TrailGuard

Advancing Hiking Footwear for Optimal Comfort and Safety

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2023

TrailGuard: Advancing hiking footwear for optimal comfort and safety.

A thesis presented in partial fulfilment of the requirements for a Master in Design at Massey University, Wellington, New Zealand.

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ABSTRACT

Tramping, known elsewhere as backpacking, rambling, hill walking or bushwalking, is a popular activity in New Zealand. Tramping is a uniquely New Zealand term and is defined as a recreational activity involving walking over rough country. The recent lifestyle developments and upgrading of many tracks in New Zealand have led to an increase in popularity within tramping. It is evident that this outdoor activity significantly contributes to injuries in adventure tourism in New Zealand. With recorded injured body parts being in the lower extremities of the body, this suggests that the type of footwear used on these walks may have an impact on the occurrence of injury among trampers.

The aim of this practice-based design project is to develop a performance hiking footwear solution that has integrated pain/injury reducing features to sustain the user when hiking on rugged uneven terrain to elevate their user journey and experience. Through iterative design and research methodology, this project outlines how the redesign of hiking footwear can lead to an innovative solution that accommodates the users wants and needs when it comes to reducing pain, discomfort, and injury whilst on the trail. The design outcome consists of key componentry prototypes and an integrated system for hiking footwear. Understanding specified performance requirements and human physiology allows design to extract insight, advancing design technology for further development and application.

ACKNOWLEDGEMENTS

I would like to give a big thanks to friends and family that helped keep me motivated throughtout this research project.

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INTRODUCTION

Following my award-winning honours project Stryde: Footwear for nurses, I decided to grasp at the opportunity in developing my footwear design process by pursuing a Master of Design research project. What sparked the decision for this specific research topic stems from an unpleasant experience I had when tramping one of New Zealand's Great Walks. Over a 3 day walk I experienced extreme discomfort and chronic blisters that had developed due to my hiking boots. As a footwear designer, I naturally had the incline to question the cause of this experience and how footwear design may have influenced this outcome.

Tramping, known elsewhere as backpacking, rambling, hill walking or bushwalking, is a popular activity in New Zealand. Tramping is a uniquely New Zealand term and is defined as a recreational activity involving walking over rough country, including day walks, day hikes, day tramps and any overnight walking. Walkers often carry a backpack and wet-weather gear, and may also carry equipment for cooking and sleeping when taking part in overnight/multi-day hikes. The recent developments and upgrading of many tracks in New Zealand has led to an increase in popularity within tramping, but previous research has shown that this outdoor-activity significantly contributes to injuries in adventure tourism here in New Zealand (Lobb 541). With 65% of the injured body parts being in the lower extremities of the body (Lobb 542), this suggest that the type of footwear used on these walks may have an impact on the occurrence of injury among trampers.

The aim of this research is to Investigate what trampers/hikers experience and need from their footwear to prevent /reduce current and ongoing injury/pain. Integrate these findings through footwear design to propose an innovative solution that includes end-users' wants and needs to help reduce injury/pain, along with performance advantages. My research methodology addresses 5 research questions: How does foot anatomy behave when hiking? What are key footwear related injury types when hiking? How have different footwear design brands addressed reducing pain/injury through their designs? How can footwear design be utilised to reduce pain/injury? Would the redesign of a hiking shoe provide benefit to end-users?

I took a heuristic approach to this study, using insight identified in my research context to direct my investigations into the key elements relevant to designing footwear for trampers/hikers, through primary research and research through design.

Qualitative/primary research was undertaken to gain connection with, and insights by: Immersive research partaking in hiking certain track categories and self-journaling experience and findings. Developing an online user survey to gain insight on end-user information, user characteristic traits, opportunity, and user wants and needs. Interviewing specialists in foot health to further understand how the foot behaves and cause of injury/pain

In the following exegesis I look deeply into the factors and influences of pain and injury experienced among trampers. This research acts as the basis for an iterative design process that analyses whether footwear design can be utilised to reduce the occurrence of pain and injury alongside providing optimal comfort while out on the trail. TrailGuard is the resulting design response in providing optimal comfort and safety within hiking footwear.

1.0 CONTEXT REVIEW

1.1 Market Overview

The New Zealand Mountain Safety Council (MSC), a national organisation with a mandate to encourage safe participation in land-based outdoor activities, states that 1,539,133 people tramped in New Zealand during 2017 ('A walk in the park?' 6), with the average New Zealander completing 8 trips per year. These vast amounts of participatory rates indicate the market size present for hiking footwear.

Through market analysis, I was able to identify and visually represent current popular hiking footwear types and models shown in Fig.1, portraying a spectrum of hiking footwear comparing price range linked to functionality. From this, I learned that at the lower price range the footwear usually consists of the trail-running type that uses engineered materials that are not always waterproof and considered durable. Moving towards the high-cost end of the price spectrum are more technical high-ankle hiking boots with specialist materiality such as carbon-fibre, leather, and Kevlar which is essential to create the rigidity and support needed for the uneven trail. Comparatively, Anderson (250) argues that "increasing rigidity of (hiking) footwear is also associated with increasing prevalence of paraesthesia...which is characterised as a painful burning, tingling, or numb sensation caused by compression and/or repetitive trauma of a peripheral nerve" (Anderson et al. 252). Fig.1 shows a niche target market where there is potential for a new type of hiking footwear that bridges the gap between trail-runners and hiking boots, having the mobility of a trail-runner, and the durability, functionality, and support of a hiking boot. More recently, researchers have understood that "stiffer cuffs reduce the ankle range of motion and reduced the walking efficiency by enhanced co-contractions primarily of knee spanning muscles" (Schwameder et al. 203). This provides insight on how hiking footwear can be redesigned to help elevate user experience despite traditional footwear design ideologies.

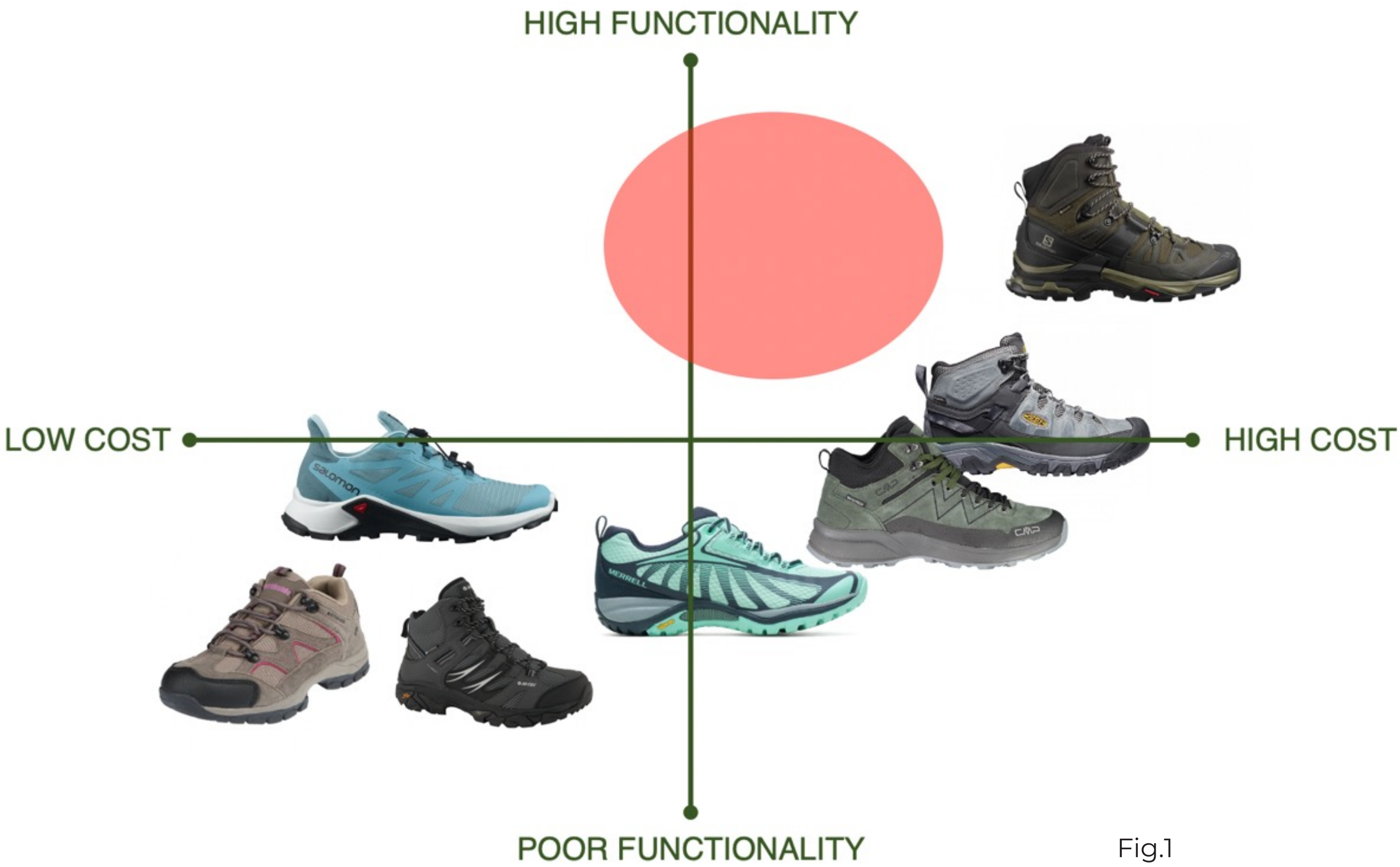


Fig.1

1.2 TRENDS

Considering that hiking footwear is a reference to footwear used in an outdoor environment, usually on a hiking trail, it is important to understand the current trends and types of hiking footwear to help determine the prevalence and predictors of injury and if type of footwear has an effect. Medicine physician Dr . Lee Anderson conducted a cross-sectional study of long-distance hikers along the Appalachian and Pacific Crest Trails to determine the impact of footwear and pack-weight on injury and illness (Anderson et al. 250). A notable demographic characteristic from Anderson's research is the footwear type used by hikers who had walked this trail. What is striking about this data (Fig.2) is that 38.1% of participants opted for trail running shoes over hiking boots (34.9%).

Anderson et al. suggest that users are opting for less rigid footwear rather than traditional hiking boots as a result of the trend 'ultralight hiking', "as a way of increasing mileage and decreasing injury" (251). Ultralight hiking equipment usually consists of the lightest and least amount of gear. Users have also been known to personally modify their equipment to achieve a more comfortable and lightweight experience. Usually constructed from lightweight engineered materials, ultralight hiking equipment is designed to supply the essential needs, whereas traditional hiking has a "heavy boots and heavy pack" (Anderson et al. 255) mindset.

Fig.3 (Anderson et al. 254) reveals that there is a significantly higher percentage rate of injury between hiking boots and users experiencing paraesthesia, compared to other footwear types used whilst hiking. What is also interesting in this chart is the high percentage of joint pain injury among those opting for trail running shoes. Therefore, although Anderson et al. claims that less rigid hiking footwear will result in reduced paraesthesia, they fail to acknowledge the rate of joint pain injury with trail running shoes, which may be a risk of the 'ultralight hiking' trend. These injuries are often due to inadequate support around the ankle joint area, where it may be crucial for walking on uneven terrain. Referring back to Fig.3, the dominant rate of users opting for a lighter option of footwear will likely increase the prevalence of joint pain/injury after 2030, based on the statistic provided in Fig.3 Using design to help bridge the gap between traditional and ultralight hiking will be key to reduce pain/injury and elevate user comfort and experience.

Fig. 2


34.9%
Hiking boots
5.6%
Sandals
38.1%
Trail running shoes
21.4%
Low hiking shoes

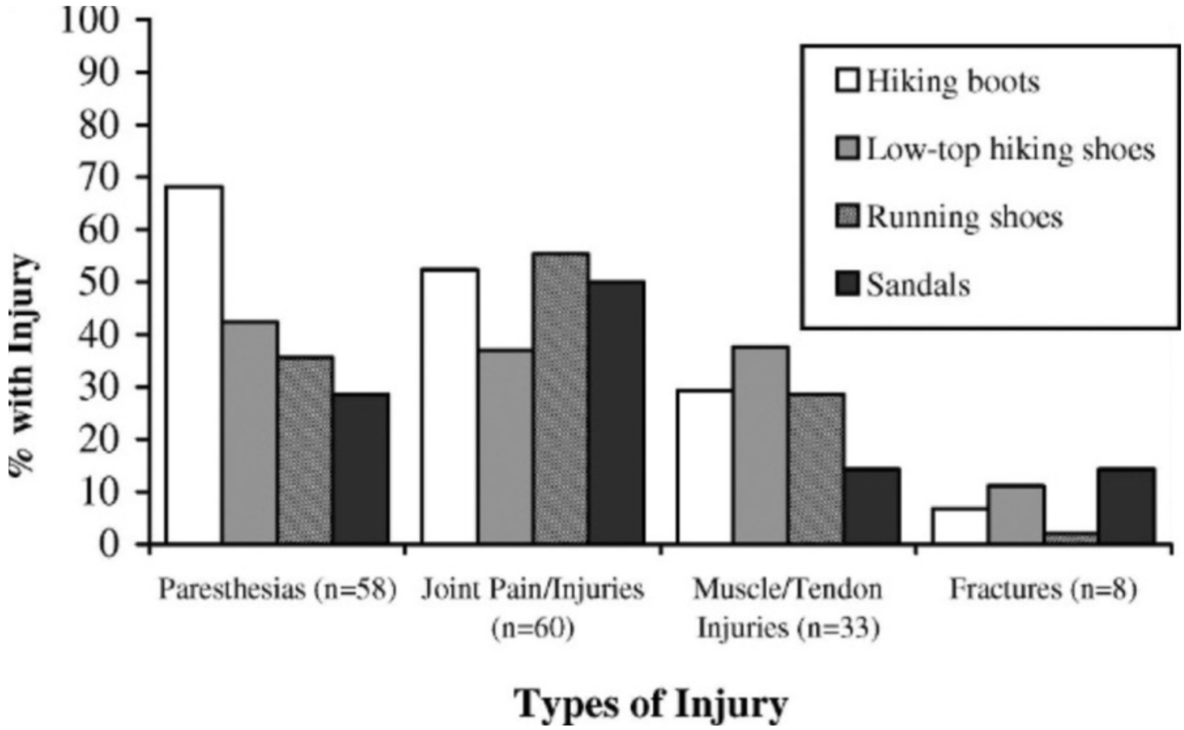

% with Injury
100
90
80
70
60
50
40
30
20
10
0
Hiking boots
Low-top hiking shoes
Running shoes
Sandals
Paresthesias (n=58)
Joint Pain/Injuries (n=60)
Muscle/Tendon Injuries (n=33)
Fractures (n=8)
Types of Injury

Fig. 3

1.3 BEHAVIOUR OF FEET

Anatomy

The foot is a complex structure composed of 26 bones, 33 joints, and more than 100 muscles, tendons, and ligaments, allowing for various movements and functions (SportsMED). The foot anatomy consists of three main parts: the hindfoot, midfoot, and forefoot. The hindfoot is composed of the calcaneus (heel bone) and talus (ankle bone), which connect the foot to the leg. The midfoot is composed of five bones, including the navicular, cuboid, and three cuneiform bones, which serve as the foundation for the arches of the foot. The forefoot is composed of the metatarsal bones and phalanges, which form the toes (Riegger 1810). The ankle joint connects the foot to the leg and allows for plantarflexion and dorsiflexion movements, which are essential for walking and running. The subtalar joint, located between the talus and calcaneus, allows for inversion and eversion movements, which are important for maintaining balance and stability (Riegger 1803). The muscles of the foot are divided into two groups: extrinsic and intrinsic. The extrinsic muscles originate in the leg and extend into the foot, while the intrinsic muscles are located entirely within the foot. The extrinsic muscles include the gastrocnemius, soleus, and tibialis anterior, while the intrinsic muscles include the plantar fascia, abductor hallucis, and flexor digitorum brevis (Manganaro et al. 2.).

Biomechanics

The biomechanics of hiking are complex and influenced by various factors such as terrain, slope, speed, and footwear. The lower extremities are subjected to significant loads during hiking. Voloshina et al. (3963) found that hiking downhill results in greater knee and ankle flexion and extension than hiking uphill or on level terrain. This increased range of motion places greater demands on the musculature of the lower extremities, which must work to stabilize the joints and attenuate impact forces. Contrastingly, studies by Wannop et al. (1221) have shown that hiking uphill requires greater knee and ankle flexion to increase stride length and maintain stability. Regardless, footwear is undoubtedly an important factor in the biomechanics of hiking. Hiking boots and shoes provide support, stability, and traction on natural terrain, reducing the impact forces on the lower extremities. Wannop et al. (1221) found that hiking boots with thicker treads and stiffer soles reduce the risk of ankle sprains and knee injuries, while Kersting et al. (1) highlighted the need for footwear design to consider the specific demands of hiking and trekking

R.O.M

During hiking, the foot undergoes a wide range of motion as it adapts to changes in terrain and slope. The ROM of the foot is particularly relevant during uphill and downhill hiking, as these activities place greater demands on the musculoskeletal system (Fong et al. 6). Uphill hiking requires the foot to dorsiflex (lift the foot upwards) to increase stride length and maintain stability. The ankle joint must be able to dorsiflex to allow the foot to come into contact with the ground and provide a stable base for the body (Boone & Azen 757). The ROM of the ankle joint, therefore, plays an important role in uphill hiking. Downhill hiking, on the other hand, requires the foot to plantarflex (point the foot downwards) to absorb shock and maintain balance. The ankle joint must be able to plantarflex to allow the foot to maintain contact with the ground and attenuate the impact forces generated during descent (Boone & Azen 757). The ROM of the ankle joint, therefore, also plays an important role in downhill hiking. In addition to the ankle joint, the ROM of other foot joints is also relevant during hiking. The subtalar joint, for example, allows for inversion (turning the foot inward) and eversion (turning the foot outward) movements, which are important for maintaining stability during uneven terrain. The metatarsophalangeal joints, located at the base of the toes, allow for flexion and extension movements that are important for maintaining balance during propulsion (Fong et al. 8). Overall, the ROM of the foot is important for maintaining stability and mobility during hiking, particularly during uphill and downhill activities. A lack of ROM in any of the foot joints can lead to compensatory movements or altered gait patterns, increasing the risk of injury (Williams & Nester 5). Therefore, understanding foot ROM and its relevance to hiking biomechanics is important for designing footwear to improve hiking performance and reduce the risk of injury.

