Snot, Sweat, Pain, Mud, and Snow - Performance and Experience in the Use of Sports Watches

Jakob Tholander
Mobile Life@Stockholm university
Postbox 7003, 16407, Kista, Sweden
jakobth@dsv.su.se

Stina Nylander
Mobile Life@SICS
Box 1263, 16429, Kista, Sweden
stny@sics.se

ABSTRACT
We have conducted interviews with ten elite and recreational athletes to understand their experiences and engagement with endurance sport and personal and wearable sports technology. The athletes emphasized the experiential aspects of doing sports and the notion of feeling was repeatedly used to talk about their activities. Technology played both an instrumental role in measuring performance and feeding bio-data back to them, and an experiential role in supporting and enhancing the sport experience. To guide further interaction design research in the sports domain, we suggest two interrelated ways of looking at sports performances and experiences, firstly through the notion of *a measured sense of performance*, and secondly as *a lived-sense of performance.*

Author Keywords
Sports; experience; heart rate monitors; performance; feeling.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Measuring results as accurately as possible is the primary way of assessing sports performance. Consequently, performance metrics have been a strong driving force in the development of sports technology for heart rate monitors, GPSs, motion-capture, and video analysis. Of the limited work in sports in HCI, the majority has taken an experiential perspective manifested as exertion games, social support, and gamification. This has created a view on people's engagement in sports as being either about improving results or about enjoying the experience. We attempt to expand what sports performance means in HCI by proposing two interrelated notions of a *measured sense of performance*, and *a lived-sense of performance*, put them in relation to themes in experience-oriented HCI, and discuss their implications for interaction design research. Similar points to our distinction have been made in experience oriented HCI research, design [17], and aesthetics [35]. We argue that HCI has not sufficiently explored the connection between experience and athletic performance, but has in most cases been limited to either viewpoint. Our paper is an attempt to engage with this connection. To design technologies for sports, we argue that these experience-focused perspectives need to be put in relation to sports performance to support a richer range of sports experiences.

Endurance sports such as running, cycling, triathlon, and cross-country skiing is currently growing remarkably. This is seen in increasing participation in races and organized training groups, and the development of new forms of mass races such as ultra-marathons, swim-run races over large distances, and trail running. Hand in hand with this, a proliferation of mobile technologies dedicated to sports and exercise has emerged, such as watches, sensors, and apps. This technical and commercial development has brought increased attention of HCI to the domain of sports and novel ways of using technology in sports activities, examples include social sharing of heart-rate during cycling [34], interactive shirts for sharing running data [33], and novel feedback mechanisms for golfers [28], skiers [21], and runners [27]. So far, a significant part of the research in interactive sports technologies has been concerned with socio-motivational technologies [2, 23, 24], new forms of play [12, 15], gamification [5], bodily interaction [36], and explorations of technical challenges for wearable sports technologies [3, 4, 21, 39]. Social and playful experiences are indeed important for many people's engagement in sports, however, our study shows that there are users that desire technology that stay within the boundaries of the sport as such and the sports performance it involves - without transforming it into play or games. When it comes to supporting, enhancing or augmenting the sporting activities through deep engagement with the details of their execution, it turns out that less work has been reported. Counter-examples include [11, 19] which led to an innovative training device for advanced psychomotor skills in handball, Stienstra et al.'s. [34] work on sonification of

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speed skating motion; and Spelmezan's [33] vibrational feedback for snowboarding instruction.

By drawing on a set of "in-depth interviews" with elite and recreational athletes, we map out key characteristics of athletes' experiences and engagement in endurance sports, and technologies that support this in various ways such as sports watches and heart-rate monitors. For a large group of engaged athletes, there is a close connection between the experience of the sport and how it is performed, and sports is valued for a lot more than pure measurable performance. Moreover, it is not only goals and results that motivate athletes, but many additional factors such as the reward from meeting various challenges, the ability to manage exertion and fatigue, and the sheer fun and enjoyment of running, skiing, and cycling. Reoccurring in our material was the notion of *feeling*, and the various roles it played in building instrumental and experiential aspects of the athletes' performances. As put by one of our participants:

"*.. and then you run ten kilometers and it feels like… well, did I run or am I going to run? I don't feel the difference in my legs. That feeling is priceless in a way*." Karl (recreational athlete)

We believe that our proposed notions of *measured sense of performance* and *lived-sense of performance* effectively characterize the experiences of doing sports in relation to sensor-based performance technologies, such as heart-rate monitors, GPS:es and sports watches.

