mHealth Self-Report Monitoring in Competitive Middle- and Long-Distance Runners: Qualitative Study of Long-Term Use Intentions Using the Technology Acceptance Model

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Abstract

**Background:** International middle- and long-distance running competitions attract millions of spectators in association with city races, world championships, and Olympic Games. It is therefore a major concern that ill health and pain as a result of sports overuse lead to numerous hours of lost training and decreased performance among competitive runners. Despite its potential for sustenance of performance, approval of mHealth self-report monitoring (mHSM) in this group of athletes has not been investigated.

**Objective:** To explore individual and situational factors associated with acceptance of long-term mHSM among competitive runners.

**Methods:** The study used qualitative research methods with the Technology Acceptance Model as the theoretical foundation. The study population included 20 middle- and long-distance runners competing at national and international levels. Two mHSM applications asking for health and training data from track and marathon runners were created on a platform for web survey development (Briteback AB™). Data collection for the technology acceptance analysis was performed by personal interviews before and after a 6-week monitoring period. Pre-use interviews investigated experience and knowledge of mHealth monitoring and thoughts on benefits and possible side effects. The post-use interviews addressed usability and usefulness, attitudes toward non-functional issues, and intentions to adhere to long-term monitoring. In addition, the runners' trustworthiness when providing mHSM data was discussed. The interview data were investigated using a deductive thematic analysis.

**Results:** The mHSM applications were considered technically easy to use. Although the runners read the instructions and entered data effortlessly, some still perceived mHSM as problematic. Concerns were raised about the selection of items for monitoring (eg, recording training load as running distance or time) and with interpretation of concepts (eg, whether subjective well-being should encompass only the running context or daily living on the whole). Usefulness of specific mHSM applications was consequently not appraised on the same bases in different sub-categories of runners. Regarding non-functional issues, the runners competing at international level requested detailed control over who in their sports club and national federation should be allowed access to their data; the less competitive runners had no such issues. Notwithstanding, the runners were willing to adhere to long-term mHSM provided the technology was adjusted to their personal routines and the output was perceived as contributing to running performance.

**Conclusions:** Achieving sustainable adherence to long-term mHSM among competitive runners requires clear definitions of monitoring purpose and population, repeated in-practice tests of monitoring items and terminology, and meticulousness regarding data-sharing routines. Further naturalistic studies of mHSM use in routine sports practice settings are needed, with non-functional ethical and legal issues included in the evaluation designs.

Keywords: Long-distance running, mobile health technologies, self-reported health, web-based monitoring, evaluation, qualitative methods, thematic analysis.
Introduction

Middle- and long-distance running is one of the most popular forms of physical exercise worldwide, and running competitions attract millions of spectators in association with city races, world championships, and Olympic Games (Figure 1) [1]. It is therefore a major concern that ill health and pain as a result of sports overuse are common causes of lost training and decreased performance among long-distance runners [2-4]. Recent research suggests that early detection of overuse syndromes may be achieved through observation of indicators at levels other than the tissue damage. One way to identify early indications of decreased performance among runners is to continuously record external loads and then evaluate how the runners are affected by these loads [5]. However, such passive monitoring requires extensive technical resources, and it is also challenging to analyze data monitoring from different individuals in a meaningful way. As an alternative, self-report measures have been described as adequately reliable and sensitive compared with other ways of measuring athletes’ response to training load [6]. Athlete self-reporting on training and health status using the World Wide Web (the Web) is simple to administer and inexpensive [7,8]. Despite its potential, research on implementation of mHealth self-report monitoring (mHSM) among runners is sparse [9].
Figure 1. City marathon races attract millions of spectators in association with world championships and Olympic Games [1].

In any setting where novel technology is incorporated with established practices, knowledge of user acceptance and usability is important [10]. The Technology Acceptance Model (TAM) was developed to help analyze, explain, and modify computer-usage behavior in a framework based on the Theory of Reasoned Action (Figure 2) [11,12]. In the TAM, it is assumed that an individual’s willingness to use a technical system or device is mediated by the quality of the man-machine interface and the perceived usefulness. Usability is defined here as the level at which a person finds using the system to be free of effort, whereas usefulness is defined as the extent to which the person finds that using a particular system enhances his or her performance of important tasks. More recent versions of the TAM also include external barriers to technology use, such as costs and maintenance [13].
Figure 2. The original version of the Technology Acceptance Model (TAM) used in the present study [12].