1.4 TRAMPING/HIKING INJURIES

Hiking is a widely embraced outdoor activity that provides various health benefits. However, inadequate hiking practices, including inappropriate footwear selection and design, can result in a range of injuries. These injuries can range from minor blisters and abrasions to severe ankle sprains, foot and toe injuries, and even fractures. Factors such as terrain, footwear characteristics, and individual fitness levels can impact the nature and distribution of such injuries, with growing prevalence of hiking injury in New Zealand being supported with data acquired from the New Zealand Mountain Safety Council (MSC), stating:

“Over ten years (01/07/07-30/06/17), 40,199 people went to a medical practitioner for an injury sustained while tramping. 80% of these were for damage to a muscle, ligament or tendon (categorised as ‘soft tissue’ injuries)(Fig5). 68% of all injuries were caused by a slip, trip and/or fall”- (MSC 16), which is an 83% increase in reported injuries over the last 10 years.

A further example of the prevalence of hiking injury within New Zealand, is Lobb (2004) exposing that “Injuries were reported by 74%, with sprains being the most common injury type and knees, ankles and feet (65%) the most frequent location of injury” (541). Whereas the data collected by MSC (2018) explains that almost half (46%) of the key injury areas on the body occurred in the knees and ankles (Fig. 6). This suggests that the redesign of hiking footwear may have a significant effect in helping reduce overall injury/pain in the lower extremities of the body.

Key injuries

!The types of injuries experienced by hikers reflect the physical demands of this activity, and are defined in research as either acute or chronic injuries (Chrusch and Kavin 327). Acute injuries are often associated with an event that causes sudden trauma to the body, such as a fall or a misstep. In hiking, this can happen due to uneven terrain, obstacles on the trail, or environmental factors such as weather conditions. Biomechanical analysis of hiking can reveal how the body moves and interacts with the environment (Voloshina et al. 3963), which can help identify potential risk factors for acute injuries. For instance, research has shown (Lobb 545) that ankle sprains are one of the most common acute injuries from hiking in New Zealand with a 16.6% occurrence rate . This is often caused by the instability of the ankle joint when stepping on uneven surfaces. A further example on the prevalence of ankle injury where Kersting (2) states that:

“Ankle sprains are the most common outdoor activity related musculoskeletal injury

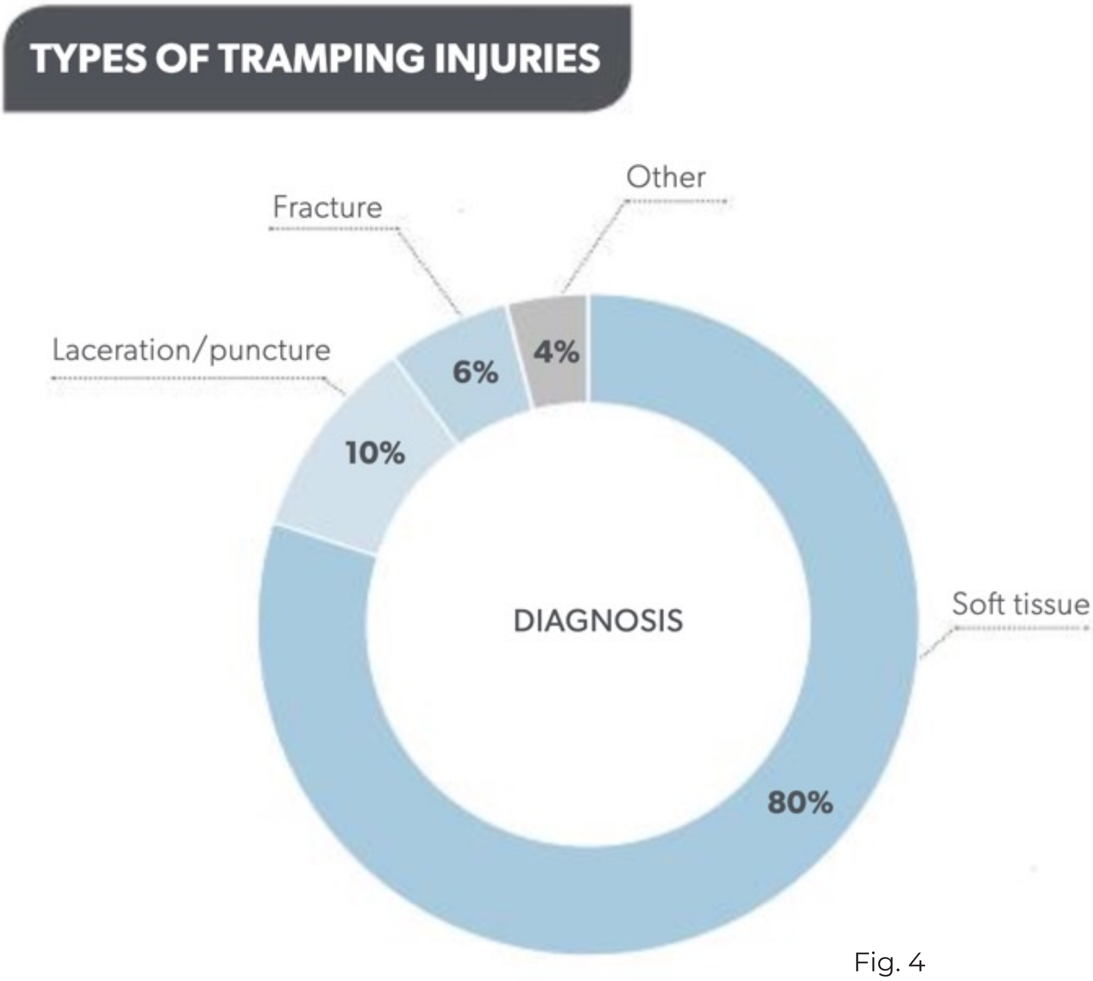

TYPES OF TRAMPING INJURIES
Other
Fracture
Laceration/puncture
4%
6%
10%
DIAGNOSIS
Soft tissue
80%

Fig. 4


TOTAL INCIDENTS
40,199
INJURIES
3,004
3,407
3,415
3,437
3,632
3,729
4,124
4,575
5,372
2007-2008
2008-2009
2009-2010
2010-2011
2011-2012
2012-2013
2013-2014
2014-2015
2015-2016
2016-2017

Fig. 5

with downhill walking being one of the main risk factors. Footwear that limits the ankle range of motion (ROM) is thought to protect against ankle sprains as most ankle sprains occur due to inversion. Footwear for outdoor activities is therefore designed to control the ankle ROM by adding shafts of various height and stiffness. Both features limit ankle motion and have therefore been proposed to protect against ankle sprains." (Kersting et al. 1)

Chronic injuries, on the other hand, are often associated with overuse and repetitive stress on a particular body part. In hiking, this can happen due to the repetitive nature of walking and the constant strain on the lower extremities. Physiological analysis of hiking can reveal how the body adapts to the stress of hiking, including changes in muscle activation, joint loading, and energy expenditure (Voloshina et al. 3964). Research by Chrusch and Kavin (327) has shown that blisters are the most common chronic injury in hiking, and accounted for 64% of the medical complaints suffered by hikers in their study. Blisters are commonly the result of friction between the skin and footwear. Uneven terrain can cause the foot to move inside the shoe, which can create rubbing and extensive pressure points that can lead to blisters. The friction causes the outer layer of skin to separate from the underlying layers, creating a space that fills with fluid to cushion and protect the underlying tissue from further damage.

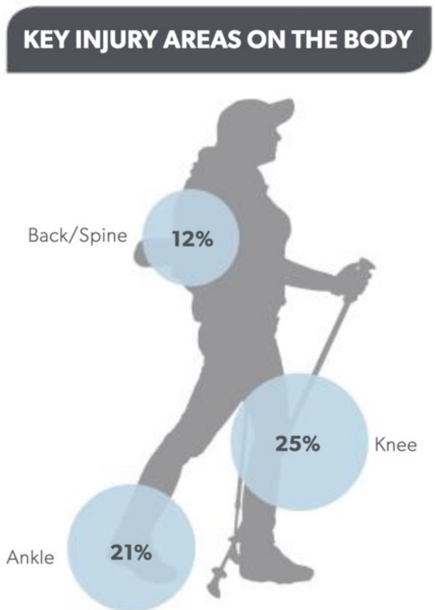


Fig. 6

1.5 TYPE OF TERRAIN

Understanding the influence of terrain on hiking-related pain and injury is essential for the research and development into preventing these issues through design. Equally important is the role of footwear design in mitigating these risks, as appropriate footwear can enhance comfort, stability, and protection (Ashley et al. 3). Several investigations have been conducted to determine the influence of hiking on uneven terrain on injury and discomfort (Wannop et al. 1221; Ashley et al. 3), however there are few solutions as to how the design or reconstruction of hiking footwear can help alleviate this. An investigation by Park et al. (1) on the development of trail walking shoes by using biomechanical evaluation, states:

"Hiking on hard, ragged, and rocky surface can cause foot injury, furthermore, long-time hiking can aggravate foot fatigue. As hiking on uneven surface involves the risk of injury, wearing specially designed performance (hiking) shoes is recommended." (Park et al. 1)

A further example of the relationship between terrain type and hiking injury can be seen in Fig.7 which was obtained from the New Zealand Mountain Safety Council (A walk in the park? 20). What stands out in this figure is the dominance of uneven/loose and steep terrain type at time of injury. This suggests that design features and characteristics of current hiking footwear such as traction and stability may play a role in the effectiveness of helping prevent/reduce injury whilst on the trail. For example, poor traction design such as ineffective shaped lugs or the depth of traction lugs may be causing users to have insufficient grip and control when hiking on uneven, loose, and steep terrain. The lack of lateral stability in combination with poor traction design in hiking footwear potentially increases the risk of the user experiencing a higher rate of injury, pain, or discomfort whilst walking.

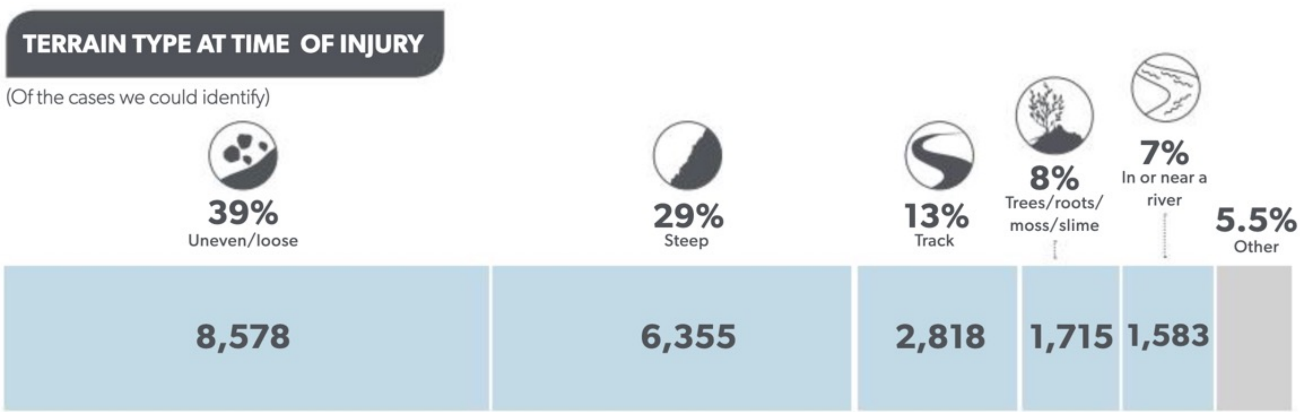


Fig. 7

Track grading

The New Zealand Department of Conservation (DOC) categorises walking tracks in the country into 6 main categories, each indicating the level of difficulty and the expected experience for hikers. These categories are in Fig. 8.

These categories show that the intermediate and advanced tracks description of terrain type aligns with the research by New Zealand Mountain Safety Council (19) on terrain type at time of injury, such as sections of the track being unformed (uneven), rough, steep, and muddy. It is also interesting to note that the suggested footwear required for intermediate tracks is light hiking boots or trail running shoes, whereas for the advanced track the suggested footwear required are hiking boots, implying the need for a high ankle cuff boot to withstand the terrain type of these tracks.

Because tramping/hiking is such a broad term incorporating different types of walks and durations, refining what type of terrain I am designing for helps me to set the design research direction. Because of the crossover of footwear silhouettes between intermediate and advanced walking tracks, and the fact that these two categories comprise the terrain type recorded by the New Zealand Mountain Safety Council (20) as being the most prevalent at the time of injury, this design research project will focus on designing for this track category type. To make it easier to understand, I have converted the category names to a number system to reference during my qualitative research and design process.

Department of Conservation: Walking track categories

Easiest: Easy access short walk	*Easiest:* Short walk	*Easy:* Walking track	*Intermediate:* Great Walk/Easier tramping track	*Advanced:* Tramping track	*Expert:* Route
					
Duration: Easy walking for up to an hour. **Suitable for:** People of all abilities, wheelchairs, buggies and strollers. **Standard:** Even surface, well formed with no steps or steep sections. Stream and rivers are bridged. **Track markers:** No track markers as the track is well defined. **Footwear required:** Walking shoes.	**Duration:** Easy walking for up to an hour. **Suitable for:** People of most ages and fitness levels. **Standard:** Track is well formed, with an even, well drained surface. There may be steps. Stream and rivers crossings are bridged. **Track markers:** No track markers as the track is well defined. **Footwear required:** Walking shoes.	**Duration:** Less than 3 hours. **Suitable for:** People with low to moderate fitness and abilities. **Standard:** Track is mostly well formed, some sections may be steep, rough or muddy. Stream and river crossings are bridged. **Track markers:** Track is clearly marked where necessary with orange triangles attached to trees. **Footwear required:** Walking shoes or trail running shoes.	**Duration:** 3 hours - multiday **Suitable for:** People with limited backcountry (remote area) experience. **Standard:** Track is generally well formed, some sections may be rough, muddy or steep. Major stream and river crossings are bridged. **Track markers:** Track is clearly marked where necessary with orange triangles attached to trees. **Footwear required:** Light tramping/hiking boots or trail running shoes.	**Duration:** Challenging day or multi-day tramping/hiking **Suitable for:** People with moderate to high level backcountry skills and experience, navigation and survival skills required. **Standard:** Track is mostly unformed, may be rough and steep. Expect unbridged stream and river crossings. **Track markers:** Track is clearly marked with orange triangles attached to trees. **Footwear required:** Tramping/hiking boots.	**Duration:** Challenging day or multi-day tramping/hiking. **Suitable for:** People with high level backcountry skills and experience, navigation and survival skills required. Complete self sufficiency required. **Standard:** Track unformed and natural, may be rough, muddy or very steep. Expect unbridged stream and river crossings. **Track markers:** Track is clearly marked where necessary with orange triangles attached to trees. **Footwear required:** Sturdy tramping/hiking boots.

Department of Conservation: Walking track categories

0	1	2	3	4	5
					
Duration: Easy walking for up to an hour. **Suitable for:** People of all abilities, wheelchairs, buggies and strollers. **Standard:** Even surface, well formed with no steps or steep sections. Stream and rivers are bridged. **Track markers:** No track markers as the track is well defined. **Footwear required:** Walking shoes.	**Duration:** Easy walking for up to an hour. **Suitable for:** People of most ages and fitness levels. **Standard:** Track is well formed, with an even, well drained surface. There may be steps. Stream and rivers crossings are bridged. **Track markers:** No track markers as the track is well defined. **Footwear required:** Walking shoes.	**Duration:** Less than 3 hours. **Suitable for:** People with low to moderate fitness and abilities. **Standard:** Track is mostly well formed, some sections may be steep, rough or muddy. Stream and river crossings are bridged. **Track markers:** Track is clearly marked where necessary with orange triangles attached to trees. **Footwear required:** Walking shoes or trail running shoes.	**Duration:** 3 hours - multiday **Suitable for:** People with limited backcountry (remote area) experience. **Standard:** Track is generally well formed, some sections may be rough, muddy or steep. Major stream and river crossings are bridged. **Track markers:** Track is clearly marked where necessary with orange triangles attached to trees. **Footwear required:** Light tramping/hiking boots or trail running shoes.	**Duration:** Challenging day or multi-day tramping/hiking **Suitable for:** People with moderate to high level backcountry skills and experience, navigation and survival skills required. **Standard:** Track is mostly unformed, may be rough and steep. Expect unbridged stream and river crossings. **Track markers:** Track is clearly marked with orange triangles attached to trees. **Footwear required:** Tramping/hiking boots.	**Duration:** Challenging day or multi-day tramping/hiking. **Suitable for:** People with high level backcountry skills and experience, navigation and survival skills required. Complete self sufficiency required. **Standard:** Track unformed and natural, may be rough, muddy or very steep. Expect unbridged stream and river crossings. **Track markers:** Track is clearly marked where necessary with orange triangles attached to trees. **Footwear required:** Sturdy tramping/hiking boots.

Fig. 8

1.6 DESIGN PRECEDENTS

Design precedents have significantly contributed to the advancement of hiking footwear design aimed at reducing injuries. Examples include:

Arc’teryx Alpha FL

In the Arc’teryx Alpha FL trail running shoe, the liners are removable and interchangeable for improved washing and drying to extend the products life cycle, as well as increasing the climate adaptability and temperature regulation of the shoes (Climbing). Strengths of the Alpha FL include a removable liner for a faster drying time and increased hygiene during multi-day use. The upper material and toe box is constructed from tough TPU to keep feet protected against sharp or rough terrain. However, due to the internal liner materiality of the absorbent engineered mesh, it may not dry quick enough for use in consistently-wet or rainy conditions. Also, the upper material is stiffer than traditional material due to the reinforced nylon fabric, which some users may find uncomfortable.

NESTFIT Technology by TrekSta

”Nestfit” is a technology developed by the footwear brand Treksta. It consists of a unique fitting system designed to enhance the overall comfort and performance of their shoes. Nestfit technology takes inspiration from the natural shape of the human foot and aims to provide a more anatomical fit (Treksta). The key feature of Nestfit is its three-dimensional last design. Treksta uses advanced mapping techniques and data from thousands of foot scans to create a shoe last that closely matches the contours of the foot. This design includes a roomier toe box to allow the toes to splay naturally and have more wiggle room, while still providing a secure fit in the midfoot and heel areas. The shoes are engineered to adapt to the unique shape and movement of the foot during hiking or trail running. Treksta states “Through intensive research, it was proven of the fact that NestFIT technology reduces the pressure on your feet by 23%, and the level of fatigue on your muscle by 31%.” (Treksta)

Fig. 9


nestFIT
TECHNOLOGY
The first shose
to truly fit the human
feet.

Fig. 10

2.0 INITAL DESIGN CRITERIA

These initial design criteria are informed by the contextual research findings to date and will help set the scope and themes for this research project.

Product function

-Mobility: Should allow the end-user to move more freely without restricting their natural movement when hiking on uneven terrain for a more comfortable experience.

-Durability: Should be able to protect the end-user and withstand the rugged environment of rough, unformed trails of grade 3 and 4 tracks.

-Support: Should provide the end-user with effective foot support while walking over uneven terrain without restricting or limiting their movement to prevent acute injuries such as ankle sprains.

