A Self-Management Tool for Runners with Asthma

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Asthma in Exercise: Background

General Implications:

An overwhelming majority of the asthmatic population deals with exercise-induced asthma, which creates a barrier for those individuals to engage with healthy, enjoyable, and consistent forms of physical activity. However, physical health is something that all human beings deserve access to, and therefore, this is a problem that needs to be addressed.

More than 80% of asthmatic patients develop exercise-induced asthma (EIA)

Gong (1992)

Poorly controlled asthma can affect airway health, as well as performance and training outcomes

Hostrup et al. (2024)

Since it may cause limitations to daily life activities in up to 30% of patients, mastering EIA is important in asthma management

Carlsen & Carlsen (2002)

Variability and Unpredictable Nature:

There are numerous triggers and types of reactions that affect individuals, and also different medications types and doses that they utilize. This reiterates the need for well-designed symptom management that can replace the typical ‘one-size-fits-all’ solutions in healthcare for chronic conditions.

Asthma attacked caused by exertion are indistinguishable from those caused by other stimuli.

Kaptchuk et al. (1995)

With irritable airways, all forms of exercise cause problems; fluctuations in temperature and humidity perpetuate this. Temperatures, elevations, etc. impact different people differently

Kaptchuk et al., (1995)

Wide Range of Triggers: dust | exercise | weather changes | grass or weeds | cold air | air conditioning | work environment

Gautier & Charpin (2017)

Self-Management Tools: Background

Systematic Review Findings

Huckvale et al. (2012) conducted a systematic review of current symptom management tools for individuals with asthma, and found critical limitations in these resources. These spanned from inaccuracies to a lack in important tracking features to cater to all individuals. Additionally, several other studies in this sector have found that existing tools do not take advantage of personalization and similar HCI principles when creating health tracking technologies for those with asthma: instead, they take a more universal approach to problem solving, which does not accommodate the variability and unpredictable nature of asthma described earlier.

- Symptom diaries lack basic features, such as data entry validation
- Calculators are unreliable with several numeric errors
- No current app meeds the needs of every patient

Huckvale et al. (2012)

Asthma attack predictive models become more significant when using both patient's biosignal and environmental factors. The majority of studies use one or the other.

Alharbi et al. (2021)

Personalized self mangement programs have several advantages; current tailoring stops short of providing each patient a comprehensive asthma self-management program suited to their needs

Kotses et al. (1996)

Key Insights: Gaps and Motivation

1. Exercise-induced asthma has **severely negative implications** for asthmatic patients who wish to remain physically active and healthy.
   - It can **deter attempts at exercise**, particularly endurance and cardiovascular activity that requires higher aerobic capacity, but can also **cause severe and dangerous asthma attacks**.
   - However, **if managed properly, it will become less of an obstacle** and allow individuals to partake in healthy levels of physical activity.

2. Exercise-induced asthma is **unpredictable and highly dependent** on each individual patient: there are a multitude of triggers and additional stimuli to account for.
   - Furthermore, **medication requirements, use, and response will vary greatly** for individuals.
   - Therefore, **management will not look the same** for each patient: clinicians and resources need to be catered to each individual and their unique experiences, needs, and triggers.

3. Current **tools lack efficacy in personalization and features** that cater to the nuances in asthma symptoms and experiences across patients

User Requirements

Target Audience

- Previous studies have been conducted with participants aged **18 to 55 with varying backgrounds** in running
  - (Freeman et al., 1990)
- Existing research also highlights the **diverse needs within the asthmatic community**, as triggers vary widely—ranging from allergic and environmental factors to exercise-induced asthma. This suggests that a self-management tool **should not be limited to exercise-induced asthma** alone.
  - (Gautier & Charpin, 2017)
- Based on these insights, the **target audience will reach patients with any asthma type and severity, or running experience.** The tool will be **customizable** to accommodate unique needs of each user. This will benefit anyone within the asthmatic athlete community, helping them better manage their asthma and improve their ability to run.

Gaps & Needs

Currently, the two critical gaps in technology is self-management of triggers and personalized experiences

- **Management:** Exercise-induced asthma (EIA) can be effectively managed through proper treatment, education, and self-management tools. However, many patients rely solely on physicians for education, leaving a gap for a technological solution that offers data-driven insights. Personal informatics are already widely used by athletes, and integrating them into asthma management could provide significant benefits.
- **Personalization:** customized recommendations and data-driven insights is a critical need and will become a central feature of this tool
  - Accounting for different triggers and severity levels, the tool can provide tailored recommendations—such as when to run, when to rest, or when to adjust pace—helping asthmatic runners better manage their condition and symptoms while maintaining an active lifestyle.

Design Requirements

Purpose

The purpose of the system is to provide asthma sufferers who partake in running regularly with **real-time and predictive management techniques.** The system will leverage data that such users already collect (personal informatics data and asthma symptom or medication data), to reduce the cognitive load required from manual tracking. The system will combine **wearable technology** (such as a fitness watch) with a **mobile/web dashboard** to monitor asthma symptoms, understand how it impacts users' running and exercise, and offer recommendations for safe and effective training. Overall, this tool will provide management methods for users and simultaneously optimize their physical health and running performance.

