Skipping a Beat: Inclusion in Sports Technology, The Case of Heart Rate Monitoring

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ABSTRACT

Inclusivity and access challenges in sports are widespread, particularly in cycling, which can result in excluding those outside of the narrow view of a "typical cyclist". Unfortunately, these challenges appear to be equally common in the design of sports technologies, but despite this, there has been relatively little examination of inclusivity in sports from an HCI perspective. Partly inspired by a major manufacturer's early-2024 announcement of a new "women's" heart-rate monitor, this paper looks towards chest-worn heart rate monitors, common in sports tracking, as a narrative case study to explore inclusivity in CyclingHCI. Despite their ubiquity and relative affordability, traditional chest straps often fail to cater to diverse bodies, resulting in issues around fit, comfort and accuracy for many women and other groups. Online commentary highlights many women, trans, non-binary and cyclists of size reporting problems from discomfort, to inaccurate readings that impact training, which can further contribute to feelings of exclusion and barriers to cycling. We argue that non-inclusive design can negatively impact general engagement, so drawing on our research and experience of Equity, Diversity and Inclusion (EDI), **we highlight the importance of considering inclusivity from the outset when designing sports technology**. Ultimately, the case of chest-worn heart rate monitors demonstrates the real-world impact of inclusivity not being prioritised, presenting an opportunity to envision a more inclusive future for sports technology.

CCS CONCEPTS

• Human-centered computing • Human computer interaction (HCI) • Empirical studies in HCI

KEYWORDS

Heart Rate Monitoring, Wearability, Universal Design, Inclusivity, Feminism.

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1 INTRODUCTION AND BACKGROUND

Chest-worn, wireless EKG heart rate monitors (HRMs) are perhaps the most ubiquitous digital sports technology – introduced commercially in 1988 [12], they are widely used across many sports including cycling and running, for training, self-tracking exercise and fitness, and even for medical needs, such as moderating exercise intensity. They are relatively simple and inexpensive devices which are often bundled alongside sports watches and cycle computers, as well as being sold independently. However, despite their historic and widespread availability, there has been little evolution of their physical design over the past 40-years – which many people, including those with breasts, who wear sports bras, or have bodies that sit outside of what the industry appear to assume "typical", report lacks proper consideration of fit, leading to issues with comfort, usability, and accuracy (cf. embodied interaction [15]).

The lack of progress in the design of chest-worn HRM is reflective of broader issues in sports and physical activity, where cisgender men have historically been prioritised over women, transgender, and non-binary individuals, who are poorly considered or entirely forgotten at every level of sport from amateur to professional. Gaps in diversity and inclusion within cycling and sports communities exist, particularly around gender, sexuality, and representation of diverse body types and sizes. There are lower levels of participation among women, LGBTQ+ individuals and other marginalised groups (e.g. [13,9]), partly caused by discrimination, lack of visibility and role models, barriers in environment and infrastructure [6]. This situation leads to these individuals feeling excluded from, or less able to participate in, sports and exercise throughout their life course. This situation is compounded by the gendered access to sports and leisure time – in the UK men have, on average, 5-hours more leisure time each week than women [4]. Our ongoing work examining access and participation in cycling shows that social media and other

technologies tend to perpetuate, rather than challenge, these issues.

Focusing on sports technologies such as wearables and trackers, there is a gap in the area of inclusive design, many of which assume normative goals, use and engagement [8], which are beginning to be challenged within academia [14]. Using chest-worn HRMs as an example, many women, transgender, non-binary, and plus-sized cyclists athletes report discomfort, inaccuracy, and barriers to training due to their design, which doesn't account for the anatomical and physiological differences of diverse bodies [16]. More recent alternatives, including optical, or photoplethysmography (PPG), sensors are now commercially available, and often integrated into wearable sports and smartwatches, but these too can present accuracy issues on darker skin tones and atop tattooed skin [9]. This further reinforces barriers, further highlighting the need for inclusive design in sports and related technologies.