In theory, monitoring by self-report measures has the potential to provide useful information for competitive runners exposed to high training intensities and large volumes, predisposing them to running-related health problems [14,15]. However, the usability and usefulness of mHealth monitoring systems based on such measures have not been assessed among middle- and long-distance runners. The aim of this study is to explore individual and situational factors associated with mHSM acceptance and long-term use among competitive runners.

Methods

This study was based on a pre-post intervention design and qualitative research methods [16]. The setting was an initiative by the Swedish Athletics Federation (www.friidrott.se) to monitor the performance and health of runners competing at middle, marathon, and ultra-marathon distances. Following a development and test period, the ambition is to introduce mHealth monitoring and feedback as a regular component of coaching and medical support. The purpose of the mHSM in this research was defined as: “to collect longitudinal training and health data to be used for individual-level feedback among coach- and self-directed runners.” Before data collection, a web survey design tool was used
to develop specific mHSM applications for longitudinal data collection. Semi-structured interviews were used for collection of data before and after use of the prototype applications. The qualitative interview data were structured, interpreted, and categorized using a thematic analysis and are reported according to the COREQ criteria for reporting qualitative research based on interview data [17].

**Ethical Considerations**

In accordance with Swedish legislation, this study was subject to review by research ethics committees [18]. The project was planned and conducted in accordance with the ethical principles of the Declaration of Helsinki. Before inclusion in the study, oral and written information about the purpose of the study was provided and each participant gave their written informed consent. Participation in the study was voluntary. All study data were handled without breaching the integrity of individual athletes.

**Study Population**

The study population was defined to include adult runners (>18 years) competing at national level in middle or longer distances in elite or veteran categories. Purposive sampling was used to ensure variation in gender, age, and running events. For recruitment of participants, three running clubs in Sweden were contacted through their head coaches. After discussions with their runners, all clubs accepted at a group level to participate in the study. Individual invitations were then sent by email. According to the saturation principle, the recruitment of participants for individual interviews continued as long as new aspects appeared in the data.
**Figure 3.** Display from the web platform used to create and schedule weekly monitoring.

**mHSM Software**

The mHSM software used in this study was developed on a web platform ([https://www.briteback.com/en/solutions/research/](https://www.briteback.com/en/solutions/research/)) where web survey applications can be created and handled. For the present study, two surveys asking for health and training data were developed, adapted for track and marathon runners. Both surveys included questions about the runners’ training and if they had experienced health issues. The surveys distributed to the marathon runners were slightly more detailed regarding training load, and the surveys provided to track runners were more detailed regarding health issues. After survey items had been compiled for the monitoring events, the distribution of the events was sequenced in a monitoring plan (Figure 3), where the timing of repeated longitudinal monitoring was scheduled. The runners who did not complete the survey in 3 days received an automatic reminder by email with a new link to the survey. Automated system-generated statistics were provided for the researchers immediately after reporting of data.
**Data Collection**

The first set of semi-structured interviews were conducted by two authors (OL, SR) before the mHSM was initiated. An interview guide with open-ended questions that covered the main aspects of the TAM was used. The interviews lasted about 30 minutes and were audio recorded. The pre-use interviews investigated experience and knowledge of mHealth monitoring, followed by the runners’ thoughts on possible benefits and side effects. The post-use interviews asked for perceived usability and usefulness, attitudes toward non-functional issues, and intentions to adhere to longitudinal monitoring. In addition, the runners’ trustworthiness when using the system was questioned, and thoughts on improvements and what they would want to change to optimize the system for their training. After the interviews, the pre- and post-trial interviews were transcribed verbatim.

**Data Analysis**

A deductive thematic analysis [19] was performed using the TAM as the theoretical foundation (Table 1).

**Table 1.** The six-step method used for thematic analysis of the interview data [19].

<table>
<thead>
<tr>
<th>Thematic analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Familiarization with data</td>
</tr>
<tr>
<td>2. Initial code generation</td>
</tr>
<tr>
<td>3. Searching for themes</td>
</tr>
<tr>
<td>4. Reviewing themes</td>
</tr>
<tr>
<td>5. Naming themes and categorizing them according to the TAM</td>
</tr>
<tr>
<td>6. Producing report</td>
</tr>
</tbody>
</table>

To familiarize themselves with the data, the transcribed interviews were read through repeatedly by three authors (SR, OL, TT). With the study aims in mind, the most relevant parts of the data were identified, and key parts were extracted from the individual responses from which meaning units were identified regarding their content and context. The meaning units were interpreted at a semantic level rather than a latent level. Codes were produced consisting of keywords that captured the essence of the meaning units. The codes were used
to gain understanding and to compare meaning units. The coded meaning units were then
grouped into categories. After reviewing the categories and adjusting some of them, the
categories were grouped into themes named using a short sentence. These themes were
finally contextualized and classified according to the TAM in a process that included all
authors.