BACKGROUND

Health and wellness has been an important trend in CHI research, as well as in the domain of consumer electronics during the last decade. Many commercial and research-oriented sports technologies such as sports watches, heart-rate monitors and exercise apps are designed to automatically gather and present data with the purpose of generating a log of performed activities. The focus of these logs is on devising interactions for improved practice and racing. Rewards for improvements and goal achievements are common mechanisms used in such designs. Successful examples from research include the Ubifit project which worked on automatic recognition of activity to relieve users from data input, and combined it with visual feedback to motivate users [5], whereas Ahtinen et al. restricted their application to the activity of walking but offered goal setting and the ability to represent the goal as a journey to support motivation [1]. Many commercially developed apps such as Runkeeper, Endomondo and Run Zombie, run! also use rewards of various kinds to increase motivations.

Social mechanisms such as opportunities for sharing data is commonly used in commercial products and in research. Research systems have also explored a wider range of social mechanisms such as displaying heart-rate data to other athletes [20, 38], the ability to watch live video of others practicing [24], setting up competitions between friends [37], or interacting with others working out in remote locations [23]. These attempts have made substantial and important contributions to the field, especially when it comes to exploring how to engage people in sports and exercise.

When looking closer at the specific domain of sports, there are several bodies of research within the CHI community. Primarily the following approaches can be identified: *technical explorations* aiming at new technology for existing sports, for example wearable sensors [4, 19], *new forms of play or sports*, such as PingPongPlus [15], and various exertion games e.g. [22], *instructional technology*, aiming to improve the skills of athletes by providing instructions through various modalities such as vibration [3, 33] or sound [34].

Research has also been inspired to use sports technology in new settings. The availability of robust and accurate heart-rate monitors for sports use has made it possible to create new types of social awareness systems based on heart-rate data. Several systems have been developed around heart-rate data, such as allowing family members to see each other's' heart-rate as a way of indicating mood, activity, and emotional state [6, 32]. Heart rate monitors have also been used to select music in manner that support mood and exercise [39], and to control game features [25].

More recent research on sports and HCI has started to pick up on experiential dimensions of sports, striving to design aspects beyond the immediately instructional and result oriented. Notable examples are Pijnapple & Mueller's work on skateboarding [30], Nylander et al.'s work on golf [28], and Stienstra et al. on speed skating [34]. In line with this recent trend, we argue that the experiential aspect of sports holds a potential ground for unexplored forms of interactions [29] which has received little attention in the performance-oriented, motivational, and gamification approaches.

We argue that a key element for future research is to understand the motivations and experiences around people's engagement in sports and exercise. Much research in this area is based on the underlying assumptions that people engage in sports and exercise for result oriented and goal-directed purposes, such as running faster, finishing a race, or losing weight [3, 7, 8]. Consequently, the primary role of any kind of sports technology would then be to support or simplify for athletes in achieving these goals, supposedly by making it more fun, more social or more personally rewarding. In contrast to this, and in line with sports psychology [10], our work shows that many athletes are driven by a broader set of experiences of sports. We argue that interaction design research in this area needs to broaden what it means to engage in sports and exercise, and the underlying reasons as to why people do this, in order to find novel design directions. Another important element in furthering the research around interactive technologies for sports is to understand people's real-life practices in sports and their technology use. A number of studies have

investigated various logging [31] and bio-sensing technologies from a broader lifestyle and health point of view [32]. Contrary to those, the goal of our work has been to put sports experiences at center stage in order to draw out the elements that are characteristic to technology and interaction targeted for sports. Given the large amount of users in this area, we argue that that this is an underexplored domain.

METHOD

We conducted 10 in-depth interviews with elite (3) and recreational (7) athletes. Participants were recruited using email in the authors' extended personal network and through the Swedish Federation of Orienteering. We selected endurance athletes who practiced at least three times a week, but did not pose any requirements on their main sport, their technology use, or their level of fitness. We recruited both elite and recreational athletes, since the practices and requirements of the elite have a strong influence on what recreational athletes do or want in terms of practice schedules and choice of technology. Our elite participants spent 15-20 hours a week practicing, normally distributed on 9-13 sessions, while the recreational athletes reported 3-7 sessions a week. The recreational athletes were interviewed in locations they chose themselves, most commonly at work, and elite athletes were interviewed in conjunction to a test session of the Swedish National Orienteering team's study on running biomechanics. The interviews were semi-structured and focused on aspects such as: schedule, goals, technology used, performance, experience and motivation, social sharing, learning, and identity management. They lasted 45-70 minutes and were recorded, transcribed, and analyzed by the authors through open coding in a collaborative fashion.

