles gradually into everyday fitness environments.

CHAPTER 6: STRATEGIC INTEGRATION AND VALUE CREATION IN SMART GYMWEAR

6.1 Value Proposition

The Value Proposition Canvas (VPC), developed by Alexander Osterwalder, is a tool used to align user needs with product offerings by mapping customer jobs, pains, and gains to relevant features.

The research insights led to the development of a value proposition rooted in users' real behaviors, needs, and concerns. To ensure that subsequent design decisions remain grounded in these findings rather than being shaped purely by technological possibilities, the VPC is used as a guiding framework that links identified customer jobs, pains, and gains to corresponding product features.

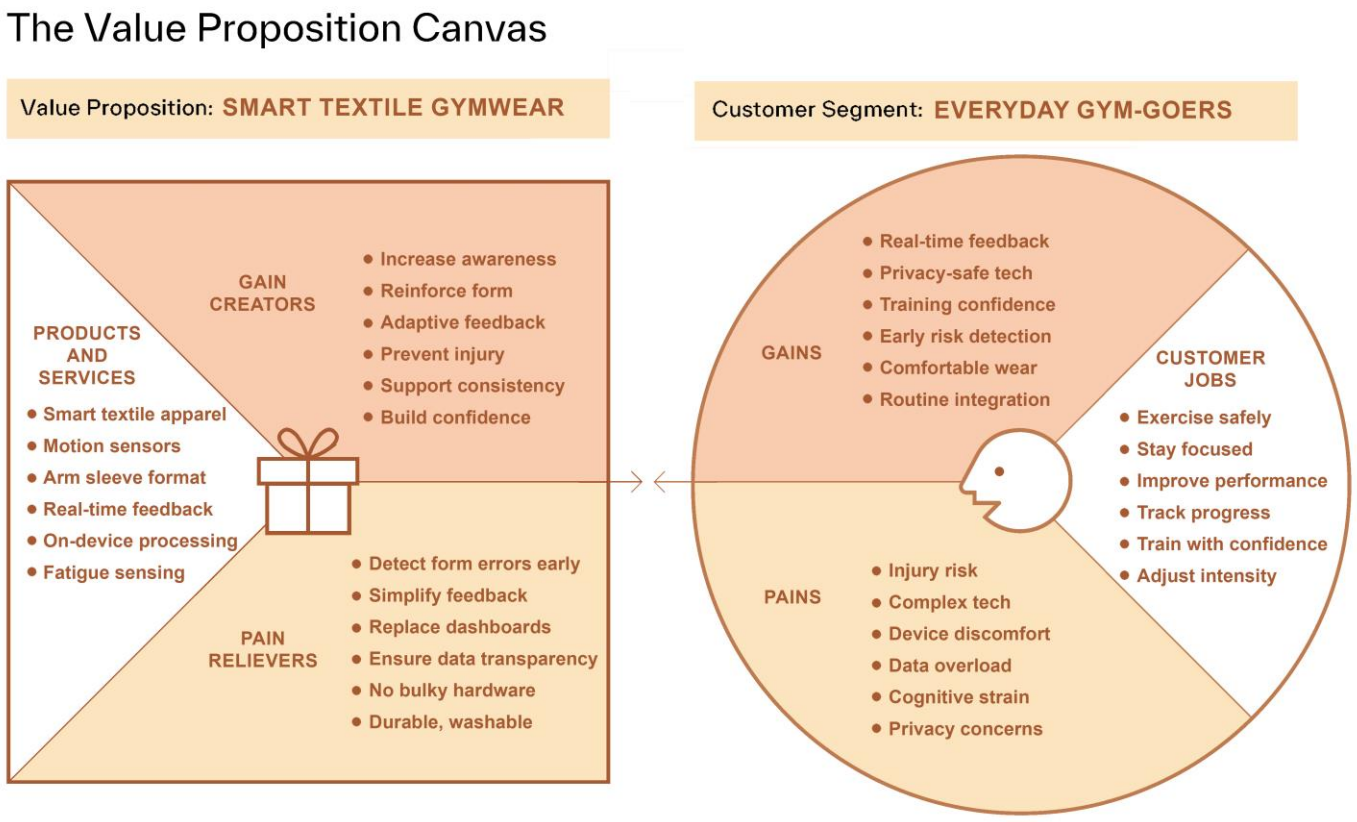

Figure 12 Value Proposition Model for Smart Gym-wear

The canvas illustrates how these insights translate into a solution for everyday gym-goers. Users want to perform exercises correctly and safely, improve consistency, stay focused during workouts, and feel confident in their training. These goals are accompanied by concerns such as uncertainty about form, risk of injury or strain, difficulty interpreting complex dashboards, discomfort with wearable technology, and hesitation about data privacy. They also seek reassurance, intuitive feedback, seamless integration into routines, motivation, and technology they can trust.

The proposed smart textile product addresses these expectations directly. Features such as early detection of form deterioration, fatigue-aware sensing, subtle feedback, on-device processing, and seamless textile integration reduce uncertainty, minimize distraction, and lower barriers to adoption. At the same time, real-time reinforcement of correct movement, adaptive guidance, intuitive cues, and effortless integration into familiar routines support confidence, safer performance, and clearer movement awareness.

6.2 Business Model and Industry Integration

The Flourishing Business Canvas, developed by Anthony Upward, is used in this research to take a broader, systems-level view of how smart gymwear can evolve within existing ecosystems. It helps shift the focus beyond functionality alone, considering how value can be created across economic, social, and environmental dimensions

