CAN DESIGN HELP MITIGATE RUNNING RELATED INJURIES?

Bhreigh Gillis, April 2019

"CAN DESIGN HELP MITIGATE RUNNING-RELATED INJURIES?"

by

Bhreigh Gillis

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ABSTRACT

Long-distance recreational running is a popular form of exercise enjoyed by many people across Canada. With a plethora of well-understood physical and mental health benefits, it is no surprise that running is so popular. These benefits, coupled with a low barrier to participation, makes running an attractive form of exercise for many.

While running may be a healthy way to stay active, many runners will inevitably sustain a running-related injury. While studies show varying degrees of injury prevalence, many indications point about 65%. These injuries often prevent people from running, which can have an impact on an individual's physical and mental health. Running is known to help prevent lifestyle-related diseases such as cardiovascular disease, diabetes, and certain forms of cancer. Thus, keeping individuals running carries health benefits to the athlete but it may also carry immense socioeconomic benefits by reducing the burden on the Canadian healthcare system.

The current research aims to review the current state of knowledge as it pertains to the physical and mental health benefits associated with running, running-related technologies, and running-related injuries. Primary research was conducted in order to understand perceptions of and attitudes toward running injuries. The insights derived from the secondary and primary research initiatives were synthesized to yield 3 injury-prevention principles designed to mitigate running related injuries through the use of technology.

ACKNOWLEDGEMENTS

I am incredibly fortunate for the support and guidance I received from many people, including my partner Robert, my advisors Helen and Mike, my Adaptive Running coaches Larry and Stan, and of course Jane for saving me from my sports-related injuries over and over and over again.

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DEFINITIONS

Aerobic: Of, relating to, or being an activity which increases the body's demand for oxygen thereby resulting in a marked temporary increase in respiration and heart rate.[1]

Anaerobic: Of, relating to, or being active in which the body incurs an oxygen debt.[2]

Cross Training: Exercise or sport that is in addition to the primary activity. For the purposes of this research, the primary activity is running.[3]

Elite Runner: Defined by Athletics Canada as a woman who can run a marathon in at least 2h30m, or a man who can run a marathon in 2h10m.[4] Elite runners tend to have physiological differences that make them faster at long-distance running than others, which includes a higher VO2 Max, more efficient cardiovascular systems, better-running economy through movement, to name a few.5

Foot Strike Dwell Time: The amount of time an individual's foot, during a stride, stays on the ground.[6]

Long-Distance: Sometimes called Endurance Running. In track and field, foot races from 3,000-metres up to the marathon distance of 42,195-metres.[7]

1 'Definition of AEROBIC.
2 'Definition of ANAEROBIC'.
3 Luff, 'Why Runners Should Consider Cross-Training'.
4 'Elite & Awards'.
5 Bobalik, 'How Are They Different?'
6 Larson, 'Facts on Foot Strike'.
7 'Long-Distance Running | Definition, History, & Facts'.

Pace: The amount of time it takes to clock one mile or kilometre.[8]

Recreational Athlete: For the purposes of this research, athletes who are not professionals, and/or do not race for a living, and/or are not sponsored, and/or do routinely compete at an elite or sub-elite level.

Running Gait: The assessment of the way an individual walks or runs, typically defined by pronation, neutral, or supination.[9]

Running-Related Injury: Any pain or discomfort associated with running that caused a restriction on training or running activities.[10]

Splits: A race or training runs total time divided into smaller parts, usually in kilometers or miles.[11]

Stride: A stride is one full cycle from when one foot enters in contact with the ground, moves through the motion, and again makes contact with the ground.[12]

Sub-Elite Runner: Sub-elite runners must be able to maintain speed for specific distances. Using the marathon distance as an example, a woman must be able to run a marathon faster than 2h45m to qualify as a sub-elite runner, and a man must be able to run faster than 2h20m.[13]

VO2 Max: The maximum values of oxygen consumption during intense exercise.[14]

8 'The Ultimate Guide to Running Lingo | Greatist'.
9 Need, 'Gait Analysis Explained'.
10 Saragiotto, Yamato, and Lopes, 'What Do Recreational Runners Think about Risk Factors for Running Injuries?'
11 'The Ultimate Guide to Running Lingo | Greatist'.
12 '(PDF) Running Injury Etiology Infographic'.
13 'Canadian Marathon Championships'.
14 Dlugosz et al., 'Phylogenetic Analysis of Mammalian Maximal Oxygen Consumption during Exercise'.

PREFACE

I started running at the end of 2014. I was in the formative years of my career, working around the clock and beginning to feel the ill-effects of sitting at a desk for most of the day. I was in a stressful career, gaining weight from being inactive at my desk, and missing the short-term satisfaction that came from projects and tests during my undergrad degree. The culmination of all of these frustrations pushed me to make a change. From doing a bit of research, from talking with friends, and just seeing people out running each morning, it seemed like going for a jog a few times a week could be the solution for a lot of my problems. Finally, in December of 2014, I built up the courage to lace up my shoes to try being a runner.

After a few years of running, with the help of coaches, consistent training, technology, and some grit, I eventually became fast enough to be eligible to apply for the Boston Marathon, which could be argued is the pinnacle running event in the world. While I beat the qualifying standard by just a couple of minutes, I was ultimately rejected due to the Boston Marathon field size. Put simply, the Boston Marathon accepts the fastest runners first until they reach the maximum allotted race participants, and for the 2018 Boston Marathon, a record 7,384 runners were rejected to run.[15] I was one of those runners, and I was absolutely gutted.

After a brief grieving period, I swore that I would re-qualify for Boston at my upcoming Spring marathon with a fast enough time that there would be no chance I could be rejected again. I built a plan, had a firm schedule ready, I was reading about running performance, thinking about how to get better, dreaming about running, all while low-key training in the off-season to ensure I would reach my goals. Everything was in line, and then, I sustained a serious injury.

15 Middlebrook, 'The Joyous, Heartbroken, and Flat-Out Furious Reactions to the Boston Cutoff'.

My injury was serious enough that I could not run for months, which may as well have been a life sentence. I did my best to distract myself from my diagnosis by going to the gym. I went on the elliptical, I tried pool-running, I swam laps, and absolutely nothing seemed to satisfy me the way running did. I became stressed, irritable, and like the worst version of myself when I was unable to run.

In a reflection of my past training, I knew that technology, usually in the form of my GPS watch, was with me every step of the way. It recorded my training every day, the routes I took, the elevation, my heart rate, and more metrics than I could possibly understand. I knew that my watched helped me perform better, but why couldn't it help me mitigate injury?

Was there a sign that I missed? Are all running injuries just par for the course and unpreventable? Is there a culture in running that prevents us from seeking preventative care?

The aim of the research is to examine the meeting point between recreational running, technology, injury, and healthcare.

The intent is to understand:

HOW MIGHT WE DESIGN OR REDESIGN SYSTEMS THAT AMATEUR RECREATIONAL ATHLETES USE TO MITIGATE PREVENTABLE LONG-DISTANCE RUNNING-RELATED INJURIES?

CONTEXT

CONTEXT

In the 1970s, running in the USA is reported to have increased from approximately 3-million to almost 30-million in just ten years. There are multiple theories on why this running boom occurred, but most indications point to team USA's Frank Shorter, who in 1972, won the first Olympic Gold for the USA in the Marathon.[16] This increase in running was not just a passing trend, it marked the onset of a broader movement that was further energized by a second boom occurring in the 1990s. This second surge in popularity is often attributed to an increase in the number of women being drawn to the sport. A lot of this secondary boom is credited to Oprah Winfrey, who ran and completed the Marine Corps Marathon in 1994, which opened up running as a possibility for many women.[17] In the 1990s, long-distance recreational running increased by a whopping 300%, with more athletes finishing races, covering greater distances, and finishing with faster times than ever before.[18] The interest in running continues to grow at a steady rate and running remains one of the most popular forms of exercise in the USA and as well in Canada.[19] [20]

For the individual Canadian, participation in physical activity carries a plethora of important physical and mental health benefits. Achieving the recommended weekly level of activity prescribed by Health Canada is thought to prevent a multitude of lifestyle-related diseases that can otherwise impose a major financial burden on our healthcare system.[21]

16 Haberman, 'Thousands of Solitary Runners Come Together'.
17 'Running: Inside women's running boom'.
18 Wegner et al., 'Get Serious'.
19 'RunningUSA_NRS_2017.Pdf'.
20 Kelly, 'Fitbit Reveals Most Popular Forms of Exercise in Canada'.
21 'Healthcare Transformation in Canada'

PHYSICAL HEALTH BENEFITS

A major global health concern is the prevention of lifestyle-related diseases.[22] These diseases are many and include obesity, cardiovascular diseases, diabetes, and specific types of cancers amongst others. Primarily through exercise and diet, Canadians can lessen the likelihood of developing these diseases.[23] While prevention of these diseases through exercise may be well-documented and widely understood, these reasons alone do not appear to be enough of a motivator to encourage Canadians to begin focusing on exercise as a part of a healthy routine. Only 20% of adults and 10% of Canadian children and youth are reaching are their minimum weekly exercise as recommended by health Canada.[24]

For many individuals, running carries key benefits over other forms of physical activity in that there are very few barriers to participation. Unlike many other forms of physical activity, running can be performed almost anywhere, at any time, and without the need for special equipment, training or skills.[25] Furthermore, running provides flexibility in that the intensity of the activity can be easily adjusted to cultivate opportunities for both aerobic and anaerobic exercise. Thus, running alone can satisfy the requirements for both moderate and vigorous exercise outlined by the Government of Canada.[26] [27]

In light of the immense personal and public health benefits associated with physical activity, it is important to encourage Canadians who are currently active to remain active. In that vein, the most significant barrier to continued participation in running is physical injury.[28] Some estimates indicate that as many as 65% of runners sustain a running related injury on an annual basis. Injury is the primary reason that individuals temporarily or permanently stop running, and some estimates state that as many as 25% of those

22 Hulme et al., 'From Control to Causation'.

23 'WHO | Diet, Nutrition and the Prevention of Chronic Diseases | Report of the Joint WHO/FAO Expert Consultation'.

24 March 15 2017, 'Canadians Need to Be More Active – It's Good for Us | Ottawa Citizen'.

25 Dillner, 'Is Running the Best Exercise?'32

26 Hulme and Finch, 'The Epistemic Basis of Distance Running Injury Research'.

27 'CSEP | SCPE'.

28 Damsted et al., 'Design of Project Run 21'.

who sustain injury fail to return to the sport and thereby reduce their level of physical activity.[29] [30] This reduced level of physical activity means that they are no longer able to enjoy the associated health benefits. However, it has also been estimated that most of these injuries are entirely preventable as they are classified as overuse injuries. Thus, It is imperative that we encourage Canadians who are active through running to continue running through the reduction of preventable running-related injuries.[31]

THE MENTAL HEALTH BENEFITS OF RUNNING

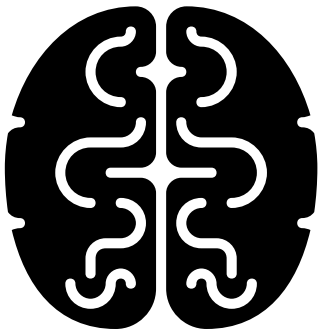
In the history of sports research, there is an over-emphasis on exercise relating to strictly physical benefits, where the body has been treated as "human-as-machine", or just mere chemical reactions in the body, rather than the complex system that it is.[32] Fortunately, the narrative around sports seems to be changing, and there has been an increased focus on the mental benefits of sports exercise, which includes long-distance running at the recreational level.[33]

Many recreational runners indicate that a surprising benefit about running is that it allows them to have an important and necessary escape from a busy and rigid daily routine.[34] Running also gives recreational athletes a chance for self-reflection, a sense of achievement, "me time" or "luxury time", a healthy way to be competitive, and a chance to connect with nature by running by parks, streams, amongst trees, and other forms of nature.[35] [36] Spending time in nature alone is also a more restorative activity for runners, as it has been shown to improve cognitive function and overall well-being.[37]

Operating on a more unconscious level, recreational runners tend to enjoy positive mental health benefits, such as having a decreased risk of depression, lowering anxiety, and improving

29 Damsted et al.
30 Sherman, 'Why Female Athletes Quit'.
31 Saragiotto, Yamato, and Lopes, 'What Do Recreational Runners Think about Risk Factors for Running Injuries?'
32 Hutchinson, Endure, 32.
33 Hutchinson.
34 Blazej et al., 'LONG-DISTANCE RUNNING AS A SOCIAL PHENOMENON'.
35 Allender, Cowburn, and Foster, 'Understanding Participation in Sport and Physical Activity among Children and Adults'.
36 '(PDF) Restorative Effects of Virtual Nature Settings'.
37 Berman, Jonides, and Kaplan, 'The Cognitive Benefits of Interacting With Nature'.

mental clarity, and focus.[38] These measures are important, especially as depression is the leading cause of disability in Canada, and worldwide.[39] For those who are living with mild to moderate depression, exercises like running can be used in conjunction with taking an antidepressant. One study cited that those who were prescribed running in addition to their medication has shown a positive impact, as 41% of those prescribed running with medication no longer met the clinical standard for major depression. Best yet, those who continued running after the study saw their depressive symptoms decreased even further.[40]



Anxiety is even more prevalent than depression, and regular aerobic exercise has consistently been shown to reduce anxiety symptoms, even when compared to placebo or no treatment. This is true for trait anxiety, which is anxiety that comes from a psychological response to a stimulus, and state anxiety, which is a more generalized form of anxiety.[41] With estimates that as many as 29% of the American population will develop anxiety in their lifetime, it may be beneficial to find outlets to channel these excesses of energy.[42] Regular aerobic exercise, like running, can be that outlet for anxiety.