Functional Requirements

Dashboard

- **Pre-run recommendations**: using the asthma forecast and previous running data to provide recommendations on training and medication.
- **Post-run analytics** with metrics and visualizations to help understand when flare-ups occur, what caused it, and what helped them mitigate.
- **Actionable recommendations and predicted metrics** (e.g. inhaler usage change overtime) to improve future runs and self-management.
- Manual data logging to reduce errors or inaccuracies from real-time data collection

Wearable

- **Real-time monitoring** of breathing rate during run to predict and warn of potential asthma attack, coupled with recommendations on how to alleviate it (e.g. slowing pace down or using inhaler)
- **Real-time data logging**: user will have the ability to log inhaler use on their run by clicking a button on the watch. This will be timestamped and incorporated into the web dashboard analytics

Both

- Asthma **risk prediction**: using environmental factors (allergens, air quality, temperature) and bio-signals
- **Personalized** to the user's unique asthma experience through data collection and input
- Smooth integration between the watch and web dashboard

Persona Development

Persona and Scenario #1

Maya

Age: 21
Location: Utah
Occupation: Student
Activity Level: Recreational

DESCRIPTION

Maya is a 21-year-old female and recreational runner with exercise-induced asthma. She resides in Utah, where there are frequent seasonal and weather changes. Her asthma is triggered when she does any form of cardio.With running as a hobby, she wants to find a way to manage her symptoms to enjoy her runs.

SYMPTOM MANAGEMENT

- Daily inhaler
- Rescue inhaler
- Has tried using an iPhone diary app to track medication and symptoms as well as a custom self-made Excel spreadsheet

GOALS

- Enjoy running as a hobby with fewer asthma flare-ups
- Gather insight into asthma symptom and trigger patterns

PAIN POINTS

- Has attempted using an iPhone diary app to track her symptoms but was unable to draw useful insights, and felt restricted to the limited data logging options
- Carries her rescue inhaler on every run and often stops runs short due to flare-ups

NEEDS

- Predictions of 'good' vs 'bad' running days based on daily symptoms
- Adaptive workout suggestions based on symptoms or recommendations on when to carry an inhaler

Maya wants to run a faster 5k time this year and decides to do an interval workout at the park. She starts a dynamic warm-up, but **after a few minutes of jogging, she feels tightness in her chest**.

She checks her smartwatch, which alerts her that **her breathing rate/pace has increased significantly faster than usual,** which is an early **sign of an impending asthma attack**. Her watch suggests that she slows down on her warm-up and increases her intensity more gradually, with a follow-up reminder that on similar days, using her rescue inhaler before exercise reduced her symptoms. She follows the suggestion and continues her intervals at a modified pace. Halfway through, **Maya's watch detected another spike in breathing strain and sends a short vibration to prompt her to take a longer recovery break** before the next interval.

She realized that without these real-time insights, she would've assumed that her breathing was only attributed to the intervals pace, not her asthma. **Had she not listened and modified her workout, she would've had an asthma attack, forcing her to stop entirely**. After her workout is complete, Maya logs her symptoms on her desktop computer, noting that adjusting her warm-up and pacing helped her complete the session without any major issues.

Reviewing her training trends, her dashboard points out that short warm-ups in colder air trigger her symptoms much faster, which she will remember for her next workout.

Persona Development

Persona and Scenario #2

Carson

Age: 27
Location: Massachusetts
Occupation: Athlete
Activity Level: Professional

DESCRIPTION

Carson is a 27-year-old professional post-collegiate track and cross country athlete. He has allergic and seasonal asthma, leading to symptoms all-year-round and severe flare-ups in the Winter and due to allergens (pollen and mold). He regularly trains in high-intensity environments, racing both indoors and outdoors.

SYMPTOM MANAGEMENT

- Daily inhaler
- Rescue inhaler
- Works with a physician during training and races to navigate flare-ups in real-time

GOALS

- Perform competitively without negative impacts from asthma symptoms and flare-ups
- Predict asthma attacks before starting a workout or race to mitigate the situation before it occurs

PAIN POINTS

- Flare-ups negatively impact his performance despite working with a coach and physician
- Races both indoors and outdoors, and cannot predict allergens such as mold indoors or pollen levels outdoors

NEEDS

- Real-time breathing feedback during training to navigate worsening symptoms
- Personalized predictions of asthma attacks based on real-time training symptoms
- Better understanding of what triggers cause the worst reactions

Carson is in peak training season for his upcoming race, but his **seasonal asthma has been unpredictable**. When he wakes up, he checks his wearable's daily asthma risk forecast. It **warns of high pollen counts and dry air, both of which have triggered breathing issues for him in the past**.
He debates whether to train indoors or outdoors and checks the personalized workout suggestion on his app. **Based on his past symptom history, the app recommends: (1) an indoor treadmill session to minimize pollen exposure and (2) if running outdoors, a pre-run inhaler dose** and to bring a rescue inhaler on the run. Wanting to simulate race conditions, his coach tells Carson to run outdoors but follows the recommended precautions.

Before leaving for his run, Carson decides to plan his route to avoid pollen exposure as much as possible. He checks the heat map on his dashboard and sees that one park near his house has extremely high pollen levels and has triggered his asthma in the past. He plans his route to avoid that park.