Results

Data were collected from 20 runners (9 males and 11 females) aged between 20 and
64 years (Table 2). Most runners reported previous monitoring experience, mainly use of
training diaries for communication with their coach. Also some self-directed runners without
a personal coach stated that they had practiced data collection during their training. The
coach-directed runners more often planned their training down to exact exercises, while the
self-directed runners scheduled their training in a less detailed way (e.g., a rough weekly plan
of the amount of training).

Table 2. Characteristics of participating runners.

<table>
<thead>
<tr>
<th></th>
<th>Sex</th>
<th>Age (years)</th>
<th>Event(s)</th>
<th>Coach-directed</th>
<th>Detailed schedule</th>
<th>Monitoring experience</th>
<th>mHSM experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Male</td>
<td>27</td>
<td>10–21 km</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Female</td>
<td>20</td>
<td>5–21 km</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>24</td>
<td>1500 m to 5 km</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>24</td>
<td>5–21 km</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>21</td>
<td>5 km</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Female</td>
<td>25</td>
<td>Middle distance</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>27</td>
<td>3–5 km, cross country</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Male</td>
<td>24</td>
<td>10–21 km</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>Female</td>
<td>34</td>
<td>5–10 km</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>Male</td>
<td>24</td>
<td>10–42 km</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>Female</td>
<td>55</td>
<td>Marathon</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>Male</td>
<td>57</td>
<td>Marathon</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
The runners’ previous mHSM experience was scarce. None of them had used more complex documentation and analysis tools than an mHealth training diary. A male runner’s description of his experiences was typical for the runners:

I have looked at some online tools, I may well say. Online coaches, those kind of automated, for instance. But it's nothing that I have followed regularly. It is mostly really training diaries that I have used.

During the mHSM trial period, 19 participants provided monitoring data every week; one runner failed to provide data for the final week because of technical issues (Table 3).

Most participants responded in the first couple of days for most of the weeks in the trial period. However, 15 of 20 runners received a first reminder (sent out 3 days after the initial weekly survey).

### Table 3. Overview of runners’ monitoring behaviors.

<table>
<thead>
<tr>
<th>Monitoring compliance</th>
<th>Response lag (days)</th>
<th>Reminders issued</th>
<th>Device used</th>
<th>Human-computer interface concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1–3</td>
<td>1</td>
<td>Phone</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>1–2</td>
<td>1</td>
<td>Phone</td>
<td>No</td>
</tr>
<tr>
<td>No</td>
<td>1–3</td>
<td>2</td>
<td>Computer</td>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
<td>1–2</td>
<td>0</td>
<td>Computer</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>1–2</td>
<td>0</td>
<td>Phone</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>1–2</td>
<td>1</td>
<td>Computer</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>1–2</td>
<td>1</td>
<td>Phone/tablet</td>
<td>Yes</td>
</tr>
<tr>
<td>Yes</td>
<td>1–4</td>
<td>3</td>
<td>Phone</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>1–3</td>
<td>1</td>
<td>Computer</td>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
<td>1–2</td>
<td>1</td>
<td>Computer</td>
<td>No</td>
</tr>
</tbody>
</table>
Problems with the human-computer interface for data entry.

Technical problems in the final week.

Predispositions and External Factors (P)

To be motivated for participation in mHSM, the runners explained that they needed to expect a positive balance between immediate burden and future reward. For example, one participant explained:

It depends on how much data I should report, that is, how many questions I have to answer. The more questions, the less keen I am to report.

Regarding rewards, the runners envisioned new services that could be provided through mHSM, such as ubiquitous availability of support to interpret trends and long-term planning of running schedules. One runner explained:
I would like to more easily be able to see trends and patterns over time. Such as ‘Oh, here I trained so and so, and then I got these results.’ It would provide a better overview of how I’ve trained and what it provides in terms of consequences, both regarding results but also injuries and other things.

Nonetheless, in contrast to the visions of new services and uses, concerns were expressed that the joy of running might disappear. One runner clarified:

Somehow, the more you record about your training and the keener you are on structure and control, the greater is the risk that the spontaneity and joy will diminish or disappear. I’m running and working out mainly because I think it is so nice and fun. Yes, in some way you can feel a little limited or controlled [by mHSM], and, if you take this too far, there is a risk that the feeling of freedom and joy of running disappears in part I think.