-Stability: Should provide lateral and torsional stability to keep the end-user stable and in control when hiking on uneven terrain.

-Traction: Should allow the end-user to have an effective grip on the various terrain types of grade 3 and 4 tracks to help prevent slips which could result in pain/injury.

-Fit: Should provide the user with a more anatomically correct fit to help reduce the prevalence of chronic injuries such as blisters, which is the result of friction between the shoe and foot.

Product Experience

-Recognition: End-users should be able understand that this hiking footwear solution offers comfort and safety through its functionality and visual language.

-Distinction: Should provide a new offering of hiking footwear with innovative features that benefit end-users while accommodating their desires.

-Emotion: Should provide the end-user with a sense of security and safety when hiking on uneven terrain.

-Association: End-users should be able to recognise that this product is associated with hiking on grade 3 and 4 tracks as well as reinforcing product benefits.

3.0 METHOD AND DESIGN PROCESSES

3.1 IMMERSIVE RESEARCH

To develop a deeper awareness of the multifaceted issues and experiences that actual end-users encounter, as a hiker myself, I was able to go out on to the trail to physically experience the journey that hikers experience to help validate my findings in my contextual research and inform my design considerations. Using New Zealand Mountain Safety Council's app 'Plan my walk', I was able to identify and plan various trips around New Zealand to walk Grade 3 and 4 tracks (various 'track profiles' were developed from my immersive research findings, highlighting the footwear styled use, and key findings experienced while hiking which can be found in the appendices). To support my contextual research on the varied characteristics and experience of hiking boots and trail shoes, I decided to use a pair of each on different tracks, sometimes repeating a track with alternating the hiking footwear style used, to compare the findings and journey experience. Pair A is a New Balance Nitrel V4 trail running shoe (Fig. 11), which features a below the ankle height cuff and is constructed out of non-waterproof polyester engineered mesh with a thin TPU toe protected. Whereas pair B is a Keen Targhee III Mid (Fig. 12), featuring an above the ankle cuff, constructed out of waterproof oiled nubuck leather, with a protective EVA rubber toe cap.

When analysing pair A and pair B on the trail, the main characteristics I measured were: stability & support, comfort & impact absorption, traction, durability, waterproofness & breathability, and weight; as well as any other key experience findings. As indicated in the context review, these are the features that play a role in the experience and prevalence of discomfort/injury. I noticed that the flare design of the midsole and outsole of pair A made me feel like I had increased stability on the trail as my footprint had a larger surface area. The engineered polyester mesh upper allowed greater inversion and eversion due to the lack of structure in the materiality. Because trail shoes prioritise flexibility and agility, pair A did not have a shank in the midsole, which caused torsional flexion when walking over uneven terrain such as an unformed rocky trail, resulting in more strain being applied to my subtalar joint. Due to the lack of torsional rigidity in pair A, landing on sharp rocks resulted in pain experienced on the underneath of my arch due to the lack of protection and no shank. Alternatively, pair B has a torsion stability ESS shank constructed from moulded nylon, which resulted in greater stability and protection when walking over uneven terrain. The high ankle profile along with the materiality of nubuck leather, provided a much more stable feel and experience when hiking, significantly restricting my inversion and eversion range

Fig. 11

Fig. 12

of motion. However this also led to a decreased range of motion of dorsiflexion when hiking uphill, making it feel unnatural at times as I could only flex upwards a fixed amount, which resulted in an altered walking pattern. On the other hand, the flexibility of pair A made this action much more comfortable. Because of the materiality used in pair B, the waterproof nubuck leather along with the durable EVA rubber toe cap made me feel like I could walk through anything. It gave me a feeling of security as I didn't have to think about where I was placing my feet to avoid discomfort. This was very interesting compared to the experience with pair A, as with the trail running footwear I was thinking more about the placement of my feet, which led to mental strain at times. The materiality of pair B also allowed me to walk through minor streams and puddles without getting wet feet. Although when doing a multi-day hike on one of New Zealand's Great Walks the Heaphy Track, I experienced chronic blisters on my fifth toe due to perspiration and friction inside pair B (Fig.13), which I also believe is due to the more narrow shaped toe box. This caused me to experience extreme pain and discomfort which greatly affected my waking pattern with a limp.

Immersive research allowed me to understand the value of certain hiking footwear characteristics such as a torsional shank and having a durable protective toe cap when hiking on grade 3 and 4 tracks. It also makes me question the last design and the influence of footwear shape, as the narrow fit of pair B caused cramping and friction in my toe area that led to chronic dermal lesions. This suggests that hiking footwear needs to be designed more around an anatomical fit, such as NestFit technology by TrekSta. This insight helped direct my approach when conducting user surveys and interviewing specialists.

Fig. 13

3.2 USER SURVEY

To expand and supplement the research context, I developed an online user survey to gain insight on end user information, user characteristic traits, opportunity, and user wants and needs. This survey was distributed through tramping club Facebook groups around multiple New Zealand regions that amassed 220 user respondents. To achieve quality response rates, I developed a mix of fixed-response and open-ended questions to provoke thought and imagination (Groves et al. 656). The user survey questionnaire can be found in the appendices.

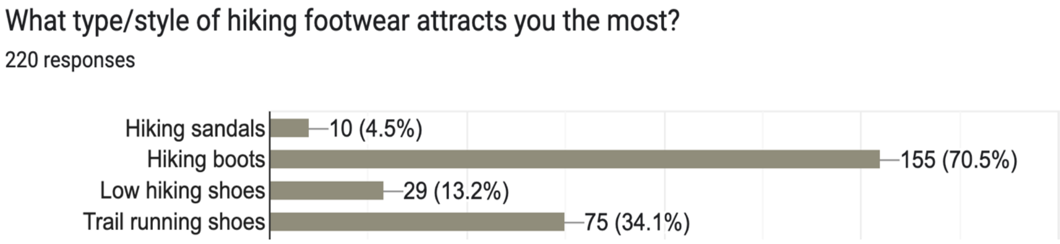


Fig. 14

aWhen asked what hiking footwear is preferred, 70.5% said hiking boots, whereas 34.1% preferred a trail running shoe. This interestingly conflicts with Anderson et al's study, which found the use of trail shoes being dominant. This suggests that trail shoes may not be durable or suited to traverse grade 3 and 4 tracks, leaving users to opt for a more durable and supportive footwear option. Insight from my immersive research also supports this, as the hiking boot made me feel more confident when hiking on rugged and uneven terrain.

An open-ended response section on why these certain types of hiking footwear styles were selected, emphasised users opting for hiking boots when hiking/tramping grade 3 and 4 tracks for the durability and stability provided.

“The rigidity of the shoe also allow you to put less mental effort into where you are walking, and/or worry less about it. There are always sharp rocks branches etc littered on the ground. Knowing that you can step on basically anything without injury means that you don't have to keep looking down at the ground before you take a step. Over the course of an 8 hr day, this actually saves a lot of time and mental energy. In this way, you can travel a little faster.”

“If it's an easy track, with no roots, mud, or difficult terrain, I wear train runners, but I usually wear tramping boots, which have more support and grip when going into more advanced tracks” **– Anonymous Survey Respondents**

Whereas some participants noted that the footwear characteristics of hiking boots, such as the weight, has made them choose trail-running shoes as their preferred style, or are currently evaluating their current selection of hiking boots and are considering trail running shoes for their next pair of hiking footwear.

"I currently wear hiking boots, but will seriously consider hiking shoes when these ones need replacing. I've rolled my ankles in boots anyway and foot/leg fatigue is a massive factor that would attract me to lighter hiking shoes"

"I go on quite long distance tramps and they are pretty much the only appropriate footwear for it - otherwise the feet are dead and covered in blisters with hiking boots"

– Anonymous Survey Respondents

To better understand what specific characteristics end users look for in their hiking footwear and how this can be used to evolve my design criteria, users were asked to select what they desire in their footwear, with the option to multi-select multiple factors. What was interesting from this data is that 214 respondents chose comfort as the top factor, which was also the most dominant characteristic out of all (Fig. 15). Below comfort, durability and traction were even (80.5%) for the next most desired feature, suggesting that these 2 characteristics are essential for hikers to traverse the terrain of grade 3 and 4 tracks.

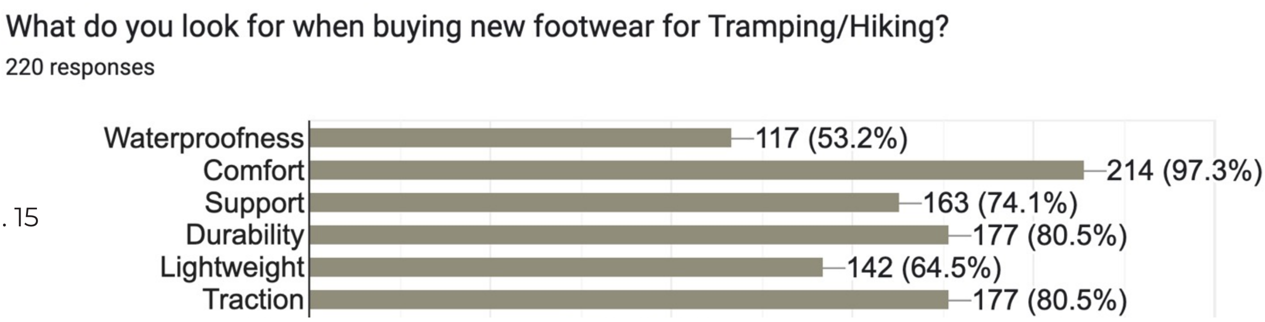


Fig. 15

With the option to explain further in an open-ended question, users were able to describe why they chose those specific features. This emphasised that majority of users chose comfort as a top priority, as having comfort in their footwear while hiking contributes to their overall experience when walking.

“All work towards comfort on the trip whether that be dry feet or preventing lacing coming undone or rolling an ankle/slipping.”

“Good fit means less chance of blisters. Comfort and support means no sore feet at the end of the day”

“I want something that lasts but also I don’t want my feet to be a source of discomfort”

– Anonymous Survey Respondents

Some participants also went into detail about the relation of each footwear characteristic they chose and how this effects their experience whilst out on the trail.

“Comfort and Light Weight both make walking more comfortable and enjoyable, when taking 10k+ steps a day a few 100 grams less on each foot makes a difference. Traction ensures I don’t slip and have good purchase on rocky ascents/descents or when scrambling. Durability ensures I get my money’s worth. Waterproof boots only keep water out until they get flooded. Even if they don’t they keep foot dampness in and it’s harder for them to dry out. Dry feet are happy feet.”

“NZ is wet. I prefer dry feet as much possible. Comfort at the end of 8 hr tramp is a dream really. Everyone wants boots that stand up to the various New Zealand conditions. Traction is essential when walking on sometimes treacherous tracks. And lightweight because packs are heavy enough without deadweight on your feet making each step a mission”

– Anonymous Survey Respondents

What is interesting about these quotes is the user emphasis on maintaining dry feet when hiking, noting the importance of waterproofing as footwear can becomes submerged and flooded while traversing unbridged river-crossings, a key trait of grade 4 tracks in New Zealand. They also noted the significance of having lightweight footwear contributing to the overall comfort and experience, and how the footwear weight can be an additional hinderance if not carefully selected.

To gain insight on the prevalence of pain/injury when hiking among targeted end-users, survey participants were asked to recount their experiences of pain/injury with an open-ended section to discuss what they experienced.

96% of the 220 participants responded yes to experiencing some sort of injury or pain in their feet when tramping/hiking.

This open-ended discussion of personal pain/injury experience signified how prevalent blisters are among hikers, supporting my contextual research on the most common chronic injury type.

“Badly blistered feet in a previous pair of boots. This led to a degradation in walking form that ended up hurting my legs, back, etc, due to repetitive strain. I ended up very sore all over because my feet got blistered.”

“Blisters on all toes and lost pinkie toe nails - bruised soles from boots too thin soled, ankle rubbed by boots as too tight around the top”

“I’ve had boots that damage toes / and one pair cut the circulation of my feet around middle of my foot. Have had blisters frequently”

“Many, swelling in the toe box area, slips due to incorrect shoes for the surface, pulled calve muscles, and the generic sore knee”

– Anonymous Survey Respondents

What was striking about these user statements were that there were multiple cases of blisters developing due to having incorrectly fitting hiking footwear, as the primary cause of blisters is the result of friction between the skin and footwear. The influence of grade 3 and 4 terrain may also be causing users’ feet to move inside the shoe, creating rubbing and extensive pressure points to the extent where one user claimed this “led to a degradation in walking form” which then led to experiencing pain and discomfort in the lower extremities of their body. Additionally of interest is that users claimed to have issues with the fit of their current footwear. For example, certain parts of their footwear restricted key areas of their feet, like being too tight around the ankles, having circulation cut off in the forefoot, and experience swelling in the toe-box area. This provides insight and direction to pursue design concepts on an adaptive fit and having hiking footwear to be designed more anatomically around the foot.

Additional user experiences on the emphasis of encountering pain/injury when hiking include:

“Previous knee injury, enflamed while crossing a stream in hiking boots, slipping off the rock and having freezing water wash over my ankles and twist my knee till it was sore. It was starting to rain, we were in a hurry to cross the river before it rose.”

“Cold feet, like chill burns from wet feet. Blisters, infection form blisters. Inflammation.”

“I have slipped a few times and rolled my ankles with previous boots. Slipping during river crossings. Toe pain/turning black from lots of downhill walking.”

– Anonymous Survey Respondents

What stands out in these experiences is the prevalence of injury from slipping during unbridged river-crossings. This suggests that the traction design of hiking footwear may not be suitable for New Zealand hiking tracks, as an external factor like walking through a river or wet rocks may cause the traction of many types of hiking footwear to diminish. This suggests a need for an improved traction solution for wet conditions.

To provide insight on specific user wants, I asked the survey participants that if they “could add any feature to your current hiking footwear, what would it be?” My experience in a previous footwear design research project demonstrated that this is an efficient way to help identity key user needs to inform design criteria. This open-ended question provided emphasis on the need for better traction in wet conditions and also the durability and fit of hiking footwear:

“Better grip on wet and submerged rocks”

“More reinforcement around the toe so they last longer before blowing out”

“Option to have extra space in bunion area. It’s a common complaint. It would be a new offering on the market.”

– Anonymous Survey Respondents

Some participants also noted the significance of needing a feature for water to escape their footwear after getting wet or submerged due to an unbridged river-crossing.

“Aesthetically more pleasing while still being comfortable/cushiony. When it heavily rains I get soggy shoes sometimes, have a feature where it is able to easily dry inside! Especially important for multiple day hikes”

“Heel activated pump in sole to pump out water driven by heel pressure from each step. Waterproof is a waste of time as they get wet from river crossings and never dry out. Get wet and the dry out fast is the way to go.”

“A way for water to escape waterproof lined footwear, as once water gets in there is no way out!”

– Anonymous Survey Respondents

These statements from end-users were very informative as they suggest that having some sort of drainage feature is essential when using waterproof hiking footwear, especially when hiking grade 3 and 4 tracks, where users encounter river-crossings.

Comparing end-user responses to the survey questions, alongside my contextual research, revealed that many of the responses were consistent with the current literature and research on this topic, such as blisters being the most prevalent chronic injury experienced by users. However, there were multiple additional insights and conflicting data provided by the user survey that added to the research. For example, that hiking boots are the preferred hiking footwear style for New Zealand hikers, whereas Anderson et al. claimed that current hikers are opting for trail running shoes instead as part of the ‘ultralight-hiking’ trend, which illustrates the need for a localised design option. I also discovered that comfort is the overall feature users look for in their footwear, but to achieve comfort involves providing sufficient additional features that contribute to the overall sense of comfort. From this survey, I was able to identify that such features should include: maintaining dry feet, having an adjustable fitting system to control pressure and tension in certain parts of the foot, improved traction design for wet surfaces, a more anatomical fit around the toe area, and also incorporating a drainage system that allows water to escape a waterproof lined shoe after being submerged by an unbridged river crossing.

3.3 EXPERT INTERVIEWS

To further understand how the foot behaves when hiking, alongside the cause of pain/injury, I decided to interview professional registered podiatrists to gain a medically-trained perspective. I interviewed two podiatrists who reside in New Zealand, one being Kathy Hitchcox (Senior Podiatrist) who I have previously worked with on a preceding footwear design research project, and Georgina Barr who is a lead biomechanical podiatrist at her clinic who has experience with treating hiking footwear injuries. The types of questions asked were aimed at identifying the most common hiking injuries, the importance of having the right footwear for hiking, and what factors influence the prevalence of pain/injury when hiking. Full questionnaire can be located in the appendices.

To better understand the most common injuries/pain associated with hiking footwear, the experts were asked to recount their experiences with treating cases relating to hiking.

“Injury generally leads us to believe there has been an incident, like they have tripped, slipped or fallen. A lot of times an injury would be an ankle sprain because they are on uneven ground and the boot doesn’t support them very well, another injury would be a slip if there’s not enough tread or grip on the outsole. In terms of general pain in tramping, definitely heel pain, forefoot pain due to the forefoot width not being correct, shin pain because of inexperience and going straight into an overnight or multi day trip.” **– Georgina Barr**

“Lateral ankle sprains are much more common compared to the inside of the ankle - due to the lack of ligament strength”**– Kathy Hitchcox**

An interesting response is Barr’s claim that often an injury is an ankle sprain due to insufficient support when walking on uneven ground, suggesting that sufficient support is needed when hiking. Hitchcox supports this claim by saying that lateral ankle sprains are most prevalent, which is due to the lack of ligament strength on the exterior of the ankle. Due to poor traction design, Barr encounters injuries that have resulted from slips, clarifying the need for improved traction design within hiking footwear as the cause of a slip may also be “not enough” tread, implying the need for more deeper lugs. Barr also talked about how forefoot pain is very common due to the forefoot width not being correct. I found this interesting as this aligns with statements made from end-users in my survey, supporting the need for a design intervention for an adaptable fit.

To understand the influence key characteristics of hiking footwear have on developing pain/injury, I asked the experts their opinion on how footwear specifically plays its part.

“There is also neuritis - pain in between the 3rd and 4th toe interspace due to compressed nerves which stems from the shape and bisection line of a shoe. A lot of last shapes are flared, not following the natural shape of the foot. When they get that compression from an unnatural shape, it squishes the nerves in your feet, which result in neuritis”

“The old-fashioned tramping boots always had high ankle supporting collars, but they are quite hard to fit as you get abrasion on your malleoli. The other thing is that a lot of them irritate the achilleas.”