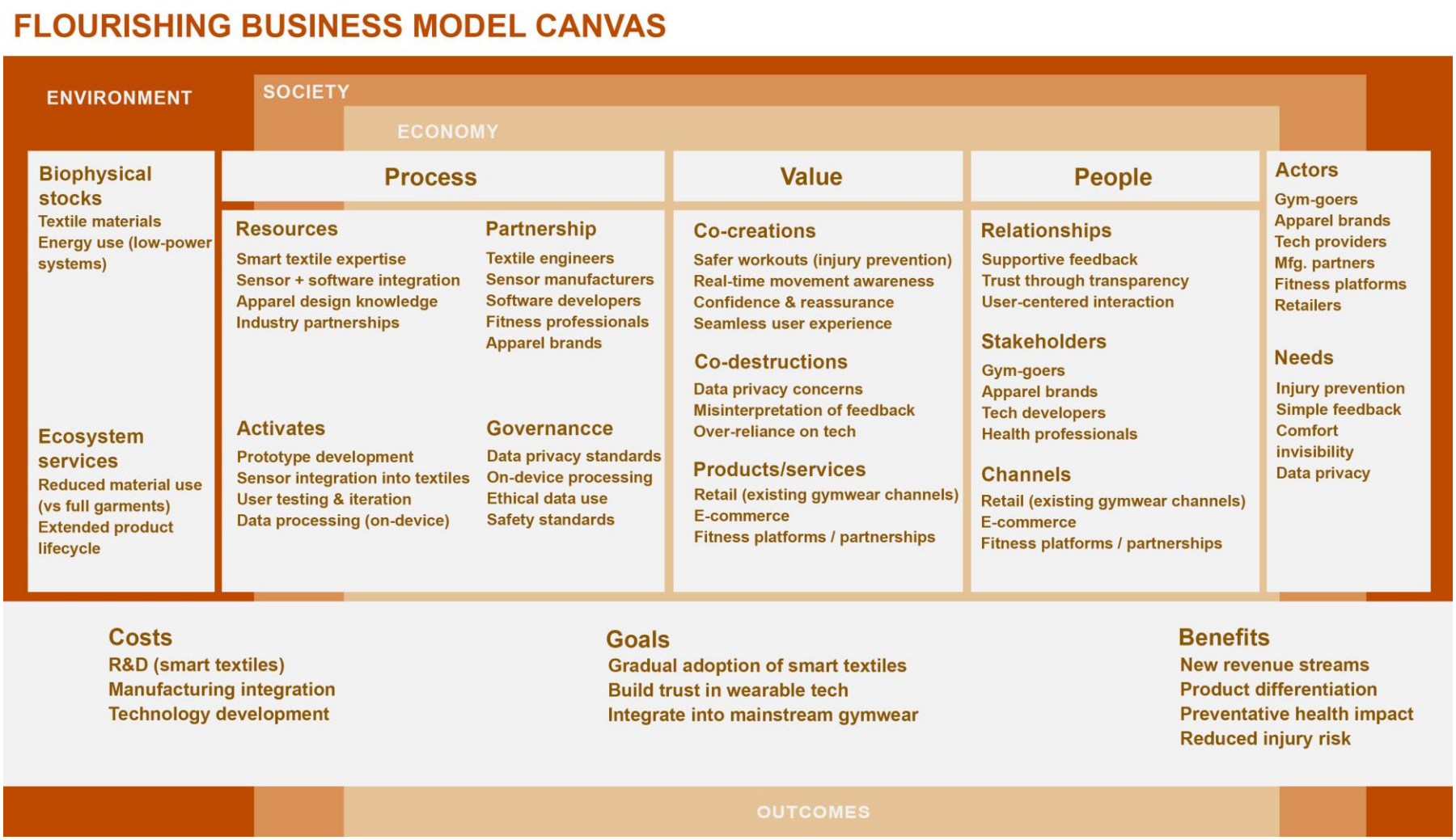

Figure 13 FBMC

Building on this perspective, rather than positioning smart textiles as replacements for conventional gymwear, this research proposes their introduction through an adjacent product strategy that integrates smart textile functionality into existing apparel ecosystems without displacing established garments. The development of a smart arm sleeve as a complementary accessory enables innovation to be layered onto current gymwear systems in a manner that preserves familiarity, comfort, and brand trust. Within a flourishing business perspective, this approach supports value co-creation across multiple ecosystem actors rather than privileging technological novelty alone.

Findings from this study demonstrate that gym-goers prioritize reassurance, comfort, and clarity over performance optimization or data-heavy analytics. Accordingly, the arm sleeve is positioned not as a monitoring device but as a supportive interface that enhances movement awareness and reduces injury risk. This distinction is critical: technologies perceived as supervisory or evaluative often generate resistance, whereas systems framed as supportive creates trust and sustained engagement. By allowing users to adopt smart textiles incrementally, the adjacent model lowers psychological, behavioral, and technological barriers simultaneously.

From an industry standpoint, the adjacent product strategy distributes innovation risk across time rather than concentrating it within a single disruptive product launch. Brands can maintain existing supply chains, manufacturing processes, and retail infrastructures while gradually building internal competencies in smart textile integration. This staged capability development aligns with flourishing business principles by supporting long-term system resilience rather than short-term technological experimentation. In this way, innovation is embedded within the current apparel ecosystem rather than imposed upon it.

The strategy also generates multi-level value co-creation. For users, it enhances safety, confidence, and autonomy during workouts. For brands, it opens new revenue pathways while strengthening differentiation through human-centered innovation. For society, it contributes to a preventative health orientation by supporting safer movement practices and reducing the likelihood of avoidable exercise-related injuries. For environmental systems, the smaller product format requires fewer material inputs than full smart garments and can extend lifecycle value through durability and modular component design.

Realizing this model requires cross-disciplinary collaboration among ecosystem stakeholders. Textile engineers, sensor manufacturers, software developers, and apparel designers must work in coordinated partnership to ensure that sensing systems remain reliable, unobtrusive, and comfortable when embedded in fabric. Equally important are collaborations with biomechanics specialists and fitness professionals, whose expertise strengthens movement validation and enhances credibility. Within a flourishing framework, these partnerships are not merely operational but constitutive of value creation, as they collectively enable the product to function as intended within real-world contexts.