Another concern was that mHSM could introduce unnecessary stress:

Some people may become slaves under the system, and get anxious. ‘I was to have a 150 km week’ and then you find that you just reached 139 km and then you feel bad because of that.

Some runners expressed that new uses of their data should not be allowed without their permission, highlighting the “market value” of the data collected:

Well, if [the data] can be linked to me as a person, I think no one should have access to [my data] without my knowledge, but it will be okay with my consent. I would think of letting physicians and coaches and others use these data. However, not always, it should be based on my consent.

**Perceived Ease of Use (E)**

The mHSM applications were considered easy to use and understand, and most runners did not experience technical difficulties during the test period. They stated that use was easier and less demanding than expected. One of the runners expressed:

The survey itself was not as long as I had feared it would be. It went a lot faster than I expected, but that’s of course linked to my expectations. I experienced it as quick and easy to fill in.
The timing of survey distribution was found to be important when introducing mHSM in the runners’ everyday routines:

I replied probably almost right away. It was sent out just before I were going to sleep so then I did it before I went to bed.

However, although the monitoring items were understandable, they still could be perceived as problematic. For example, one runner said:

It is hard to know how to report some features. They are kind of subjective, for example, ‘How you do feel today?’

Moreover, there were perceptions that safe access to the Internet was unnecessarily complicated. One of the runners expressed:

Web developers [sigh]... They are going to complicate everything. The purely IT-related parts have to be both safe and easy. Best would be if you could log in via a social network or email, so you do not have 3 billion passwords everywhere.

**Perceived Usefulness (U)**

The runners emphasized that the items being monitored had to be formulated so that they were relevant to improving their running. A certain level of detail in the training data was needed to offer this usefulness, although the effort had to stay as low as possible.

Opinions varied on useful levels of sports load recording, but the runners agreed that the balance between information detail and the recording burden was important. One runner said:

The length of the survey was really good. Comprehensive, but not too extensive. It cannot be too long if you're going to fill it in frequently … Multiple choice questions, ratings, and such are good. It becomes fairly accurate and time efficient.

However, another runner stated:
I would probably want it more detailed; the survey was a little too brief for it to be really useful. But, more detail would be more demanding. However as long as you can feel motivation and purpose, there is no problem with more extent.

However, in some circumstances, there were differing opinions about what data to report (eg, recording training volume as running distance or time) and difficulties with interpretation of concepts (eg, whether subjective well-being should encompass daily living as a whole or only the running context). The runners also pointed out questions and functions that were not included in the monitoring. For example, one runner asked for more open reporting formats:

The survey questions were very specific. Yes, running is what it was about, so that was no problem [to report]. But then using skiing and swimming as alternative forms of exercise [were also asked for]. There may well be many other relevant alternative forms of exercise that runners use.

Another runner explained that:

I think you could record flexibility training as well. Runners are so inflexible, so then perhaps it’s relevant how much they flexibility training they do.

**Attitudes Toward Using (A)**

Regarding access to the data, researchers and individuals directly supporting the runners were generally tolerated. However, attitudes associated with access privileges differed between training and health data; data on personal health and mental well-being were considered more sensitive. One runner explained:

I thought about the questions regarding personal health, which are quite private. I had that in mind when I answered the surveys. A running diary can be really personal. Then I found that integrity is very important. Everybody may not want to show how they train or how they feel.
However, the perceptions of integrity breaches were contextual and relatively specific.

Another runner explained:

It would be [sensitive for runners] if anything about mental health aspects was included, but it was not. There were questions only about general well-being and nothing about ‘Have you visited a psychologist?’ No, it would only be [sensitive] if deeper issues such as performance anxiety and depression were asked about. But such questions were not included.

A few of the runners said that if the information was made anonymous, access could be completely open.

Regarding access to training data access, there were notable differences between different groups of runners. A typical standpoint among the runners was expressed by a veteran marathon runner, who summarized his views after having used the mHSM system:

I feel that it does not matter if anyone knows that I’ve gone to the gym 2 days a week for 5 weeks, which I actually did, and ran 20 km one week and 100 km next week. I do not think that would be an invasion of privacy for me.

The runners also stated that, in the main, they were truthful when providing data, as is shown in the following examples:

I tried to be very honest, there’s no reason to lie, it’s not a competition that way.

Since I keep a paper backup [for myself] as well, I know that [the data I provide] are honest [and accurate].