“If you have a shallow toe-box, toes are more susceptible to blood blisters from the repetitive impact when walking down hill”

– Kathy Hitchcox

Hitchcox interestingly references the old-fashioned tramping/hiking boots which are heavy and fully constructed from leather, commenting that she has seen multiple cases where they have irritated parts of the foot like the malleoli (ankle bone) and also the achilleas which could result in blisters due to friction. Also the depth of the toe-box may cause more prevalent blood blisters when walking down hill due to the lack of space. This suggests that materiality change needs to happen to help relieve abrasion in certain areas of the foot, alongside developing a solution that incorporates a well-fitted toe box. This again supports the need for a more anatomically correct fitting shoe. A further example of this can be seen in Hitchcox’s comment on how the unnatural shape of some shoe lasts can cause compression which results in neuritis, a nerve injury.

Barr’s opinion on the influence of key characteristics of hiking footwear in relation to developing pain/injury also emphasises appropriate ankle support alongside the influence width of the forefoot has.

“Sometimes it’s not necessarily about the height of the ankle support, but it’s the amount of control. When you’re tramping on uneven ground, you want a bit of pronation and supination movement to adapt to the uneven terrain. So if you’ve got a high ankle boot which is also overly supportive, that is where I think the problem starts to occur. It’s not necessarily the height, but the support that’s a part of it.”

“Appropriate ankle support - not only the type of padding around the ankle, but also the structure. Making sure the ankle support and the ankle cushioning gives the foot and ankle freedom and flexibility to do its job.”

“Definitely the width of the forefoot, most people fit their shoes lengthwise and pay very little attention to width.”

– Georgina Barr

Notable here is the significance Barr puts on the amount of control in ankle support rather than the height. This allows the user to adapt better to uneven terrain through the natural foot movement of pronation and supination (also known as inversion and eversion as stated in my contextual research). This relates back to Anderson et al. and their claim that having too much rigidity in hiking footwear can lead to prevalent ankle injuries. This suggests that materiality with flexible but supportive properties would be suitable in efficiently supporting the ankle through hiking footwear.

Informing Barr on key insights from my user-survey, specifically around the key features users desired in their hiking footwear, Barr emphasised what comfort means and how you can arrive there by saying:

“It’s interesting because lots of people say they want comfort but to get comfort, often you need to look for stability. Comfort is the end result of having a product which stabilizes and supports. I mean, most people say that the most comfortable shoes they have are their slippers.”

“Comfort is the end result, so you need to look at what you are putting in that mixture to achieve that end result.”

– Georgina Barr

What is striking about this is the connection between my user survey results that indicate comfort as the most desired feature, and the expert emphasis that achieving comfort involves incorporating a combination of features that work together provide optimal comfort.

When asked for their professional opinion on what key hiking footwear features could contribute to achieving comfort on the hiking trail, both Hitchcox and Barr pointed to the general construction of hiking footwear.

“Instead of using an insole to ‘fill’ in a shoe, you fill it from the top as this stops your foot from slipping and holds the foot into the back of the shoe. Whereas if you fill it from the bottom, that just pushes your foot up and creates more pressure, that’s why the depth of the toe box will be very important.”

“The seams are important as a lot of hiking boots look beautiful on the outside but on the inside it’s really messy finishing, so the seams end up rubbing, especially on the fifth digit. Cushioning shouldn’t compress quickly, you definitely want a material which rebounds. You also need support in combination with control. You don’t want to stick someone in a straightjacket, but you don’t want to let them flop about, so kind of trying to find that middle ground.”

– Georgina Barr

Interestingly, Hitchcox advises filling in a shoe from the top rather than the bottom, as this method may prevent the user’s foot from slipping by pushing the foot into the back of a shoe for a more stable feeling. Barr also points out that the internal seams should be a consideration as these can create small pressure points which can aggravate the user’s foot in certain areas. Alongside this, Barr again clarifies the importance of having ankle support in combination with control to allow the user’s feet to naturally accommodate pronation and supination when walking on uneven terrain.

Insight gained from these expert interviews helped me to develop a deeper understanding on what end-users experience when hiking/tramping in New Zealand, as well as the effect certain hiking footwear characteristics have on the prevalence of injury/pain experienced. The suggestions made by Hitchcox and Barr have also helped to inform design considerations such as the significance of traction design and how this attributes to slip injuries, to maintain control and stability whilst providing ankle support, to design more anatomically around the foot to avoid pressure, and how the construction of hiking footwear can play a part in comfort and fit.

3.4 REVERSE ENGINEERING AND PRODUCT TESTING

Reverse Engineering

To gain a deeper understanding on product componentry, materials, and construction, I employed a reverse engineering research method which is used to inform a product redesign process (Otto & Wood 1). Two different hiking footwear styles were used for this dissection (Fig. 16 & Fig. 17), one being a high ankle hiking boot constructed from traditional materials like leather, and the other being a low ankle hiking shoe constructed out of materials such as synthetic leather, suede, and engineered mesh. I chose these two types of hiking footwear because of the contrasted materials used in construction, and also the two varied ankle heights of the footwear. The disassembly process consisted of removing the midsole and outsole from the upper, allowing for further disassembly of each internal and external component of the upper, alongside analysing the contents within the midsole and outsole. Throughout this process notes were made on the general assembly and construction of selected footwear.

Fig. 16

Fig. 17

What was interesting from the dissection of pair A, was the location of regional foam cushioning that had been added to the shoe. There was only cushioning at the very top of the tongue which measured at only 3mm thick, as well as at the top of the ankle. This suggests that the reason was to alleviate pressure around the ankle and also at the top of the forefoot when users are tightening the laces. I found it intriguing that there was no allocation of cushioning along the whole tongue, as suggested by Hitchcox, to help fill the shoe. Upon analysing the midsole of pair A, I noticed that it did not contain a shank to help with torsional rigidity, which was heavily suggested throughout my contextual research to help keep the user stable on uneven terrain. The internal lining also had one main seam that extended down through the middle of the forefoot, which could cause implications for the user by creating a pressure point causing discomfort.

of the forefoot, which could cause implications for the user by creating a pressure point causing discomfort.

Fig. 18

What was striking from the dissection of pair B, was the notable wear areas from the previous owner. There was significant tearing located on the internal heel and also the internal toe box. This suggests that the toe box area may not be deep enough, causing friction when walking and potentially blisters to occur. The heel tearing suggests that the user's foot is not pushed back into the heel enough due to incorrectly fitting footwear, causing abrasion in the lower heel/achilleas area which is another common area for blisters. It was interesting to compare these findings to what Hitchcox suggested about toe box depth and the occurrence of discomfort, as well as the tongue needing extra cushion to help push the user's foot into the back of the shoe. I also noted the internal construction of pair B had significant seams in the forefoot and lateral parts of the shoe, providing potential for increased pressure points that could also cause user discomfort. As Barr suggests, internal seam construction needs to be greatly considered to help provide comfort when hiking.

Fig. 19

As for the midsole of pair B, I noticed that it contained a midfoot plastic torsional rigidity shank that measured at 30mm by 80mm and 2mm thick. When bending and twisting the midsole, I noticed a slight reinforcement from the shank compared to when removing the shank, but not at a great difference. This suggests the need for an improved shape and thickness to accommodate a larger area of the midsole when hiking on uneven terrain. What was also interesting about pair B midsole was the regional cushioning located at the heel. A softer section of EVA foam had been inserted to help with shock absorption when heel striking.

Fig. 20

Product Testing

To further investigate hiking footwear inspired by insight gained in my prior user-centred research that once water gets into a waterproof boot during an unbridged river-crossing there is no exit point, I decided to simulate this user experience by conducting tests on the footwear used in my self journaling research. I conducted two tests on the waterproof hiking boots and trail running footwear. The first test consisted of submerging both styles of footwear in water externally for a set period of 10 minutes to notice how they behave. The second test consisted of internally flooding the selected footwear for a set period of 10 minutes to simulate a river crossing.

Fig. 21

What I noticed from pair A (hiking boot) when submerged from the outside, is that the water was prevented from entering the shoe due to the waterproof liner. However after the set period of 10 minutes, I noticed that there was a slight presence of water on the inside of the shoe. I concluded this is because of water entering through the sole, or through the seam where the upper is connected to the midsole. I found this very interesting as even though the waterproof liner stopped water from entering the hiking boot, water found another entry point due to the footwear construction.

When testing the same method for pair B (trail-running footwear), I noticed that the water immediately entered the entire shoe due to the mesh material that the upper consisted of.


Fig. 23

When conducting the second test where the footwear is flooded internally to simulate a river-crossing, I noticed that pair A retained most of the water for the set duration of 10 minutes due to the waterproof liner. However there was very slight drainage on the forefoot area due to the seam construction. This insight supports the users' desire for a drainage intervention in waterproof hiking footwear to help trapped water escape to alleviate injuries such as blisters from wet footwear.

Fig. 24

When simulating a river-crossing with pair B, the water exited the shoe mainly through the toe area as I was pouring water into the shoe due to the porous materiality of the upper. However after the set duration of 10 minutes, not all of the water had escaped and there was a small pool of water retained on the inside of the shoe. This suggests that even though the materiality of pair B allowed water to escape, a drainage feature would also benefit this hiking footwear type to get rid of all the water and provide the user with dry feet after a river-crossing.

Fig. 25

Reverse engineering and product testing helped point out design issues within the construction and componentry of current hiking footwear. Regional cushioning of the upper needs to be considered alongside findings from expert interviews, such as providing necessary cushioning in the tongue of the shoe as well as the consideration of internal seams and the effect this has on creating unwanted pressure points. A drainage feature will also aid in helping water escape flooded waterproof hiking footwear from unbridged river-crossings to alleviate the occurrence of blisters due to wet feet as identified in user-surveys.

3.5 RESEARCH THROUGH DESIGN

Introduction

My design research methods follow an iterative design process, as it enables me to draw inspiration from insight and learnt concepts, explore and test prototypes, and refine them based on thorough research and evaluation (Milton and Rodgers 14-15). This is achieved through a circulatory four step process consisting of understanding the aims and goals of the research, examining end-user insight, visualising insight through sketching and prototyping, and evaluating against the initial aims and design criteria for this research project.

Design Research Methods

Sketching: A key research and iterative development tool used to evaluate ideas generated from research insight to help shape the final design outcome and each major component. This design method is used throughout this research project, with thematic sketching used for the aesthetic development.

Modelling and Prototyping: This enables the visualisation of two-dimensional sketches into a three-dimensional form through physical prototyping and 3D modelling software, this also helps with capturing the prominent ideas generated in the initial concept development. Through the design research the developing models and prototypes will advance in complexity and resolution, resulting in an appearance model to simulate the look of the final design as a production product. Three dimensional modelling and prototyping throughout this design process also allowed for enhanced evaluation and testing of functionality, proportion, and aesthetics

3.5.1 CONCEPT GENERATION

A range of concepts were generated through sketch ideation. As footwear are quite complex products consisting of a multitude of components, I decided to first focus on creating concepts around the specific componentry and function which would then lead to combining the strongest concepts into a full hiking footwear system in the design development stage. Initial concepts generated were inspired directly from the initial design criteria alongside insight learnt from my qualitative research such as trends and patterns from my end-user survey and expert interviews with podiatrists. To gain a better understanding of some of the concepts generated, especially when transitioning from two-dimensional to three-dimensional, rough sketch models and prototypes were created in accordance.

In response to creating a better fit for the end-user which ultimately helps reduce the possibility of blisters and discomfort due to friction and compression in certain areas of the feet, this concept looks at having sections of the insole to be malleable to adapt to the users for profile and shape. The hooks along the sole act as anchor points which are attached to the malleable sections around the shoe, allowing for manipulation via the lacing system to create a more personal fit. To simulate these malleable sections I created a solution consisting of corn flour and silicone, which results in a dough like consistency that air dries in an hour for a more firm finish.

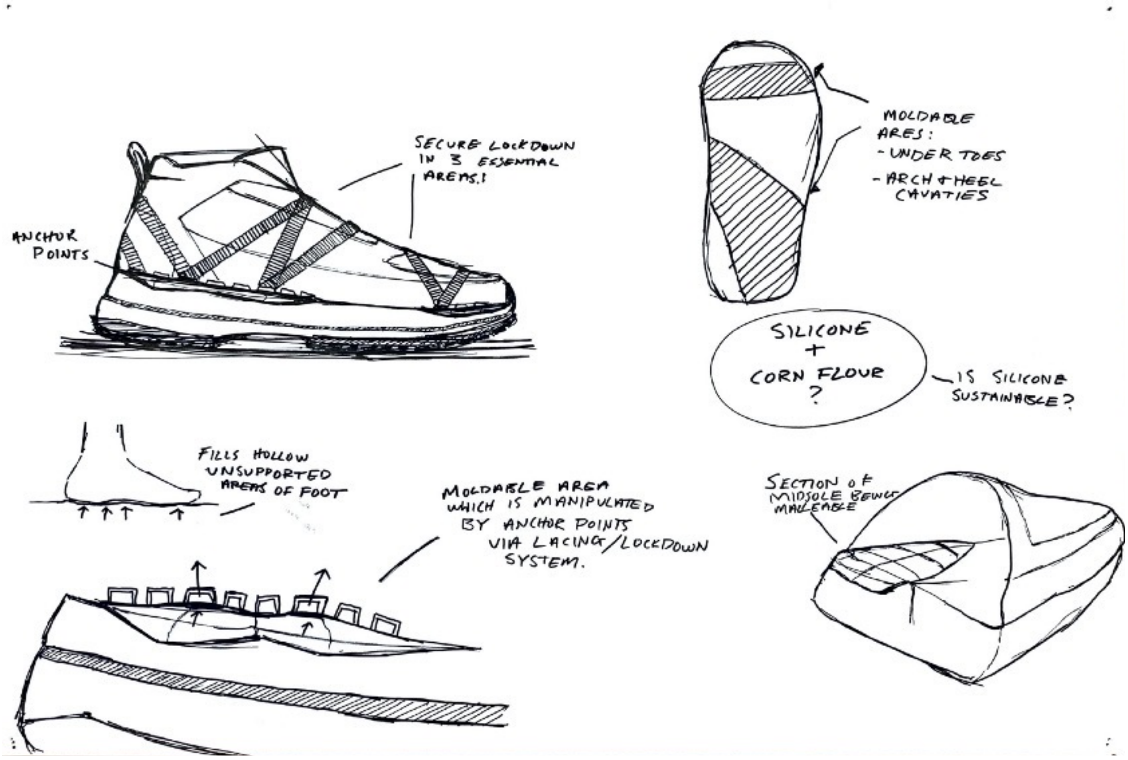
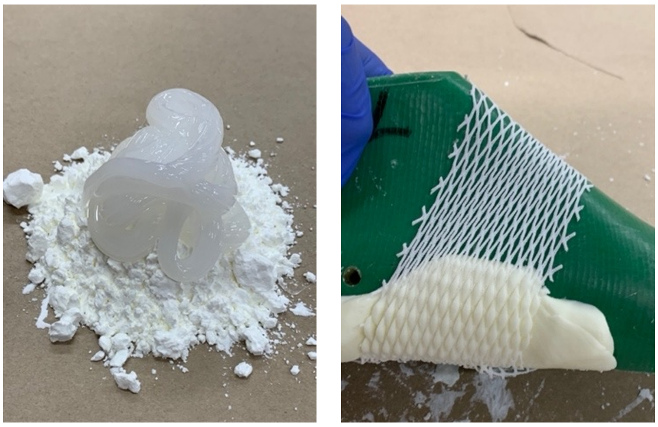


Fig. 26

Fig. 27



This concept looks at using a mesh-like structure where I was able to alter the size of holes by creating tension from pulling it at certain anchor points. Benefits of this concept would allow the end-user to control the density of holes in certain areas of the foot to help with breathability and the flexibility of the shoe. Some drawbacks of this concept would be losing structural integrity in certain areas of the foot, perhaps leading to an increase of injury/pain due to the lack of stability.

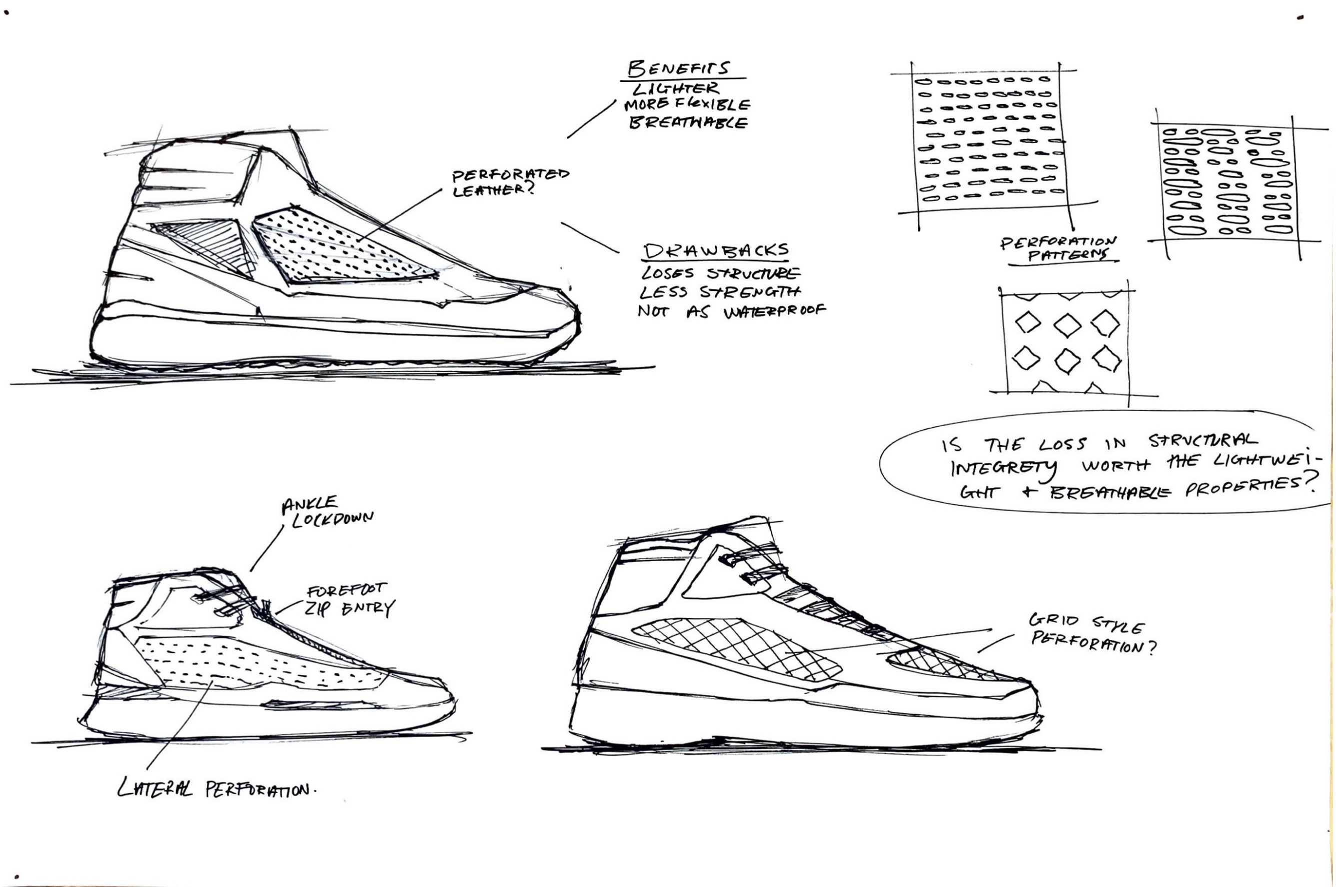
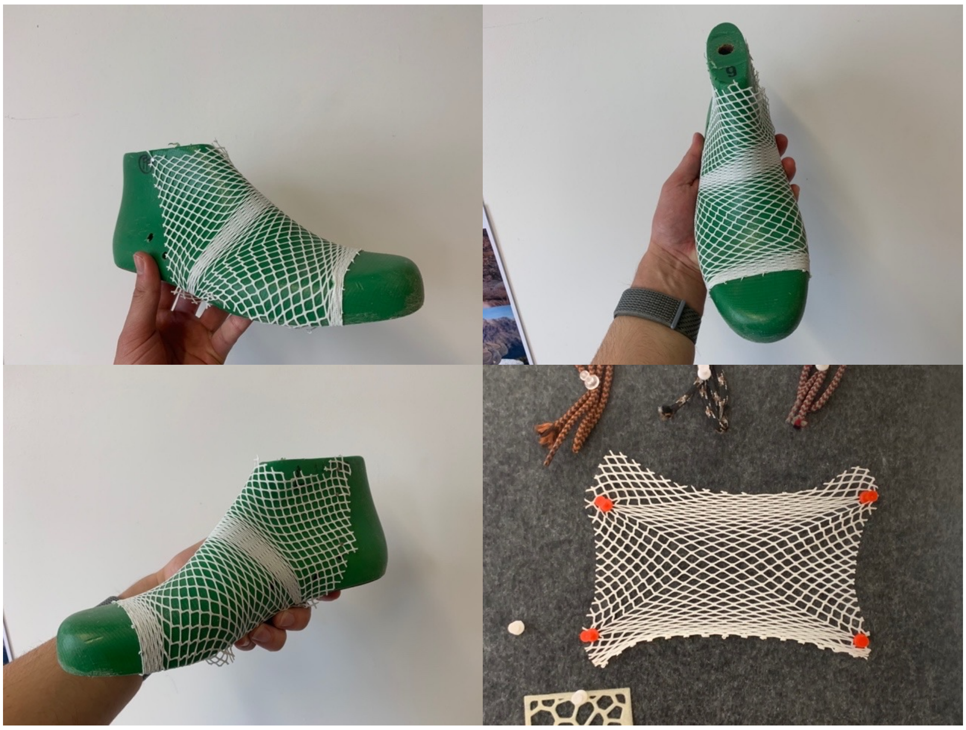