Figure 1 Garmin HRM-Fit

Motivated by Garmin's announcement of the HRM-Fit[1] in January 2024 (Figure 1), a new HRM marketed towards *women* and designed to fit underneath the underband of a sports-bra (*"Purpose-built for women, HRM-Fit is the heart rate monitor you need to capture the important metrics — all with a comfortable clip-on design"*), this paper uses chest-worn HRMs as a lens to explore broader inclusivity issues in CyclingHCI. Following the launch of the device, we used key search terms to collect data from related online media reports, comments sections, and social media discussions in order to understand the current issues, previous solutions, and online reactions to the announcement – specifically focusing on topics around inclusivity. Further research is needed from CyclingHCI and SportsHCI perspectives, to investigate how technologies can better support all diversity and accessibility in sports.

2 CHALLENGES AND ISSUES

Focusing on chest-worn HRMs, their design has been a long-term challenge for many people who wish to track their heart rate data, but find chest-worn devices to be a poor fit for their bodies. Online discussions highlight issues in comfort and fit, and even challenges with accurate data collection, leading to feelings of exclusion. The design, largely unchanged and apparently based on a slim cisgender male body, fails to accommodate more diverse anatomies including feminine and larger bodies, highlighting a critical need for more inclusive design. Despite these challenges being widely documented online and in popular media, we were unable to find academic literature specifically focused towards the wearability and usability of these devices, which are generally considered the "gold standard" of mobile heart rate monitoring [7], further underlining the need for more inclusive design considerations.

Comfort and wearability issues are most frequently mentioned, with users reporting discomfort, chafing, and skin irritation when using chest straps. These devices do not appear to consider the presence of breast tissue or the use of bras in their design, leading to straps that rub against the skin and sit awkwardly against the body and clothing. Bodily movements during activities can then cause the device to move, rub, pinch and lift, thus causing signal loss as well as discomfort during physical activity. This impacts the reliability of data, with users experiencing erratic and inaccurate heart rate readings from chest strap monitors, caused by the sensors on the strap losing physical contact with the against wearers chest, resulting in data artifacts and gaps in the numbers broadcast, rendering the data as unreliable (or useless). To maximise the effects of training, or during endurance events, athletes often aim to keep their effort within a particular zone, as indicated by their measured heart rate, so inaccurate data can be to the detriment of performance and training for impacted athletes. However, inaccuracies can be particularly problematic for individuals using HRMs to moderate their heart rate for medical purposes, such as following heart surgery, where a doctor may have advised to keep heart rate within safe zones. In this case, the unreliability of data could have significant health implications.

Together, the challenges associated with non-inclusive design of chest HRMs can significantly impact participation and exacerbate issues of inclusion in sports. Discomfort from poorly fitting devices, unreliable data, and a sense of exclusion can deter individuals from using HRMs, hindering their ability to achieve fitness goals and potentially impeding those who require medical monitoring post-cardiac events. Consequently, enhancing inclusivity in the design of sports wearables is imperative not only for improving user experience but also for ensuring equitable access to sports technology, which is crucial in promoting broader

[1] https://www.garmin.com/en-GB/p/1132094

participation and engagement in physical activities across all demographics.

3 SOLUTIONS AND MOVING FORWARDS

As mentioned in the introduction, this paper was inspired by recent release of a new chest-worn HRM which was specifically designed with the requirements of those who wear sports-bras in mind. Designed to clip onto the bottom band of the bra, the HRM is effectively integrated and removes many of the issues associated with the separate HRM strap, according to online reviews and commentary. The device has been widely applauded, and while this as a positive move from a major manufacturer, the requirement for a sports bra means this is not a solution that is inclusive for all underserved groups – indeed, given the diverse nature of our bodies and requirements, it is not likely that any single device would be ideal for all. In addition, the predominance of male voices in reviews and commentary around this product should be highlighted – perhaps indicative of the sometimes-toxic environment sports and technology discussions sometimes seem to foster. Indeed, one does not need to delve too deeply into the comments section of reviews of this product to see men discussing the appearance of the athletes wearing the device. Together, this highlights the need for increased gender diversity and inclusion in the sports technology community to ensure a comprehensive perspective on user needs and requirements.