Governance considerations further reinforce the viability of this approach. Transparent data practices, privacy-first system architecture, and on-device processing support user trust while minimizing ethical risks associated with wearable technology. By embedding these principles into the design process rather than retrofitting them afterward, brands can ensure that technological innovation aligns with user expectations and societal standards.

Positioning the smart arm sleeve as a complementary innovation therefore enables a gradual transition toward human-centered smart apparel. Instead of disrupting existing systems, the model cultivates adoption through familiarity, builds technical capacity over time, and supports systemic flourishing across economic, social, and environmental dimensions. Through this approach, smart textiles can be normalized within everyday fitness contexts, transforming gymwear from passive clothing into an active yet unobtrusive partner in preventative wellbeing.

6.3 Why Should the Industry Care?

The integration of smart textiles into gymwear is not only a technological opportunity, but also a strategic one for the apparel industry. As fitness consumers increasingly seek products that support wellbeing, safety, and ease of use, there is a growing need for solutions that move beyond passive clothing and offer more meaningful forms of engagement.

For brands, this shift presents an opportunity to differentiate within a highly saturated activewear market. Rather than competing solely on aesthetics or performance claims, it opens space for new forms of value that extend beyond traditional product expectations.

At the same time, the approach proposed in this research offers a lower-risk pathway for innovation. By introducing smart functionality in a way that integrates with existing products and systems, brands can explore new capabilities without disrupting established operations or user habits.

More broadly, this signals a shift in how gymwear is positioned within the industry. Instead of functioning as passive apparel, it begins to take on a more active role within the fitness experience, supporting users in ways that align with evolving expectations around health, usability, and everyday performance.

To understand how this shift can be evaluated in practice, the following metrics outline key indicators of success from an industry perspective.

6.4 Success Metrics and Key Performance Indicators

From an industry perspective, these metrics are important because they indicate not only short-term product performance, but also the viability of integrating smart textiles into mainstream gymwear systems. For brands, this extends beyond immediate sales outcomes to understanding whether the product can fit within existing retail, manufacturing, and user ecosystems over time.

Evaluation of the smart arm sleeve should extend beyond short-term revenue and include structural indicators of integration and sustainability.

Economic indicators include:

- Sell-through rates within existing apparel channels
- Conversion rates from traditional gymwear customers
- Margin performance relative to core apparel lines

Operational indicators include:

- Manufacturing defect rates
- Sensor calibration consistency
- Product return rates
- Wash-cycle durability performance

Market development indicators include:

- Expansion into additional retail partnerships
- Repeat purchase behavior
- Cross-category bundling with core apparel

Together, these measures assess not only whether the product sells, but whether it integrates successfully into mainstream gymwear ecosystems and maintains performance reliability at scale.