Fig. 28

Fig. 29



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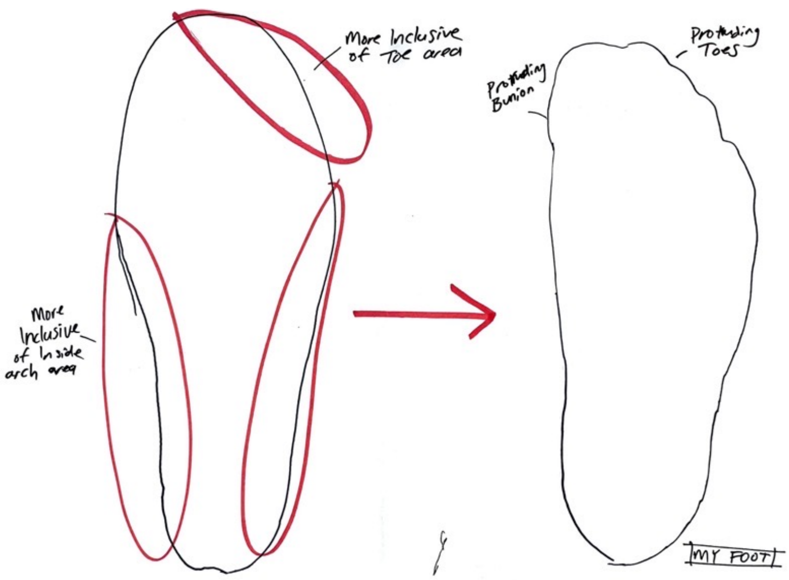
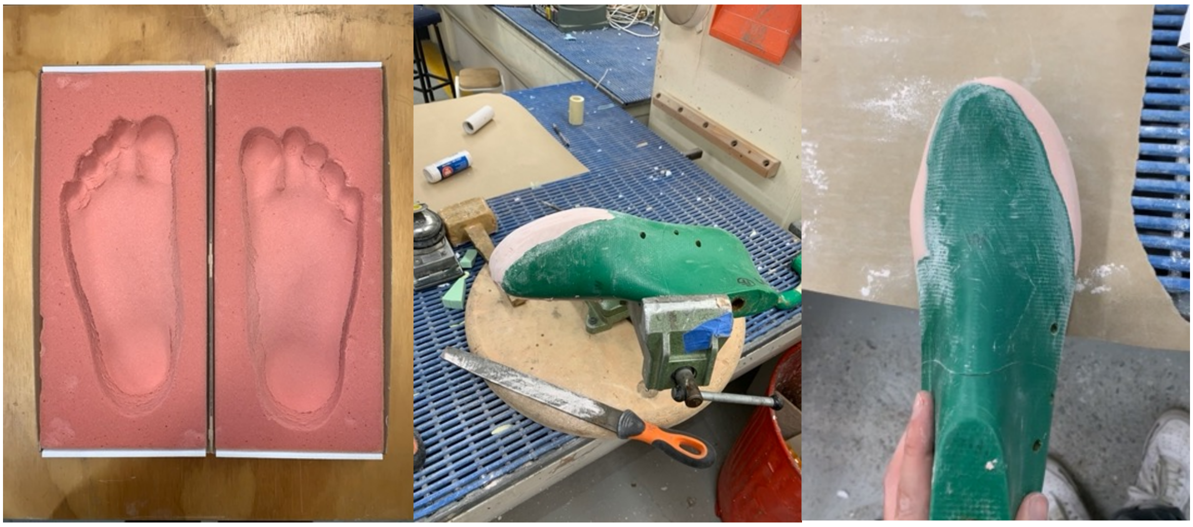


Fig. 30

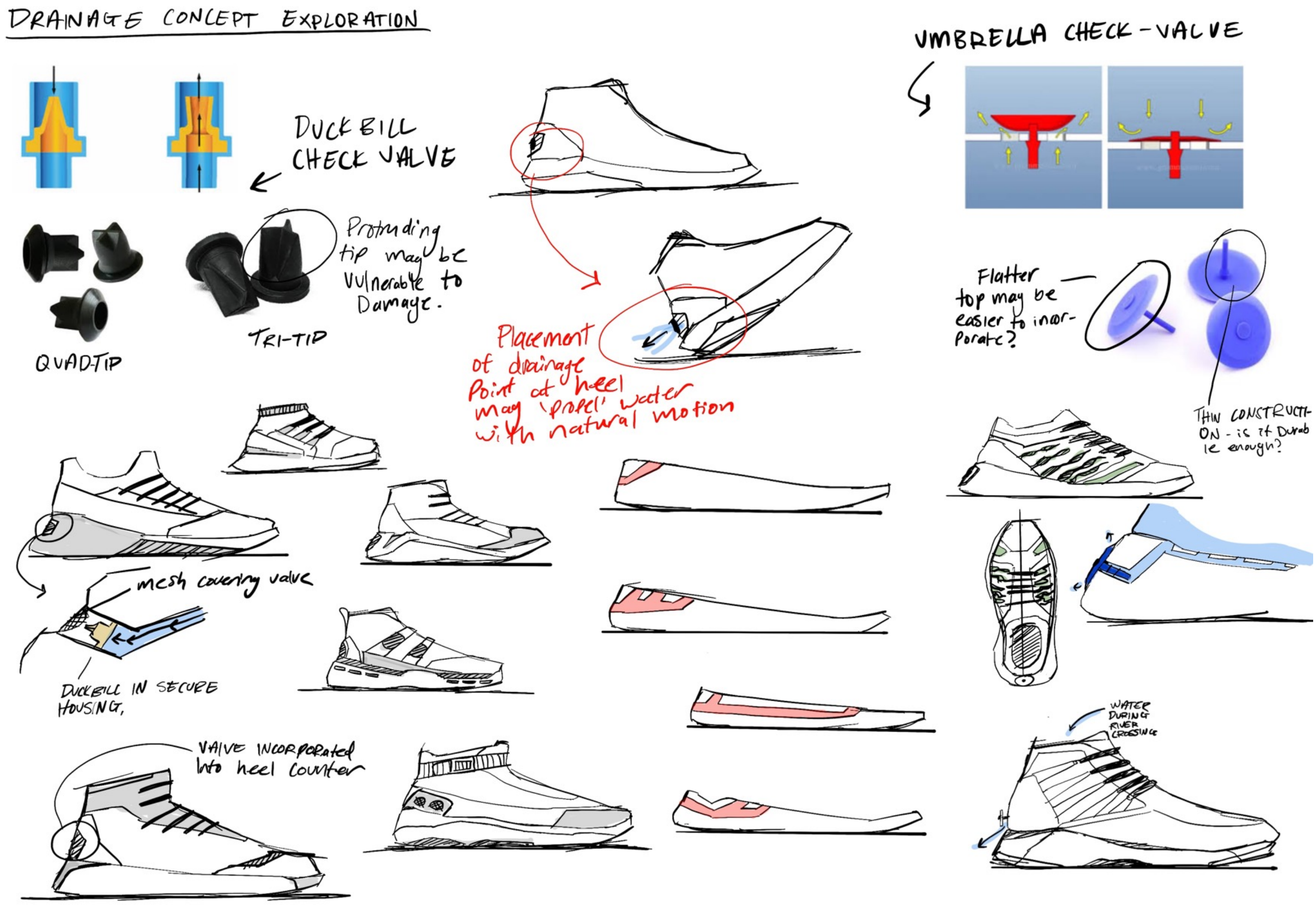
Fig. 31



Inspired by NestFit, this concept looks at accommodating a more natural fit of the users foot by reshaping a shoe last to follow an anatomical profile of a foot. This would result in a less cramping toe-box, allowing for the users toes to spread naturally when walking on uneven terrain. Using a podiatrists foot impression foam box, I was able to create an impression of my own feet to base my reshaping of the last where I used a two-part builders filler to create additive material, then used tools such as sandpaper and filers to subtract material from the shoe last. Benefits of this would result in a more comfortable fit for the user, allowing for extra space around the toes and bunion area, as desired by end-users drawn from my user-survey.

Directed from insight drawn from the user-survey, one of the key trends that emerged was the need for a drainage feature in hiking footwear to accommodate water entering a waterproof boot when doing an unbridged river-crossing, as having wet feet can highly increase the chance of chronic blisters to develop, causing extreme discomfort and hindering users ability to walk. Concept exploration around drainage consisted of looking at current one-way valves that have been incorporated into the infrastructure of the shoe. From this, I developed a series of drainage prototypes consisting of various valve mechanisms.

Fig. 32



DRAINAGE CONCEPT EXPLORATION
DUCK BILL CHECK VALVE
Protruding tip may be vulnerable to Damage.
QUADTIP
TRI-TIP
Placement of drainage Point at heel may 'propel' water with natural motion
UMBRELLA CHECK-VALVE
Flatter top may be easier to incorporate?
THIN CONSTRUCTION - is it Durable enough?
mesh covering valve
DUCKBILL IN SECURE HOUSING,
VALVE INCORPORATED into heel counter
WATER DURING RIVER CROSSING

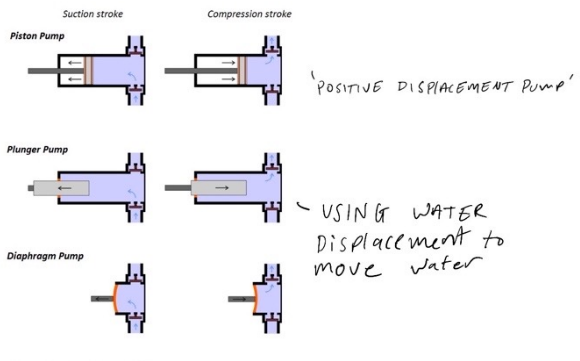
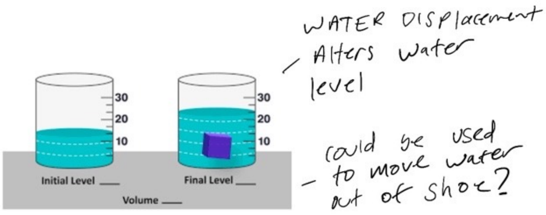
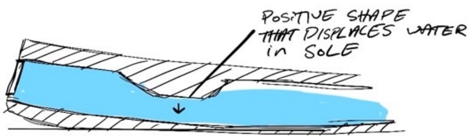
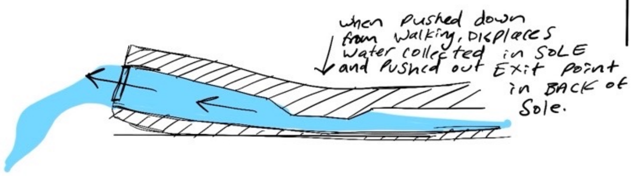
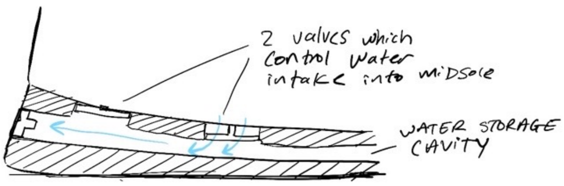


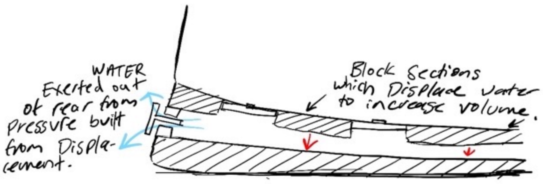
Figure 1. Basic reciprocating pump designs











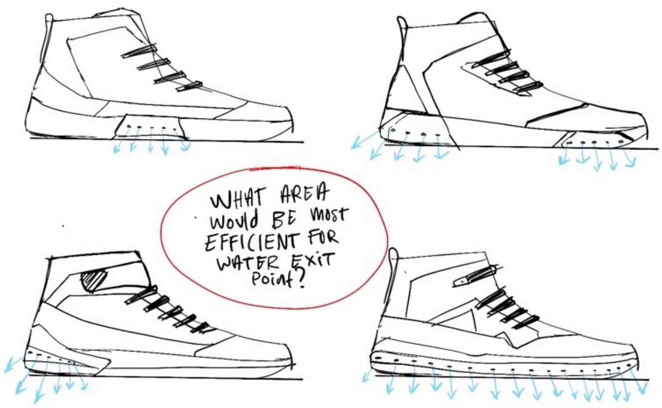


Fig. 33

Here I incorporated a standard ball bearing check valve into the heel of the sole. The limitations of this is that the check valve required a certain amount of pressure to activate the mechanism. This was an insufficient application for the passive result I was intending for.

Fig. 34

Using miniature silicone duck-bill valves, I prototyped a drainage sample where a number of this valves were allocated around the sole with the purpose of draining water from the inside of the shoe. This concept did not work very well as I noticed that these also require a certain amount of pressure to activate, resulting in this test to fail.

Fig. 35

Here I incorporated a standard ball bearing check valve into the heel of the sole. The Here I used a check-valve which was a part of a drinking bladder system. The way this valve worked was by pulling the outer mechanism to unlock the passage for water to escape through. Some limitations with this specific test was that having the location of the valve where it is, would allow for certain amount of water to retain in the shoe due to the height of valve location.

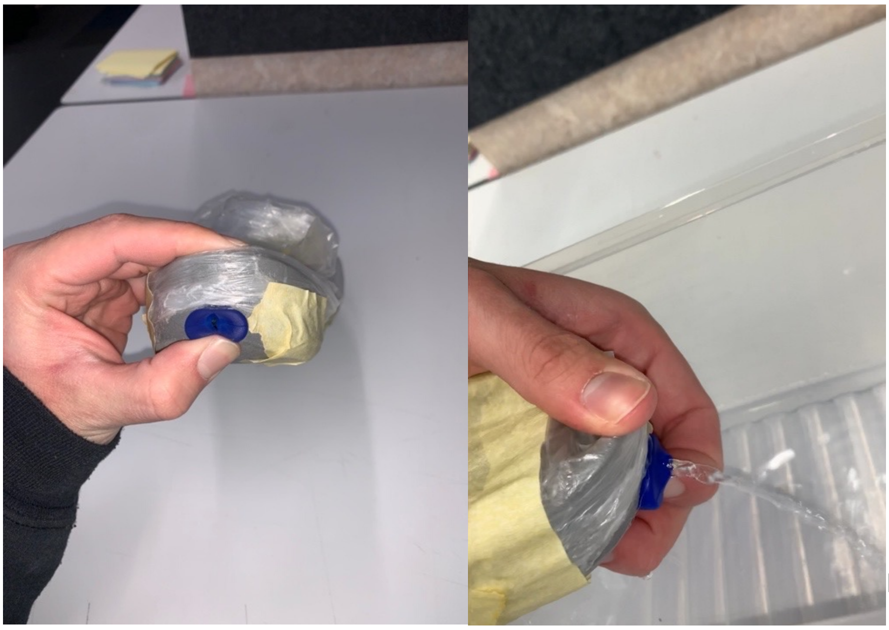


Fig. 36

Using another component of the drinking bladder, this bite valve functions by the user applicating pressure to allow for deformation which resulted in a small slit to create an opening for water to escape. Incorporating this valve into the centre of the midsole resulted in a successful test to get rid of most of the water from this test rig. To simulate a waterproof liner, I attached a plastic casing on top of this sole so no water could escape. The location of the valve at the heel is because as the user walks, the pressure from the heel strike will cause this bite valve to deform, allowing for water to escape.

Fig. 37

Here I used a check valve that was a part of a CamelBak drink bottle. I tested this specific valve as it required a lot less pressure to activate. This concept consists of having a small air pocket in the heel which would be used to activate the valve. To simulate this air pocket I used a small hand air-pump to simulate this function. Some limitations of this, is that I was not convinced that I could have an air unit in the shoe without the need to refill that air pocket once pressure had been applied without drawing water into the shoe if the user were to be walking through water.

