Circulation and Thermoregulation for Female Snowboarders:
An Analysis of Female Specific Needs for Snow Footwear

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Contents

Phase 1: Research

History of Sport

Snowboarding is believed to have developed in the 1960s and 1970s in the United States and grew popular in the 1980s. The modern snowboard is credited to Sherman Poppen, who created a prototype as a toy for his daughters to play with. The concept of sliding down snow using a single board gained popularity within skateboarding and surf communities, where the manufacturing and distribution of snowboards became more widely available. Different manufacturing pioneers such as Burton, Sims, Gnu, and Barfoot Snowboards organized the first official snowboard competitions such as the first National Snow Surfing Championships at South Pomfret, Vermont. In 1998, snowboarding became an Olympic sport (Britannica).

Women in Snowboarding

The first professional snowboarding event in 1982, the U.S. Open, featured only male athletes. Two years later, the first women participated in the event's halfpipe contest as the first documented professional women's snowboarding competition (Smithsonian, 2022). While the history of females in snowboarding isn't widely documented in this male-dominated sport, magazines in the 1990s like TransWorld SNOWboarding featured pioneers of women in snowboarding like Tina Basich, Shannon Dunn, and Barret Christy. This first wave of sponsored competitive female athletes helped establish the first female-specific women's snowboarding gear. In 1994, the first women's signature pro model snowboards were released by Shannon Dunn through the company Sims, along with releases from Tina Basich through the company Kemper (Snowboarder, 2014).

Currently, female participants at ski areas in the United States make up 37 percent of total participants (NSAA, 2022). Brands like Burton, Ride, Salomon, and Vans create the top female snowboarding footwear products (Evo, 2023). The current market size of the ski and snowboard industry is $4.4 billion (IBIS World, 2023), with 462 ski resorts in the United States alone.(statistica.com, 2022).

User/Athlete

This product will be a domestic product sold within the United States where the median age of the snowsports participants is 35 years. The median age can vary by region with median ages ranging between ages 17 and 39 years. (NSAA, 2022). As of 2020, there were approximately 7.61 million snowboarders in the United States (Must-Know Snowboard Statistics, 2023). Of these, about 37 percent were female (National Ski Areas Association, 2022). This means that there are about 2.8 million U.S. female snow athletes. The target user/athlete for this project is females between the ages of 13 and 40, specifically pubescent to premenopausal women. The target audience is snowboarders who travel to ski resorts, national parks, or ski towns to participate in snow activities. The general skill level of the athlete in this target audience is advanced to expert—specifically, those who participate in Black, Double Black, Park, or Freestyle routes—types of routes where technical gear impacts performance.

Product Classifications

This project will focus on footwear solutions for female snowboard athletes. The two types of footwear include a snowboard boot shell and a snowboard boot liner.

Problems to Solve

The focus of this project is on the specific thermoregulation and circulatory needs of female snowboard athletes. As written in *Gender Differences in Thermoregulation*, "Women differ from men in thermal responses to exogenous heat load and heat loss as well as to endogenous head load during exercise", explaining how having a larger ratio of body surface to body mass is one of the causes of thermoregulation differences (Kuciuba-Uscilko, Grucza, 2001). While women also generally have a lower resting body rate, they can also have significantly colder extremities with 82.7 °F versus men at 90°F. Women's higher fat content helps protect and keep organs warm but blocks the flow of blood to extremities. This causes women to generally lose heat quicker through their skin (Pfizer, 2023). In addition, a study found

that “under local cooling, females have a greater variation in thermal sensation than men” (Zhao, et al., 2023) meaning that female skin temperatures are more sensitive to local cooling than men.

Women are five times more likely to have Reynaud’s Disease, where blood vessels constrict in response to cold or stress (Branch, 2017) (Pfizer, 2023). In addition, women’s cardiovascular health is linked to women’s hormones, where changes in their hormones can affect the body’s ability to circulate blood, affecting temperature and blood pressure (Huxley, 2007). Women’s temperature regulation is linked to their menstrual cycle, with differences in temperature regulation based on the phase of the 29 day cycle (Baker, 2020).