However, the most competitive runners wanted to control their training data in detail. One of these runners stated:
I would not like it to influence selection to competitions and national teams. There should not be any reason not to be honest in your training diary or such. But all in your personal team should have access, if relevant. Otherwise I prefer it not spread.

Another competitive runner said:

No, I believe that selections and so on should be based on performance and other ways [than monitoring]. It is difficult, I think to associate competition results with this type of statistics and data. No, no I do not think it would be reasonable.

A third runner added:

How I have carried out my training and what I have done should not be a concern of the selection committee.

**Behavioral Intention to Use (BI)**

The runners were willing to use mHSM for extended periods of time provided that the monitoring was adjusted to their personal setting and answered to their needs. Reporting on a weekly basis was preferred. One runner explained:

At least once a week. Otherwise, you start to forget. Above all, you forget how it felt. It would be most favorable to report each session but then it can be difficult to get it done.

The technology was regarded as potentially beneficial for their personal development as runners, eg, for performance improvement through injury prevention. Even so, the runners highlighted the balance between cost and benefit:

If you think it is meaningful, it is time well invested considering what you can get out of it, as long as the system is easy to use.

The perfect balance between usefulness and burden was not the same for different categories of runners. However, the prevailing opinion regarding reporting periodicity was that weekly
responses were sufficient, combined with receiving reminders. In the main, the runners found that acceptable reporting habits could be achieved.

There were modest concerns about general privacy issues that hypothetically could influence use. Questions about anxiety, distress, and health status were considered more sensitive and were associated with a higher demand for confidential treatment. However, the dominant concerns about integrity were related to team selection. The most competitive runners requested detailed control over who in the sports organizations they belonged to, from clubs to federations, should be allowed access to their training data. Nonetheless, using their data for research purposes would not be a problem for them.

Discussion

Reviewing the results of this qualitative study in light of the TAM, we interpret that achieving acceptance of long-term mHSM among competitive runners requires clear definitions of the purpose and population, meticulousness regarding data-sharing routines, and extensive in-practice tests of items to be monitored and terminology.

Usefulness of mHSM

We found that the competitive runners needed to see a positive balance between immediate burden and future reward to be motivated for mHSM. Among self-directed runners, the burden of analyzing the data and using the results for own health maintenance and performance improvement may be overwhelming. However, these athletes also need to gain a positive balance from a monitoring process to be sufficiently motivated to record data [20]. Consequently, being able to effortlessly generate interesting output from mHSM data analyses, such as graphical displays of performance and health trends, is particularly important for self-directed athletes. In comparison, for coach-supported runners, the burden
of supplying mHSM data is more likely to be balanced by factors such as improved coordination of training management [21]. The perceptions of the members of the support team, in particular the coach, are therefore important to consider when assessing the usefulness of mHSM for this category of runners. The accuracy of the self-reported data is a related concern. Although the runners generally stated that they supplied accurate data, some athletes indicated that they occasionally guessed or made estimations. Acquiescent responding, or indiscriminate agreement irrespective of survey content [7,22], may thus affect the quality of mHSM data among runners. In addition, conscious bias may occur. For instance, coach-supported athletes may report favorable data and under-report unfavorable data to gain selection, ie, ‘faking good’ [23]. However, the validity of objective recording of physical load, such as accelerometer data, has recently been questioned [24], and self-reporting has been shown to be the favored monitoring method regarding well-being and health influencing athletes’ performance [21,25]. This study did not analyze the validity of the reported training load data or of the well-being and health data. The quality of self-reported data for these parameters should be further assessed among both self- and coach-directed athletes.

**Usability Issues**

The finding that mHSM usability was associated with the structure of the survey items can be compared to experiences from electronic data collection on pre-participation health in association with athletics championships [26] and mHSM among Paralympic athletes [27]. In both these contexts, the athletes encountered few usability problems, but expressed concerns about medical terminology and formulation of the survey items. In sports settings where standardized questionnaires have been used for data collection from athletes, differences have been observed regarding the ability to interpret concepts and respond as intended [28]. We infer that adequate adaption of monitoring items with regard to the
characteristics and heterogeneity of the monitored population is key to be able to attain meaningful and useful data from long-term mHSM. However, before addressing the items, decisions need to be made on what proportions of standardized questionnaires, specific variables of interest, and pragmatic measures should be included in the monitoring. We therefore recommend that, when developing an mHSM tool for long-term use, sufficient time and effort is allocated to define the specific purposes and goals of the data collection, whether the data are to be used by self-directed or coach-directed runners, and the individuals and groups that will have access to the data. Thereafter, instruments need to be chosen or customized monitoring items formulated such that the intended users understand and are motivated to use them. The runners in this study were not directly (hands on) involved in the creation of the mHSM items. We agree with the recommendations from a recent Dutch study that providing athletes with a tangible take-away benefit from mHSM is essential [29], but add that inclusion of runners early in the design process of the application is strongly desirable. Before wide dissemination of an mHSM application for long-term use, several test periods when intended users try out both the technical system and the monitoring items should be completed. At the end of each period, experiences should be collected and the application design updated. Availability of a flexible software environment where survey items can be changed easily during pilot trial processes is a necessity.