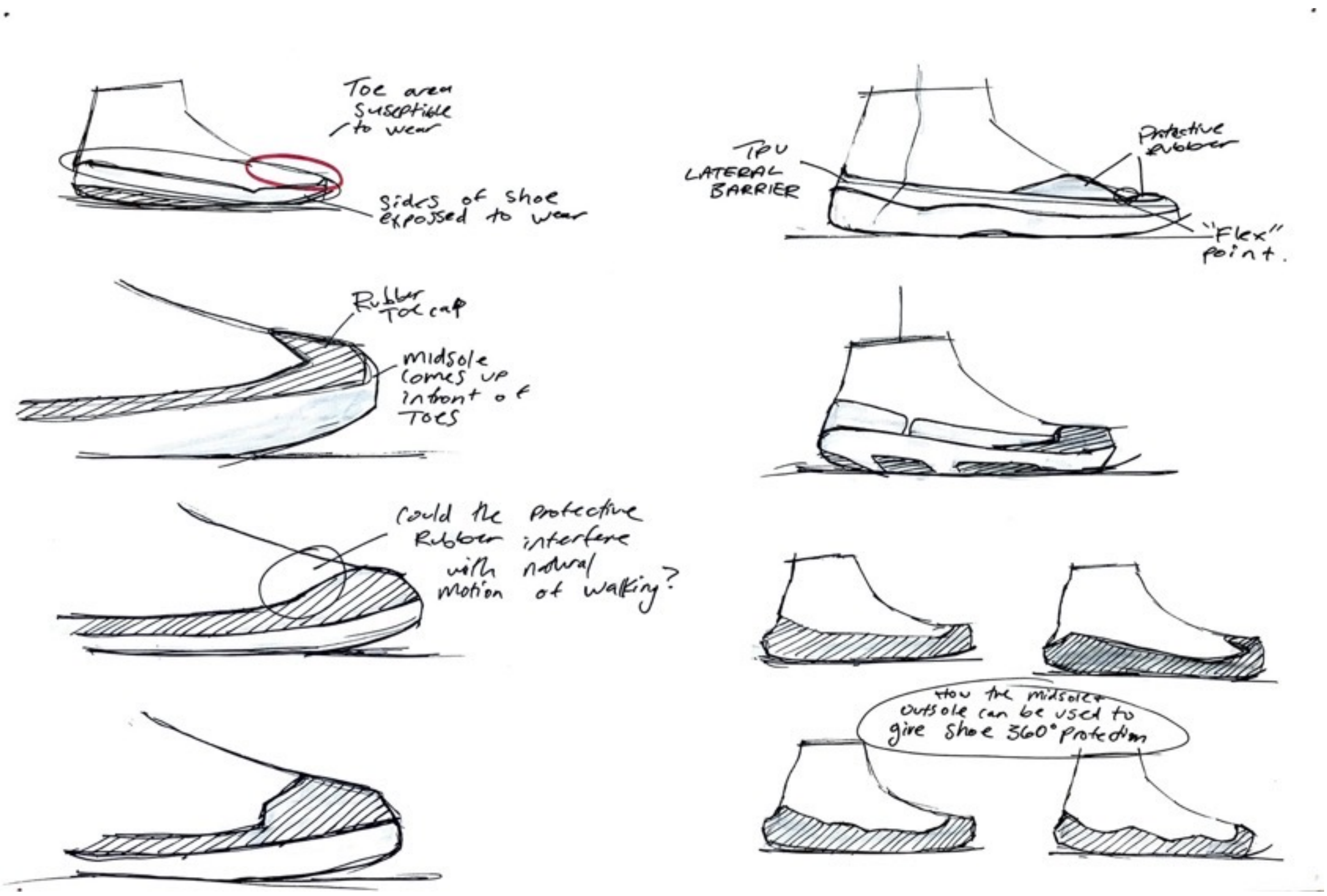


Fig. 38

This concept is in response to end-users wanting more protection around the shoe to allow for the bumping and abrasion on unformed rough tracks. Some limitations of this concept was the conflict of having 360 degree rubber protection and how the properties of rubber could potentially interfere with the natural movement of walking. This suggested that instead of a continuous protection barrier, it may need to be split up into sections to allow for natural mobility.

Fig. 39

On the left of these concept sketches I am exploring how I could incorporate support structure into the shoe that can be manipulated by the lacing to conform around the shape of the users foot to allow for slight personalisation of fit. This would allow the user to increase or decrease the amount of pressure in certain areas of the foot to accommodate comfort and also friction which would alleviate the chances of chronic blisters to develop.

Visualising this concept through prototyping, I attached a series of straps to the inner liner of an existing shoe. These straps would create loop holes in the lacing area to allow the user to alter the internal shape via the lacing system.

This concept looks at modifying the existing speed hook found on many existing hiking footwear. Instead of having a standard opening to allow for quick lacing, this concept consists of a regular speed hook with a second lacing function attached to conforming straps which would alter the fit of the shoe. Since these would be placed throughout the shoe, this would also allow for the user to individually tighten each lace row to accommodate the shape of their foot, resulting in a more personalised and less-restrictive fit.

Fig. 40

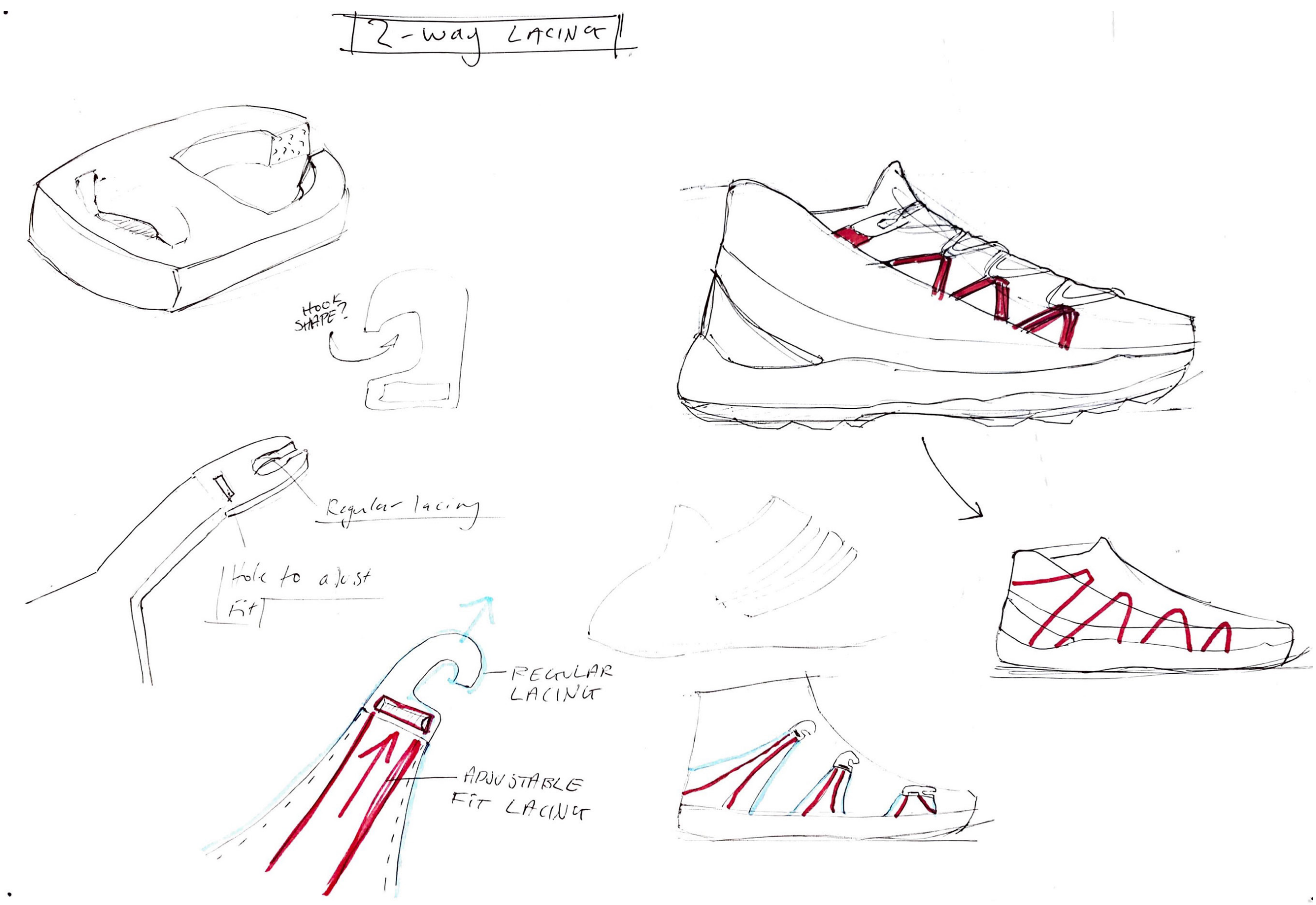
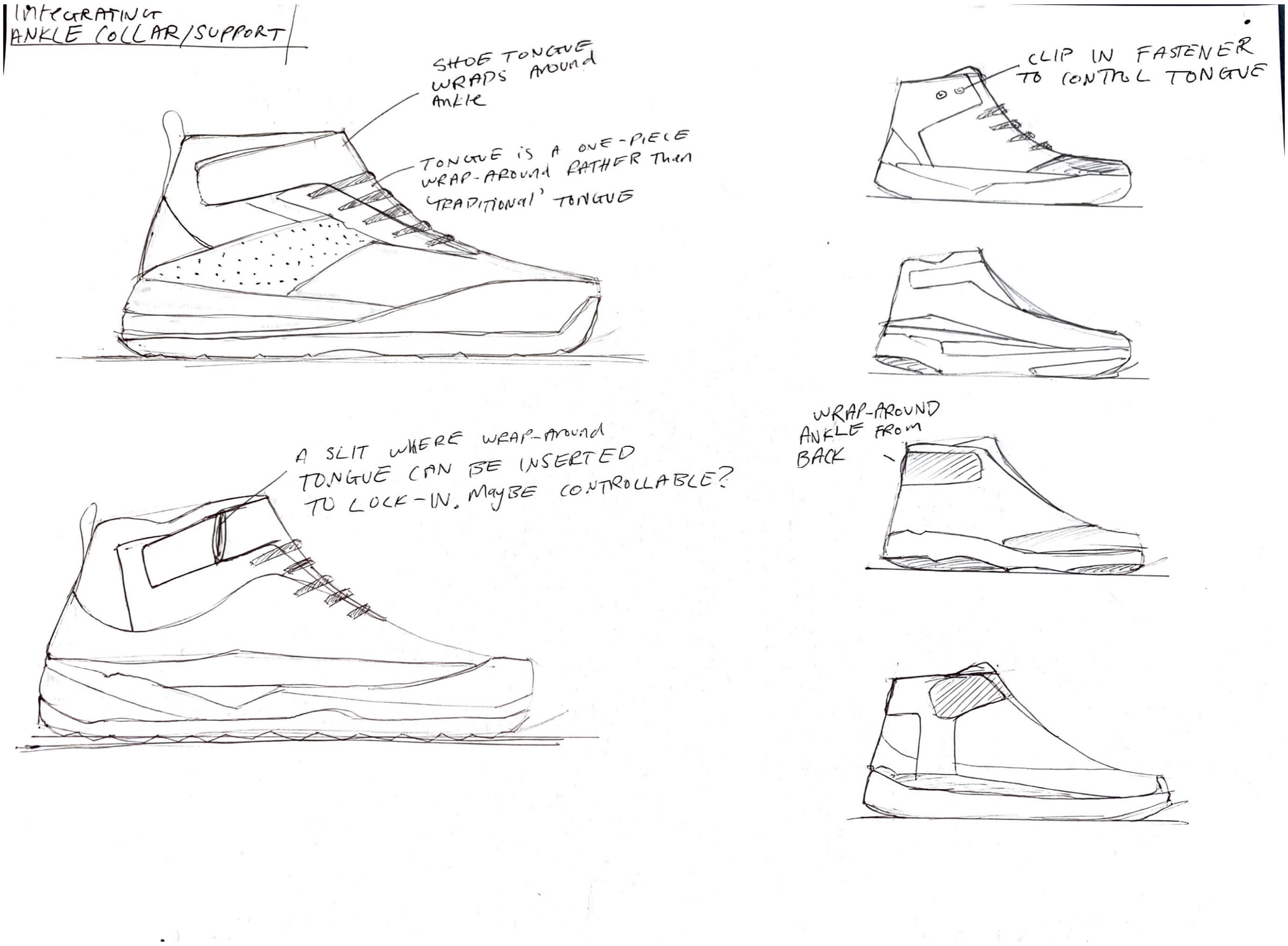

2-way LACING
HOOK SHAPE?
Regular lacing
Hole to adjust fit
REGULAR LACING
ADJUSTABLE FIT LACING

Fig. 41

Fig. 42

Here I was inspired by the method of 'razor siping' which is currently used in automotive track racing on wet surfaces. By conducting small razor cuts into the rubber of the tire, this allows the rubber to slightly expand, resulting in increased traction due to the higher surface area on wet surfaces. Using this idea, I generated concepts where siping would be applied to the tread of hiking footwear, resulting in increased traction when walking over slippery and wet surfaces such as wet rocks and also during a river-crossing.

Fig. 43



This concept looks at how to improve the ankle support of hiking footwear by looking at an ankle strap that wraps around the ankle. Some limitations of this is that after evaluation I believe that this doesn't have the effect of stabilising the ankle as suggested by podiatrists, as the strap could act as a source of restricting the ankle movement too much, not allowing for natural pronation and supination.

Fig. 44

3.5.2 CONCEPT EVALUATION

After analysing and comparing the ideas generated in my concept creation stage alongside my initial set of design criteria and insight from my qualitative research methods, I was able to identify six design directions to inform my updated design criteria:

Last reshaping: By reshaping the component that a shoe is built around, developing the shape of the shoe last will allow the end-user to feel more comfortable in their hiking footwear and reduce the chance of developing chronic blisters due to friction between the foot and shoe. This was also noted as a dominant 'want', discovered from my user-survey.

Deformation valve: In response to end-users wanting a drainage solution for when their waterproof hiking footwear gets internally flooded which results in a higher chance of developing blisters and other injuries, the deformation valve seemed to be most efficient in my testing of drainage concepts. The nature of the deformation valve represents itself as a viable solution because of its passive function and simple manufacturing process of injection moulded silicone.

Footwear protection: As noted throughout this research project, walking on rough uneven terrain requires external protection from sharp rocks and scrapes. In order to develop a footwear design solution that makes the end-user more comfortable and pain free, I believe that it will be essential to incorporate protection and durability.

Adjustable lacing: In order to help end-users have more control over the fit of their shoes, the adjustable lacing will benefit users by allowing them to individually adjust and retain the tension for each lace section. This contributes to the overall comfort experienced.

Lateral supports: The lateral support concept also contributes to a more personalised fit by allowing users to slightly control the width of the shoe to alleviate unwanted pressure and friction which could result in pain/injury. As suggested by podiatrists, taking note of the width of how a shoe fit is just as important as the length.

Razor siping: In order advance traction design for end-users hiking on grade 3 and 4 tracks, razor siping presents itself as a viable solution in increasing traction in wet conditions, as proven by the common method used in automotive track racing. This will help the user be more stable and decrease the occurrence of slips and falls due to poor traction design on wet surfaces.

3.5.3 UPDATED DESIGN CRITERIA

Research through design and qualitative research informed this next iteration set of design criteria.

Product Function:

-Mobility: Should allow the end-user to move more freely without restricting their natural movement when hiking on uneven terrain for a more comfortable experience. Using materiality that has flexible properties yet supportive. Not allowing the system of componentry to alter natural walking movement.

-Durability: Should be able to protect the end-user and withstand the rugged environment of rough, unformed trails of grade 3 and 4 tracks. Providing all-around protection constructed out of a hard wearing material to precent bumps and scrapes.

-Support: Should provide the end-user with effective foot support while walking over uneven terrain without restricting or limiting their movement to prevent acute injuries such as ankle sprains. Needs to support and control the ankle, whilst being constructed from materiality with flexible but supportive properties.

-Stability: Should provide lateral and torsional stability to keep the end-user stable and in control when hiking on uneven terrain. Needs to stabilise the foot and also incorporate a torsional rigidity shank.

-Traction: Should allow the end-user to have an effective grip on the various terrain types of grade 3 and 4 tracks to help prevent slips which could result in pain/injury. Needs to incorporate razor-siping to improve traction in wet conditions.

-Fit: Should provide the user with a more anatomically correct fit to help reduce the prevalence of chronic injuries such as blisters, which is the result of friction between the shoe and foot. Needs to provide the user with slight customisability of the width of the shoe. The toe-box needs to be deeper. The tongue cushioning must be padded more than 2mm to help ‘fill’ the shoe in.

-Drainage: Should allow for water to escape an internally flooded waterproof lined shoe to prevent pain and discomfort after crossing an unbridged river-crossing.

Product Experience

-Recognition: End-users should be able understand that this hiking footwear solution offers comfort and safety through its functionality and visual language.

-Distinction: Should provide a new offering of hiking footwear with innovative features that benefit end-users while accommodating their desires.

-Emotion: Should provide the end-user with a sense of security and safety when hiking on uneven terrain.

-Association: End-users should be able to recognise that this product is associated with hiking on grade 3 and 4 tracks as well as reinforcing product benefits.

User Wants

-Better grip on wet and submerged rocks

-More reinforcement around the toe

-Extra space in the bunion area

-Aesthetically more pleasing while still being comfortable

-A way for water to escape waterproof lined hiking footwear

User Needs

-Structural ankle support that allows for control and flexibility to do its job

-Correctly fitting width and depth of toe-box

-Fitting into the back of the shoe

3.5.4 COMPONENTRY DESIGN DEVELOPMENT

This section of research through design focuses on the design development of four key components that make up TrailGuard: Last shaping, drainage, speed hooks, and lateral support.

Last shaping

Using my foot impression for reference, further refinement of the shoe last shape was made to achieve an optimal anatomical shaped last. From here I transferred the final last shape into 3D software Rhinoceros for further adjustments and to make sure that the development of other componentry revolved around the new last shape. This allowed me to 3D print the improved last to use as an accurate representation for my prototype sampling. Having a shoe last which fits more anatomically to the end-users foot profile allows for a more comfortable overall fit, as it acts as the initial frame for the construction of footwear to be based around.