Knowing this information, we can see how thermoregulation and circulation differ from male to female. Women’s ability for circulation and thermoregulation is only further intensified by ill-fitting female snowboard boots. Incorrect heel position, toe position, pressure on dorsal nerves of the feet, or fastening/lacing can cause further issues with circulation (Ethan, 2021). For female snowboarders, an identifiable problem is solving for increased circulation in snowboarding footwear to ultimately improve comfort, perceived coldness, and performance.

How Can We Statement

How could we support women’s circulatory health in snow mountain conditions through footwear design?

Athlete’s Role

What do athletes experience while participating in snow sports? For the athlete to partake in this sport, they would spend 5-10 hours in snow weather, with additional time to travel to the snow. They may spend 2-8 hours straight in 5-40°F outdoor snow environment going down the slopes, on the chair lifts, traversing across the mountain to get to specific gates or routes, and sitting down on the ground to strap in. They may spend periods of time with inactivity. While on the ski chair lifts, athletes will spend 5-15 minutes without any athletic activity. Snowboarders

will also sit down for a minute after the lifts to strap into their bindings or might stop on a route to take a break, wait their turn, or wait for others if they are snowboarding in a group. The job of the athlete is to lap up and down the resort for multiple hours while the athlete challenges themselves regarding skill, speed, and endurance. The athlete is looking for a positive experience on the slopes—having a fun time, staying comfortable in their gear, and coming down from the mountain safely without any injuries.

Sports Environment

Typical weather for snowboarding falls between 0°F and 30°F, with upwards of 40°F (Snow Types and their Best Temperature, 2021). Snowboarders will experience different types of snow, including ice, powder, and slush (Snow Types and their Best Temperature, 2021). Snowboarding will take place at ski resorts, which tend to be at higher elevations but under 14,000 meters (USA: ski resort elevation differences).

Product Rules

The product types are snowboard footwear for resort, park, or ski town/city use. Many people who attend a ski resort will drive or travel to the resort to participate in snow activities. Users may show up to the resort in regular footwear, change into snowboard boots before hitting the slopes, and change back into their regular footwear at the end of the snow day. Snowboarding boots will be worn on the mountain, but also in the lodge and the parking lot. While snowboarding, boots will be strapped into snowboard bindings made of metal, plastic, or lined with EVA foam. Snowboard boots will be strapped into the bindings when the athlete is actively snowboarding, but in between routes, athletes may have one foot not strapped in or might walk on the snow with both boots unstrapped.

A snowboard boot needs to keep the athlete securely locked in while they ride, meaning that the fit has to be fairly tight while still allowing the athlete to flex as they shift their weight

from toe to heel edge. They are worn with socks, and users will feel pressure at the heel, instep, and toe box (Snowboard Boot Guide). Athletes will fasten themselves into the boot liner and the boot to ensure a secure and safe ride. Currently, there are a few standards in place to determine proper snowboard boot quality. ISO 11634:1996 is the standard used for determining if the snowboard boot interacts with the bindings correctly. There are other standards for testing and quality of Step-In boots, as well as binding standards (Kelechava, 2016).

Product Areas

The two types of footwear includes a snowboard boot shell and liner that solves problems regarding the lockdown of the athlete's foot while still helping the athlete maintain circulation for women-specific needs.

Relevant Products: Snowboard Boots

Three Snowboarding boots chosen for competitor research are RIDE's Sage Snowboard Boots, Burton's Limelight Snowboard Boots, and DC's Mora Snowboard Boots for women. Ride's Sage snowboard boots retail for $269.95 and feature a H4 Boa® Coiler Fit System, with heat reflective foil to keep feet warm and a flex rating of 4/10 for medium flex. They use a heat moldable Intuition™ Plush liner, with the liner being "factory molded inside the shell to create the most efficient 'net fit'" (Ride Sage Snowboard Boots). Their women-specific sizing uses their Calf Adjustment Technology System to size for women's calf sizes. They also include their company's technology for traction and midsole to work for snow and ice conditions.