Depression, anxiety, and a host of other mental health benefits like improved sustained mental focus, visuospatial processing, attentional focus and cognitive engagement are just a few of the positive health benefits that can be enjoyed by those who run routinely.[43] With as much as $51-billion per year due to additional healthcare costs, lost productivity, and other health-related quality of life measures, it is likely within the benefit of the Canadian healthcare system to promote and prevent mental health illnesses.[44] Regular exercise, like running, may be a potential solution for many Canadians

38 Douglas, Running Is My Therapy, 111.
39 'Mental Illness and Addiction'.
40 'Douglas, Running Is My Therapy, 49.
41 Douglas. Running Is My Therapy, 78.
42 'NIMH » Any Anxiety Disorder'.
43 '10 Ways That Running Changes Your Mind and Brain'.
44 'Mental Illness and Addiction'.

who are looking to improve their mental health.

HEALTHCARE IN CANADA

While running may be beneficial to an individual's physical and mental health, information has shown that it can be beneficial to the maintenance of the Canadian healthcare system by alleviating the likelihood of costly lifestyle-related diseases. Individuals who are exercising are decreasing the likelihood of developing a non-communicable chronic lifestyle-related disease, like obesity, cardiovascular disease, diabetes, and more. These chronic lifestyle-related diseases, including those stemming from smoking tobacco, are taxing on the already overburdened Canadian healthcare system, which alone cost a staggering $50.3-billion annually.[45]

There is also evidence that those who exercise tend to utilize the healthcare system in a more preventative manner when compared to those who do not exercise, which is less expensive and therefore beneficial for the healthcare system.[46] This is important, as preventative medicine tends to be less costly to the healthcare system, as for every $1 spent in prevention is about $6 saved in treatment/cure in the future.[47] Also as further evidence, those who tend to lead unhealthy lifestyles tend to cost the healthcare system $10,000 annually compared to those who are healthy, who instead cost the system about $2,300.[48]

The Canadian healthcare system has also made moves to encourage exercise as a means of prevention, especially as prevention has been outlined as a key priority.[49] There is evidence of this, as the Government of Canada funds a multitude of programs designed to encourage healthy lifestyle participation. Some of these include programs at the Running Room, such as their Run to Quit program, which aims to reduce smoking by adopting running. The Government of Canada has also worked in partnership with

45 Krueger, Krueger, and Koot, 'Variation across Canada in the Economic Burden Attributable to Excess Weight, Tobacco Smoking and Physical Inactivity'.

46 Lee, Chang, and Du, 'Do Healthier Lifestyles Lead to Less Utilization of Healthcare Resources?'

47 March 15 and 2017, 'Canadians Need to Be More Active – It's Good for Us | Ottawa Citizen'.

48 'More Preventive Health Care Could Save Canada Billions'.

49 Canada and Canada, 'Creating a Healthier Canada'.

non-governmental organizations to develop the application Carrot Insights, which focuses on nudging users to adopt healthy lifestyles by offering rewards for healthy eating, exercise, and answering successfully on quizzes about living a holistic and healthy life.[50] [51]

It's important to encourage those who want to run and be active, to continue to their healthy active lifestyle. This not only tends to benefit the individual, but also to the healthcare system as a whole. As well, those who exercise rely more on preventative care, which lines up with the goals of the Canadian healthcare system that is continuing to shift to a more prevention-based structure.[52]

TECHNOLOGY & RUNNING

Since the running boom in the 1970s, ways for athletes to measure running efforts have seen improvements in multiple ways, including with some early starts in footwear and in most recent years, with global positioning system (GPS) enabled watches. Some of the efforts found mass appeal like the GPS running watch, while others have faltered over the years in a changing technology landscape.[53]

FOOTWEAR

Often cited as ahead of its time, in 1984 Adidas launched a shoe called the Adidas Micropacer, a running shoe that was the first to feature a small sensor that operated when the wearer began propelling forward.[54] In the left shoe, the small sensor would calculate distance, speed, and calories burned on a small digital screen on the tongue of the shoe. The pair of runners were controversial, largely due to the technology-first approach to the shoe development as well as the steep price to own a pair. Unfortunately, the shoe screen was difficult to read, as the digital face would often just read as '88888' when viewed under sunlight, which made the screen unusable during sunny day runs. The shoes often showed inaccurate calculations, were made

50 Canada, 'Government of Canada Launches Run To Quit Smoking Cessation Program'.

51 Insights, 'Canadian Public Engagement Platform Carrot Rewards Ranks Top 20 on the Canadian Business and Maclean's 2018 Startup 50'.

52 Canada and Canada, 'Creating a Healthier Canada'.

53 'GPS Fitness Device Market Size - Industry Share Report, 2023'.

54 'Memories of the Future'.

of leather or nylon which was not breathable for the foot of the wearer, and tended to be heavier than a conventional running shoe.[55]

The Micropacer today is a shoe cited by many as having been ahead of its time, especially considering it arrived on the market before household computers were available for most people.[56] Fortunately, the Micropacer is often viewed as the launchpad for other running-related technology that is more familiar today such as the Nike+iPod Sports Kit Sensor Pod.[57]

Flash forward to 2006, when Nike launched a sensor pod that could be slotted into select pairs of Nike+ enabled running shoes.[58] The sensor pod could be added to the shoes by lifting the insole where there would be a small cavity for the sensor, or by simply clipping the device onto a pair of shoes.[59] The sensor would record and transmit information such as pace, distance, and time elapsed to a Nike+ enabled application, whether that be the now discontinued Nike FuelBand, an Apple iPod, or a host of other Nike+ enabled devices.[60] After 1000 hours, the device would need to be replaced as there was no way to charge or replace the battery component.[61] While Nike+ iPod Sports Kit was considered a success, the Nike+ family has evolved and changed to no longer include the use of a foot pod or their hallmark Nike FuelBand.[62]

While digitally inserted shoe technology appears to have remained niche, there are products that are available today like the Stryd, which is a small device that clips to the laces of a shoe to provide an individual's information on running power.[63] Also available is RunScribe, a pod that provides additional running foot analytics. These devices, and others similar to it, are still relatively new to the market, with Stryd

55 'Micropacer-Smart-Running-Shoes_page_21985.Jpg (1500×2055)'.
56 'Memories of the Future'.
57 'The Rise of Sneaker Culture'.
58 'Nike and Apple Launch Nike + IPod Sport Kit'.
59 'Nike+ Sensor'.
60 McClusky, 'The Nike Experiment'.
61 'Nike+ Sensor'.
62 Bowman, 'Why Ditching the FuelBand Turned Out to Be One of Nike's Best Moves -'.
63 'Stryd, Power Meter for Running'.

released on Kickstarter in 2015, and RunScribe shifting from a consumer focus to a universities, clinics, and running gait labs. [64] [65] [66]

WATCHES

Running watches, at least in the style known today, became popularized in 2003 with the Garmin Forerunner 101. This watch includes the basic metrics that are available on most running watches today, which include distance, pace, and calories burned. Unlike today's GPS watches, this device is powered by batteries rather than being a rechargeable unit.[67]

Since the launch of the Garmin 101, the GPS watch market has grown significantly and continues to show signs of growth. The GPS watch market is anticipated to reach $3-billion USD by 2023, a 15% growth from 2016.[78]

Figure 1. RunScribe pods that clip to running shoe laces.[69]

Figure 2. Garmin 101, the first GPS enabled running watch.[70]

64 'RunScribe | RunScribe – The Ultimate Running Analysis Tool'.
65 'Stryd, Power Meter for Running'.
66 'Stryd – The World's First Wearable Power Meter for Running'.
67 'RunScribe Shifts Away from Consumer Focus, but Also Launches New Features'.
68 'RunScribe | RunScribe – The Ultimate Running Analysis Tool'.
69 Gerweck, 'Product Review'.
70 Garmin and subsidiaries, 'Forerunner 101'.

Below are some of the potential reasons that GPS fitness devices are expected to continue to grow:

1. RISING CONCERNS AND AWARENESS OF HEALTH

There has been a growing awareness of non-communicable chronic, lifestyle related diseases amongst Canadians.[71] This awareness is predicted to help fuel the wearables market.[72]

2. MINIATURIZATION OF TECHNOLOGY

The miniaturization of technology has eliminated barriers for athletes who are looking to capitalize on their health devices. As an example, some of the first heart-rate monitors that athletes wore featured a separate device that was worn around the torso to get a heart-rate reading.[73] While these devices are effective and still commonplace, they could cause chafing, they posed challenges getting an initial reading, and were often damp and uncomfortable towards the end of a run due to sweat and salt building up on the strap. Thanks to miniaturization, the latest watches feature a heart rate monitoring device integrated into the wrist of the watch.[74]

3. A REDUCTION IN THE DEVICE PRICES

New players have come into the wearables market, offering devices that are for more serious athletes that track a series of complex metrics, as well a simpler and less expensive devices for a more casual user.[75]

4. HEALTHCARE PROVIDERS AND NEXT GENERATION HEALTHCARE

The sensing capabilities of these wearable devices has usefulness in healthcare applications.[76] The data collected by the devices has potential to show early warning signs of health issues that can be analyzed by a general practitioner.[77] There is also an anticipation that healthcare providers may begin

71 'GPS Fitness Device Market Size - Industry Share Report, 2023'.
72 Hulme et al., 'From Control to Causation'.
73 'GPS Fitness Device Market Size - Industry Share Report, 2023'.
74 Palladino, 'How Wearable Heart-Rate Monitors Work, and Which Is Best for You'.
75 'GPS Fitness Device Market Size - Industry Share Report, 2023'.
76 Lewy, 'Wearable Technologies – Future Challenges for Implementation in Healthcare Services'.
77 Henriksen et al., 'Using Fitness Trackers and Smartwatches to Measure Physical Activity in Research'.

prescribing these devices to patients as a means to monitor ongoing health concerns.[78]

SMARTPHONES

The iPhone first hit the market in 2008 and the Apple app store launched Map My Run as one of its first applications, which today continues to be a popular application to build running routes, track friends, and record personal progress.[79] An athlete could now use the Map My Run application and begin tracking their progress with their smartphone, which was dramatically different than manually measuring routes using printed maps, estimating pace using elapsed time, or using a odometer on a car or bike that runners used just a few years earlier.[80]

Today, there are a host of free smartphone applications that offer runners pace, distance, elevation and other basic information.[81] As an example, the Nike+ application, as a component of the original Nike+ Sports Kit Sensor Pod, has evolved into a free running application called the Nike Run Club. This application even includes guided workouts, integration with workout music playlists, and the option for "personalized" running plans based on current mileage, pace, and a recent race result. Similar to the original Nike+ Sports Kit, this device connects with other Nike enabled devices such as the Apple watch for an enhanced fitness experience. [82] [83]

78 'Running Watches Market 2018 Global Share, Trend, Segmentation, Analysis and Forecast to 2025'.
79 Stahl, 'The Technology That Created a New Generation of Runners'.
80 Hoskyn, 'Reader To Reader'.
81 Stahl, 'The Technology That Created a New Generation of Runners'.
82 'Nike+ Run Club'.
83 'Running-App-Gps'.

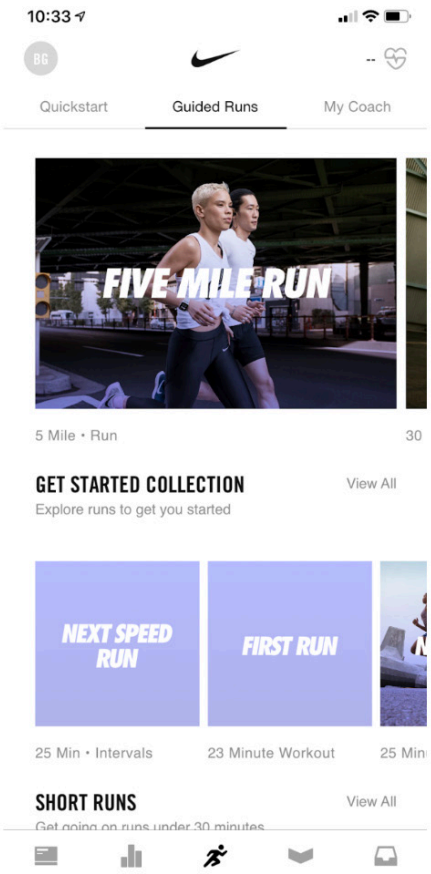


Figure 3. Nike Run Club Application, showing different free workouts available. Screenshot provided by author.

The smartphone is a key tool for many runners, especially as it is the primary way individuals keep track of their mileage, goals, and personal best times. Currently, it is estimated that 63% of runners use a smartphone as the primary way to track and record their running history.[84]

INJURY-PREVENTION TECHNOLOGY

Given that running-related injuries are so prevalent, there is technology on the market that boasts the possibility of preventing injury through monitoring an individual's analytics.

RunScribe, a foot pod sensor that tracks foot specific analytics, expresses that injury-prevention is part of the RunScribe system. An individual is able to compare their information from current and previous runs to analyze and ultimately make decisions about changes in their footfall patterns.[85] The device, at least for the injury prevention component, calculates key parameters like foot strike dwell time. As dwell time increases, which is more likely at the end of an exercise, fatigue may be present which adds a risk of injury.[86] From the records online when an individual is fatigued, there does not seem to be an indication that no notification would be triggered to alert a change in footfall patterns without the runner championing the monitoring of

84 'RunningUSA_NRS_2017.Pdf'.
85 'RunScribe | RunScribe – The Ultimate Running Analysis Tool'.
86 ' Spinks, 'Say Goodbye to Running Injuries Forever'.

their own data and analytics.