Midway through his run, **his smartwatch detects an increase in his respiratory rate and senses wheezing beyond his normal training pattern**. His watch vibrates and prompts him to slow down for two minutes to recover. By following the guidance, **he avoids a full asthma attack and finishes his workout strong.**

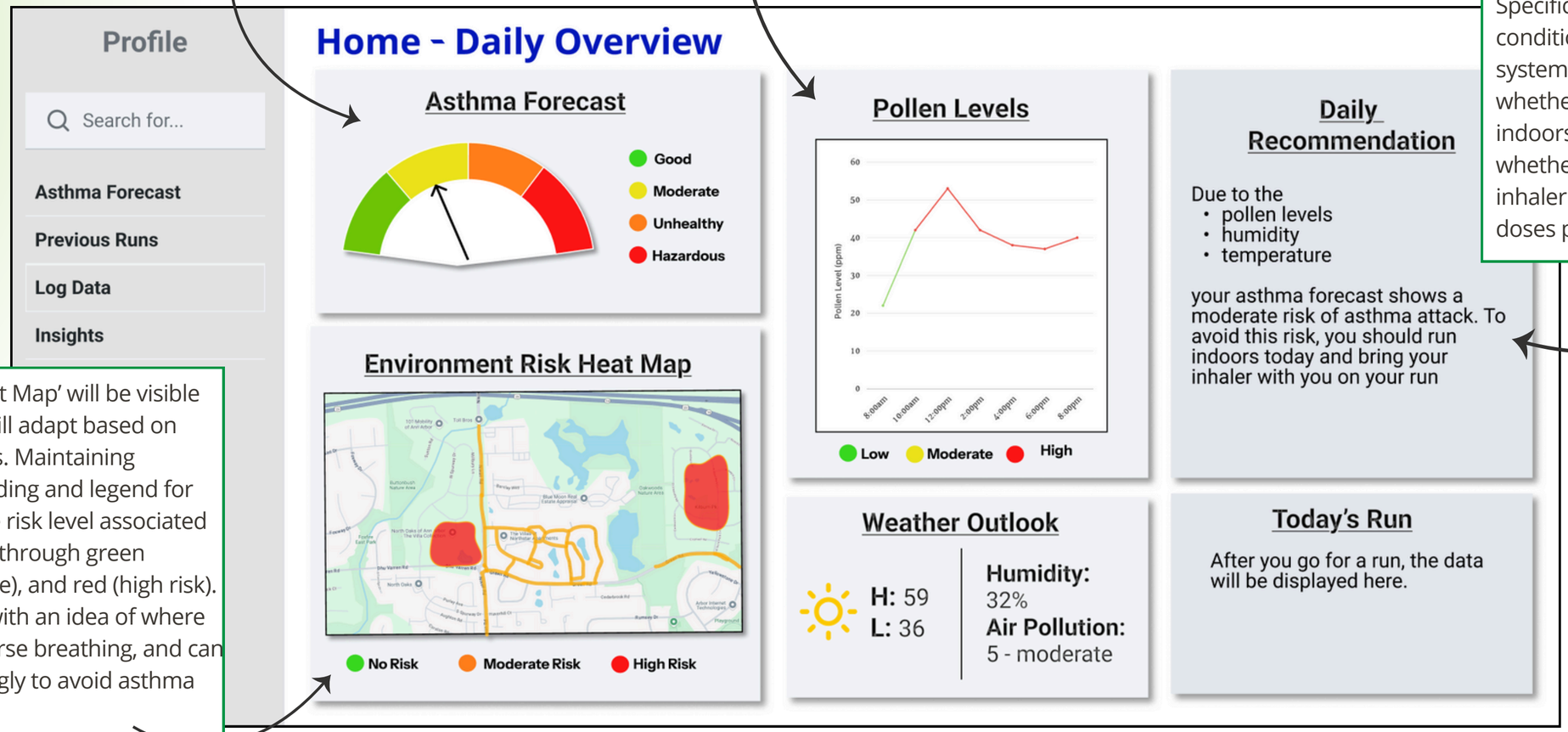
Later, reviewing his post-run analytics with his physio, Carson sees how environmental factors impacted his breathing efficiency. He notes that his wearable helped him adjust in real-time to make a better decision about when and where to train.

Prototype - web dashboard ‘home’

This interface is the **‘Home’ page** of the web dashboard. It is highly personalized to each individual, with visualizations charting information about their particular triggers and geographic location. For example, this user (due to historical responses to pollen levels, humidity, and air quality) has an asthma forecast of ‘Moderate’, whereas another user may have ‘Good’ if pollen is not a common trigger for them.

The next chart shows the top trigger for this individual (pollen) and how it will change throughout the day, giving them idea of what time of day is best to run outdoors. For another user, this may show a different allergen such as dust mites or smoke levels in the air.

The daily recommendation box will provide the user with a written summary given the key points from these visualizations, that will inform the user of how they should plan to run this day. Specifically, given environmental conditions and bio-signals, the system will recommend whether the user should run indoors or outdoors, and whether they should carry their inhaler or take precautionary doses prior to running.