Fig 1: RIDE's Sage Snowboard Boots | $269.95

Burton’s Limelight Snowboard Boots retails for $339.95, has a medium flex of 4-7/10, and features a Boa® Coiler™ Closure System with an integrated lacing system and inner lace lock (Burton Limelight Boa Snowboard Boots, 2021). Burton uses their “Women's Specific True Fit™ Design” which has been “designed and engineered for the way women ride” (Burton Limelight Boa Snowboard Boots, 2021). They use their Imprint™ 2 Liner – Burton's Imprint™ 2 liner along with their 3M™ Thinsulate™ mapped synthetic insulation to provide comfort and warmth to the rider. They have the cuff of the boot constructed for female calf size, sleeping bag foil technology to help warm the foot, and an outsole to help grip snow and ice.

Fig 2: Burton’s Limelight Snowboard Boots | $339.95

DC’s Mora Snowboard Boots for women are priced at $329.95. They have a flex rating of 7/10, a Dual BOA® Fit System, and an internal ankle harness for support. They use a premium R2 liner and 3M™ Thinsulate™ insulation with the liner made of EVA memory foam and high rebound heat-moldable EVA (DC Mora Snowboard Boots). Their outsole uses designs based on skateboarding shoes for a traditional board riding feel.

Fig 3: DC’s Mora Snowboard Boots | $329.95

Things to consider across the competitor market include how companies size for women, how they approach lockdown (and if it is women-specific), and how the boot is insulated. For the Ride and Burton boots, their sizing took into account women's calf size when designing the product. Two of the boots use the same technology for insulation.

Fig 7: Composition of a snowboard boot.

Construction and Manufacturing of Parts and Pieces

The construction of the snowboard boot includes materials and manufacturing for separate components, along with the process of assembling all of these components to create a boot. The upper is made up of durable synthetic materials, with higher-end boots potentially made of leather (Snowboard Boot Guide). The liner is typically made of EVA foam (DC Mora Snowboard Boots, 2021). The lacing system for the boot depends on the boot type, but Boa systems use a reel-based system made of 7x7 stainless steel cables (Hammerslag, 2012). The sole usually has an EVA footbed, EVA or PU midsole, and rubber outsole (RIDE Anthem Snowboard Boots 2024).

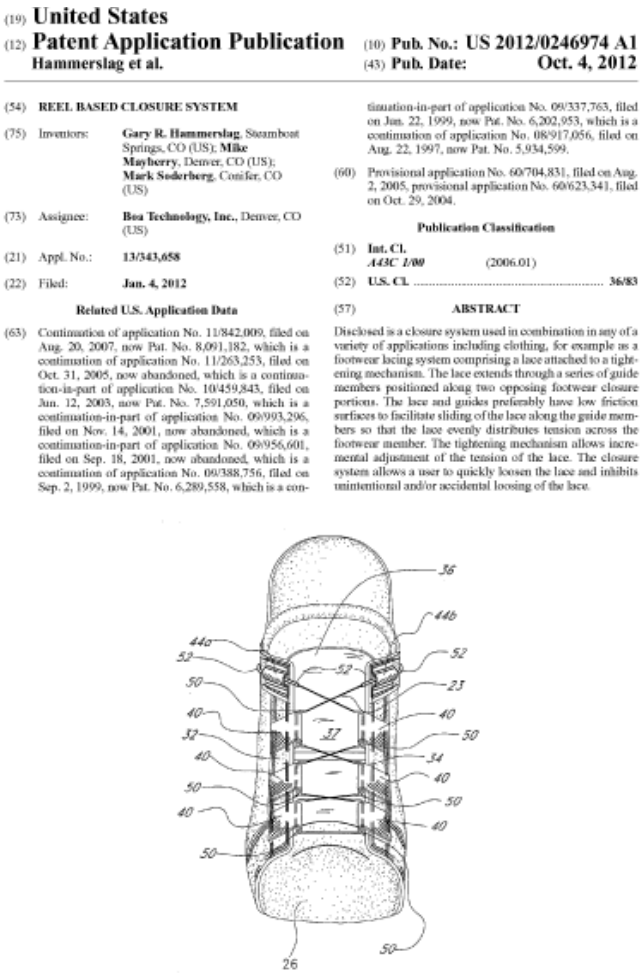
Footwear typically follows a general construction process of cut and sew, sole manufacturing process, stitch and assembly, and finishing (Ahimsa). However, specific components of the products or steps of manufacturing may have specific changes based on the functional needs of the products. For snowboard boots, the upper and liner are both cut and sew. According to a *How It's Made* video on ski boots, these upper parts that have insulation are usually glued before being sewn to keep all of the layers in place (Quest TV, 2018). They also show a waterproofing step where a piece of waterproofing material is added to the bottom of the Strobel board, covering the seams of the bottom of the upper pattern.