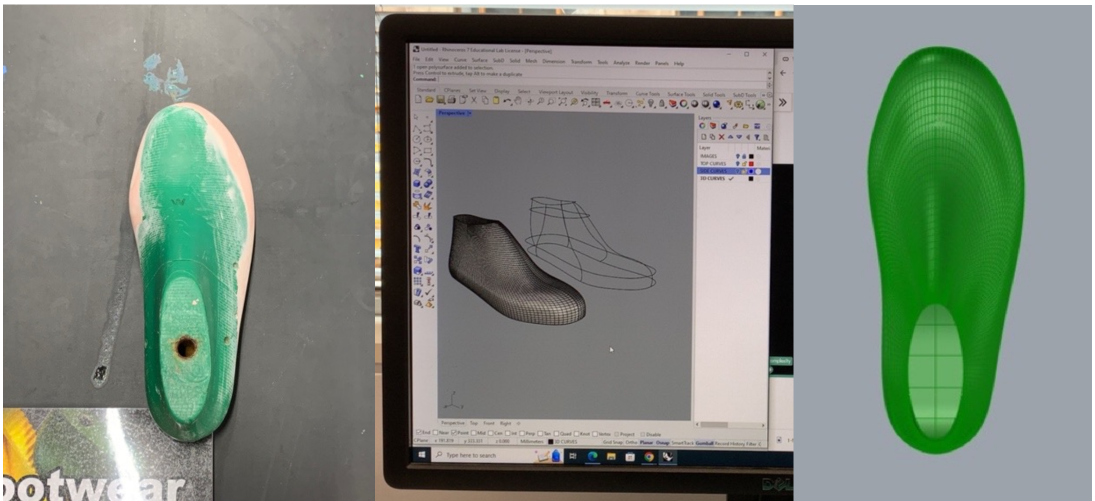
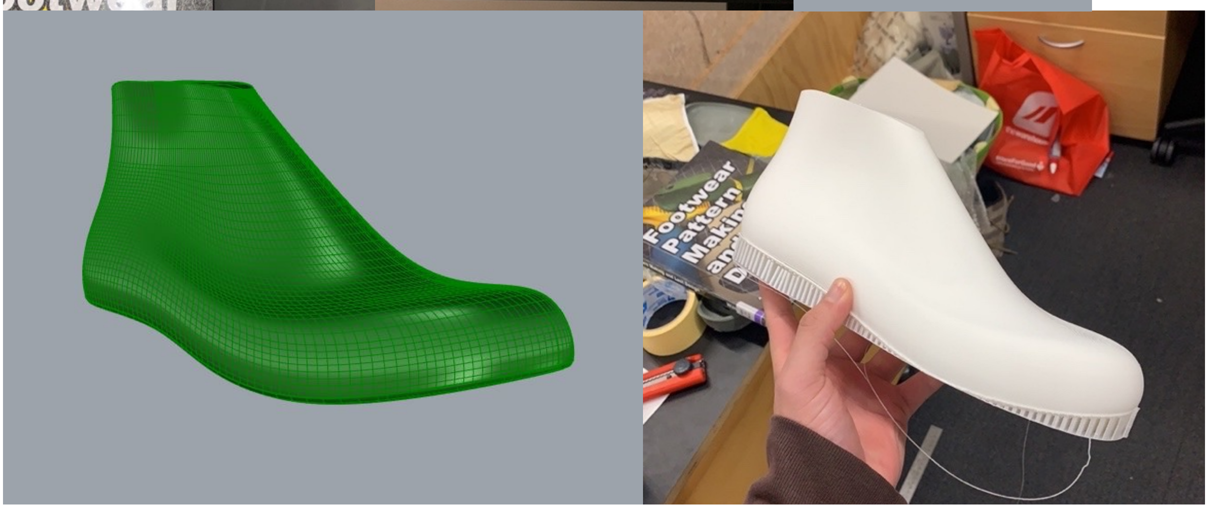


Fig. 45



Drainage

Further development of the drainage feature was focused around how I could incorporate the deformation valve effectively into the infrastructure of hiking footwear. Initially I pursued the idea if having a section of the heel to consist of the drainage unit. I 3D modelled two versions of valves that would be fitted onto existing hiking footwear midsoles to analyse the findings. By creating silicone moulds of the deformation valve variations, I was able to test how the materiality of these prototypes would behave. Alongside this I tested different shore hardness silicones ranging from 10A to 51A to determine what would work best.

I found out that valves which had a more focused contact point performed best at opening the valve under exerted pressure, and that having half of the valve being exposed helped with catching the water as it flowed down to the heel from the natural motion of walking. From here I developed a series of valves at smaller scale as it was not necessary to have the valve take up the entire section of the heel.

From critique, I identified the issue of the valve allowing water into the shoe when it is opened during a river crossing. To help prevent this a drainage cap was developed to be used whilst the end-user is walking through an unbridged river-crossing.

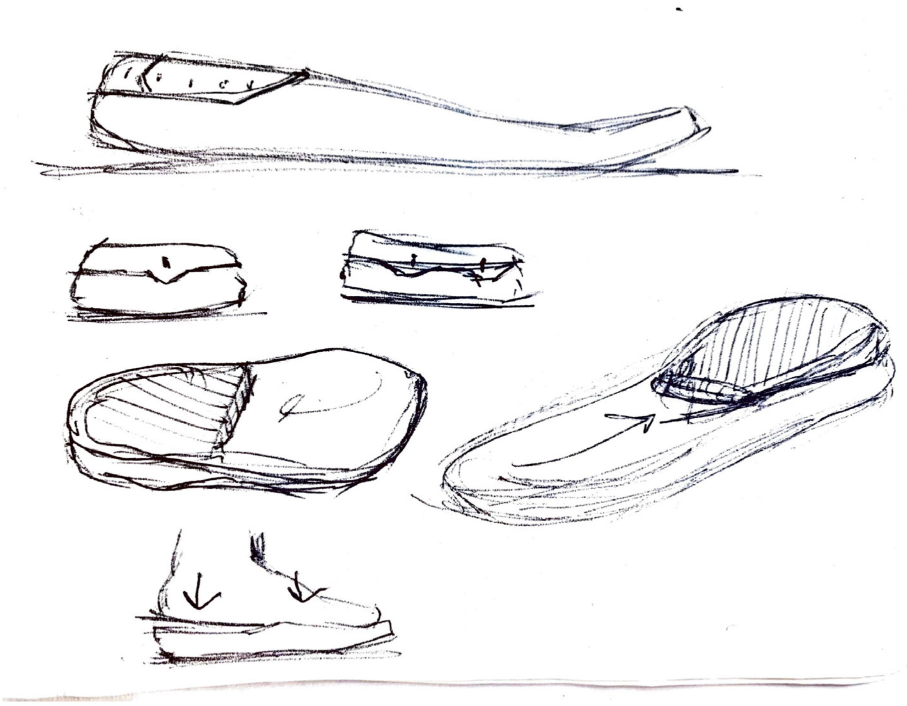


Fig. 46

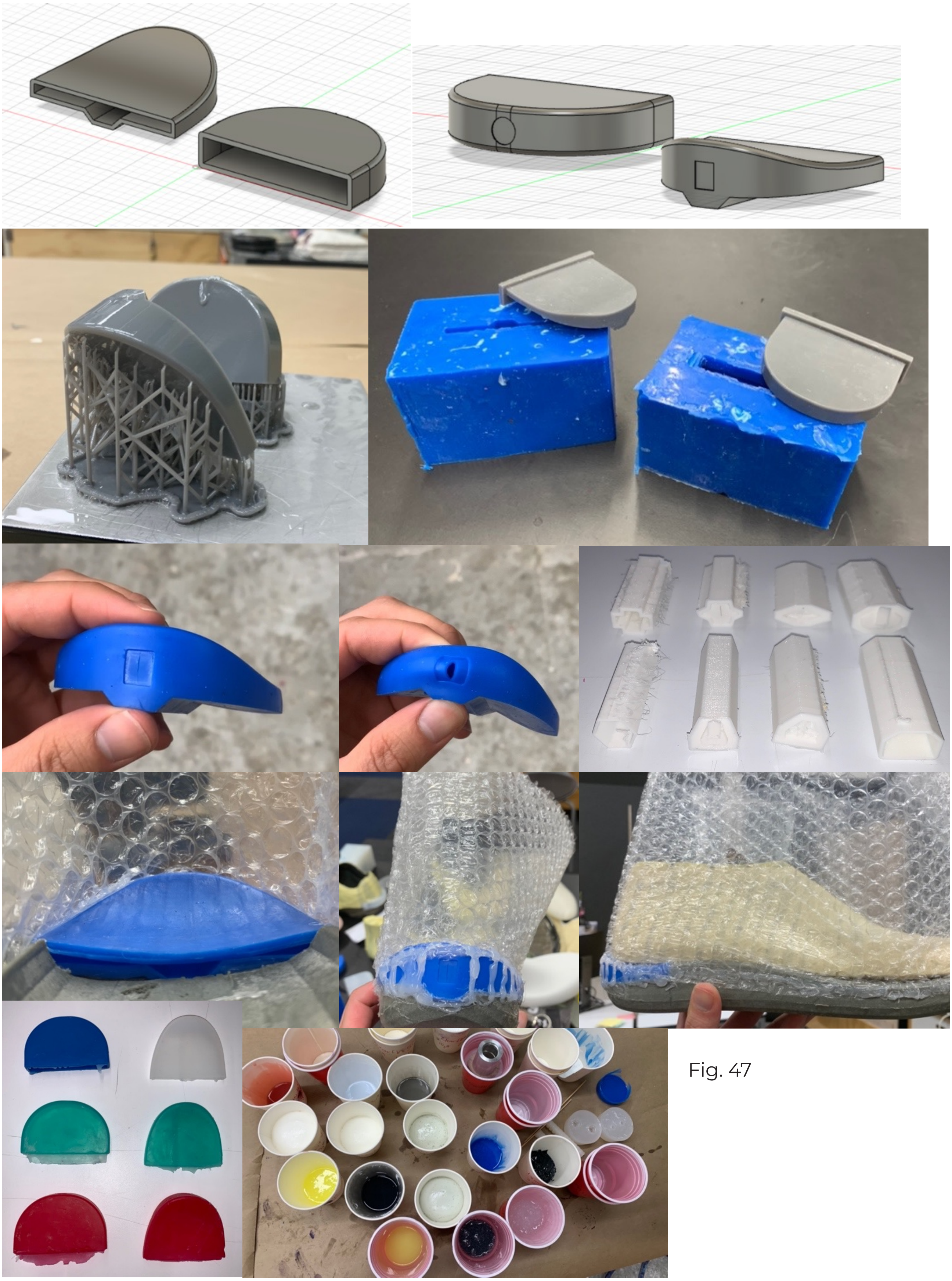


Fig. 47

Speed Hooks

To help achieve adjustable lacing, I focused on developing the speed hook which is commonly used in a variety of hiking footwear to aid in the lacing process. By developing speed hooks that are able to retain the tension of laces, the end-user is able to individually adjust certain sections of their shoe to create a more personalised fit to prevent discomfort and friction.

Three variants of speed hooks were initially modelled and printed out of tough resin to test how well they retain tension. I found out that the speed hook design which narrows into a small, tight fitting cavity retained lace movement best, but with further improvements needed. A series of iterations followed incorporating a similar design with design changes being made for an optimal result. These changes consisted of changing the scale, adding directional spikes to help lock the lace movement, and also the entry point of the speed hook to improve function.

Fig. 48

Lateral Support

Following my concept of having adjustable straps on the internal construction of the shoe, I decided to move with the direction of applying the same concept but on the exterior of the shoe. As evaluation presented the opportunity for these support panels to also contribute to lateral protection from rough terrain when hiking. I also noted that exterior support would help conform the fit of the shoe better to the user.

A series of prototypes were produced to test these support panels alongside the development of speed hooks. Various thicknesses and construction of panels were tested out of 3D printed resin to see how well they conformed to the shoe last as in combination of the speed hook lacing system.

Fig. 49

3.5.5 AESTHETIC DEVELOPMENT

Ideation/Thematic Sketching

Using desired product characteristic traits, a visual mood board was created to inform the design process of the aesthetic development of TrailGuard.

A wide variety of concepts were created which incorporated the key componentry that would be used in the final design. Considerations when generating these concepts consisted of reflecting back on my updated design criteria, facilitating the product function, product experience, and users wants and needs. This also aided in the understanding of product proportion and how each key component relates to the overall aesthetic.

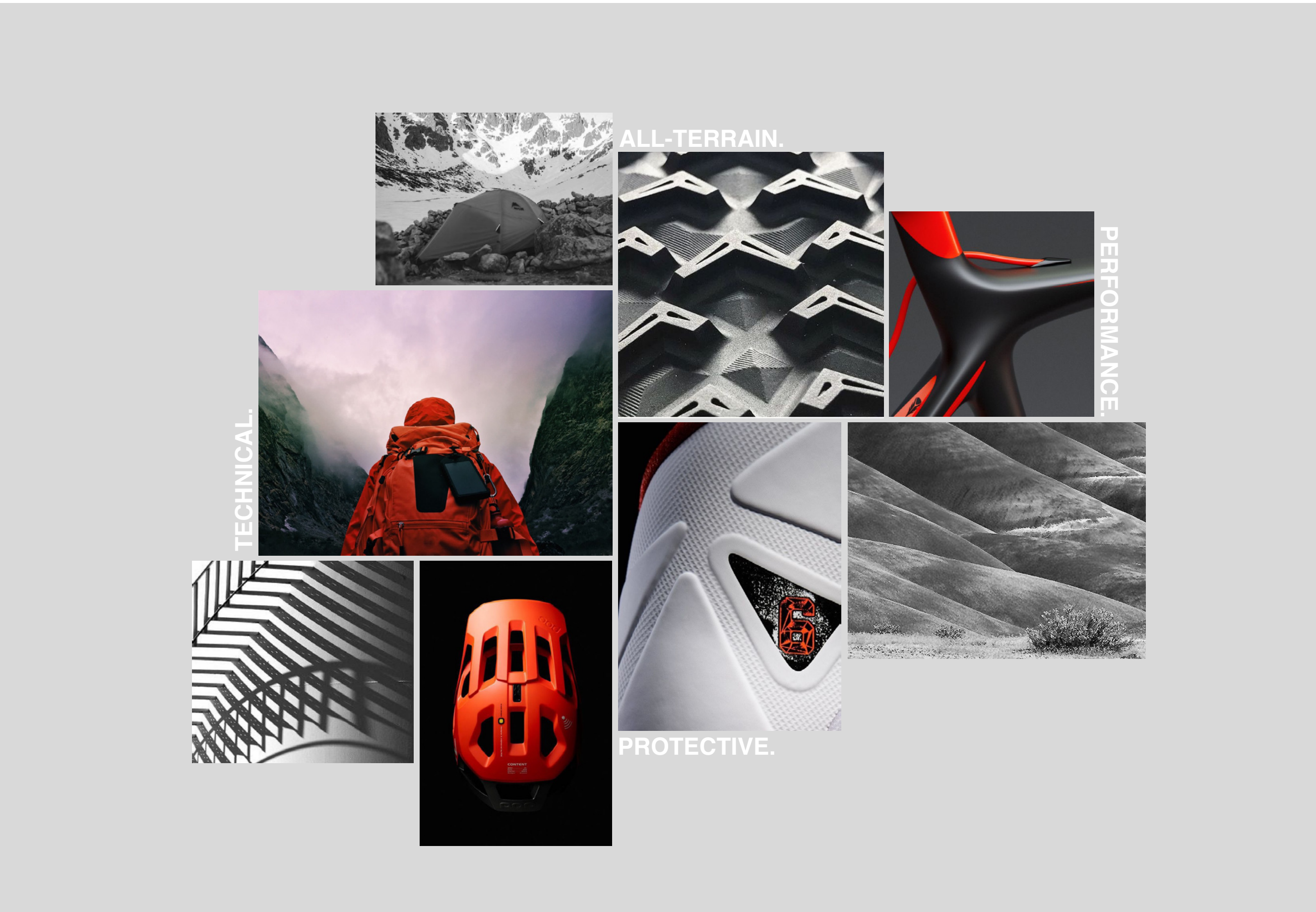


Fig. 50

Fig. 51

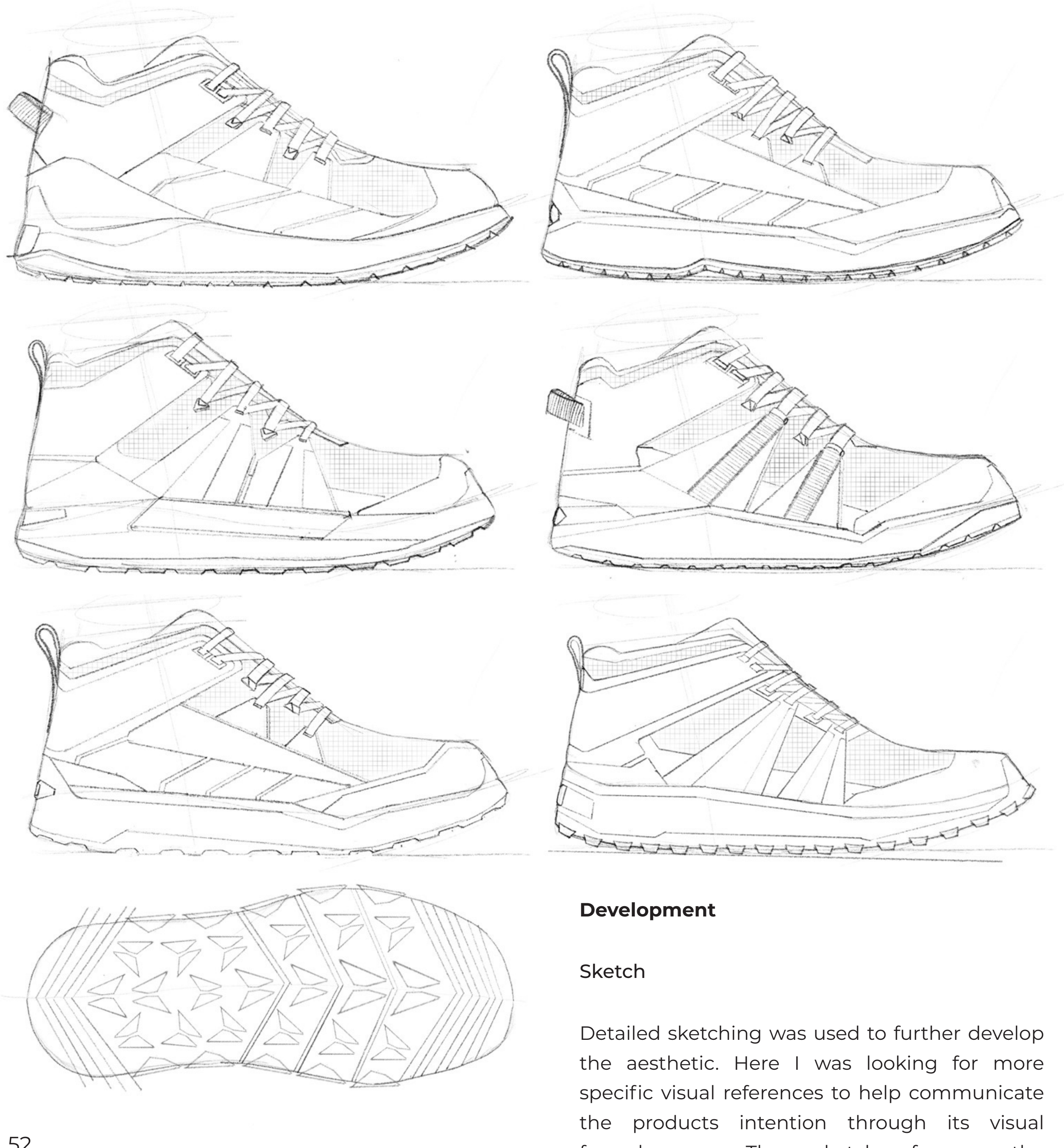


Fig. 52

Development

Sketch

Detailed sketching was used to further develop the aesthetic. Here I was looking for more specific visual references to help communicate the products intention through its visual form language. These sketches focus on the integration of lateral supports, speed hooks, drainage, protection, and outsole pattern. I explored several solutions on how the overall form of the shoe can provide the end-user with a visual understanding that this hiking footwear solution offers comfort and safety.