The Garmin HRM-Fit was by no means the first product to address the broader needs of those who wear sports bras, other companies have attempted to create more inclusive chest-based HRMs specifically for those with breasts, including bras with built-in ECG sensors or a pocket to hold the device itself[2]. These products, generally from smaller manufacturers, have received mixed reviews but have helped solve issues for some users. Other solutions have been designed, developed and evaluated within academic research projects (e.g. [11]), though for the most these have been for use outside of sporting contexts. More recently, optical PPG HRMs that can more flexibly measure heart rate from various parts of the body (though generally the wrist or arm) have emerged as an alternative, enabled by advances in sensor and algorithm development [5]. Optical monitors avoid chest discomfort issues and provide more flexible wearing positions [1], but are less accurate on darker skin tones and tattooed skin [9], introducing further EDI issues. Furthermore, the accuracy of such devices can be questionable in particular health and fitness contexts – including in cycling activities where they have been shown to "lock" onto artefacts in the sensor data, particularly with continuous motions, such as bodily movements while pedalling [3].

Whilst the Garmin HRM-Fit and other recent products represent positive steps forward, there is still significant room for improvement. There is likely no "one size fits all" solution, and no single device is likely to meet the diverse needs of all. Participatory design processes that actively engage a wide range of people could help uncover usability issues, comfort challenges and other barriers that may otherwise be overlooked. Customisable, adaptable wearable designs with adjustable components and personalised fitting may provide better comfort and accuracy than one-size-fits-all approaches. Ultimately, centring the voices and lived experiences of underrepresented groups is critical for creating sports wearables that are truly universal.

4 DISCUSSION AND LESSONS LEARNED

In this paper we have highlighted the importance of **considering inclusivity from the outset when designing sports technology**. The challenges that some users face when attempting to use chest-worn heart rate monitors are not novel, yet they have only recently begun to receive attention – perhaps aligned with a more inclusive view of an athlete's identity – such as the introduction of optical PPG heart rate monitors. This technology provides benefits for a wider audience, yet has relied on significant technological developments. Simpler changes to the design of chest-worn HRM, such as Garmin's HRM-Fit, could have implemented much earlier to better support a more diverse range of bodies, but such considerations have historically been overlooked. The case of chest-worn HRM illustrates the problems that can arise when diversity and inclusion are not considerations of sports technology design, providing an opportunity for CyclingHCI and SportsHCI to lead in inclusive design and research.

This case study reinforces the criticality of inclusive design in CyclingHCI and SportsHCI, further evidencing the importance of understanding and supporting diverse needs and perspectives, and the value of customisation and flexibility, especially in design of wearable technologies [8]. There is an opportunity for HCI researchers to set a precedent in inclusive design, co-design, and customisation to better cater to the diverse populations engaging with sports technology, and sports more generally. A future vision for CyclingHCI is one where technologies are inclusively designed, promoting wider participation by meeting the diverse needs of all. However, the lessons learned from this paper are broadly applicable across many areas beyond cycling specifically, including sports, healthcare, workplace ergonomics, and any domain involving wearable or body-mounted technologies. To realise this, integrating inclusivity at every stage of the design process is essential, ensuring that the advancements are accessible and beneficial to everyone.

[2] https://emglare.com/products/bra

Finally, we acknowledge the irony that the first author of this paper identifies as a cisgender man, especially considering our critique of the male-dominated discourse in this field. However, we argue that the importance of inclusivity in HCI is bigger than individual identities and should be a collective movement with shared responsibility, not just of those who are marginalised or underrepresented.

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