The ‘Environment Risk Heat Map’ will be visible on all user’s profiles, but will adapt based on their typical running routes. Maintaining consistency in the color coding and legend for previous visualizations, the risk level associated with each area is reflected through green (healthy), orange (moderate), and red (high risk). This will provide the user with an idea of where they will have better or worse breathing, and can adjust their route accordingly to avoid asthma flare-ups

Prototype - web dashboard ‘analytics’

This page provides historical and predictive analytics to help the user understand their progress and any changes in their self-management. For example, the first chart on this page shows the users’ breathing rates on previous runs, along with when they used an inhaler on that run. They are able to navigate to different runs on different dates using the button below the chart. This can provide critical insight as to if and how using the inhaler helped relieve their symptoms

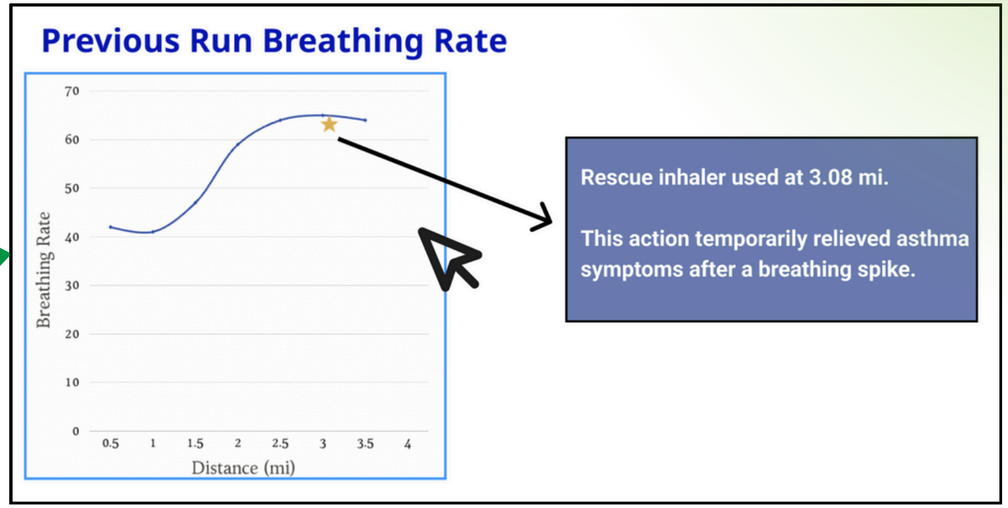
This chart shows the predicted average weekly inhaler use by upcoming months, based on historical trends of that particular user. This will look different for each user, as they will react differently to seasonal changes based on their asthma condition and geographic location. The chart can be toggled by ‘Existing’ to show data from the months of the year that have already passed (in blue) and ‘Predicted’ to show the upcoming months, giving the user the ability to plan ahead for more problematic months.

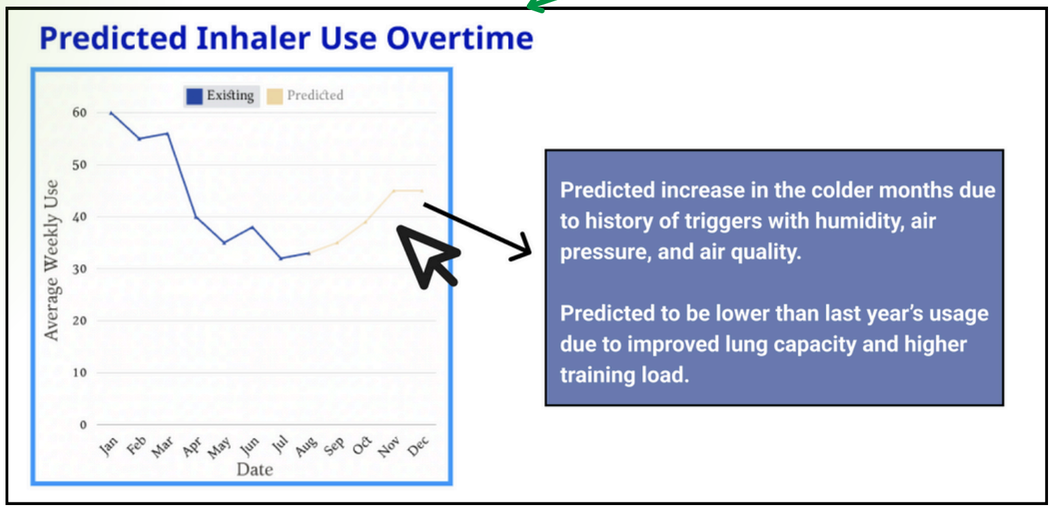
Similarly, this chart represents the average breathing rate experienced by the user in each season–this is particularly helpful for those who experience allergic asthma flare-ups, so they can see if they are on track (within target range), and what months they require more effort in management (for this athlete, Winter and Summer).