Nine of the participants owned GPS equipped heart-rate monitors, and seven used them regularly during practice. One of the participants was recovering from injury and found the heart-rate monitor stressful during the rehabilitation phase, and one only used the GPS functionality in the watch. Our three elite athletes were members of the Swedish national team of orienteerers and diligent users of GPS using special purpose tools to analyze their data and evaluating their orienteering skills. Several participants also used various apps such as Runkeeper or Funbeat, as well as the online forums that heart-rate monitor suppliers provide for storing and analyzing data.

RESULTS

The participants in our interviews were happy to talk about their practice and openly shared stories of successes as well as failures. Some of them had brought the technology they used and showed us their training plans. Technology has shaped and reshaped the practice of training of several of the participants. Heart-rate monitoring has changed the aims of various workouts and to some extent created new forms of practice. Certainly they talked a lot about becoming better runners and cross-country skiers and how the technology played a part in that. However, they repeatedly came back to the importance of the subjective experiences of running or skiing both for the sake of improvement, and just as importantly, for the experience itself. We will go into detail on the three main themes from the interviews: feeling and experience; goals and rewards; and collecting, perceiving and sharing data.

FEELING AND EXPERIENCE

A theme that kept coming back in our interviews regarded the notion of feeling. We will unpack some ways that the notion of feeling were used, and how we can understand that in relation to interaction design research in sports. Technology served both the purpose of improving performance and enhancing experiences, and played a role in the participants' getting to know their bodies better. The relationships between the technology and the various ways that the participants expressed themselves around the notion of feeling served a variety of purposes. We have organised these into three main themes: technologies and feeling for a) enhancing experiences, b) improving sports performance, c) learning about effort and performance.

Enhancing experiences

A first observation is that the word 'feeling' was used to describe a variety of aspects of their practice, racing and overall experiences of their sport. Feeling was used to describe the role of the technology they used, what they were striving to achieve, and to talk about the role of speed, distance and exertion during practice. Feeling thus had a number of different meanings to our participants, but in overall it points to the centrality of the felt dimensions of their experiences of training and racing. When talking about practice, they kept coming back to the importance of having a good feeling, and the necessity of developing a sense of a number of factors such as exertion, speed, and heart-rate level. These were considered critical to learn to know their bodies. They considered all this as essential both for improving performance and having a desired experience.

Let us illustrate this broad usage of the word feeling by a quote from one of our participants. In the following, he discusses how he looks at his training and the use of heart-rate monitors.

"*on some routes I check how it feels, because that is what I use my heart-rate monitor for, it is to describe the embodied feeling in relation to the perceived effort, so it is a lot of feedback, that is what I use it for. That is what I say to a lot of people who start using a heart-rate monitor is that they should learn about their bodies via their watch, how it feels and so that you know how it is to breathe at a certain heart-rate level … but then you have to know your maximum heart-rate, you have to know a little more about how recovery works. If I do interval training, I check the span a lot, from going towards maximum, and the recovery job. When doing hills for instance, I check when I start*

again, so I don't check the time that much, I go more on heart-rate and feeling ... like now it is the right time to go for another one." Paul (recreational athlete).

Throughout this quote Paul repeatedly uses the notion of "feeling" and "feel" when talking about his practice. For instance, to calibrate his feeling for various exertion levels to his actual heart-rate levels during practice and racing, learn about how his body feels and responds to various forms of practice. Breathing and feeling and exertion relates to various heart-rate levels, and guide him during interval sessions regarding how fast to run, how long to rest between repetitions. The heart-rate monitor is thus used as a support for looking inwards towards his subjective experiences of how his body feels, as well as for looking outwards towards objective measures about his performance. These processes are interrelated and plays a dual role in creating his experience of practice.

Let us further analyze the experiential dimensions of how the participants talked about the notion of feeling and their experiences of endurance training and sports watches. Paul used the notion of feeling to emphasize a variety of felt dimensions of his practice in relation to his body, and particularly the role of heart-rate data in building these. Examples include sense of speed, sense of exertion, runners high, being one with nature. Paul, who had used heart-rate based training for more than ten years, described the process of adjusting his level of exertion during a workout in the following way:

"[it's] *like a mirroring of the feeling I am aiming for, that is why I use a heart-rate monitor. Like a confirmation about how it feels when I breathe*" Paul (recreational athlete).

This stands in contrast to some of our other participants who had racing performance in focus. Paul focused on the experiences he got from his practice saying things like that he strove to "find the right feeling", to "get to know your body", and "it must be fun". His attention always first went to himself and his body, and secondly to the watch and the heart-rate data to nuance or confirm the feeling.