CHAPTER 7: FUTURE DIRECTIONS & ADOPTION ROADMAP

7.1 Road map for Smart Gymwear Adoption

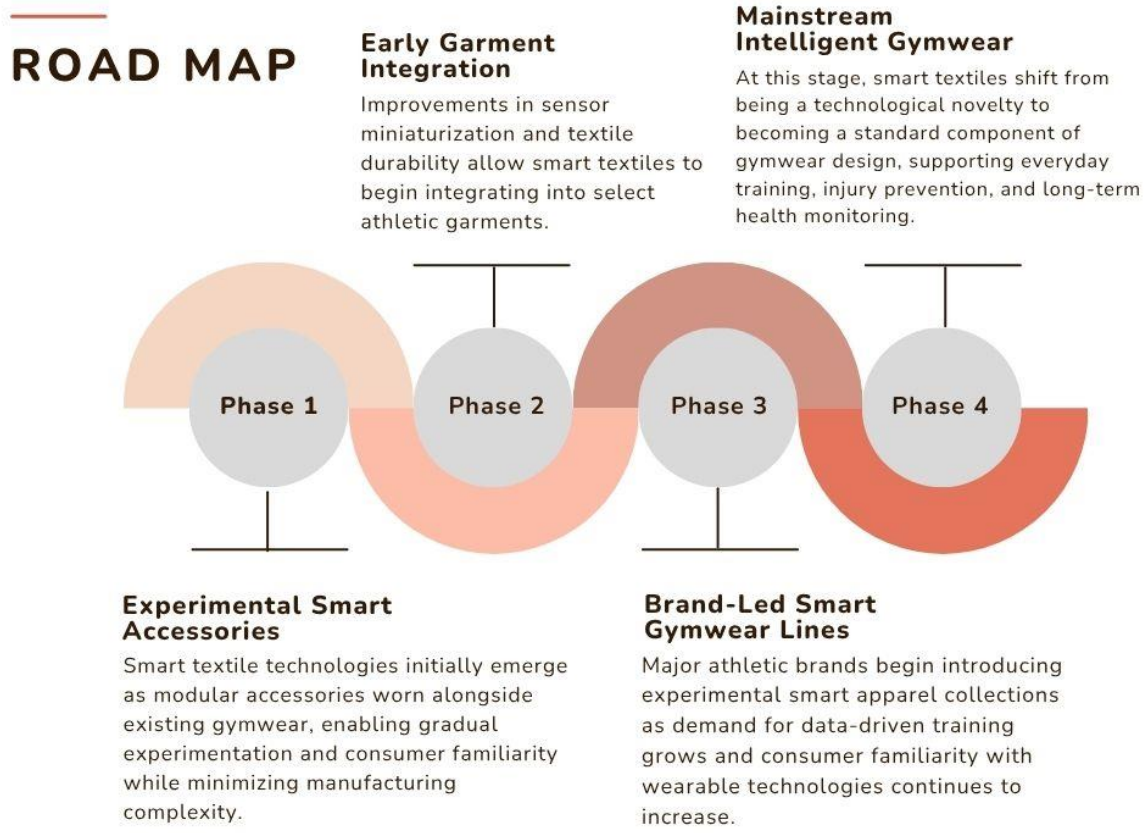

Figure 14 Implementation Plan

The roadmap shows a step-by-step plan for how smart textile technologies could slowly be added to the gymwear sector. Instead of presuming that sensing technologies will be widely used right away, the roadmap lays out a series of practical steps that will gradually lead to their use in gymwear. Each step shows how textile engineering, manufacturing feasibility, and consumer knowledge with fitness technologies are expected to change. The roadmap shows how gymwear businesses may bring smart textile technologies into current product ecosystems, test them, and grow them without causing too much disruption to established production processes and user behaviors.

The first phase represents a period of early experimentation in which smart textile technologies are most likely to appear as modular accessories rather than fully integrated garments. Sensor-enabled sleeves, compression bands, and attachable sensing modules could enable manufacturers to integrate smart functionality without significantly redesigning their existing gymwear manufacturing infrastructure. Accessory-based solutions lower the barrier to entry for both producers and customers, allowing for early testing of sensing capabilities while preserving established training routines. During this stage, businesses may also utilize these products to collect user feedback, assess durability in active environments, and improve sensor accuracy under real-world training conditions.

The second phase captures the early stages of garment-level integration. As sensor miniaturization, textile durability, and washability improve, sensing components may be integrated into specific performance clothes such as compression tops, base layers, or training shirts. Integrating sensors directly into fabric structures allows for more solid and constant contact with the body, potentially improving the accuracy of physiological and biomechanical data collecting during exercise. At this point, smart gymwear is likely to arrive in limited product lines or pilot efforts, allowing manufacturers to see how integrated sensor technologies operate in commercial garments.

Adoption is also projected to be predominantly driven by early adopters, fitness enthusiasts, and athletes who are already familiar with wearable fitness technologies and are more willing to try out new performance-enhancing solutions.