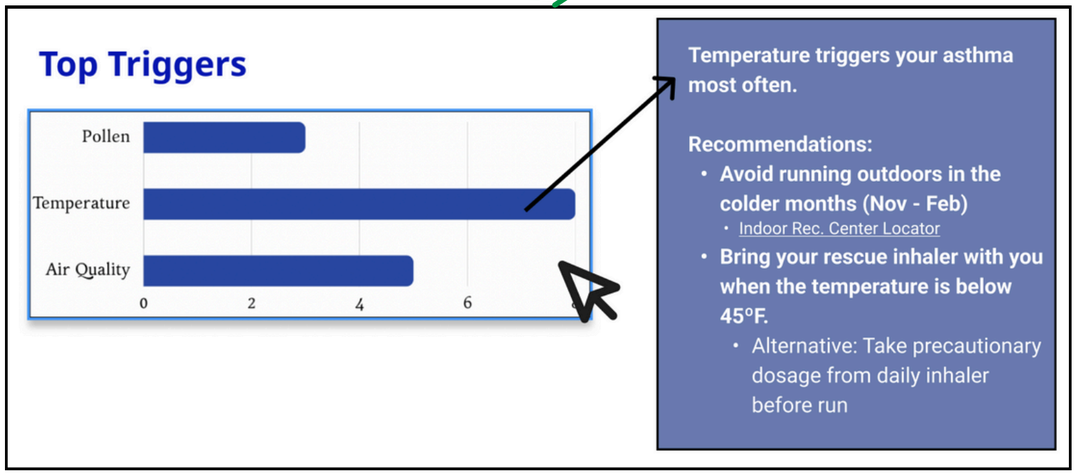
The top triggers chart will be tailored to each individual as well - the system will keep track of environmental conditions and bio-signals that are highest when the user’s breathing rate is most high or troubled during runs to create this chart. It can provide important information on what to avoid and look out for to mitigate and avoid flare-ups

The “Smart Training Suggestions” are similar to the ‘Daily Recommendations” from the Home page, but are more tailored to long-term management. This will include patterns from the user’s history, such as these examples (“warm up for at least 10 minutes”, “hills exacerbate your symptoms”, “it may be time to check in with your doctor”, etc.)

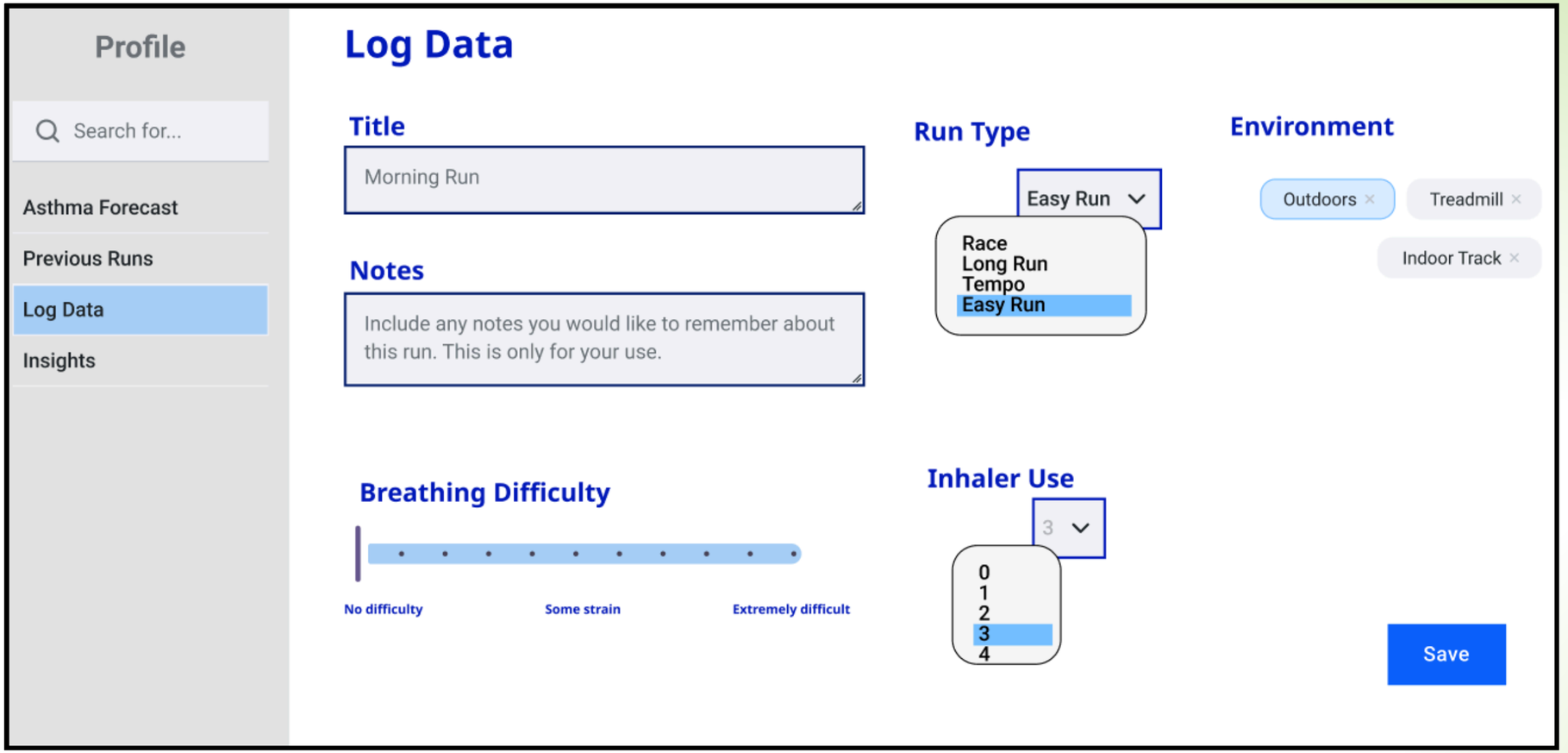
Aside from the visualizations, to keep the dashboard accessible to users with all technical backgrounds, if the user hovers over a visualizations with their mouse, an informative pop-up will be displayed. This will provide context and a description of the visualization and its implications. This helps with error prevention and avoiding misinterpretations from the data. It may also ease any feeling of information overload users with less experience with personal informatics or self-management may have.