Liners are heat molded to provide a good fit. The lacing system could be installed at this point. The sole could be broken down into the footbed, the midsole, and the outsole. The footbed is either injection-molded or compression-molded EVA foam. The midsole is also injection or compression molded, and the outsole or traction pad is vulcanized, using molding or extruding to form the shape of the outsole (LinkedIn). The vulcanization process of rubber involves selecting natural or synthetic compounds, mixing and compounding with stabilizers, colors, and plasticizers, and shaping through heat and pressure to crosslink the rubber's polymers (LinkedIn). To assemble these components using the typical footwear assembly process, the uppers and liner would be cut, glued, and sewn. The liner would be molded. The upper and midsole would be adhered/stitched to the sole. Finishing could include trimming and cutting vulcanized rubber soles, or surface treatments (LinkedIn)

Fig. 9: Construction and Manufacturing

Intellectual Property Landscape

Three main areas of patents that can be identified for snowboard boots include patents for a snowboard boot's closure system, internal lockdown, and upper design. A patent to highlight the boot's closure system is Boa's Reel Based Closure System (Hammerslag, G. R., Mayberry, M., & Soderberg, M., 2012). This technology is widely used in various snow products, and other athletic products/footwear as well. Simply put, the Boa System uses thin steel cords as laces that tighten in a spool to provide efficient security through the lock and twist of a knob. This invention is either an invention that I need to steer clear from, or that I need to design for compatibility as part of my snowboard boot system given that a large number of snowboard boots available today use Boa Reel Based Closure Systems in their products.



(19) **United States**

(12) **Patent Application Publication**

Hammerslag et al.

(10) **Pub. No.: US 2012/0246974 A1**

(43) **Pub. Date: Oct. 4, 2012**

(54) **REEL BASED CLOSURE SYSTEM**

(75) Inventors: **Gary R. Hammerslag**, Steamboat Springs, CO (US); **Mike Mayberry**, Denver, CO (US); **Mark Soderberg**, Conifer, CO (US)

(73) Assignee: **Boa Technology, Inc.**, Denver, CO (US)

(21) Appl. No.: **13/343,658**

(22) Filed: **Jan. 4, 2012**

Related U.S. Application Data

(63) Continuation of application No. 11/842,009, filed on Aug. 20, 2007, now Pat. No. 8,091,182, which is a continuation of application No. 11/263,253, filed on Oct. 31, 2005, now abandoned, which is a continuation-in-part of application No. 10/459,843, filed on Jun. 12, 2003, now Pat. No. 7,591,050, which is a continuation-in-part of application No. 09/993,296, filed on Nov. 14, 2001, now abandoned, which is a continuation-in-part of application No. 09/956,601, filed on Sep. 18, 2001, now abandoned, which is a continuation of application No. 09/388,756, filed on Sep. 2, 1999, now Pat. No. 6,289,558, which is a continuation-in-part of application No. 09/337,763, filed on Jun. 22, 1999, now Pat. No. 6,202,953, which is a continuation of application No. 08/917,056, filed on Aug. 22, 1997, now Pat. No. 5,934,599.