CAD Development

To gain a better understanding of the potential aesthetic design direction, concepts were chosen from the development stage to be transferred into 3D CAD software. This helped me see the concept in a three-dimensional space to evaluate its visual form language, proportion, and the integration of key componentry. The CAD assets also aided in the production of my final prototype.

From this I found out that the lateral supports would be most effective on the exterior of all other componentry as I experimented with placing them in-between layers of material but concluded that this would only distort certain areas of the shoe. For it be effective in conforming to the shape of the end-users foot, the lateral supports should be placed on the very exterior.

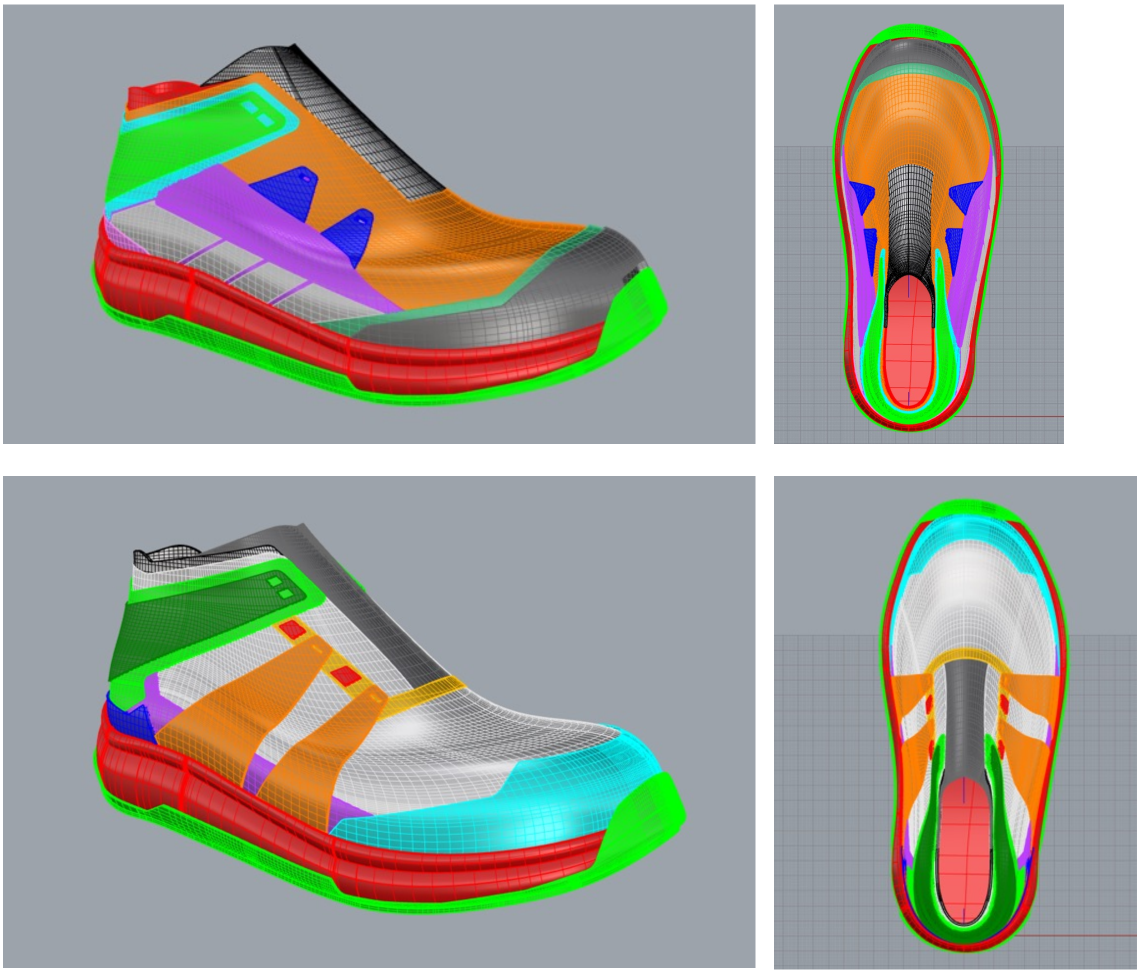


Fig. 53

Colourway Exploration

I decided to develop a variety of colourway options which were derived directly from imagery that I had taken during my immersive research. Using encounters with natural arrangements while out on the trail, I selected various imagery which I believe would help visualise the colour arrangement. I decided on pursuing the colour option which was inspired by the Emerald Lakes on the Tongariro Alpine Crossing, as this walk was the first track that was conducted as part of my immersive research. The earthy tones of the terrain in combination of the blue and green hues of the water acted as an opportunity to create a subtle colourway with colour accents highlighting design features.

Fig. 54

Fig. 55

3.5.6 FINAL DESIGN CRITERIA

Product Function:

-Mobility: Should allow the end-user to move more freely without restricting their natural movement when hiking on uneven terrain for a more comfortable experience. Using materiality that has flexible properties yet supportive. Not allowing the system of componentry to alter natural walking movement.

-Durability: Should be able to protect the end-user and withstand the rugged environment of rough, unformed trails of grade 3 and 4 tracks. Providing all-around protection constructed out of a hard wearing material to prevent bumps and scrapes. Protection should be allocated to high wear areas such as the toe and lateral sections of the shoe.

-Support: Should provide the end-user with effective foot support while walking over uneven terrain without restricting or limiting their movement to prevent acute injuries such as ankle sprains. Needs to support the ankle and the lateral sides of the shoe, whilst being constructed from materiality with flexible but supportive properties.

-Stability: Should provide lateral and torsional stability to keep the end-user stable and in control when hiking on uneven terrain. Needs to stabilise the foot and also incorporate a torsional rigidity shank. Should have a heel counter for heel strike on uneven terrain.

-Traction: Should allow the end-user to have an effective grip on the various terrain types of grade 3 and 4 tracks to help prevent slips which could result in pain/injury. Needs to incorporate razor-siping to improve traction in wet conditions. Should be multi-directional.

-Fit: Should provide the user with a more anatomically correct fit to help reduce the prevalence of chronic injuries such as blisters, which is the result of friction between the shoe and foot. Needs to provide the user with slight customisability of the width of the shoe. The toe-box needs to be deeper and wider. The tongue cushioning must be padded more than 2mm to help 'fill' the shoe in.

-Drainage: Should incorporate a deformation valve that activates on heel strike, to allow for water to passively escape an internally flooded waterproof lined shoe to prevent pain and discomfort after crossing an unbridged river-crossing.

Product Experience

-Recognition: End-users should be able understand that this hiking footwear solution offers comfort and safety through its functionality and visual language.

-Distinction: Should provide a new offering of hiking footwear with innovative features that benefit end-users while accommodating their desires.

-Emotion: Should provide the end-user with a sense of security and safety when hiking on uneven terrain.

-Association: End-users should be able to recognise that this product is associated with hiking on grade 3 and 4 tracks as well as reinforcing product benefits.

User Wants

-Better grip on wet and submerged rocks

-More reinforcement around the toe

-Extra space in the bunion area

-Aesthetically more pleasing while still being comfortable

-A way for water to escape waterproof lined hiking footwear

User Needs

-Structural ankle support that allows for control and flexibility to do its job

-Correctly fitting width and depth of toe-box

-Fitting into the back of the shoe

4.0 THE FINAL DESIGN

TRAILGUARD

TrailGuard is a performance shoe for hikers, designed and made to provide optimal comfort and safety for hikers walking on rugged and uneven terrain. The key components that make up TrailGuard have been developed into an integrated system that help improve the end-users overall experience whilst providing sufficient protection from the trail. TrailGuard is designed to help reduce the possibility of pain and discomfort with innovative features that contribute to the overall comfort. It allows for personal alteration of fit and tension of lacing to alleviate unwanted friction and to accommodate foot shape width. TrailGuard allows for internal water to escape a flooded shoe due to a river-crossing by passively pumping water out the heel.

Fig. 56

Fig. 57

Key Components and Benefits

Speed hooks: The speed hooks retain the tension of laces without letting them slip, allowing the user to individually adjust the tension of each speed hook to achieve the most comfortable fit. This benefits the end-user as it allows them to also reduce focused pressure areas and to avoid friction in certain areas of their foot which could cause chronic blisters.

Support panels: The support panels act as reinforcement and protection to the lateral areas of the foot from rough terrain and also conform to the users foot to provide stability on uneven terrain. By conforming to the users foot, there is the ability to slightly increase or decrease the width of the upper which allows for an improved fit and sense of security.

Passive drainage: The passive drainage feature consists of a deformation valve located in the heel of the midsole which activates through pressure exerted onto the valve, allowing for the small slit to open and release trapped water. To prevent water entering the shoe whilst walking through deep water, a drainage cap can be used to temporarily disable the valve function. This drainage feature benefits the user by allowing trapped water inside the shoe to escape, which helps reduce the chance of chronic blisters developing due to moisture and friction. The deformation valve also moves air through the shoe, resulting in increased ventilation.

Protective toe cap and outsole: The toe cap provides protection by acting as a barrier from falling rocks and sharp terrain. The extended outsole also provides protection by acting as a rubber bumper from rugged elements. This benefits the user through increased durability, allowing for extensive use, protection, and safety.

Multi-directional tread: The tread has been designed with special traction in the toe and heel area for better grip on toe off and heel strike. The multi-directional lugs in the central area of the tread have razor siping to allow for improved traction on wet surfaces by increasing the surface area when flexed. This benefits the user by reducing the risks of slipping and falling on uneven terrain due to poor traction, resulting in pain/injury.

Heel counter: The heel counter acts as stabilisation when walking on rough terrain. It benefits the user by stabilising the heel during heel strike to prevent twisting which can cause sprains and slips.

Seamless Upper: The main upper consists of one seamless piece. This benefits the user by removing the potential of focused pressure points due to the internal seam arrangement which would cause discomfort and friction.

Fig. 58

Fig. 58

5.0 CONCLUSION

This design research explores how footwear design can be utilised to reduce the possibility of discomfort and pain, through innovative design solutions that facilitate end-users wants and needs. TrailGuard is a performance shoe for hikers, designed and made to provide optimal comfort and safety when walking on rugged and uneven terrain. This was designed in response to the growing participatory rates of tramping in New Zealand, where Lobb describes 65% of injuries and pain experienced are in the lower extremities of the body. Current traditional hiking footwear contributes to the prevalence of pain and injury through its product characteristics such as rigidity and restriction from natural movement, being unnaturally shaped, and internally trapping water. TrailGuard allows for the customisability of width and tension of laces through its conforming lateral support panels and tension retaining speed hooks, which will aid in providing a more comfortable fit and reduce unwanted pressure points and friction. The passive deformation valve allows for water to escape a flooded shoe due to the user crossing an unbridged river, reducing the chance of chronic blisters due to moisture and friction. Razor siped tread allows for increased contact surface area on wet surfaces, providing sense of security when walking on slippery surfaces which could result in a slip or fall. Collaboration and engagement with end-users and expert podiatrists enabled the realisation of this design. I would like to keep learning on how key stakeholders can be used to help inform my design process in solving challenges through footwear design.

My research process has provided me with a deeper understanding around footwear design requirements to reduce the chance of pain, and how key product componentry contribute to the end-users overall experience. Throughout the design development I learnt the importance of visualising insight led design direction through sketching in accordance with prototyping, and the value of an iterative design process. Using this, I want to apply this learnt insight into the footwear industry by continuing to develop my craft for innovative footwear solutions that resolve design challenges. This project has made me aware of how much there is still yet to know, and has opened pathways for future learning. As a tutor at Massey University, I can work with the next generation of designers, learning and exploring with them on how research through design can contribute to complex and innovative design solutions.

TrailGuide contains innovative design features aimed at trampers in New Zealand. However I can see how certain aspects could also be applied to different sectors within the footwear design industry to help elevate users experience and reduce pain. The lateral supports which provide adjustment of width and protection could be applied to an alternative footwear area which requires stability such as basketball shoes. I can also see how TrailGuard's passive drainage feature could be implemented into boat shoes and other outdoor water based activity. I hope that TrailGuard inspires future footwear innovation that elevates end-users experience and resolves unique design challenges.

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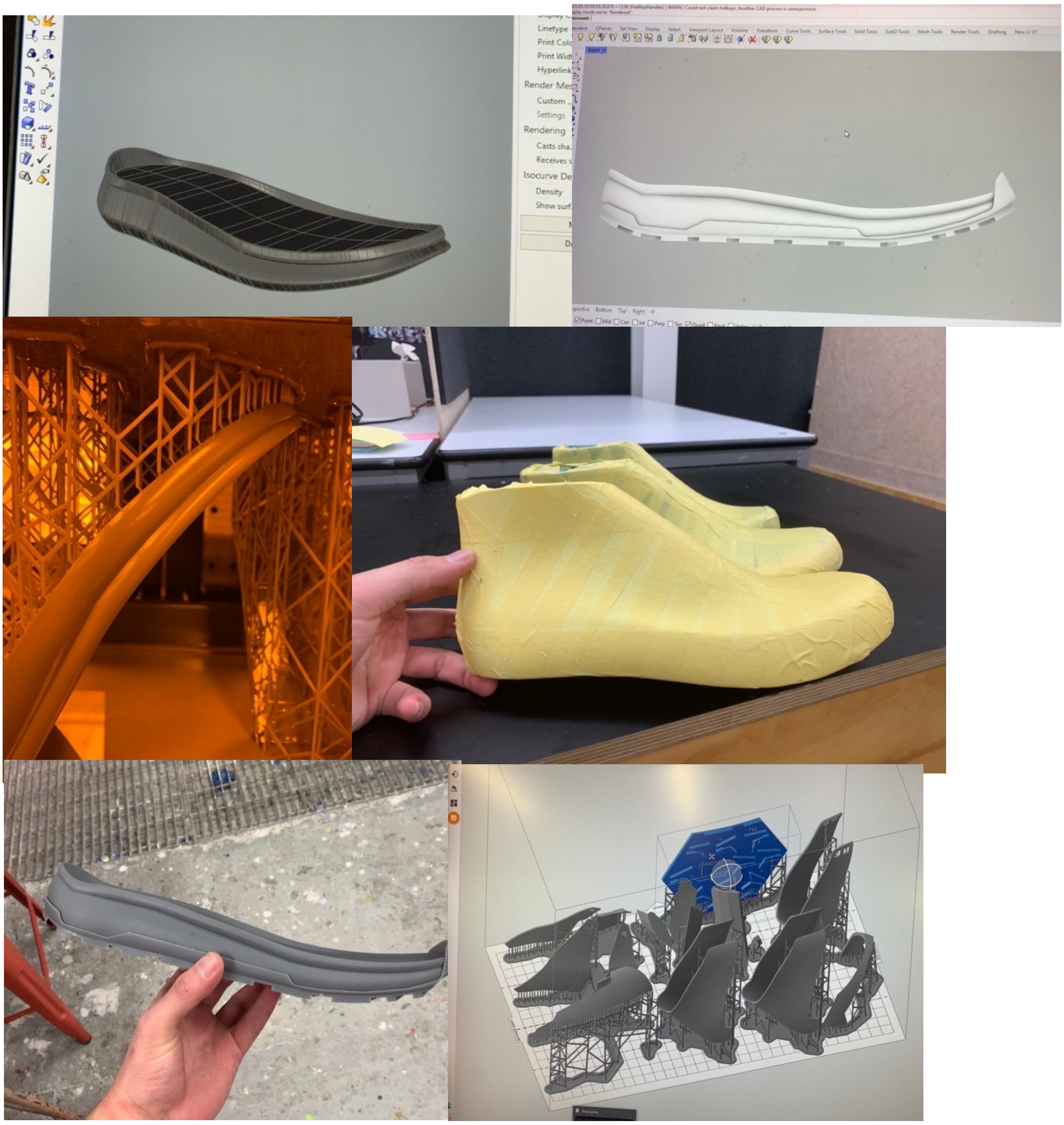
LIST OF FIGURES

APPENDICES

Prototyping

Throughout the aesthetic development I used prototyping to help visualise my concepts and design directions which would eventually result in my final appearance model, which represents my proposed final design in an arrangement which simulates the colour and materiality if it were to be manufactured. Processes involved in this include: resin printing key components in high detail, patternmaking onto shoe lasts to create the upper, and silicone moulding and casting the drainage valve. All of this contributed to iterations developed towards the final resolved design.






Interview – Specialists (Podiatrist)

Thank you for agreeing to talk to me about my research project, it really helps me to better understand who and what I am dealing with when I can talk to experts like yourself.

Context

The recent developments and upgrading of many tracks in New Zealand, this has led to an increase in popularity within tramping, but previous research has shown that this outdoor-activity significantly contributes to injuries in adventure tourism here in New Zealand

With 65% of the injured body parts being in the lower extremities of the body (Lobb 2004), this suggest that the type of footwear used on these walks may have an impact on the occurrence of injury among trampers.

This research aims to investigate what trampers/hikers need from their footwear to prevent current and ongoing injury, and to use footwear design to integrate injury prevention and user experience.

- Through my own research/context review, as well as surveys with end users – the scope of my research has shifted from developing injury prevention footwear for hikers to designing performance footwear for hikers which will have key features that may alleviate the prevalence of injury when hiking

- *What are the most common injuries have you seen from hiking?*
- *What parts of hiking footwear do you think may play a part in developing these injuries?*
- *What is the importance in having the right footwear for hiking?*
- *Could the redesign of a hiking shoe help prevent current short and long term injuries? What are some considerations do you think I should take into account?*

Ankle sprains, blisters, stress fractures, and even ingrown toenails can all be nasty outcomes of not having correctly fitted shoes for a hike.

The long term side effects of wearing unsupportive shoes can be detrimental, but also easily avoided. Hikes are long and often on uneven terrain. Your feet are put under a lot of pressure so it's important they are supported to prevent any injuries both during and after a walk.

Choosing the proper boot to wear can be challenging as every foot is so unique.

Insights from survey:

- *"I've seen too many people roll/sprain ankles whilst wearing good supportive boots"*
- *What are your thoughts on high ankle support boots in regards to preventing injury? Could it affect ROM of ankle?*
- *How to alleviate pressure points in shoe*

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