Prototype – web dashboard manual data entry



Users can manually log or edit exercise data collected by the wearable device in the dashboard ‘Log Data’ page.

This accommodates the product requirement of mitigating mitigates incomplete or inaccurate data collection (Huckvale et al., 2012) from the wearable device.

Design and motivation inspired by Strava (https://support.strava.com/hc/en-us/articles/216919557-Strava-Run-Types)

Prototype - watch interface

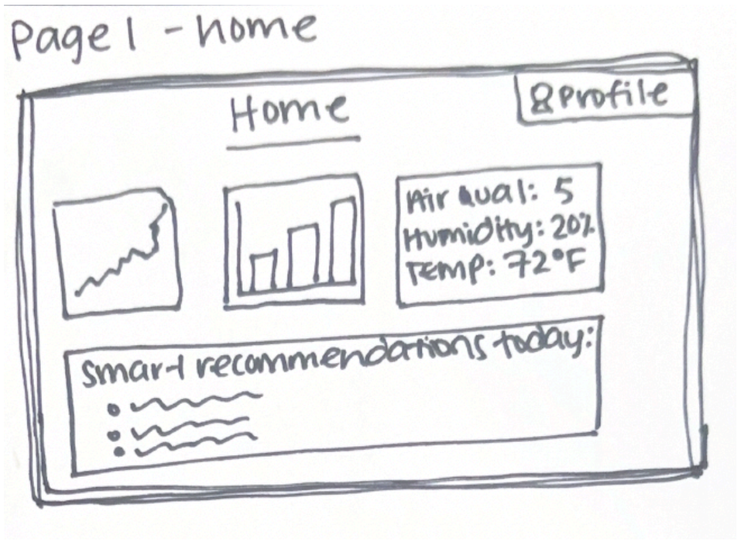
Monitoring of breathing rate & recommendations based on breathing rate level to avoid flare-up (e.g. slowing down or using inhaler)

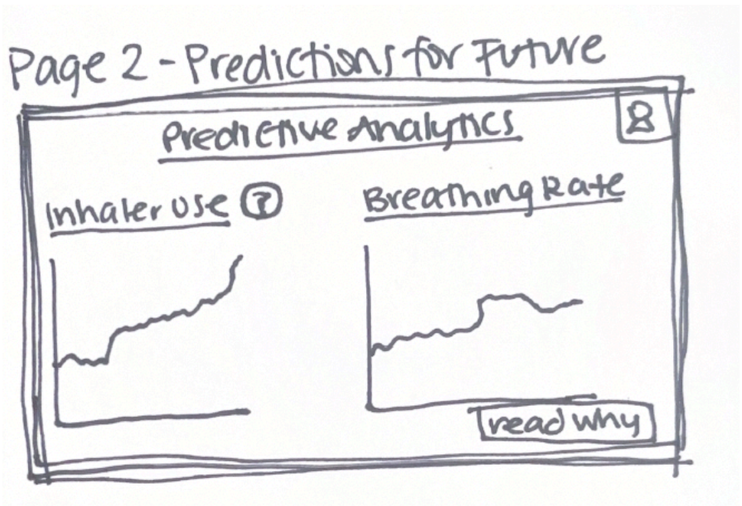
Can log inhaler use during run --> this will feed into the dashboard data later to provide insights on inhaler use

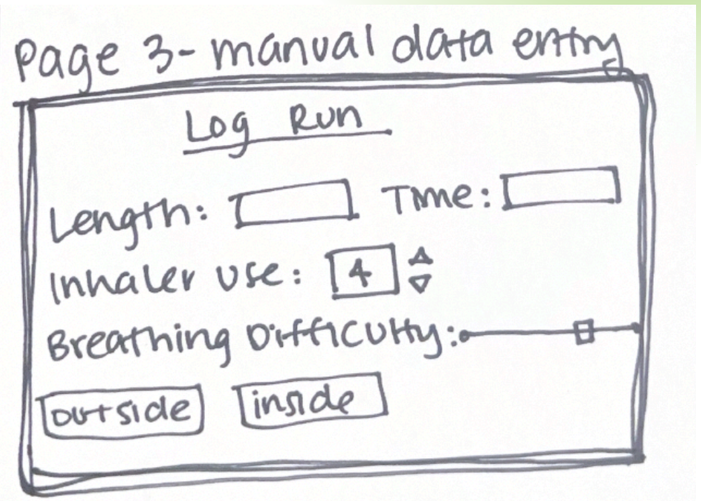
The interface during a run (without any warnings) uses color to differentiate between healthy, mild, and high breathing rates so the athlete is aware of their symptoms