Improving the performance

Another common way that the participants talked about feeling was as a tool or instrument that they 'used' during their practice sessions. For instance, Peter, an experienced runner, skier and coach of runners and swimmers, talked about how a workout feels in a similar way to how he talked about heart-rate data from his watch. Feeling was treated an additional data source comparable to speed, time, distance, and heart-rate. According to him, the feeling during a workout should match data from the watch, and especially the heart-rate. He argued that during practice, heart-rate data was the most important data from the watch since cardio vascular capacity is what in the end determines someone's performance.

"Well, what you want to see is, I mean, exertion in relation to your speed is where you strive for an improvement ... either make your running more efficient so that you can run faster with less exertion, or improve your 'engine' so that you can run faster at lower heart-rate. "Peter (recreational athlete).

Contrary to some of the other participants, this instrumental view is illustrated in his emphasis that his goal was not to achieve a good feeling for the sake of itself. The goal is to be able to run faster, and feeling is an important tool in the process of improvement. A nuanced sense for your heart-rate allows athletes to control the level of exertion that is required to carry out various workouts for improving the factors that build cardio vascular capacity. At the end of the day, for Peter, it is how fast one can run that counts, so the final evaluation is still based on time and distance.

Heart-rate data was claimed by the participants to support them in following their plan for a particular workout. Several participants had defined the heart-rate zones that they should stay within during a particular work out. For instance, Mark discussed the difficulties he had in staying within the so-called A1-zone, the zone defined for plus two-hour workouts. On several occasions, he had tested his heart-rate thresholds at a professional testing facility and had his upper A1-threshold defined at 125. However, he often ended up above this which could cause the workout to not have the intended effect:

"*so it it is so easy for me to end up at a heart-rate of 135 even though I want to stay below 125, but then I let the heart-rate control, so that is what keeps the speed down. Because if I rely on speed and feeling, I go too fast*" Mark (recreational athlete).

Learning about effort and performance

For Mark, relying on feeling is not sufficient to allow him to efficiently follow his workout plan. He has a solid background in long-distance running at national elite level, however, compared to some of our other participants he was rather unexperienced in heart-rate based training (about 18 months). His subjective sense for his level of exertion was not fine-grained enough to stay in the A1 zone without relying on his watch. Based on his heart-rate readings he adjusted the speed, and thereby the exertion level to follow his workout plan. Ultimately, through further interaction he might learn to calibrate his speed and exertion to appropriate heart-rate levels without relying on his watch.

The way the heart-rate monitor help to support the learning about one's body was brought up by Max who had experiences similar to Mark. When talking about how he used his watch, he said that by looking at the heart-rate data in real-time, he learned about the relation between his perceived exertion levels and his heart-rate:

"*if you are not in good shape it always feels like you are going really hard, but the more you run you the better you*

become at knowing your level of exertion. In the beginning, it could feel hard even though my heart-rate was low so then the watch helped me increase the speed. That I don't have to do that much anymore." Max (recreational athlete)

Firstly, quite similar to Mark's experiences this points to how the heart-rate data helped him realize that often when he felt that he was going as hard as he could, he was actually not close to maximum heart-rate. Secondly, through his interaction with the watch he has built up a more nuanced feeling of his level of exertion. An exertion level that he previously experienced as really hard, was now understood as not being at his maximum. Thus, he had learnt to reinterpret how to relate such a feeling of exertion to a particular heart-rate level, and adjust how to carry out his workout. This shows how an improvement of physical capacity together with interaction with heart-rate data not only provided instrumental information about his workouts, but also transformed his subjective experiences of running.

Interacting with the heart-rate monitor is a learning process in which athletes build a more nuanced picture of their bodies. In such a process, the heart-rate monitor works as an instrument to help athletes to build such knowledge and how they react to various forms of practice. In the long run they might develop a sense for their bodies that does not require relying on the heart-rate monitor in their practice.

GOALS AND REWARDS

The majority of our participants were not primarily goal-driven in terms of measurable results. Given the significant amount and time and effort that that such keen athletes put in, elite as well as amateurs, we had expected this to be more prominent. Quite the contrary though, several of them primarily brought more 'soft' benefits as key goals that they strived for. These aspects included a mix of social motivations, aspects of well-being, lifestyle, and identity. While most of them did have performance goals such as running a marathon under three hours or winning medals at international championships, these were always interwoven with other "softer" rewards. When asking the elite athletes that were part of the national team in orienteering what motivated them to put in all the hours, sometimes during the most unpleasant conditions, apart from mentioning the dream of becoming world number one, they all emphasized less measurable factors such as the social aspects of practice and competing, their social life together with the team, and the rewards from challenging oneself.