Similar to the above, Garmin has released a Running Dynamics Pod, which is an additional device that clips to apparel to add further analytics for an individual looking for more information than their GPS watch offers.[87] The pod, with a solution similar to the RunScribe pod, suggests the personal monitoring of an individual's personal data and analytics to make decisions if they are overtraining, fatigued, or showing signs of other stress factors that may lead to injury.[88]

These devices, and other additions to performance and tracking technology, are what appears to be commonplace in the market. Select Garmin includes a suggestion of rest time before the next run is performed. Some Polar devices alert the wearer that they are not getting enough sleep. However, it is unclear if the purpose of the notifications are for maximizing performance, such as pushing the user to rest and recover for an optimal performance at an upcoming workout, or if the notifications are to minimize injury by suggesting to delay running again until muscles and tissues have repaired. In Figure 4, the Polar Vantage watch shows detraining, maintaining fitness, productive training, or overtraining as measures to assist the user to their training load.

Figure 4. Polar Vantage, displaying training load metrics.[89]

87 'Garmin Running Dynamics Pod Review'.
88 'Garmin Running Dynamics Pod Review'.
89 'PolarVantage M Multisport & Running GPS Watch (Small/Medium, Black)'.

Injury prevention is not exclusively a concern with running. Efforts are being made across a multitude of sports in order to help reduce the risk of sports-related injuries, such as through the improvement of equipment like helmets, or through the use of camera and sensor technology to help identify and prevent injuries before they occur.[90]

BENEFITS ASSOCIATED WITH CURRENT TECHNOLOGY

Functionally, being able to use technology to record, track, and analyze running statistics is useful as it is often more reliable and simple than analog ways to measure performance. Using technology may allow an individual to train better and make decisions based on metrics available through technology that were previously not available.

Emotionally, there are areas for personal growth and development. Runners often cite the enjoyment from being able to visualize their accomplishments which is rewarding for those who are seeking to improve. Technology allows an individual to share their performances on social media, celebrate race results, and evaluate their other personal statistics on social media.[91] Finally, seeing progress often helps build self-esteem.[92]

Sharing on social media also appears to be a force of inspiration for runners. Estimates suggest that almost 80% of runners have shared and posted race photos and 62% share race results.[93] For many people, competing against other runners on social running applications like Strava are motivating. On Strava, there are stretches of road or trail called segments that an athlete can compete on with other athletes. These stretches of road or trail have the top performances listed for time, weight, gender, and other factors where you can compete with yourself or against other athletes. This gamification of social stats on Strava is often a motivator, helping individuals continue their running routines.[94]

LIMITATIONS TO TECHNOLOGY

90 'The Latest Sports Technology Available to Prevent Injuries'.
91 'RunningUSA_NRS_2017.Pdf'.
92 Stahl, 'The Technology That Created a New Generation of Runners'.
93 Stahl.
94 'Strava App Tips – How to Motivate Yourself with Segments – Cactus Bike'.

Functionally, technology has many limits for runners. Calculations that are being used to suggest training load, such as being productive or overtraining, are based on inputs from the user. If the user does not update these metrics as they change (for example, a change in weight), the suggestions may not be accurate reflections of reality. Technology also makes recommendations to push past performances by running at a faster pace or longer distance in order to outperform previous metrics. While these are motivating for some, pushing further and faster for many (specifically an aging or injured population) may not actually be the best course of action.

The social component, especially on platforms like Strava, provide another challenging limitation to technology. Social comparison has a fair-share of well-documented downsides, especially if runners are perceiving themselves to be under performing compared to their friends or peers.

RUNNING-RELATED INJURIES

Running can be both advantageous for an individual, and the Canadian healthcare system as a whole. However, injuries often impede the continuation of exercise.

Running related injuries can be defined as "any pain or discomfort associated with running that caused a restriction on training or running activities", or put simply, injuries that prevent people from running.[95] As it stands, the number of running-related injuries is very worrisome for athletes. While studies show varying degrees of injury prevalence, many indications suggest that about 65% of runners are injured in a given year. This is troublesome as the number one reason to quit running is due to injury.[96] With the number of people who run annually in Canada to stay healthy, the low barrier to participation, the and the physical and mental health benefits for individuals and the healthcare system as a whole, efforts should be made to encourage people to continue their fitness routines.

95 Saragiotto, Yamato, and Lopes, 'What Do Recreational Runners Think about Risk Factors for Running Injuries?'

96 Damsted et al., 'Design of ProjectRun21'.

Unfortunately, running is a sport that is known to be injury causing. During a study undertaken by Aarhus University in Denmark and the Danish Institute of Sports Studies, research was conducted with people who exercised over a 12 month period. This study included people who run recreationally, amongst other activities, and the results showed that the greatest prevalence of injuries was amongst those who ran recreationally.[97] The numbers do not discriminate either, and there was no significant difference between men, women, and children who sustained injury.

Running is advocated as an exercise that can improve overall health and wellbeing.[98] With the low barrier to participation, the multitude of physical and mental health benefits, the benefits to the Canadian healthcare system, is it time for a new way of approaching running-related injuries? Or Are injuries just "par for the course" in running? [99] [100] [101]

HOW INJURIES HAPPEN

Running injuries are rarely based on a single traumatic event. Instead, the vast majority of running injuries are the result of some form of repetitive stress. Running imposes a set of forces on the body called load. This load is not inherently harmful because all runners have some ability to bear load or load capacity. However, when the load capacity is exceeded, this is when injuries can occur. The illustration on the next page is an interpreted version of how a load-capacity model can be used to explain the onset of running-related injuries. The sections below will operationally define the concept of load as it relates to the onset of running injuries.

97 Bueno et al., 'Injury Prevalence across Sports'.
98 'GP Life'.
99 Dillner, 'Is Running the Best Exercise?'
100 Lavie, Archer, and Lee, 'Persistent Physical Activity Translating to Persistent Reduction in Mortality'.
101 Canada and Canada, 'Creating a Healthier Canada'.

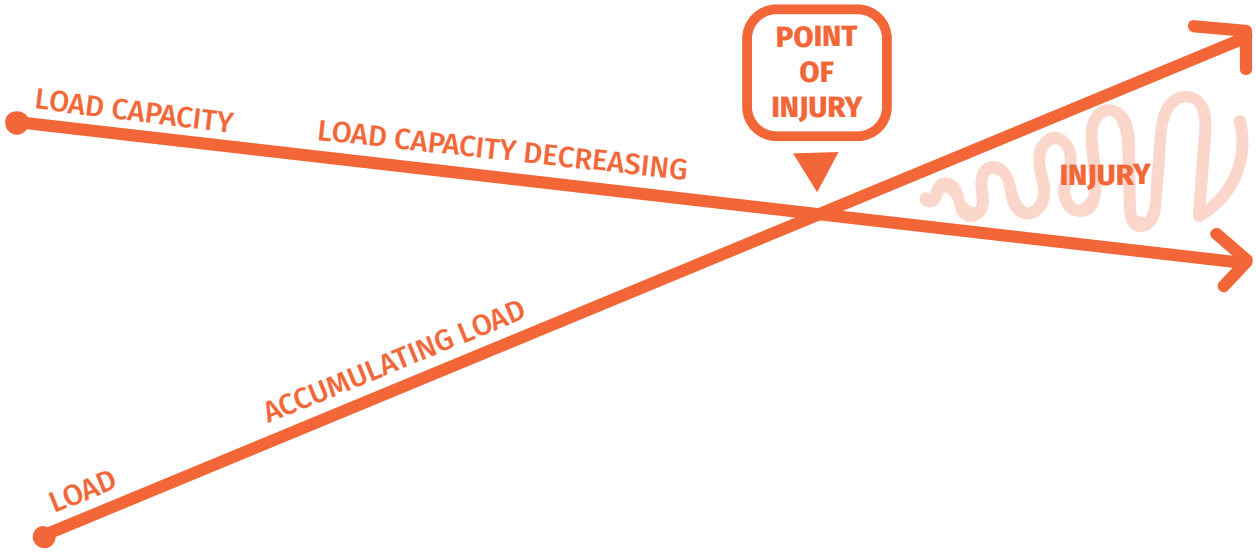


Figure 5. Interpreted diagram illustrating training load and training capacity.[102]

Load Capacity is the ability a person's bodily tissues are able to endure through sport, and for the purposes of this research, through running.[103] Load capacity is individual from person to person and encapsulates a multitude of factors such as previous experience running, diseases, age, diet, recovery time from the previous run or workout, previous injuries, genes, and amount of sleep. Each time an individual runs, their load capacity decreases until an individual recovers.[104]

On the other side of the equation, a load is the impact on a person's body takes during each stride of the run. A load has two parts:

1. MAGNITUDE

The magnitude of the load is determined by a host of things, including body weight, the type of terrain being run on (i.e. cement road, concrete sidewalk, snowy trail, track), and the pace at which an individual is running.

102 '(PDF) Running Injury Etiology Infographic'.
103 Cook and Docking, '"Rehabilitation Will Increase the 'Capacity' of Your ...insert Musculoskeletal Tissue Here...." Defining "Tissue Capacity"'.
104 '(PDF) Running Injury Etiology Infographic'.

2. DISTRIBUTION

The magnitude has a distribution where the load is applied, which is impacted by body weight, running form, and running shoes.

Both the load magnitude and the load distribution determine the total cumulative load. This cumulative load increases as an individual continues to run, and should not exceed the load capacity. If the load exceeds the capacity, injury occurs.[105] As illustrated in Figure 5, the angles of these lines pivot, depending on the multitude of factors outlined above that impact the load capacity and load.

Fortunately, there are methods to reduce the risk of injury or diminish the likelihood of approaching the point where the load exceeds the load capacity. Some of these methods include decreasing participation in running, changing the load capacity (improving diet, improving sleep), changing the pace at which the individual performs the activity, or changing running shoes. Strength training is also recommended to avoid injury, to increase the strength of the remainder of the musculoskeletal system, which can improve form, and correct structural imbalances.[106] Another method to reduce the risk of injury is to plan a gradual progression in mileage and training.[107]

105 '(PDF) Running Injury Etiology Infographic'.
106 'Why Runners Need Strength Training (And How to Get Started)'.
107 'Balancing Training Load and Tissue Capacity | BJSM Blog - Social Media's Leading SEM Voice'.

PROJECT OVERVIEW

The purpose of this MRP is to create principles for new technologies in order to help mitigate preventable running-related injuries. Supporting individuals to stay active should be a priority for the healthcare system in Canada, as well as the physical and mental health of the individual runner.[108] The aim of this project is to understand if, and how, running tools can be designed or redesigned as aids those who are looking to prevent running-related injuries so they are able to continue to reap the benefits of their healthy running routine.

This project, in one question, is:

"HOW MIGHT WE DESIGN OR REDESIGN SYSTEMS THAT AMATEUR RECREATIONAL ATHLETES USE TO MITIGATE PREVENTABLE LONG-DISTANCE RUNNING-RELATED INJURIES?"

108 Canada and Canada, 'Creating a Healthier Canada'.

HOW MIGHT WE

This question, broken down, means this:

How might we: Phrasing the question as a ‘how might we’ frames the problem with injuries and long-distance running as a challenge that is open for an innovative opportunity.

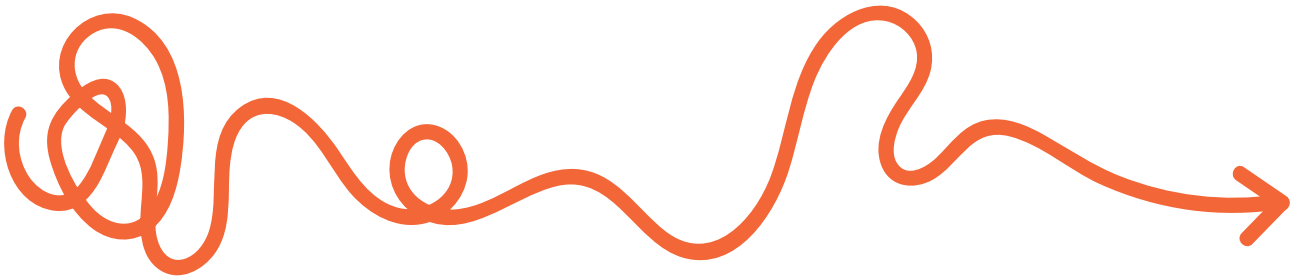
DESIGN OR REDESIGN: There are currently some systems in place for injury prevention. Should these be designed fully new, or redesigned to uncover an opportunity?

AMATEUR RECREATIONAL: Athletes who are not professionals, and/or do not race for a living, and/or are not sponsored through financial means, and/or do routinely compete at an elite or sub-elite level.

MITIGATE PREVENTABLE: Not all injuries are preventable. Slipping due to misstepping on a curb, unexpectedly colliding with a cyclist, or trial and error to discover personal limits are often not preventable and are outside of the scope of this research.

LONG-DISTANCE: Long-distance can be defined as anything above a 3,000-meter distance run, and as long as a 42,195-meter run.

APPROACH



PART 1
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Figure 6. The process and approach for this research.

Throughout the course of this research, a number of methods were employed to explore how, or if, design can be used to help mitigate preventable running-related injuries. These methods follow a series set of phases, which include gathering, analyzing, synthesizing, gathering again, resynthesizing, and an exploration of possibilities to prevent running-related injuries.[109]

These methods include:

PART 1 / GROUNDWORK

The purpose of this first phase is to sense the intent of what the trends and changes within the current landscape of long-distance running, and where any important trends are moving.