Appendix

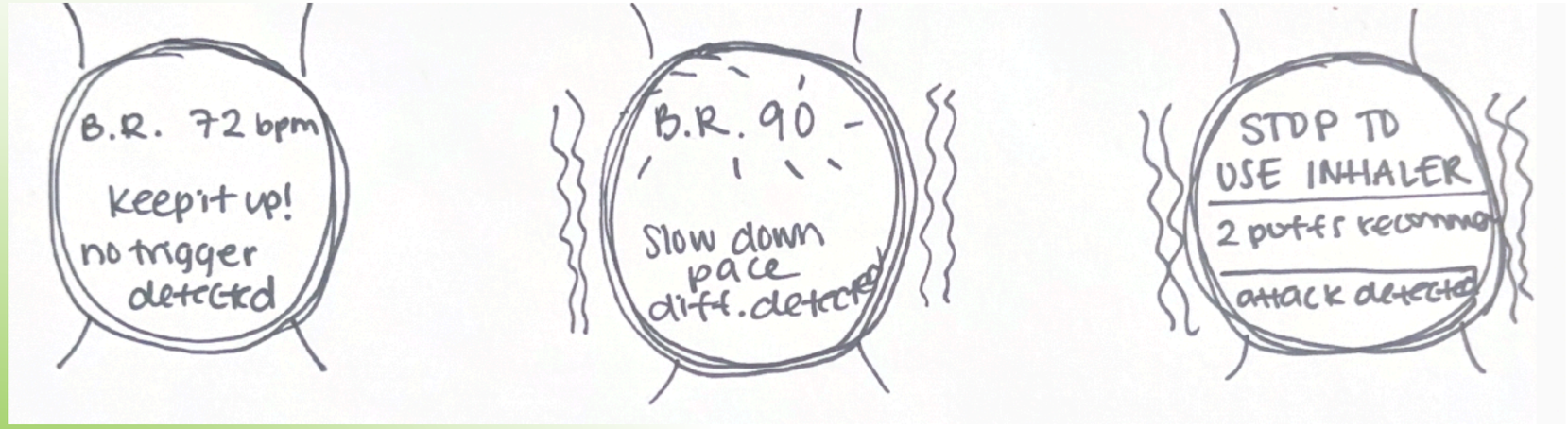
A1: Dashboard Sketches

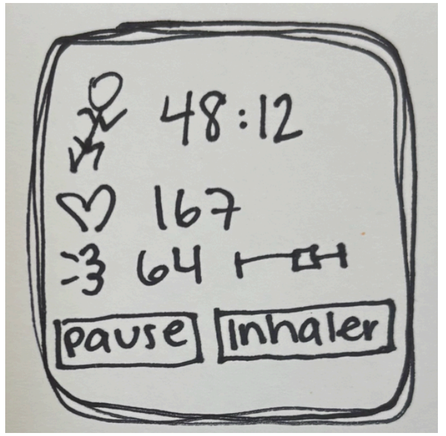






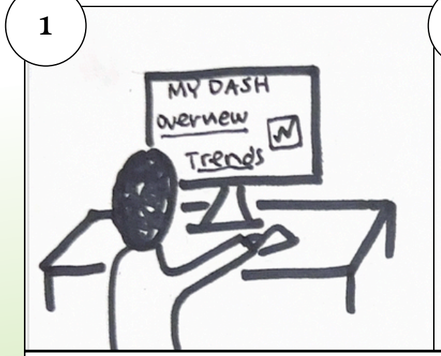
A2: Watch Interface Sketches





Storyboard #1

1

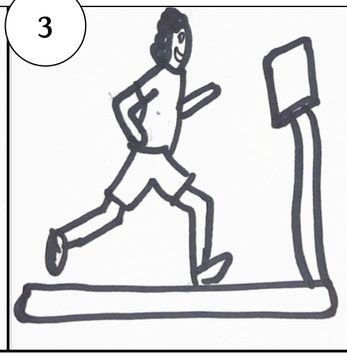


Carson's coach scheduled a long tempo workout today. Carson checks his dashboard to know what to expect from his asthma during the day. He sees that the pollen levels are high and that the last time the pollen levels were high, it led to him stopping his outdoor run and finishing it in the indoor track.

2

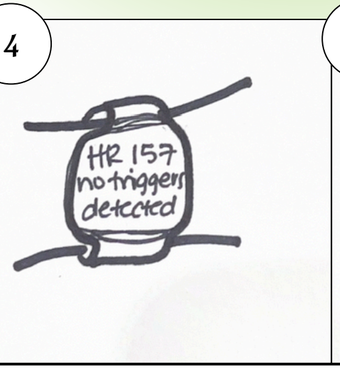
The dashboard gives him a recommendation to run on the treadmill today and to bring his inhaler just in case.

3



Carson decides to run on the treadmill and feels great. He finishes the tempo workout without any breaks or flare-ups.