In a similar fashion, most of the amateurs presented well-defined goals when specifically being asked for it. These goals ranged from running an ultra marathon, running a 45 minutes 10k, or a sub 5 hour Vasaloppet a (Swedish ski race). However, for several of them, achievements in the form of reaching measurable goals were much less important than training as part of a lifestyle and the role of their sport in building their identities.

Paul for instance said that his goal was that it should feel good when practicing. He wanted it to "feel good" in the Vasaloppet. He did not have a specific time goal even though he would appreciate a good result. Similarly, Karl talked about goals as

"if you do not have any goals that are really important to you, then it is the everyday practice that are the actual goals. They are kind of the product,that is what you do. Karl (recreational athlete)

The participants brought up a variety of rewards that they got from their training. These ranged from appreciating the feeling of exhaustion after having completed a really tough workout, making a plan and following it over a long period of time, as well as to beating your personal record in a race. Thus, in addition to being rewarded by the measurable results and improvements, the experiential aspects of practice including planning, execution, and reflection, was described as important goals and rewards.

Rewards were not necessarily formulated as being about performing well and feeling strong, but often linked to the satisfaction of achieving what they had set out to do, in a specific way. Sometimes this was to push themselves really hard and thus the rewarding feeling would be about a combination of exhaustion and sense of achievement.

"*It felt really tough, and I knew that my legs would be completely dead for the coming two days, and the other day I walked like … I could hardly walk in the hallway, it was ridiculous.* " Paul.

This is an example of how participants appreciatively talked about aspects that in other circumstances would not necessarily be categorized as rewards, such as pain and exhaustion. Other forms of rewarding feelings were connected to the experience of the results of the practice in terms of performing better and thus feeling a clear improvement in following workouts. For Paul, the reward is a combination of feeling and result, he manages something that he did not before while feeling stronger. He connects his story of the reward with the preparations, the preceding heavy gym work which made him feel anything but good:

"*sometimes when I have done a leg workout at the gym, and then two days later get on the bike. Then you notice the effect of the workout and the rest, in certain stretches uphill you notice that you can push a lot harder than usual without the heart-rate rising very much …* " Paul.

The fact that he managed to push himself hard enough during the gym workout adds value since it shows him that he could put in the effort needed to achieve the result.

Rewards were sometimes not related to a specific workout or even participants' exercise plans or goals. Karl's feeling cited above about having completed his practice without effort, is both a sense of being a really strong and fit runner and a deep sense of happiness in being able to run without even getting tired. In line with this, several of the other

participants brought up that short-cuts in the training are not interesting, rather, rewards come in relation to the effort you put in. One of them said that the optimal reward did not necessarily increase with an improved time in race, but came that he throughout the race had the sense that he had done everything right, that his body felt really good, no matter if he beat his personal best in the race or not.

"*Downhill from Evertsberg, that is so damn great, you just wow ... that feeling is really hard to beat, if you have done it right up to the top, and then you get the downhill, I mean, that!*" Paul.

One participant formulated this as finding the "right equation"; figuring out everything that needed to be done, and then being able do it. He emphasized that the reward of practice cannot simply be measured from how well you performed in the final race, but rather in the experience of completing the whole process from start to end. The motivation came from range of factors such as performing the sports itself, challenge oneself, and following a plan. This created long-term motivation for engaging in these activities for substantial periods of time.

COLLECTING, PERCEIVING, AND SHARING DATA

Most commercial applications for endurance sports focus on automated data collection and documentation of your practice, thus providing a training log based on data, such as time distance, speed, and heart- rate, and various sharing opportunities through social media. However, the participants in our study manipulated their data in a number of ways since they found that the basic measures provided were not sufficient.

Precision of data

Our participants critically examined data in relation to how they perceived their practice. One common way was to analyze the reliability of the data. Peter, e.g., emphasized that the he always strove for the most accurate data.

"Well, what you want to see is the exertion in relation to your speed, that is where you strive for an improvement ... either make your running more efficient so that you can run faster with less exertion, or improve your 'engine' so that you can run faster at lower heart-rate. Peter

For him it was of key importance to have the most accurate measurement of speed since he found speed to be the most accurate measure of improvement and wanted to put it in exact relation to heart-rate. He found that the GPS-based speed calculation was too coarse. Therefore, he used an additional foot sensor to measure speed and calibrated his foot sensor each time he bought a new pair of shoes.

A related aspect of the precision of data reported by our participant regarded the accuracy of GPS data. Especially interesting was how the elite orienteerers reviewed their GPS logs after workouts and races in order to analyze their route choices and orienteering technique, for improvement of speed and map reading, and managing difficult passages such as going in and out from check-points.