For this research, a literature review was conducted to understand the physical health benefits, the mental health benefits, the technology, and the injuries that are contained in academic sources, journals, newspapers, books, blogs, and online forums.

109 Kumar, 101 Design Methods.

PART 2 / RESEARCH

This section of the research is the Know People phase, which is conducted to better understand the participants that this research is ultimately being researched on behalf of, with a focus on empathy, engagement, problem-solving, and observation.

In order to better know people, two methods were used:

INITIAL INTERVIEWS: 12 one-hour long in-person semi-structured interviews were conducted surrounding running injuries, technology, apparel, and attitudes around long-distance recreational running. The interview contained 27 questions. To see the interview questions, please see **Appendix A**.

CULTURAL PROBE, AKA 'RUNNING KIT': A package of items delivered to 16 individuals in the running community, with an estimate of a one hour completion time. These packages contained general questions about injuries, apparel, technology and attitudes that participants were instructed to fill out. Also included in the kit was a map of Toronto, Canada, which was used to discover if places in the city hold specific meaning for runners. Finally, the kit contained a disposable camera and a notebook for participants to record meaningful aspects of their running life, including a booklet for a place to record a further description. To see the questions, the map, and a visual of the cultural probe/running kit contents, please see **Appendix B**.

SECONDARY INTERVIEWS: 12 individuals were emailed a series of an additional 9 questions, with sub-questions, surrounding technology specific to running, as further questions were raised from the initial interviews and the cultural probe. To see these interview questions, please see **Appendix C**.

PART 3 / INSIGHTS

This phase, using the method of Insight Sorting, was the system used to collect information from the primary and secondary research, including the literature review both interviews and the cultural probe contents (map, photographs, etc.).[110] This method of organizing information allows insights, patterns, and clusters to be uncovered. Insights gleaned from this part of the research focused primarily around technology, although additional not related to the scope of this research can be found in the **Appendix D**.

PART 4 / POTENTIAL APPROACHES

The Frame Insights phase had a series of trends emerge relating to running-related injuries and technology. These insights were distilled into 3 principles for further design and consideration of technology for long-distance recreational athletes. Potential approaches were informed by the predominantly technology-focused insights.

110 Kumar, 101 Design Methods.

RESEARCH LIMITATIONS

Attempts were made to ensure that this research was conducted in a manner with as little bias as possible from the researcher. However, like all research, there are limitations:

PARTICIPANT SELECTION

The participants involved in this research largely reside in the Greater Toronto Area, with an overemphasis on the Eastern side of the city of Toronto. This could potentially have an impact on running, as residents in different areas of Toronto may hold different attitudes from one another. As well, different attitudes may be shared differently with non-urban runners.

RECRUITMENT

Recruitment was conducted through 2 research ethics board approved recruitment posts on Facebook. The first one, for the cultural probe/the running kit, a request was posted to a local running group, the Beaches Runners Club, with the ask if anybody was interested in participating in the research. The recruitment quota was quickly filled (goal: 10, actual: 16) and no further recruitment efforts were required.

For the initial interview portion of the research, participants were recruited via a research ethics board approved message on a general Facebook post. Similar to the Cultural Probe, the participant count was quickly reached (goal: 10, actual: 12) and no further recruitment efforts were required.

Finally, for the secondary interview portion of the research, participants were recruited from the existing pool of participants who had already completed either the initial interview or the cultural probe/the running kit.

There was no overlap between the individuals who completed the initial interview and the cultural probe/running kit.

FINANCIAL LIMITATIONS

Many participants who offered to be involved in the research were not able to participate, specifically for the Cultural Probe exercise. This was due to the cost of each cultural probe/running kit, which was approximately $25-30 per person. With funding for this project, the research could have included more participants from the initial group of runners in the Beaches Runners Club, as well as expanded further to other clubs across the Greater Toronto Area and beyond.

PRIMARY AND SECONDARY PARTICIPANTS

The research could have benefitted from participants other than the runners themselves, including the family and friends of runners who have unique perspectives to offer. This information could have added a deeper dimension to the report.

PARTICIPANTS INVOLVED IN GROUPS

Almost all of the participants who were involved in the research were part of a running group. While many runners are involved in running groups, there are plenty of people who run solo.[111] This research only includes 1-2 participants who do not routinely participate in a group. This is important to note as it is estimated that about 40% of runners do not belong to a running group.[112]

AVAILABILITY OF INFORMATION

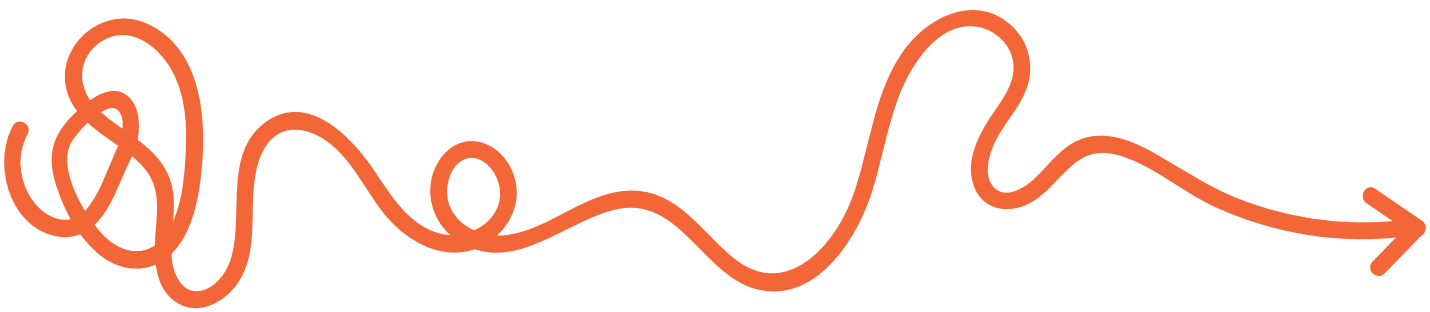
The data first sources from Canadian sources. However, when no Canadian information was available, American sources of information were used; and finally,

NON-CANADIAN PERSPECTIVE

Injury prevention in nations that do not have a publicly funded healthcare system may approach injuries differently, and therefore, these perspectives should be explored through future research.

111 'Running Is Not Just A Solo Sport'.
112 'RunningUSA_NRS_2017.Pdf'.

PART 1
GROUNDWORK



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GROUNDWORK

The first part of this project was to perform a scan of the literature, including academic journals, magazines, newspapers, blogs, and other publications. This was a critical part of beginning the exploration, as key challenges and attitudes needed to be discovered and uncovered as a basis for the research. For this exploration, it was also imperative to get an understanding of how long-distance recreational runners are approaching injury prevention as part of their lifestyle.

For the environmental scan, the project was largely sectioned into a series of topics, including:

1. APPAREL

This includes shoes, clothing, and other textiles. Currently, in the market, there are many trends around compression materials, fabrics that keep your skin cool, or warm, and are anti-chafe, anti-odour, and even personalized footwear and materials.

2. TECHNOLOGY

Primarily, commercially available technology designed for running that recreational athletes take advantage of. This includes a standard watch, a GPS enabled watch, a smart-watch, fitness-tracker, or smartphone applications.[113] Typically, these technologies include ways to measure performance, including steps, calories burned, pace, distance, time, and more depending on the different kinds of metrics the device offers.

113 'Should You Get a GPS Running Watch, Fitness Tracker, or Smartwatch?'

3. INJURIES

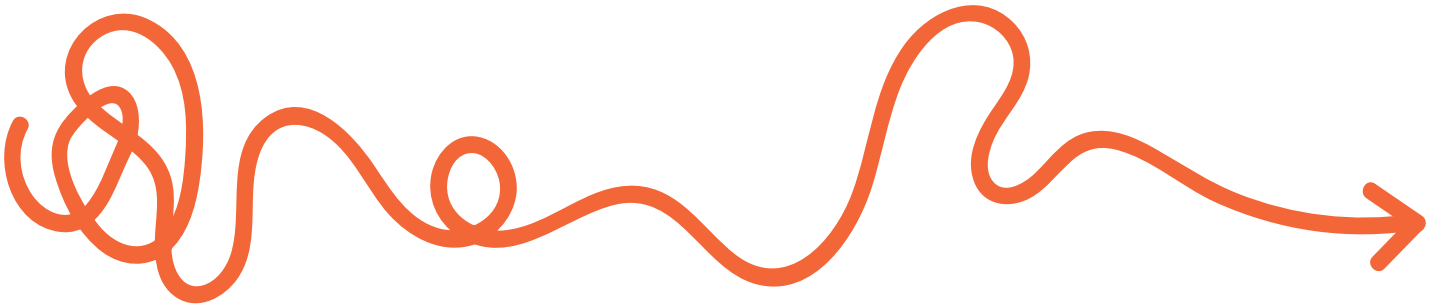
Prevention specific methods, as in stretches, cross-training, other forms of training, warming up, cooling down, and other biophysical ways that may help prevent injury.

4. HEALTHCARE

Efforts by the Canadian Government made to encourage a more active society, which includes the prevention of chronic lifestyle-related diseases, such as obesity, diabetes, cardiovascular disease, and specific types of cancers.

These categories helped shape and form a general understanding of the current state of running-related injuries from long-distance recreational running. While the search was exhaustive, the primary focus ended up being on fitness technologies in the performance and injuries space, healthcare priorities and prevention with the Government of Canada, and current prevention efforts that are being made, largely in the tech space.

PART 2
PRIMARY RESEARCH



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PRIMARY RESEARCH

INTERVIEWS

To gain a deeper understanding of attitudes and opinions around running, apparel, technology, and running-related injuries, a series of interviews were conducted. 12 interviews were completed in total. Participants in the interview process ranged across ages, from as young as in their early 20s to as experienced as in their late 60s. There was a near-even gender divide for individuals who participated in the research.

The interviews focused on 4 elements of running, including apparel for running, technology, running-related injuries, and questions surrounding how a person thinks and feels about aspects of running, including elements such as superstition in the sport. The interview guide was semi-structured, and the full 27 question interview can be found in **Appendix A**.

CULTURAL PROBES AKA "RUNNING KIT"

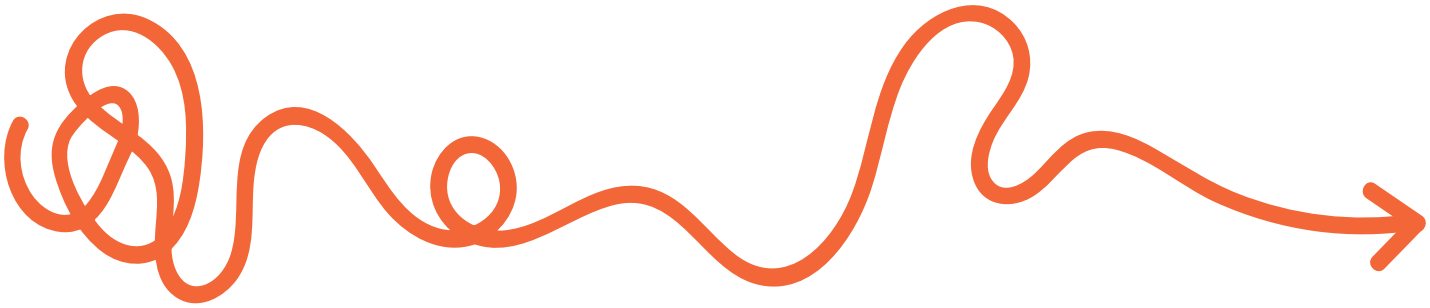
For the cultural probe exercise, the participants recruited were not participants in the interview exercise. The cultural probe was a hand-delivered box that was sent to 16 participants, of a mix of ages (between ~20-70 years old) and a near even gender split.

The cultural probe, dubbed “the running kit”, contained a mix of items for participants to reflect and provide details on the importance that running plays in their lives. The intent was to uncover attitudes around running technology, apparel, running-related injuries, and any other areas of inquiry that may come forward. The cultural probe contained (1) a disposable camera, (2) a booklet to record the significance of the images taken with the disposable camera, (3) a series of ‘prompts’, or questions that were either open-ended or fill-in-the-blank about running, (4) a map of Toronto, for participants to record points along a map that held significance for their running, and (5) an energy gel as a token of appreciation for participating in the exercise.

Participants were given two weeks (or, longer if requested) to fill out the cultural probe, and participants were encouraged to send in images via email if they would prefer to not use a disposable camera or handwrite their answers. The prompts and a photo of the materials can be found in **Appendix B**.

Finally, at the end of the first round of primary research, select participants were asked a series of questions to dig deeper at their perspectives surrounding fitness technology, as the initial interview and cultural probe “running kit” were broader in scope compared to the final outcome. These questions are in **Appendix C** of the report.

PART 3
INSIGHTS



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INSIGHTS

The literature review, the initial interview content, the elements of the cultural probe, and the second round of interviews were all a part of the insight analysis. Insights were sorted using the Insights Sorting approach, as described in the 101 Design Methods.[114] Key information was documented, sorted, and clustered as data began to formed patterns. When patterns were arranged, the largest areas of inquiry focused on technology. Additional insights not related to technology can be found in **Appendix D**.

INSIGHT 1

WHEN IT COMES TO TECH, LESS IS MORE.

Athletes who participated in the research were asked questions specifically around technology, and a majority of individuals stated that they understood running technology as a double-edged sword.

Individuals pointed out that using technology in running is a distraction or barrier to the activity, and notifications through their device often interrupted their flow state.[115] This concern was voiced in both the interviews and the cultural probe. Many individuals indicated that running was a way to truly disconnect, an escape from daily work or family stress, the only time they're not facing a screen, and time that was set aside as "me time". Thus, the participants did not have interest in being further connected.