(60) Provisional application No. 60/704,831, filed on Aug. 2, 2005, provisional application No. 60/623,341, filed on Oct. 29, 2004.

Publication Classification

(51) **Int. Cl.**
A43C 1/00 (2006.01)

(52) **U.S. Cl.** **36/83**

(57) **ABSTRACT**

Disclosed is a closure system used in combination in any of a variety of applications including clothing, for example as a footwear lacing system comprising a lace attached to a tightening mechanism. The lace extends through a series of guide members positioned along two opposing footwear closure portions. The lace and guides preferably have low friction surfaces to facilitate sliding of the lace along the guide members so that the lace evenly distributes tension across the footwear member. The tightening mechanism allows incremental adjustment of the tension of the lace. The closure system allows a user to quickly loosen the lace and inhibits unintentional and/or accidental loosing of the lace.

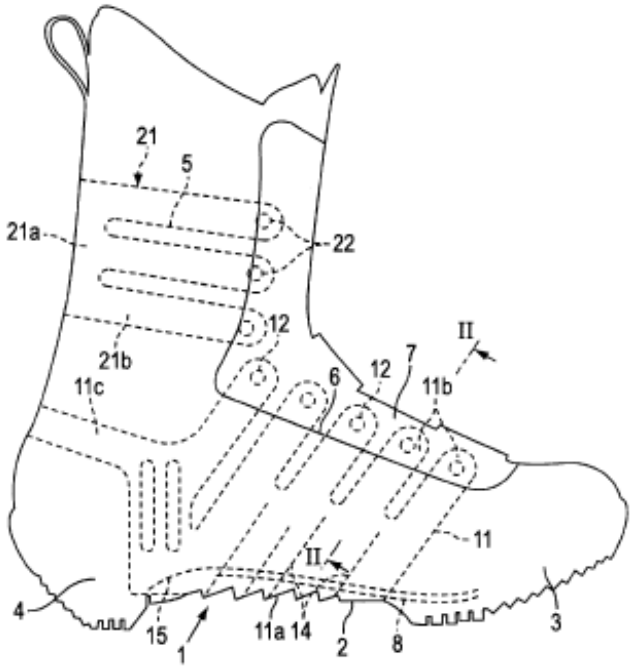
Fig. 10: Pub. No.: US 2012/0246974

A Patent pertaining to the lockdown of a boot highlights how various companies create their own lockdown system to provide stability for riders. This patent highlights an interior tightening mechanism for snowboard boots along with eyelets that a tightening cord is threaded through (*US5950335A*). It is important to note that this particular patent is expired, however, companies come up with their own proprietary way to lock down their boots.