I overlay data on the map, often it's quite quick to get it to fit, but it depends... I mean, the GPS is probably right but not the map, which is an interpretation of the reality. Then I can adjust the GPS trail to the map. It's simple, I just drag it. Susan (elite athlete).

This process of correcting the GPS track according to the correct track points to the importance of acknowledging that GPS data in combination with maps has error sources, not only because of the off-drift of the GPS but also because of limits of cartography, (rocks can only be of two sizes on the map). Orienteers could in some detail remember the exact route choices they had made based on the GPS data. Similarly, Paul had quite exact recollections of his heart-rate and breathing at various points in the terrain. The sense for his body and the heart-rate data played a role in how he experienced and remembered the physical environment. Based on this he could remember a workout in detail, as well as adapt and combine the various trails he ran, biked, and skied. The sense of his body, such as heart-rate and breathing, was a way of remembering that was tightly coupled with his experience of the local geography and the parts of nature he used.

Using heart-rate data in practice

One central aspect that we explored in the interviews concerned how the participants used and interpreted the data from their heart-rate monitors. The most important use of the data was when participants looked at, and reflected on, their data during workouts. The purpose was to quickly verify that their heart rate were at the level they wanted it and to make sure they could complete the session the way they wanted to.

"*It can be super quick, just like, how does it feel when I breathe...like the general feeling and the level of exertion*." Paul.

The participants often had specific goals for a workout, for example, reaching a certain heart-rate threshold, or staying within a certain heart-rate zone. To make sure that the workout would have the desired effect they calibrated their pace by checking their heart-rate so that they worked hard enough, or not too hard.

"*When I felt like, this is really tough, I can't keep the pressure up, I checked the watch and saw I had a heart-rate of 153 and realized I needed to slow down to be able to keep on going the last 90 seconds. So the combination of how it feels and the watch makes me slow down*" Mark

The only case of looking at the data in any detail were Karl who had seen that some of his readings were really off for a long period. In combination with unusual tiredness and difficulties of sleeping after workouts he made an EKG and it turned out that he had a heart condition that required two operations. This is an interesting case of how sports

technology potentially can interact with health care, even though it was quite unusual.

Post-practice analysis was reported as being less frequent. It was done both on separate sessions and for longer periods of time. Post-analysis of specific workouts mostly concerned the specific goals set for a certain workout, and served as input for learning how to perform similar workouts in the future.

"*I check that the level of the heart-rate is where I want it to be, for example for 800 meter intervals, I want around 92, 93, 95, well at least above 92% of my max heart-rate. If it's lower I didn't push hard enough, and will try to push harder next time.* " Peter

When analyzing longer periods of time, as well as long-term goals, participants looked at high level information rather than data from specific workouts, or even aggregated data from series of workouts such hours and kilometers during a given time period.

Often, the subjective comments that athletes made after each practice session were the parts of their data that was given most weight in the analysis. In a way, how athletes experienced the different components and sessions in their practice was used as a coarse tool for evaluation. Negative comments, or a sequence of negative comments, indicated that a closer analysis of the exercise plan was needed.

"*well, if you evaluate continuously, you often start from my comments. And if that is, like, if it felt bad several days in a row, well, then you might need to look at heart-rate data, speed data, or everything to find out what is wrong*." Lisa (elite athlete)

In summary, analysis of collected data rarely occurred at the level of detail that sports watches and exercise apps provide. However, subjective aspects of practice and racing plays in important role both during practice and in post activity analysis of short as well as the long term perspectives. Therefore, we argue that given the fact that participant spent little time on post analysis, we argue that next generation sports technology should support users by aggregating data and representing data in novel ways, supporting users in real-time and post-activity reflection and analysis of their practice, and more importantly designing ways of meaningfully integrating the subjective experiences of their practice with the collected data.

Sharing of data

Our participants only shared data through online tools to a limited extent. Neither did they look at the data of others in any significant way. All of them used various online forums for uploading and saving data, and they did store it publically. Some of them had a few friends in their forum, like 'my wife', or 'one of my running buddies', but the interaction was limited to occasional brief comments. When we probed them about their use of sharing features they had difficulties seeing any personal value or purpose, beyond basic awareness of the number of workouts their friends did. Since social features are some of the most appreciated aspects of endurance sports applications and online training forum are highly used, we had expected this to be the case also among our participants. For instance, Anna who had several running friends and belonged to a running club said:

"*Why should I want to share and why would anyone want to look*" Anna (recreational athlete)

Anna's quite absolute denial of any value for her in sharing data illustrate the position of most of our participants on this matter, namely that their reasons for the significant time put into practice and racing was primarily personal. They did not actively share information about their activities or their data, neither did they look at the data of others. This does not mean that they were asocial in any way, or found no value in learning and socialising with others around their sport. Most of them practiced together with friends and in training groups to various extents. However, the social values of their practice were not found through online sports forums or social media.