114 Kumar, 101 Design Methods.
115 Csikszentmihalyi, 'FLOW: The Psychology of Optimal Experience'.

"I only use my watch so I don't have to keep asking people how far we've gone all of the time. It is probably really annoying for them when I forget my watch and ask constantly. It is the only reason I own a watch... that and because my partner got it for me as a gift."

"I haven't worn a watch in a few years, I don't feel like I really need it. I know the routes I like and the distance of each. I'm planning to get back into racing longer distances, so I'll need to begin using a watch again."

"I don't want more bells and whistles. Just give me something simple so I can get out the door."

Even though there was a strong sentiment that the runners researched did not want more technology, almost all individuals indicated that they wear a GPS watch or use a GPS enabled smartphone to track and record their runs in real time. This was true even though the technology had the potential to be irritating and distracting, as most of these runners felt like technology simply made them better.

"I like using my watch, I couldn't imagine not using one. At least just for distance and pace."

"Forgetting my watch before a race would be devastating, I'd rather forget anything else. How else would I check my splits?"

Throughout the literature review, it appears that current and emerging technologies are becoming more complicated. There are a growing number of peripheral devices designed to augment existing technologies Examples include the Garmin Running Dynamics Pod, Stryd, and RunScribe, which offer more metrics but ultimately add further complexity to the experience. Given that complexity represents a barrier to adopting running-related technologies, these additional devices are not likely to attain mass appeal.

INSIGHT 2

INFORMATION IS TOO COMPLEX.

Individuals who participated in the research often indicated that they were not interested in technology, not good at technology, or a technology "Luddite". This was surprising given that almost all of those who expressed these views owned and routinely used mid-to-high tier watches, which are watches with features beyond basics like pace, distance, and elapsed time. Mid and high-tier watches often include features like navigation, VO2 max estimates, race predictors, and integration with 3rd party applications. Even more surprising is that the most frequently used measures on the watches or smartphone tracking applications were distance, pace, and elapsed time, which are available on the entry-level lower-tier GPS enabled devices.

Some participants indicated that they did use advanced features, such as heart-rate monitors or route planning, but the majority did not take advantage of those features. When prompted further, those individuals who did not use their watch to a greater extent voiced a frustration around the menus, the accompanying application, and the understanding of how to use the information.

"I definitely do not take full advantage of my watch. I just sync it when I'm done, let it automatically connect to Strava, and forget about it."

"I sometimes look into my numbers. For a race anyway. I think there is too much data."

"I don't analyze my data. It may be useful for professional athletes, but not for me. I think it is a hindrance, I don't want to get bogged down by the numbers"

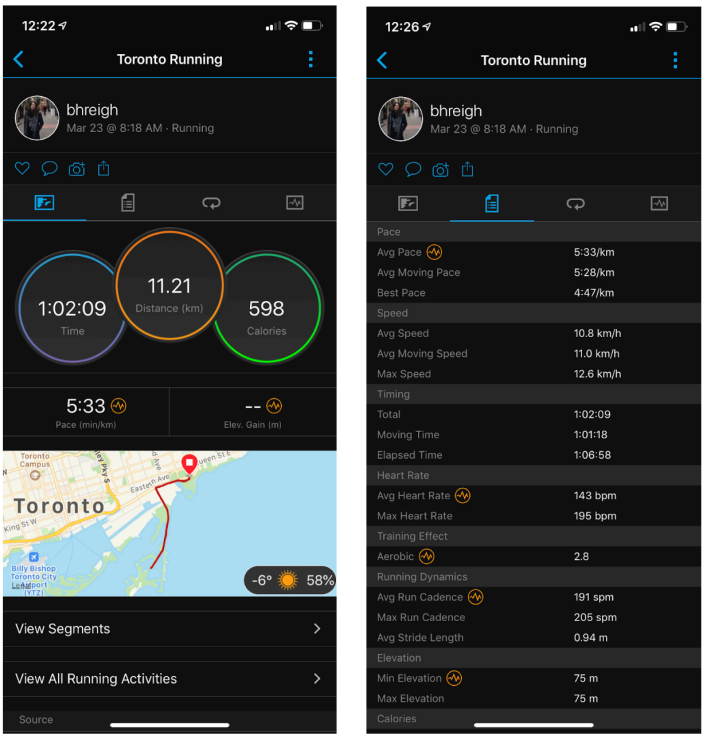


Figure 7. Sample from Garmin Connect dashboard, showing completed run with two screens of metrics. Screenshots and information provided by author.

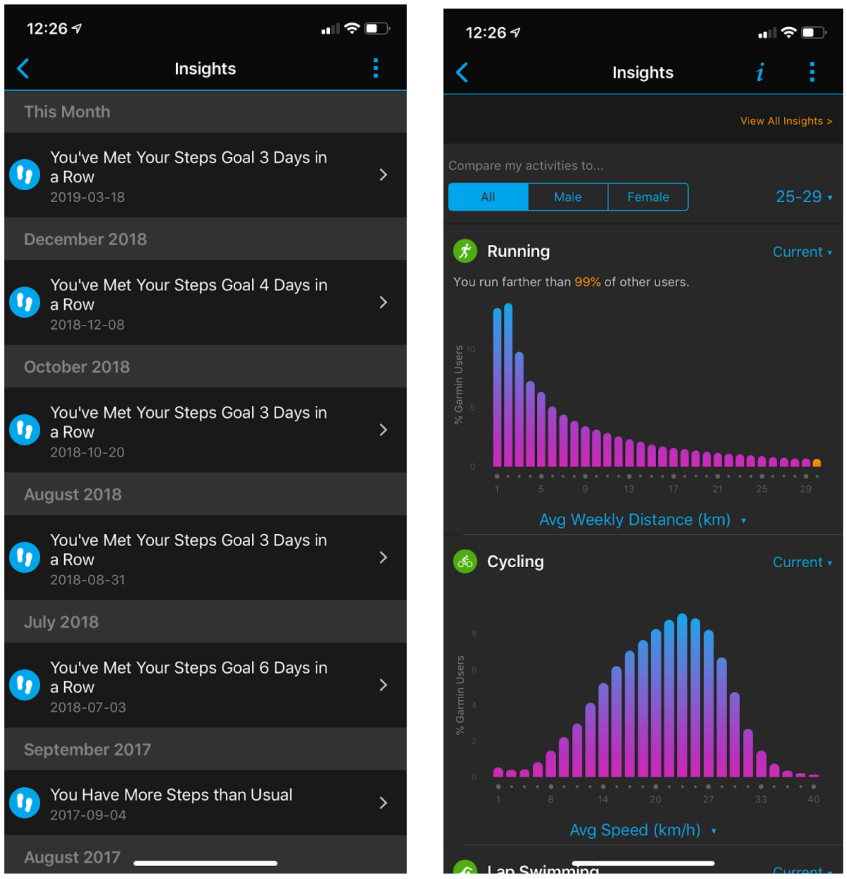


Figure 8. Sample from Garmin Insights dashboard. Screenshots and information provided by author.

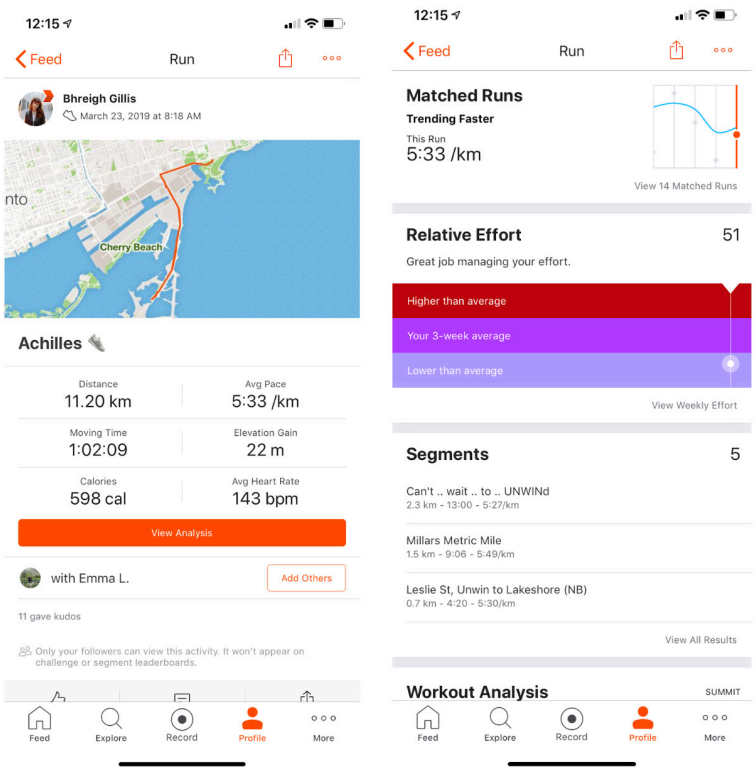


Figure 9. Sample from Strava dashboard, showing a completed run. Screenshots and information provided by author.

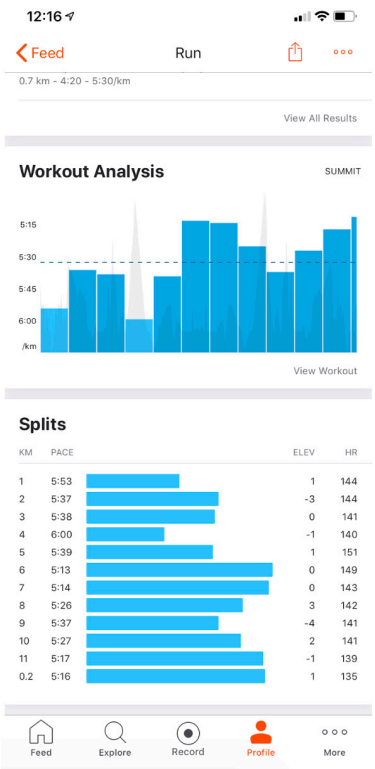


Figure 10. Samples from Strava dashboards, showing a completed run splits and elevation. Screenshots and information provided by author.

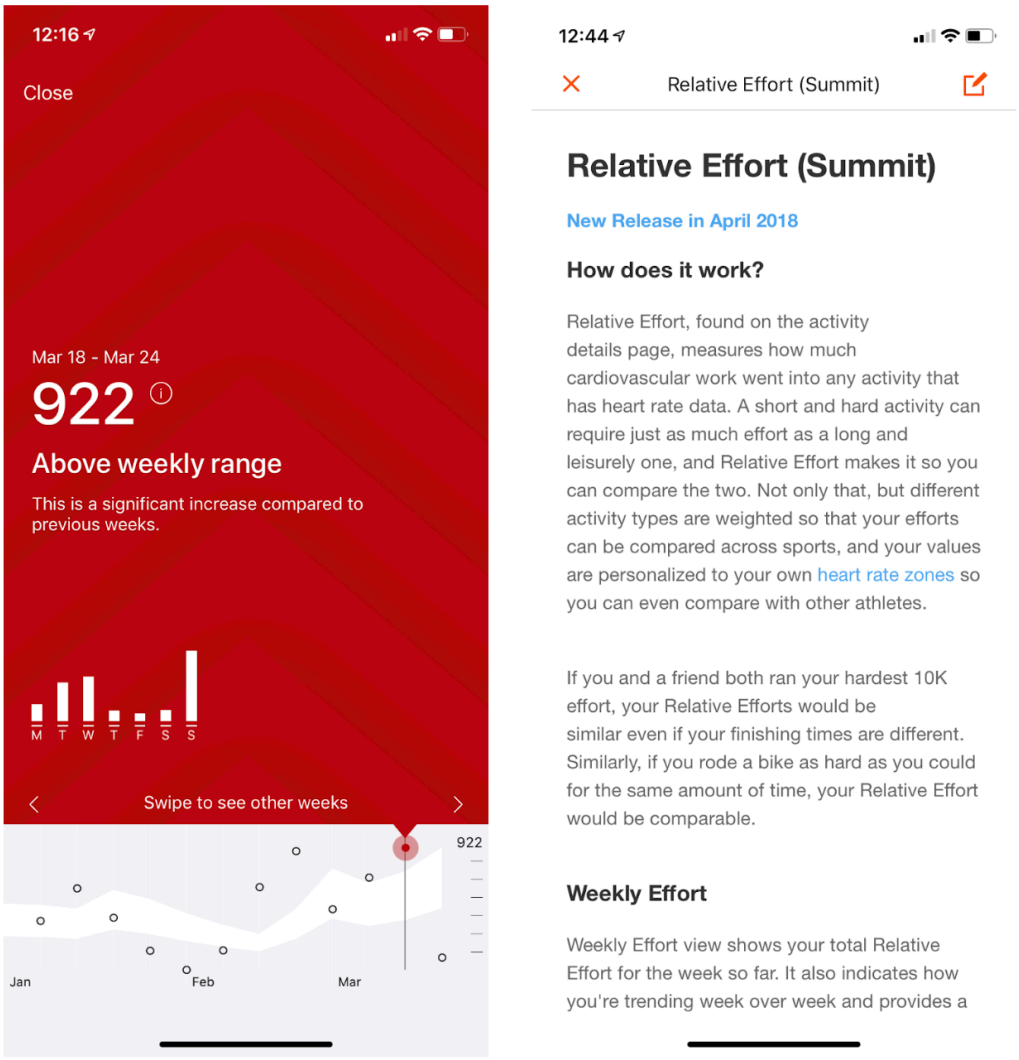


Figure 11. Sample of a Strava dashboards showing Relative Effort, and an explanation. Available on the paid Summit version add on for Strava. Screenshots and information provided by author.