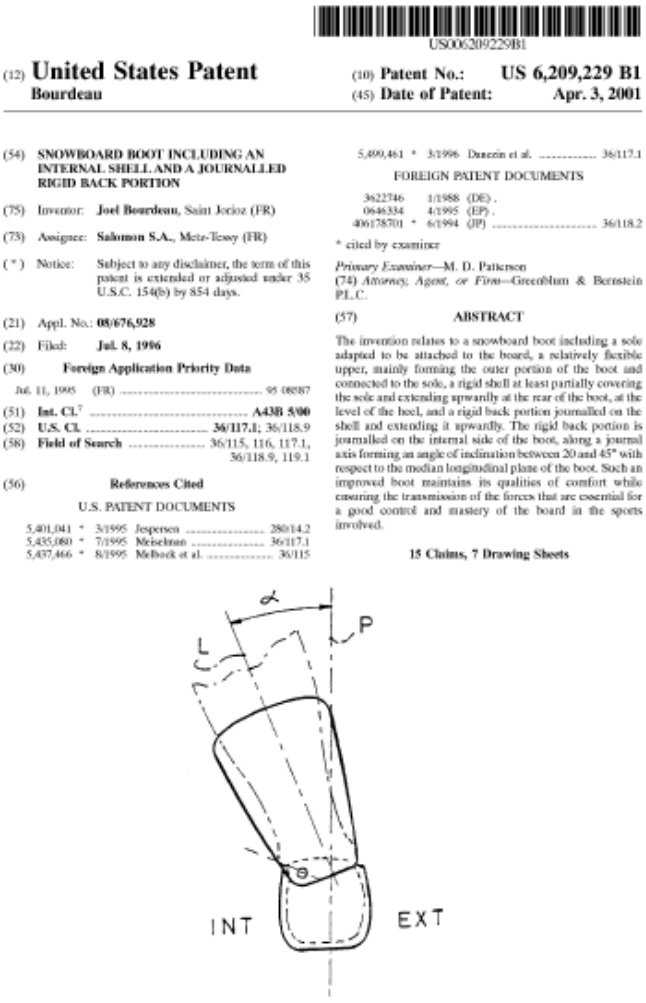
Fig. 11: Patent Number: 5,950,335

U.S. Patent Sep. 14, 1999 Sheet 1 of 2 5,950,335

FIG. 1



Lastly, this patent is for an Internal Shell and a Journalled Rigid Back (Bourdeau, J., 2001). The shell includes a rigid back to provide differences in flex for the athlete to have support for bent knees when riding. It is important to note innovations within the product space like this because This technology is less visible and noticeable, so accidentally creating a product with a similar design could be easy to do if an individual does not do a thorough sweep of the current technology out there for snowboard boots.



US006209229B1

(12) **United States Patent**
Bourdeau

(10) **Patent No.: US 6,209,229 B1**
(45) **Date of Patent: Apr. 3, 2001**

(54) **SNOWBOARD BOOT INCLUDING AN INTERNAL SHELL AND A JOURNALLED RIGID BACK PORTION**

(75) Inventor: **Joel Bourdeau**, Saint Jorioz (FR)

(73) Assignee: **Salomon S.A.**, Metz-Tessy (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 854 days.

(21) Appl. No.: **08/676,928**

(22) Filed: **Jul. 8, 1996**

(30) **Foreign Application Priority Data**

Jul. 11, 1995 (FR) 95 08587

(51) **Int. Cl.**[7] **A43B 5/00**
(52) **U.S. Cl.** **36/117.1**; 36/118.9
(58) **Field of Search** 36/115, 116, 117.1, 36/118.9, 119.1

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Primary Examiner—M. D. Patterson
(74) *Attorney, Agent, or Firm*—Greenblum & Bernstein P.L.C.

(57) **ABSTRACT**

The invention relates to a snowboard boot including a sole adapted to be attached to the board, a relatively flexible upper, mainly forming the outer portion of the boot and connected to the sole, a rigid shell at least partially covering the sole and extending upwardly at the rear of the boot, at the level of the heel, and a rigid back portion journalled on the shell and extending it upwardly. The rigid back portion is journalled on the internal side of the boot, along a journal axis forming an angle of inclination between 20 and 45° with respect to the median longitudinal plane of the boot. Such an improved boot maintains its qualities of comfort while ensuring the transmission of the forces that are essential for a good control and mastery of the board in the sports involved.

15 Claims, 7 Drawing Sheets

Fig 12: Patent No.: US 6,209,229

State-of-the-art and Future Color Trends

WGSN had 2023-24 color trends predictions that identified a few colors to be trending in the fall and winter seasons of 2023/2024. Some colors they predicted included Galactice Cobalt, Astro Dust, Sage Leaf, and Digital Lavender (WGSN's Fall/Winter 23-24 Color Forecast, 2021). Sightings for these colors within the snowboard industry include Burton Snowboard's use of

Galactic Colbalt (Men's Burton Ripcord Flat Top Snowboard, 2023), K2's use of Astro Dust in their boot (K2 Contour Women's Snowboard Boots, 2023), Jones' use of Sage Leaf within their Dream Weaver Snowboard (Jones Dream Weaver Snowboard, 2023) and Digital Lavender seen in Ride's Warpig snowboard (Ride Warpig Snowboard, 2023). WGSN also released a report for future colors, including Future Dusk, 2025's color of the year (Introducing our Colour of the Year for 2025: Future Dusk, Oct 25, 2023), along with a few other fall/winter colors including Midnight Plum, Sustained Grey, and Cool Matcha (Velasquez, 2022).