4



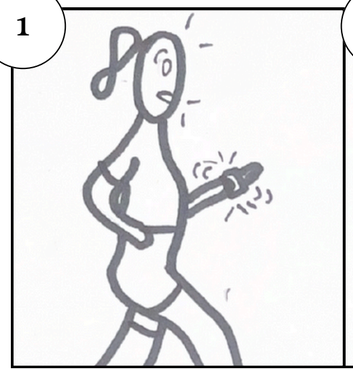
His watch gives him feedback about his breathing and heart rate during the run, which are positive, so he continues without using his inhaler.

5

Once his workout is complete, Carson is ecstatic. If he had done this workout outside like he planned, he likely would've had to stop or take breaks, making it a less efficient speed workout. He knows how useful his dashboard was and makes sure to listen to its recommendations more.

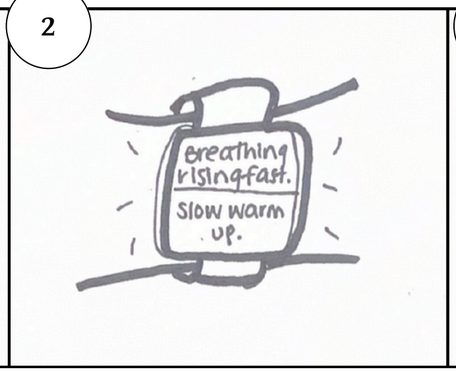
Storyboard #2

1



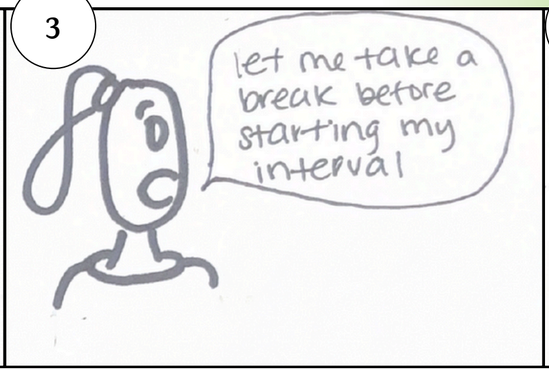
Maya starts a slow warm-up to prepare for her interval workout. These faster sprints usually trigger her asthma, so she proceeds carefully and brought her inhaler like her dashboard recommended.

2



Her watch vibrates and alerts her that her breathing rate is already faster than usual, indicating her asthma may be flaring up.

3

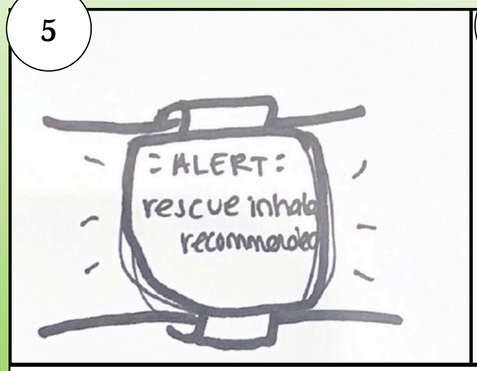


Maya follows her device's recommendation to slow down to prepare before starting her sprints.

4

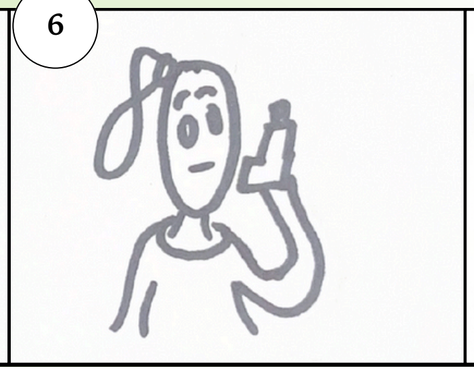
She starts her first interval and struggles to regulate her short breaths.

5



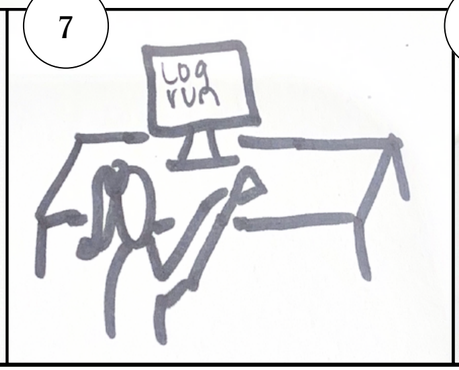
Her watch vibrates to alert her of a potential asthma attack and recommends taking a dose from her rescue inhaler.

6



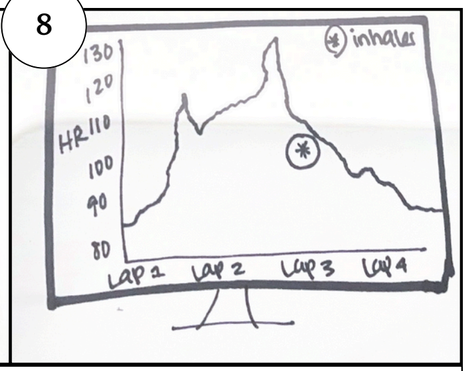
She listens to the recommendation and begins to feel better.

7



After she completes the rest of her intervals at a modified pace, she logs the asthma symptoms she experienced into her dashboard so her watch can continue to give her helpful suggestions during her runs.

8



Later, she can check her dashboard to see how using her inhaler helped her recover and continue her workout. She can use this information for future similar workouts.