The clearest case of interest in what others shared was by Mark who regularly checked the workouts of those his training friends that used the same watch brand, which gave suggested recovery time after each workout.

"... he is always at 90 hours of rest, and it's like, it's a bit prestigious …" Mark.

This was interpreted primarily in a 'macho' way as a measure of how hard you practiced, and not of any significant value that they would use to adapt their practice.

Given the strong interest in heart-rate based training it could be expected that the participants would also show interest in sharing and looking at others heart-rate data to learn more. We believe that one important reason for this is due to the physiological differences between individuals which cause heart-rate data to differ extensively between individuals. This makes it difficult, or even meaningless, to compare and interpret someone else's heart-rate data without knowing at least their maximum and minimum heart-rate, their various thresholds and preferably also a number other aspects of their practice.

The heart-rate diagrams that most systems generate are quite detailed, based on moment-to-moment readings. Most users claimed that this level of granularity was too detailed in order to conduct post-workout analysis of any significance. Most participants based any post-workout analysis on fairly basic measures such as average and maximum heart-rate of a workout. Not even the elite runners claimed that their coaches analysed the heart-rate diagrams for each workout, or over longer periods of time.

DISCUSSION

What we first would like to highlight from our study is how our participants emphasized the felt dimensions and

experiences of doing sports, and in particular, the lived-sense of being an athlete. One of them aptly labeled the deep engagement in the sports that he loved to perform under the notion of "snotsport". To him, such a notion included a deep appreciation of the sport as such, the pain, lactic acid, exertion, exhaustion, snot, sweat, and the rewards that he experienced from taking these on as they are. He loved endurance practice and the ability to manage the effort and the exertion that followed. He even claimed that it put him in closer connection to his body during exertion. Important about the characteristics of 'snotsport' is that athletes of our study did not want distractions from them while performing their sport, rather these were core elements as to why many of them loved their sport and continued to engage in it. Hence, sports should be challenging and one does not need distractions from that.

Furthermore, our results point to a number of tensions in the relationship between subjective experiences and instrumental purposes of sports performance. This could be seen in (i) how technology was used both for looking 'inwards' towards their felt bodies, and looking 'outwards' towards objective measures of the performance, (ii) how technology and feeling worked as complementary sources in analysing workouts and learning about their bodies reactions to various experiences, (iii) how subjective memories were put in relation to external data, such as GPS and heart rate, in order to interpret the outcome of workouts and filling gaps in accuracy of the data. From a interaction design point of view this suggest that technologies for sports performance need to be understood as serving dual purposes that live between the athletes' experiences and objective measure of their performance. This duality will be further conceptualized below.

A lived and a measured sense of performance

A key finding regards the centrality of the *notion of feeling* to the users' experiences of their sport. The notion of feeling played a number of roles in participants' practice, such as being a tool for interpreting signals from their bodies, developing a sense of speed in relation to intensity of breathing, and learning about their bodies' reactions at various perceived exertion levels. Subjective experiences played a similar role as data received from sports watches, as well as being goals to strive for in themselves.

The notion of feeling can be understood in two main ways in relation to endurance training and the use of heart-rate monitoring, *instrumentally and experientially*. These two ways can be illustrated by the perspectives on practice of two of our participants. Firstly, Peter who had a strong focus on improving his performance and used his watch and heart-rate monitor primarily as a tool to improve his practice, and thereby in the end reaching his over-arching goal of racing faster. Secondly, Paul who had a strong focus on the experiential and felt dimensions of his practice and used his watch to enhance its experiential aspects.

Thus, to our participants *performance* came to mean more than measurable effects or results achieved in races. We argue that a design oriented understanding of sports performance needs to capture instrumental as well as experiential dimensions. To conceptualize the use of sports technologies, we argue that it requires an understanding of the relationship between the technologies and the experiences people have. This relationship is necessarily of an interrelated character. Such a dual appreciation of instrumental and experiential aspects of sports and exercise can be distinguished through what we call a *lived sense of performance* and *a measured sense of performance.*

- A *measured sense of performance* captures the instrumental purposes of the use of sports technologies. External data sources and information about users' practice and bodies provide possibilities for an outside perspective of their performance and how that contributes to efficiently carry out workouts and races. Examples of this is how they pace themselves, balance their various thresholds, and evaluate performances.
- A *lived sense of performance* captures the subjective and experiential purposes of sport technology use and how it enriches the various experiences that users get engaged in during practice. Memories, experiences, and technology also provide users with opportunities to look inward. Examples of this include performing workouts in a way that puts them in closer connection to the bodily experiences or their strive for runners' high. This notion contributes to pin-pointing the felt-life and lived-dimensions of performing in sports.