INSIGHT 3

IGNORING ADVICE OF PROFESSIONALS.

Part of the primary research was related to professional healthcare treatments, specifically surrounding running-related injuries. Most runners who participated in the research indicated that the care providers they saw for running-related injuries were sports doctors, general practitioners, physiotherapists, chiropractors, and manual therapists such as those who offer massages or fascia stretching.

More than half of participants stated that when they seek professional medical attention to address running-related injuries, they often seek professionals who are currently runners themselves, who have experience in distance running, or at least have an understanding of the drive of a runner. Most runners also indicated that for their past injuries, they would resume regular running routines earlier than recommended by their medical professional. Some individuals went as far as directly telling the medical professional that abstinence or inactivity would not be an acceptable recommendation and thus they would not adhere to a treatment plan involving the complete cessation of running activity.

"I've told my doctor, before the appointment even began, not to tell me that I'm missing my race. I'm not missing my race. I've worked too long and too hard."

"I do prefer to find doctors who run, they just get it. Whenever you see someone who doesn't run, they just prescribe ceasing running. I don't believe that is the solution for me."

"Movement is medicine is my mantra, so I don't like to see providers who simply recommend to stop running until the pain goes away."

INSIGHT 4

IGNORING NOTIFICATIONS.

On most GPS enabled devices, push notifications are sent through to the user. Some of these notifications provide pace per kilometer or achievements, but many of them are notifications that provide rest or move notifications. Participants in the research indicated that they did not take notifications seriously that were generated on their devices, such as the recommended rest prompt that follows immediately after a workout is complete on versions of the Garmin watch. Another notification ignored routinely is the often ill-timed "move" reminder that appears in the hours following a long run or marathon.

Figure 12. Garmin 235 showing a recommended recovery time immediately after a run. Screenshots and information provided by author.

INSIGHT 5

SOCIAL COMPARISON.

Many runners pointed to applications, like Strava, as a routine part of their running. Strava is a hub where runners upload their workouts, share photos, celebrate races, and like or give 'kudos' for each other's efforts. Strava is also a hub where people can keep track of personal bests, weekly mileage, annual mileage, and participate in segments.

"I don't even know if it would be worth doing a marathon without Strava. What is the point?"

While a few participants indicated that Strava created a positive environment, a greater number expressed that it was a place that made them feel like they were missing out, that they were not good enough to participate, or that they compared themselves to others too much. This went as far as some individuals expressing that they have taken a hiatus from using Strava, because the pressure to perform was becoming too great.

A few individuals even indicated that they simply didn't trust Strava, as the paces and distances could be fake indications of real performance by utilizing the pause feature on their devices.

"I don't trust Strava. Someone posts that they did a 5k in 20 minutes, but I'm familiar with their running and I don't believe it. I think they stopped multiple times and paused their watch and caught their breath."

"I'm not on Strava, it would be a crazy-making place for me"

"I've taken a break. I don't do well in the heat and other people seem to be excelling. They're probably wondering why I'm underperforming."

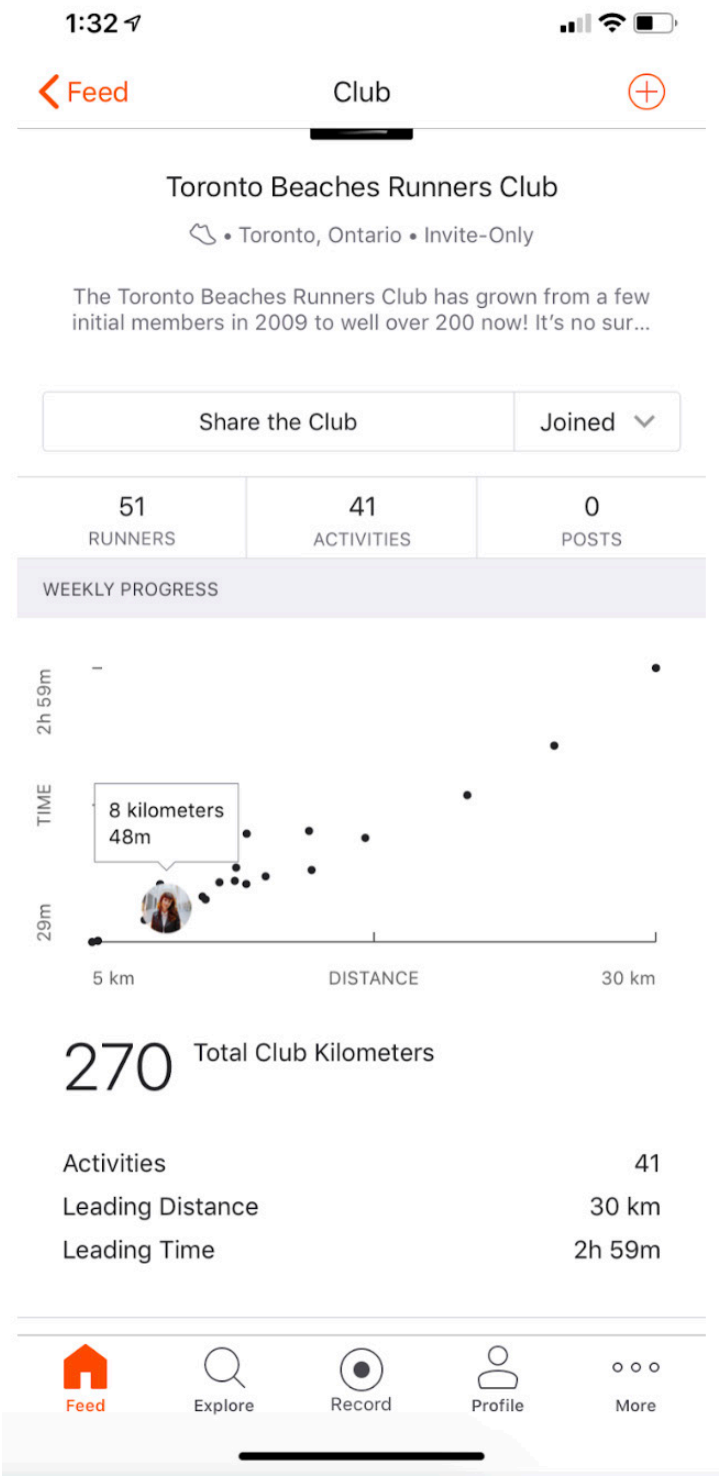
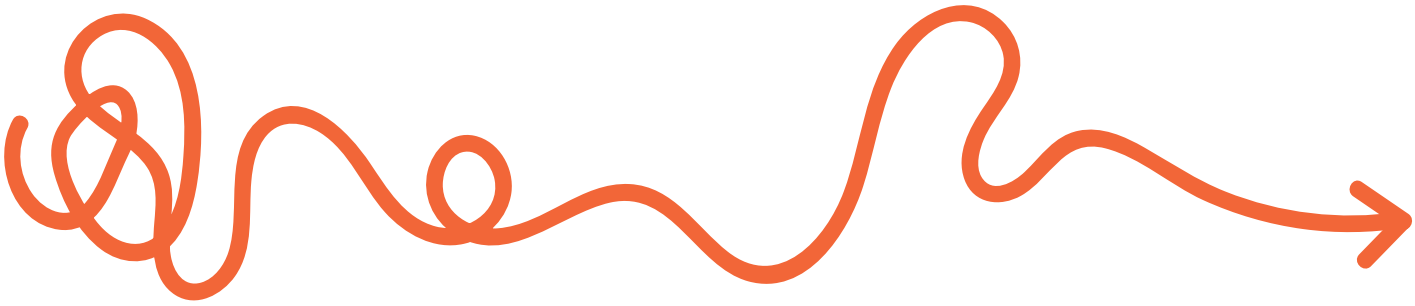


Figure 13. Strava comparing mileage across group members. Screenshot and information provided by author.

PART 4
POTENTIAL APPROACHES



PART 1
GROUNDWORK

PART 2
PRIMARY
RESEARCH

PART 3
INSIGHTS

PART 4
POTENTIAL
APPROACHES

POTENTIAL APPROACHES

From the literature review and the insights from the primary research, a few key themes were identified as common pain points for runners. Many solutions are possible, but the below principals should be considered and tested for the next generation of technology, with an aim of mitigating running-related injury.

PRINCIPLE 1

OPTIMIZING NOTIFICATIONS.

From the primary research, there was general consensus that individuals ignored some of the current available notifications on their devices, such as reminder to 'recover' that immediately follows the completion of a run. This makes providing injury-prevention notifications and education challenging.

The devices that athletes use to track their performances should ideally provide the necessary information in a well-timed manner. Presenting information during a run is likely to be met with frustration, and presenting information immediately after a run may be ignored as the individual may be experiencing runners high, or simply is moving onto their next task immediately. The notifications, such as the recovery time calculator, does not make it clear if these notifications are calculated as performance enhancing notifications, notifications built using personalized information, injury-prevention notices, or simply general suggestions. As an example, one participant indicated that they laughed at their watch recommendation to move, as they had just completed a marathon earlier that day. The watch recorded that a marathon was completed, yet still recommended a notification that would likely be ignored.

HOW TECH CAN HELP

Using the value human attention principle would be advantageous to incorporate into the design of a devices notifications, which is finding a seamless way to incorporate the respect of the individual's time and attention into the interface and interaction design.[116]

This could be done through finding an ideal time for the individual participant through prototyping design periods, or through an analysis of the individuals data to understand when the runner is most open to information.

There is an added challenge, which is overcoming optimism bias, or, the over anticipation of positive future events.[117] Optimism bias has plenty of desirable consequences, but also has a host of negative ones. These include decreasing the likelihood of getting a routine check-up, applying sunblock, or opening an emergency savings account.[118] 80% of the general population is estimated to exhibit an optimism bias regularly.[119]

Fortunately, there are methods to combat optimism bias through framing. Framing notifications in a positive manner rather than a negative one tends to have a stronger impact on people who exhibit an optimism bias. This would ideally help increase the likelihood of an individual giving attention and action to address important notifications.[120] To illustrate framing further, consider a runner and sports medicine physician interaction. The patient is likely to be more compelled to modify a training routine if the doctor describes the positive benefits from deviating from the plan, rather than the risks that are associated with not modifying.

A potential solution could be to begin by looking at ways to utilize notifications, such as through email, including timing, information provided, and further personalization. This would be useful as most running-related injuries are classified as overuse injuries and an immediate prompt to recover would not only irritate the user, but likely provide no immediate

116 'Value Human Attention'.
117 Sharot, 'The Optimism Bias', 6 December 2011.
118 Sharot, 'The Optimism Bias', 28 May 2011.
119 'Thinking about the Optimism Bias'.
120 Levy, 'An Introduction to Prospect Theory'.

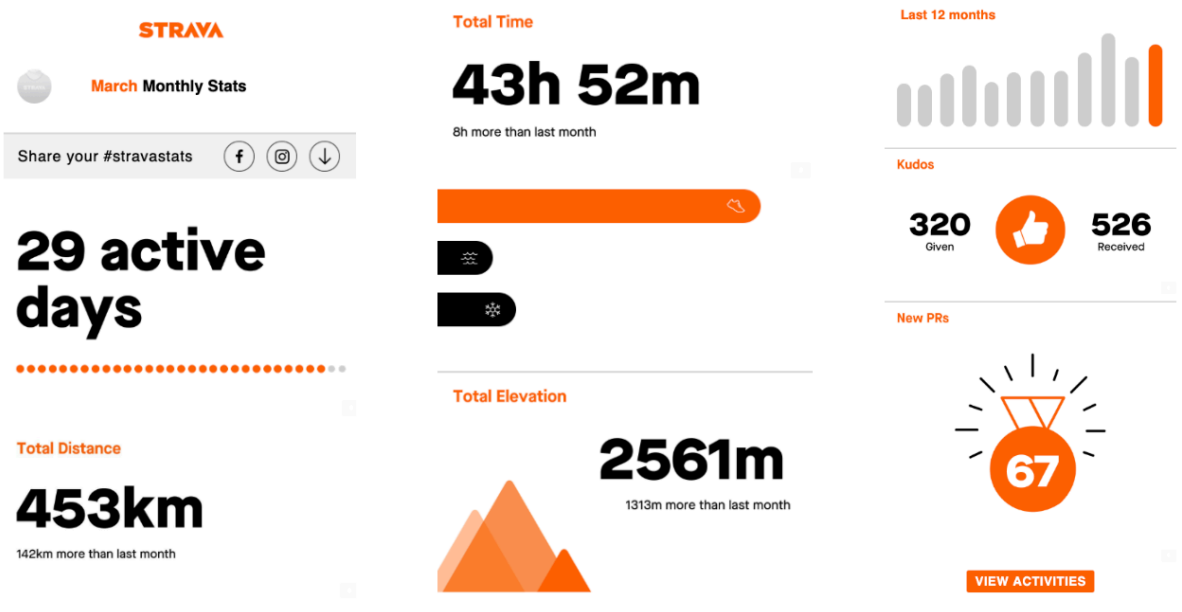


Figure 14. A Strava sample email of a monthly report on active days. Screenshots and information provided by author.

benefit in the short-term.[121] Consider a current email notification from Strava which is, a popular social networking application that is targeted to runners, cyclists, and other forms of fitness activities for sharing workouts with networks. Strava releases a monthly email with statistics for the individuals month, including days active, elevation, "kudos" or "likes" given and received, and any personal records achieved in the month. These notifications could instead be tailored to include injury-prevention notifications and messages, and be served to the user. These injury-prevention tactics could even potentially woven into the existing information presented, such as hours of monthly activity. The frequency of the notifications should also be considered, testing both weekly, biweekly, and monthly adjustments. Email open rates and other measured email tactics should be considered in the development of these notifications for optimal functionality for the user.