The third phase marks a period of market expansion and increased visibility for smart gymwear. Following early test integrations in certain garments, gymwear brands may begin to place smart gymwear more prominently in their product offerings. During this stage, businesses are more likely to invest extensively in marketing techniques targeted at introducing smart clothing to a larger consumer base. Collaborations with well-known athletes, fitness influencers, trainers, and public personalities could be leveraged to demonstrate the practical usefulness of smart gymwear in real-world training settings. Brands may raise awareness and credibility for smart textile technology through targeted ads, product endorsements, and fitness industry partnerships. As a result, smart gymwear may begin to expand beyond early adopters and into larger commercial markets, becoming more prominent among mainstream athletic apparel products.

The final phase and fourth phase illustrate the potential widespread integration of smart textiles into everyday gymwear. At this stage, sensing capabilities may become embedded within core gymwear products rather than appearing as specialized technological additions. Smart gymwear could function as a continuous monitoring interface capable of providing real-time feedback on movement patterns, physiological responses, and training intensity. Importantly, the value of these systems extends beyond performance tracking to supporting safer training practices. By monitoring movement quality, identifying fatigue-related changes in technique, and offering feedback on exercise form, smart gymwear could contribute to reducing injury risk among recreational gym-goers. As this transition occurs, smart textile functionality may become integrated into the design logic of gymwear itself, supporting comfort, safety, and long-term physical wellbeing.

Taken together, the roadmap shows how smart gymwear adoption can move incrementally, from accessory-based experimentation to fully integrated textile systems embedded in everyday gymwear. This stepwise progression represents both technology maturation and the progressive adoption of data-driven training approaches in modern gym culture.

7.2 Implications for Gymwear Brands

Long-term success will depend on aligning smart textile development with broader cultural shifts occurring within contemporary fitness practices. The growing emphasis on injury prevention, embodied awareness, and sustainable training habits suggests that gymwear brands may profit from promoting smart gymwear as tools that encourage safer and more attentive exercise rather than just as performance-enhancing technologies. However, incorporating smart technology into gymwear brings several obstacles and restrictions that companies must carefully consider. Consumers' distrust of wearable technologies implanted directly into garments, particularly in terms of comfort, durability, and washability, is one potential hurdle. Unlike standard fitness wearables, smart gymwear must resist repeated laundering, perspiration exposure, and continual physical movement, which might impair sensor performance over time. Addressing these durability issues will be crucial to ensuring product reliability and consumer trust.

Data privacy and ethical concerns may also impact adoption. Because smart gymwear has the potential to continuously capture sensitive physiological and movement data, customers may be

concerned about how their personal information is stored, processed, and shared. Trust in these technologies may be reduced in the absence of transparent data governance regulations and user control over personal data. Furthermore, cost and accessibility may pose barriers to widespread adoption. Because of the difficulty of integrating sensors and electronic components into fabric structures, early smart textile products are likely to be priced higher.

Despite these limitations, the roadmap identifies an opportunity for gymwear brands to gradually integrate smart textile systems in ways that promote safer and more informed exercise behaviors. Companies that take a tiered approach to innovation and prioritize user-centered design can promote smart gymwear as tools that improve comfort, safety, and long-term physical well-being in everyday training contexts.

CHAPTER 8: CONCLUSION & REFLECTION

8.1 Reflection on the Research

Over the course of this research, the exploration of smart textiles in gymwear gradually unfolded into a deeper understanding of everyday training experiences. What initially appeared to be a straightforward design investigation quickly revealed a more complex landscape shaped by human behavior, uncertainty, and the subtle challenges that gym-goers encounter during exercise.

Conversations with participants, time spent observing gym environments, and engagement through co-design sessions highlighted how easily small shifts in movement, fatigue, and technique can go unnoticed during training. Injuries in recreational fitness often do not stem from a lack of effort or discipline, but from subtle moments that are difficult to perceive in real time, as form begins to deteriorate or uncertainty about proper movement quietly emerges.