Similar to ideas proposed in other domains such as that of celebratory technologies in food experiences [9], these two notions of performance suggests that experiences of sports and sports technology arises in an interplay between instrumental and measureable on the one hand, and subjective and felt aspects of performing in sports on the other. We argue that sports provide a rich, and currently largely unexplored area for the design of technologies for such experiences, even though other domains of HCI, such as embodied and affective interaction have addressed such non-functional and non-instrumental aspects of bodily experiences in various design projects [13, 18, 36].

The notions of *a measured and lived-sense of performance* connect to current conceptualizations of interaction design research that brings in ideas from STS theory relating notions of performativity and material agency [16]. The distinction between *representational and performative technologies* proposed by [26] suggest that technology plays dual roles in the users' experiences, both as ways of portraying real-life events, and as agents that interfere in users' activities. From such a viewpoint, sports technologies not only measure and represent data from users' activities and bodies, they reflexively act as agents that do things in and affects these experiences, thus performing aspects of the experience together with the

users. Technologies provide representations of established facts as well as dynamically intervene in user's felt lives during, before and after practice.

Toward novel representations of sports experiences

The deep appreciation of the *sport* including all elements that come with it, painful as well as enjoyable, is what the participants found rewarding and motivating and the reasons for putting in the time and efforts that they did. Participants came back to how painful elements such as fatigue and lactic acid gave them a sense of achievement that were central to their enjoyment of the sport. Hence, this was not parts of the experience that they would like to get rid of, or something that technology in any sense should 'design away'. This would provide a new starting point for technologies design for such a practice. Key elements of the activity should not be transformed into something playful or game-like. Thus, from this perspective, interaction design research need to reflect on the ways in which technology transforms the key elements of the sport.

This perspective resembles what Grimes & Harper [9] call celebratory technologies. Such technologies would draw on what athletes claim to be the central elements of their experiences to design engaging sports experiences. One way of realizing this could be through Interactional Empowerment [14], which advocates designs that empower and support users in creating their own meaning from biodata, not designing systems which create the meaning for the users. Thereby such design would put users in an even stronger connection to their sport. Such explorations should build on the core elements of people's experiences of sports, as properties to highlight, emphasize and support rather than to conceal and diminish.

Novel measures and representations of sports data

We argue that there is a need for novel kinds of representations and "measuring sticks" of sports performances. This is especially relevant for data such as heart-rate data which is highly individual. The fact that two individuals with equal physical capacity in most cases has different maximum heart-rate and different heart-rate thresholds means that there is a *lack of common reference points* that allow for straightforward understanding, interpretation, and comparison between individuals. This requires a partially different set of aggregations than the current ones, in order to bridge individual variations. By developing a richer set of measures that connects to heart-rate rather than to speed and distance, it could be easier for athletes to perform workouts the way they had intended.

The fact that people are not only driven by 'hard' goals in their training, but largely emphasized the "soft" elements, often without connecting them to the measurable goals, has consequences for what we put in focus in the design of technologies for these users. Given that it was primarily the bodily experiences and the joy they got from a really good workout or race that motivated several of our participants, we should explore ways of designing sports technologies that better match those drivers. This leads to the question of what kinds of measures and perspectives current systems provide. Should data by necessity be considered as true or should it rather be one of many elements the build user experience. What new measures can we design that suites the variety of goals athletes have for their practice, such as getting to the perfect feeling in training and following their workout regimen. We argue for the importance of showing users that sports data have sources of error relevant to deal with. Data of this kind should not be treated in a black-box fashion but looked upon as opening up interesting opportunities for interaction. Current systems gather data that are seen as objective, such as distance, speed, time and heart-rate, and are consequently presented as such to the user. However, as our study shows, athletes have a variety of subjective ways of valuing their performance, which cannot straightforwardly be connected to the data in its current form. Thus, we need representations that relate to users' individual and subjective measures for their performances.

FINAL REMARKS

While the field of sports and sports technology is rapidly growing with the possibility of light-weight sensors our results point to that these should not only be designed with exact measurements of technique and performance in mind, but also as a way to connect to and enrich users lived-sense and experiences of performing their sports. We propose that the notions of measured sense of performance and lived sense of performance push us to think about what kind of technologies we design in health, exercise and sports. These technologies should not only provide sports performance data, but should aim at opening up possibilities for interactions that connect to the lived, and felt-life of doing various physical activities.

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