PRINCIPLE 2

DEVELOP DIGESTIBLE DATA

From the research insights, few participants have expressed satisfaction with how current information derived from running-related technologies is displayed to

121 Messier et al., 'A 2-Year Prospective Cohort Study of Overuse Running Injuries'.

them. This includes their watches, phones, and desktop applications. Statements such as “There are too many bells and whistles” were common sentiments shared during the primary research phase. A handful of participants, when asked about the use of specific more advanced features on their devices responded with, “You can do that? Can you show me?”.

Further exploration on some of the most common devices used (Garmin Connect desktop and mobile as well as Strava desktop and mobile being the most commonly cited) suggests that information tools do appear to be complex. For example, Insights on the Garmin mobile and desktop applications offer little more than statistics based on an individual versus people of their same age and gender, such as steps or distance. These insights are inactionable, appear to be strictly performance oriented, and offer unclear information of what to do with the information. On the Strava mobile and desktop application, there is more actionable analytics on load and load capacity. These however are currently offered just for users who pay a monthly or annual fee to access these analytics. Furthermore, these insights provide information but again, few actionable steps to prevent injury. Some of the latest watch manufacturers appear to be beginning to incorporate some of these features as well, however, they only appear to be available on higher-tier smart watches.

There is opportunity to develop a more human-centric way to explore, display, and develop actionable insights that ease frustrations and dissatisfaction amongst the users of these devices. Options that are ideally not behind a paywall, not only on the highest tier watches, options that have actionable next steps, and put injury prevention rather than performance at the forefront.

There is an added challenge beyond presenting the information in a human-centered way. Participants indicated that injury prevention was not top of mind and they are not actively taking preventative measures in their routine. With the combination of individuals feeling their technology is too complex while not having injury top-of-mind, this makes the development of a more

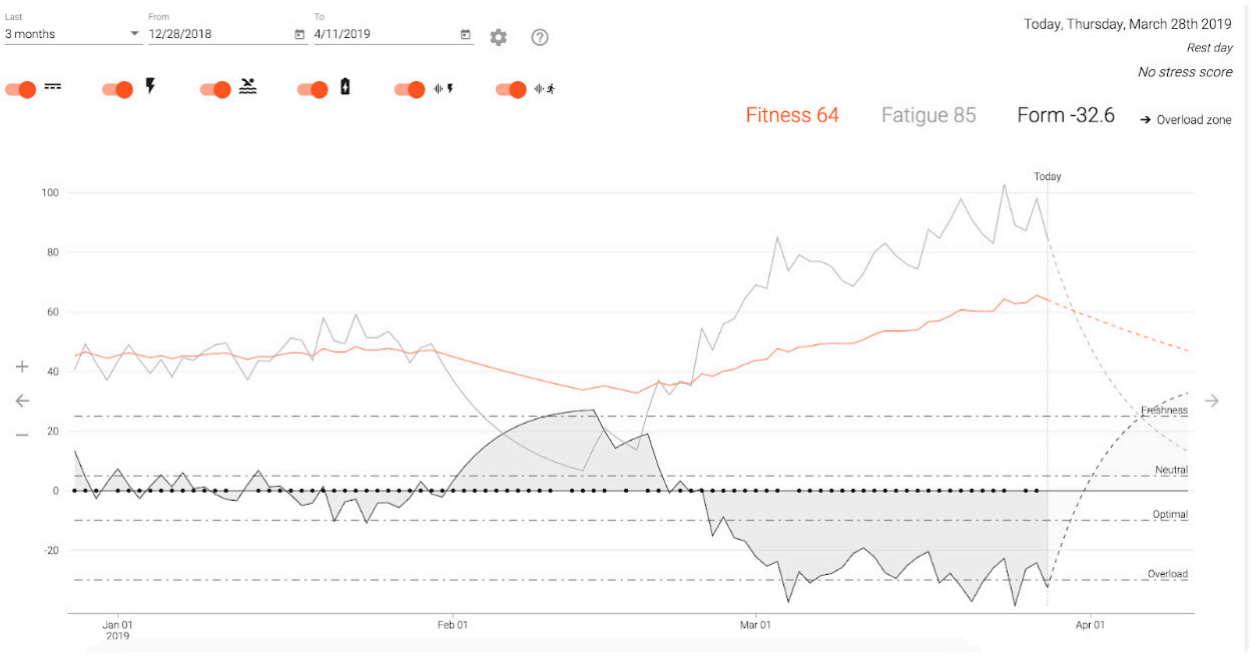


Figure 15. Sample of the 'Elevate' plug-in for Strava, showing 'Freshness', 'Neutral', 'Optimal' & 'Overload' charted. Screenshot and information provided by author.

human-centered calculator an extra challenge.

POTENTIAL SIGN OF DISSATISFACTION WITH STATUS QUO

There is currently a new and relatively unknown third-party plug-in for Strava called Elevate, which synthesizes Strava data and charts Fitness, Fatigue, and Form as a means to provide information to improve fitness and reduce the risk of overload/injury. These elements are mapped on a chart similar to training load and load capacity, pointing to potential points of overtraining and risking injury as a ways to either optimize performance or mitigate injury.

Fortunately, this application appears to be an improvement on the default charts and graphs by including elements such as 'Fatigue' and spelling out the risk of injury more front and centre, how the data is represented still requires a time investment to understand the graph to make decisions. This application, while only in operation since early 2018, appears to be making efforts to improve the usability and information that comes from Strava. This appears to be a further signal of the dissatisfaction with the current way key players like Garmin and Strava display information.

HOW TECH CAN HELP

Technology can aid individuals to make more informed injury-

prevention decisions. With an improvement in current available running-related tech, the way the information is displayed, and an increased accessibility for runners, running-related injuries could be mitigated.

Knowing that injury-prevention is not top of mind for individuals, technology can assist in ways to help educate and provide a synthesis of information for runners. This information should be available to the runner in real time through their device, mobile, and desktop application. Alternatively, as a way to have individuals begin to develop an understanding of their load and load capacity, a weekly/monthly digest could be used to track if the individual is approaching threshold.

As technology continues to advance, these injury-prevention features should be added into the load and load capacity calculator. This way, a runner's individual profile can be better reflected in the metrics being presented.

Ideally, as a load and load capacity model become clearer and more top of mind for a runner, the athlete may also benefit from a real-time indicator showing overload capacity through their watch. A potential solution could be to have an indicator that could work in two ways:

1. REAL TIME/NON-INTRUSIVE OPTION

Using the visibility of the system status user experience principle, an individual could have the ability to check-in during their run to see if they are approaching their load.[122] This would be a non-intrusive indicator as to ensure not to break the flow state of the athlete, which was a commonly marked pain-point from the primary research.[123]

2. NOTIFICATION/DELIBERATE OPTION

If an individual is concerned about approaching their threshold actively, and they want more than a more deliberate notification, they should be able to set a notification for when they are approaching threshold. Similar features presently exist on many GPS enabled watches today, which use a tone or vibration to indicate if an athlete is above/below pace or heart rate. This existing feature can be adapted to focus on injury-prevention.

122 'Visibility of System Status'.
123 Csikszentmihalyi, 'FLOW: The Psychology of Optimal Experience'.

PRINCIPLE 3

RUNNING MATCHMAKER

There are large social networks dedicated to athletes where photos, workouts, and routes can be shared with friends. Similar to popular social networking sites, users can scroll infinitely (similar to social applications like Facebook and Instagram) through posts and updates from friends and offer likes and comments on posts.[124] These environments, like the popular application Strava or Runkeeper, provide motivation and a way to track personal information. One of the drawbacks to a performance oriented sharing environment is that individuals naturally try to seek accurate self-evaluations of themselves, and this is done through social comparison.[125] Many runners, especially those who are comparing themselves with others unlike themselves, will be competing on uneven playing fields. For many, the social comparison can cause stress and anxiety, which is not good news for an individual's mental health.[126] This is important, as many of those who participated in the research felt their mental health improved through running.

These sentiments were strongly reflected in the primary research. For some, Strava was a motivator and provided an overall positive place for runners to keep track of one another, with sentiments such as, “I love keeping track of my friends that I don’t run with anymore. Then we see each other at races and it still feels we have a pulse on one another's lives. It’s also fun, I have people I follow who I recognize because of Strava even though we’ve never met in real life.” Strava for others was not viewed as favourably. The environment provides rich territory for social comparison, a feeling of missing out, and a negative place for one’s mental health when a runner is injured. Some of these sentiments include, “I had to take a break from Strava. When I was injured, it felt like everyone was progressing and doing races and I was left behind. I had to stop obsessing.”

The sentiment of being left behind in fitness progression is strong

124 ‘Dashboard | Strava’.
125 ‘Downward Social Comparison (SOCIAL PSYCHOLOGY) - IResearchNet’.
126 ‘Social Comparison In Sport - Sports Psychology - IResearchNet’.

in the primary research, especially as maintaining endurance while injured is challenging.[127] Many runners indicated that they returned to running too fast after injury, as they didn't want to fall behind or lose fitness. This feeling of falling behind, coupled with environments that foster social comparison, can be detrimental. An individual can push too hard to keep up with peers causing injury, or push to return to running faster than recommended.

HOW TECH CAN HELP

Understanding that people naturally compare themselves to others, it may be beneficial to mold the environment on running specific platforms, such as Strava.

Fortunately, these environments host an immense amount of data which could be used to match runners with a pool of people most similar to themselves. The formula could algorithmically pair individuals with similarities like age, gender, VO2 max, weight, number of kilometers run in a season, and other factors. This would be beneficial, as individuals comparing themselves against others would ultimately be using a more realistic comparison. Currently, the Garmin Connect application has a version of this but just maps age and gender against others using Garmin Connect.

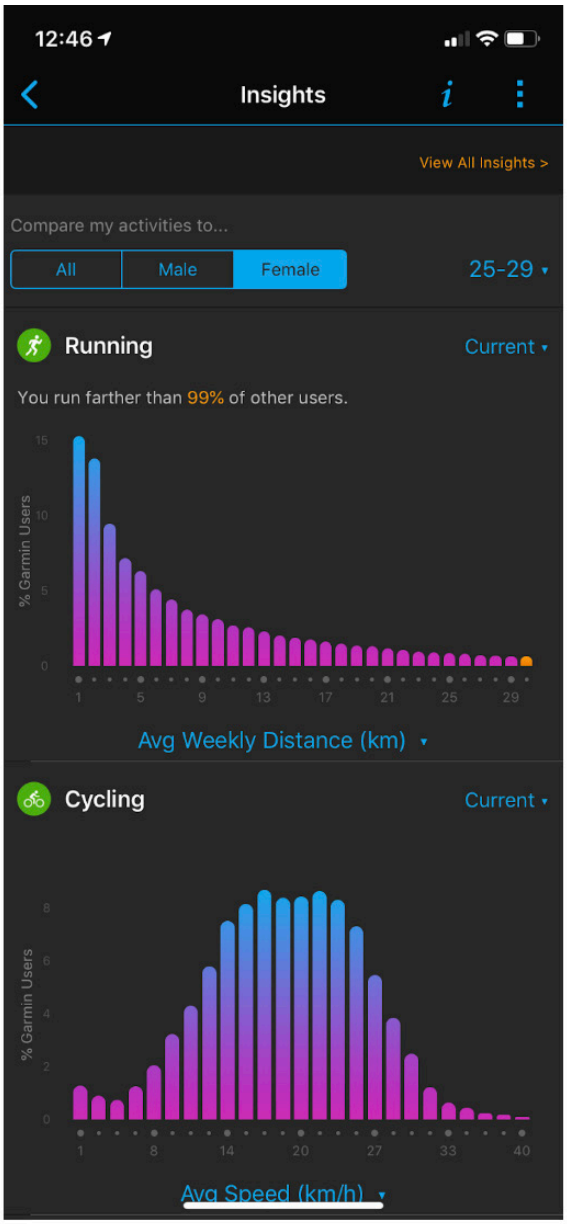


Figure 16. Sample of Garmin Connect 'Insights' comparison page. Screenshot and information provided by author.

127 'Returning to Exercise After Injury'.

A secondary or additional way to help ease social comparison would be to provide an option of masking the data of peers using age grading. Age grading is a formula that allows runners to compare performances against all runners, regardless of age and gender.[128] This is particularly useful, especially as with age a runner's performance decline.[129] An example of age comparison in action would be to look at the world famous Canadian distance runner Ed Whitlock, who completed the Scotiabank Waterfront Toronto Marathon in 2016 with a time of 3 hours and 56 minutes. While a performance of 3 hours and 56 minutes may not seem particularly elite, it is considering Ed Whitlock was 85 years old.[130] Using age grading, that time is equivalent to a 2 hour and 7 minute marathon, which is just 6 minutes over the current world marathon record for men.[131]

Providing a pool of similar runners and/or using age-grading, may mitigate running-related injuries that stem from social comparison.

PRINCIPLE 4

IMPROVE TABLE STAKES

While the way recreational runners interact with technology has room for innovation, there are still table stakes that need to be improved. From the primary research, many individuals stated an underlying frustration with where the technology currently stands. Without improvement in these areas and breakthroughs in more human-centred design, efforts to prevent injuries through technology may not be realized.

Some of these "table stakes" requirements include:

128 Mateo, 'What Exactly Is Age Grading and Why Does It Matter?'
129 Ransdell, Vener, and Huberty, 'Masters Athletes'.
130 'Masters Legend and Canadian Record Holder Ed Whitlock Dies at Age 86'.
131 'World Records Ratified| News | Iaaf.Org'.