**Non-functional Issues**

The finding that the most competitive runners were concerned about access to their data can be compared with a recent study [8] reporting that coach-supported athletes were no more concerned than self-directed athletes about data being secure and not misused. This lack of concern among coach-supported athletes was interpreted to reflect either a lower subjective importance of data sharing compared with the other factors or a particularly positive social environment in the study setting. However, other studies among coach-
Supported athletes have reported concerns about athletes reporting their injury data to coaches [23]. In individual sports such as middle- and long-distance running, athlete selection for major competitions and teams usually takes place above the personal coaching level. The critical circumstance influencing attitudes toward data sharing in this setting thus appears to be athlete ranking and selection, and not the coaching relationship per se. From these observations, we infer that ethical issues associated with mHSM among competitive runners cannot be evaluated without first defining the exact purpose of the monitoring and describing the individuals and groups that will have access to the data. We therefore suggest that future studies of mHSM usefulness are performed in routine sports practice settings. This implies that non-functional ethical and legal issues also need to be included in evaluations and that their solutions are allowed to influence the results.

**Future mHSM Applications**

Pre-intervention, the participating runners reported having routinely recorded and analyzed training load data, but had almost no mHSM experience. Accordingly, several novel uses of mHSM technology were suggested after the trial period. Alternative ways of using mHSM than those addressed in this study have been reported in the scientific literature. For instance, rather than using mHSM data for self-direction or traditional coaching support, the data analysis can be performed cooperatively in peer-to-peer learning processes. For professional runners, their sport is a job of work. By including mHSM data in structured peer-to-peer communication, self-employed runners can share information about training performed as well as planned training programs, competition calendars, and competition venues. Groups of runners can thereby establish a contextualized learning process based on co-operative discovery. Web technology and devices are then used as facilitators and mHSM data as reference for learning by comparison. Evaluations have highlighted that professional runners find discussions and sharing of experiences with peers in chat forums stimulating
Self-esteem and self-reliance were found to improve as a consequence of receiving feedback, analyzing that feedback, and using the results to make adjustments to increase performance. Peer-to-peer communication supported by mHSM can thus predispose toward a learning process where runners access education at low cost and are simultaneously empowered through integration into a wider community of sporting peers [31]. Sharing of training and health data thereby becomes the basis for a highly contextualized performance enhancement program.

**Strengths and Limitations**

This study has strengths and weaknesses that need to be taken into consideration when interpreting the results. A strength is that the study used a pre-post design, which allowed analysis of attitude stability over time. An important limitation is that the mHSM system used in the trial only covered the initial mHSM phases (to record and review data) [32]. Inclusion of the remaining aspects (to contextualize and act) would have required involvement of coaches and other staff supporting the runners. In addition, such an extended evaluation should be performed using more recent versions of TAM that include aspects such as costs, maintenance, integrity, and privacy [33,34]. Another weakness is that in this study, as in many other qualitative studies, the study group was relatively small (n=20). Nonetheless, recruitment of participants continued until saturation of the data was reached. Also, every runner category has unique features and needs. Therefore, extrapolating experiences of using mHSM from one category of runners to other running contexts should be done with caution. This study addressed usability and issues that might occur when attempting to create an mHSM application for long-term surveillance of competitive middle- and long-distance runners, and the results do not provide complete information for the design of such a system for other runner categories. However, it still highlights important aspects that should be considered when designing mHSM tools in other areas of sports epidemiology.
Conclusions

Achieving adherence to long-term mHSM among competitive runners requires clear definitions of purpose and population, extensive in-practice tests of survey items and terminology, and meticulousness regarding data-sharing routines. We suggest further naturalistic studies of mHSM should be performed in routine sports practice settings. This implies that non-functional ethical and legal issues need to be included in the evaluation designs and that the solutions to these challenges are allowed to influence the results.

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