One of the most revealing insights to emerge during the research was that gym-goers were not necessarily searching for more performance data or advanced technological features. Instead, participants repeatedly spoke about wanting reassurance and confidence during their workouts. Subtle forms of guidance that could help them recognize fatigue, adjust technique, or feel more secure while exercising was valued far more than complex dashboards or numerical metrics.

Working through the design exploration also revealed how sensitive the relationship between technology and clothing can be. Comfort, trust, privacy, and even how a garment might appear in a shared gym space all played an important role in shaping perceptions of smart gymwear. These insights reinforced the understanding that technological feasibility alone is not enough to ensure adoption.

Rather than dramatic technological disruption, the findings suggest that the future of smart gymwear will likely emerge through careful, gradual integration. Clothing that quietly supports the body, respects familiar routines, and provides subtle awareness during movement may offer a more meaningful path forward for innovation in everyday fitness environments.

8.2 Limitations and Future Research

Like many exploratory design research projects, this study also comes with certain limitations. The participant group was relatively small and geographically concentrated, meaning the insights reflect a specific set of experiences rather than representing the broader population of gym-goers. The prototype developed during the research was intentionally low fidelity and focused on a single exercise, serving primarily as a tool for discussion and exploration rather than a fully developed technological solution.

These limitations also point toward opportunities for future work. Expanding participant diversity, exploring different garment formats, and testing smart gymwear in real gym environments could provide a deeper understanding of how these systems function in everyday training contexts. Longer-term studies may also reveal how continuous, subtle feedback influences movement awareness, training behaviors, and injury prevention over time.

Further collaboration between designers, gymwear brands, textile engineers, and fitness professionals could help translate early design research into practical applications. Such partnerships may support the development of pilot products that bring smart textile concepts closer to real-world implementation while continuing to prioritize comfort, trust, and usability within everyday fitness environments.

8.3 Conclusion

The gymwear industry is evolving alongside broader cultural shifts toward preventative health, embodied awareness, and everyday participation in fitness. While wearable technologies have made training increasingly data-driven, many gym-goers still lack real-time guidance that helps them move safely and confidently during exercise.

Smart textiles introduce the possibility of transforming clothing into a subtle interface for movement awareness. By embedding sensing capabilities directly within garments, gymwear may be able to provide feedback that helps individuals recognize fatigue, adjust technique, and reduce the risk of injury during training.

However, meaningful adoption will depend on careful and thoughtful integration. For smart gymwear to become part of everyday fitness routines, it must remain comfortable, discreet, and familiar to wear. Rather than replacing traditional gym clothing, smart textile technologies are

more likely to emerge gradually through complementary products and incremental innovation that builds trust over time.

Looking ahead, smart gymwear has the potential to shift gym clothing from passive garments to systems that actively support safer and more informed training. As textile technologies continue to evolve and design approaches remain grounded in human needs, everyday gymwear may begin to play a more active role in supporting safer movement, building confidence, and encouraging long-term wellbeing. In this future, clothing is no longer simply worn during exercise, but becomes a subtle layer of support that helps people train with greater awareness, resilience, and care for their bodies.

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Appendix

System Overview and Operation Summary of Prototype:

mrp_arduino.pdf

All Additional Documentation:

https://ocaduniversity-my.sharepoint.com/my?id=%2Fpersonal%2Fnoorulsabah_ocadu_ca%2FDocuments%2FMRP%20Documents&viewid=05f15cd8-f621-460d-861e-9ed90cc5e9fa

Research Boards and Affinity Mapping:

https://miro.com/app/board/uXjVIKxQCsQ=/

https://www.figma.com/board/jFMUgZuaNo0NdUJF0iHazb/Smart-Textile-Market-Causal-Loop-Diagram?node-id=0-1&t=10PA7M9GSKThbMjs-0