1. SIMPLICITY

An overwhelming majority of users stated that they felt they do not use their running technology to its fullest capacity. When asked further, many stated that technology was either too confusing, too complicated, the font was too small, or the metrics were indecipherable. Without a clearer user experience in a place that aids in the individual going for a run, further technological improvements may increase these frustrations further.

"I don't want more bells and whistles. I want my watch to make it easier for me to go out and just forget about technology."

2. ACCURACY AND RELIABILITY

Accuracy and reliability is a key concern for athletes, even at the recreational level. From the primary research, both accuracy and reliability were raised multiple times as the most important part of technology. One of the key frustrations with individuals, specifically those who did not use a smart-watch but instead use a phone app to track workouts, was that they felt their phones were less trustworthy compared to a GPS enabled watch.

"There is nothing more frustrating than Strava misrecording my pace or distance. It happens downtown all of the time!"

3. FASTER GPS CONNECTIVITY

A few individuals stated that they become frustrated with their running technology due to how long it takes to connect to a satellite for them to begin their run. This was a stated problem for those who used GPS enabled watches but did not seem to be an issue for those connected via smartphone on popular fitness recording applications, such as Nike+ and Strava.

CONCLUSION + WRAPPING IT UP

FUTURE CONSIDERATIONS

SEGMENTATION

There are a multitude of beneficiaries to the continuation of a healthy running-related routine for stakeholders, including the individual runners themselves and the well-being of the healthcare system. There is an additional level advantage that could be realized through the collection of data.

HEALTHCARE PROVIDERS

With technology collecting a host of individual factors, such as distance, pace, heart-rate, elevation and more, healthcare providers in Canada could use this data as a way to further diagnose or manage running-related injuries. With information being shared and co-managed between the runner and the healthcare provider, care plans could be tailored and injury-indicators managed by both parties. This notion approach appears to have salience in the healthcare community, as the growth in wearable technology watches is predominantly due to healthcare providers beginning to utilize this technology.[132]

RUNNER SEGMENTATION

Data collected through technology has benefits for runner segmentation as well, which can be utilized by the application collecting data for further segmented and more personalized injury-prevention strategies. This is important as there are many different types of runners, which could be divided into different groups for more personalized injury-prevention strategies. For example, injury-prevention approaches could vary for individuals who are exclusively treadmill runners, seasonal runners, or those who routinely race. Data could also be segmented by average weekly distance, which could provide further insights into injury-prevention techniques for different groups.

132 'GPS Fitness Device Market Size - Industry Share Report, 2023'.

FINAL NOTES

There is well-documented evidence and research backing the benefits of Exercise and running as a way to manage health. The endorphins that provide a runner's high, being outdoors in nature, being social, and setting goals, are all part of a fairly comprehensive toolbox that can help manage stress, anxiety, and depression amongst other conditions. However, running is not the solution to every problem.[133]

When running is used as the primary way to cope with stress, anxiety, or other depressive symptoms, injury can derail an individual's mental health care plan, especially if the individuals' way of habitually coping is disrupted.[134] This is a concern when it comes to preventing injuries, as many individuals continue to resume exercise at the expense of their treatment plan as a way to feel an, “instant reduction in the negative psychological feelings”.[135] This, if further injury is sustained, creates a negative feedback loop of becoming injured, becoming stressed, and subsequently resuming exercise too soon, furthering injury, furthering stress. Running should be thought of like the maintenance for an individuals health, but not the cure.[136]

Figure 17. Systems diagram showing the a negative-feedback loop of returning from injury too early.

133 ‘The Shakeout Podcast’.
134 Egorov and Szabo, ‘The Exercise Paradox’.
135 Baron, Reardon, and Baron, Clinical Sports Psychiatry.
136 ‘The Shakeout Podcast’.

CONCLUSION + NEXT STEPS

This research is just the beginning of potential ways to help mitigate running-related injuries. These ideas should be treated as thought starters or a foundation for further research, as these potential solutions have not been prototyped and vetted with the experts in the field, the runners, healthcare providers, and fitness tech developers themselves.

These insights and potential solutions ideally would inspire a user experience team, or product designer, to design and iterate on technology products that are aimed at more than the current technology offers. Technology that can prioritize injury-prevention rather than just athletic performance, and technology that can help people achieve their running goals while staying healthy.

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APPENDIX A

INITIAL INTERVIEW QUESTIONS

1. Why did you start running?

2. Why do you continue to run?

3. What is the best part of running?

4. What is your least liked part of running?

5. Tell me a time that an injury has impacted your training or running routine.

6. Have you ever pushed through an injury? If so, what happened?

7. Have you ever ignored the advice of a professional and continued to run through injury?

8. If you've had to take time off from running due to injury, how do you handle being off your running plan?

9. What has been the hardest part of recovering from a sports-related injury?

10. Would you like to share anything else about sports-related injuries?

11. Do you wear a running GPS watch? If so, what are the measures you use? [If not, skip to question 14]

12. Would you say you use your GPS watch to its fullest capacity?

13. Is there anything you dislike about your GPS watch?

14. Tell me a time your apparel has let you down. How did it let you down?

15. Tell me about your go-to running apparel. Why do you like it?

16. Tell me an innovation you've made when your apparel doesn't meet the requirements of your workout (for example, not having enough carrying

capacity for gels, or not having a water container large enough).

17. Are you brand loyal?

18. Are you superstitious with running? (For example, do you not wear or buy race gear from a race you haven't completed yet?)

19. Do you prefer to run alone, or in a group?

20. What is your pre-run routine? Pre-race routine?

21. You're racing out of town and forgot an item. Luckily, you can replace it/go without it before the race. What is the worst thing you could possibly forget at home?

   a. Shoes

   b. Watch

   c. Tried and true apparel

   d. Gels/nutrition

22. Do you have a running mantra when things get tough? If so, what is it?

23. Do you read running books? If so, what has been the most impactful?

24. What have you learned about yourself through running?

25. Want have been some surprising benefits about long-distance running?

26. What have been some surprising downfalls about long-distance running?

27. Is there anything else you'd like to share about sports-related injuries, running, apparel, or technology?

APPENDIX B

CULTURAL PROBE / "RUNNING KIT"

PROMPTS

I started running because...

I continue to run so that...

My favourite part of running is...

Sports-related injuries are...

When an injury gets in the way of my run/race, I feel...

What frustrates me the most about running is...

I really like wearing _____ on my runs, because...

I feel like my running technology could benefit from...

I feel most accomplished when...

When I run, I like to think about...

I tend to injure myself more often when...

I believe I could avoid injury by...

PHOTO OF FULL KIT

PHOTO OF MAP, FOLDED.

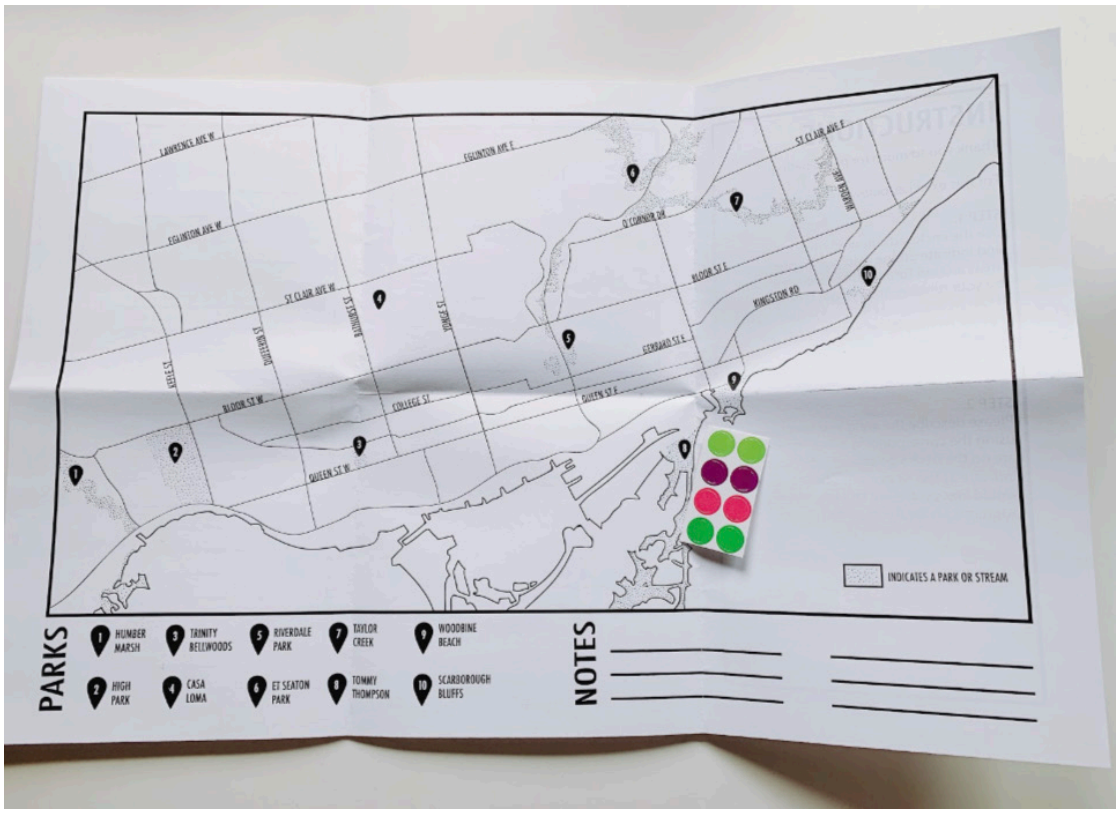

PHOTO OF MAP, UNFOLDED WITH STICKERS.

APPENDIX C
SECONDARY INTERVIEW QUESTIONS

1. Tell me about your favourite piece of technology. This does not have to be running related.

> Why do you love it?

> How long have you used it?

> Do you still use it? If not, why did you stop? What do you do now instead? What do you dislike about it?

2. Do you use a voice assistant? (i.e. Google Home, Amazon Alexa, Siri at home or on your phone?)

> If yes, please tell me about what you like and dislike about it?

> Why did you purchase the voice assistant you chose?

3. Thinking about running technology, do you feel like you benefit fully from your watch?

4. What measures (distance, heart-rate, etc.) do you use on your watch? What do you do with that information? What insights do you come up with from this info?

5. Do you dig deeper into the information through your GPS watch app? (SPM, cadence, etc.)

6. Do you connect with third-party applications? (i.e. Strava, MyFitnessPal)

> What do you do with the third-party app?

> What is your top 2-3 most used features and why?

> What is your least favourite feature and why?

7. Thinking about your running watch, why did you choose the watch you're using?

> Would you select that watch again?

> What do you like about it?

> What do you not like about it?

8. Have you ever used another watch? If yes, why did you switch? What pulled you towards your current watch? Did it meet your expectations? Was there anything holding you back from making this switch?

9. Does your GPS watch include push-notifications from your phone? i.e. text messages, emails, etc.?

> If yes, was that an important feature for you?

> If yes, please tell me about your thoughts on having those features integrated.

Do you have any additional thoughts you would like to share on technology and sports in general? If so, I'd love to hear it.

APPENDIX D

ADDITIONAL NON-TECHNOLOGY FOCUSED INSIGHTS

1. THE IMPORTANCE OF NATURE

Nature appears to be a key driver for the participants researched. While landmarks such as a building were sometimes cited as important, more often participants indicated special trees, rocks, or views that they enjoyed as part of their running route. Participants also indicated that being amongst nature, especially in large parks and trails like the Tommy Thompson Park in Toronto were important in allowing them to feel like they are not in the city and have "escaped".

"Being able to run by lake Ontario is magic"

"I love being able to watch the sunrise/sunset from the boardwalk"

"I can appreciate my surroundings when I run"

2. COMMUNITY BUILDING

The Running Room, a popular running store across Canada, appears to have been instrumental in the development of creating running communities. Most participants indicated that they began running with The Running Room, either through their weekly group runs, or through their more formal running "clinics", which are programs designed to teach people how to run short or long distances. The community building that The Running Room provides seems to

be instrumental in developing runners at the onset of their running careers.

3. CROSS-TRAINING

Cross training, or training that can supplement running that tends to ultimately improve running, appears to have wide recognition as a point of a way to prevent running-related injuries. Many participants indicated that they felt they had to do more cross-training but were unsure how much to add to their already packed running routine. Furthermore, many indicated that they dislike doing cross-training as it tends to be a solo exercise, and many participants enjoy running with friends or in a group.

4. INJURIES ARE UNAVOIDABLE

Many participants indicated that running-related injuries were unavoidable, and that as you age, they tend to happen more frequently. Very few people interviewed felt that injuries could be completely prevented, but there was a general attitude that injuries were a matter of when they would happen, and not if they would happen.

5. GOAL SETTING

From the participants interviewed, many indicated that running was a great way to set and achieve short and medium term goals. Many indicated that work and other feats such as buying a house were longer term goals, and running allowed shorter and medium term goals to be realized.

6. FEELING LIKE AN ATHLETE

Most participants indicated that they were not active as children or youth, and that they picked up running later in life. Running for allowed them to “feel like an athlete”, and grow into a person they felt was reserved for those who were active throughout their youth.

“I was never expected to do anything active in my life”

“I was not active as a child. I was much nerdier and into books, I was not a jock who did sports”

“It makes me feel young”

“I feel ALIVE”

7. LOSING WEIGHT

An almost overwhelming majority of participants began running with the goal to lose weight, but the sport eventually evolved into much more as they made it part of their routine. Friends, mental health, and achievement seemed to be key after the individual began running.