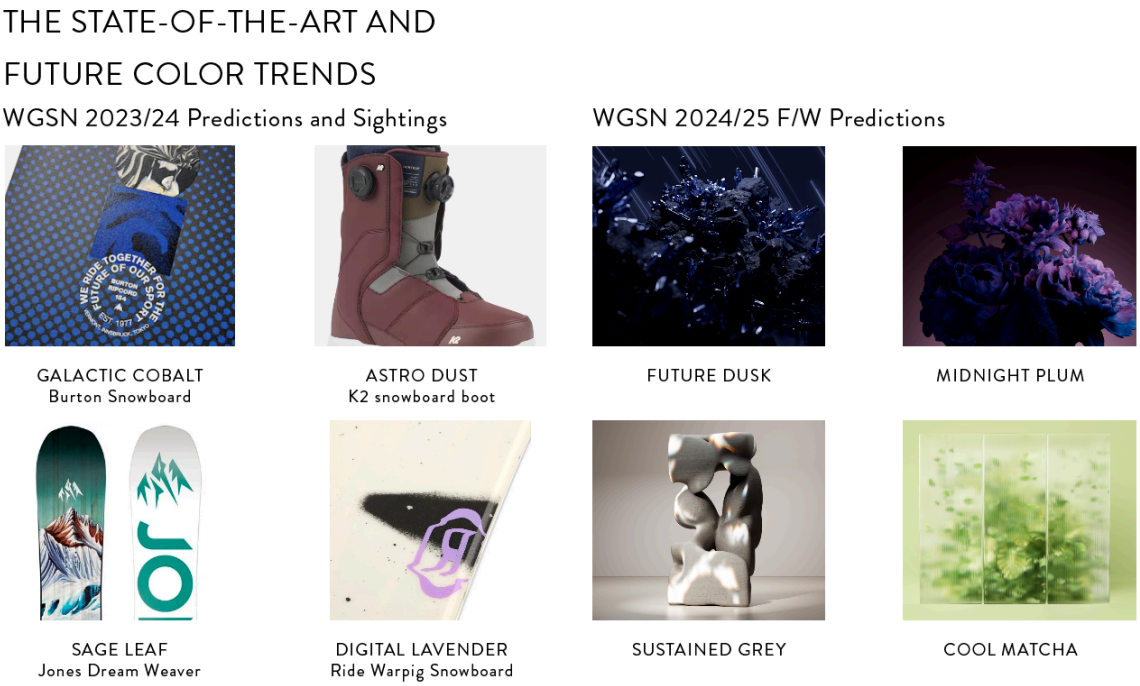


Fig 13: WGSN color predictions for F/W 2023, 2024, and 2025

State-of-the-art and Future Graphic Trends

While snowboard boots and snowboard footwear tend to not have many graphic elements, researching graphic trends can still help create a design direction and a brand image catering to the future market of this product. A 2023 report highlighted a few different graphic trends, including design styles such as Risoprint, Holographic Surrealism, Modern Nostalgia,

and AI Design (Muavia, 2023). Riso print is a printing method using bright colored ink, but this general design style can be seen as graphics mimicking the general appearance of this printing method. Holographic Surrealism uses gradients, metallic 3D objects, and contrasting colors within its design concept. Modern Nostalgia depicts nostalgic old-tech elements in a modern way. This theme could include stylizing web tabs, loading bars, and chat boxes to provide a technology feel from 20 years ago but using modern graphic elements. AI design is the creation of design through AI. This concept may take over creative spaces, with computer-generated art being for the sake of time and ease (Muavia, 2023).

WGSN released autumn and winter 2024-2025 predictions describing different graphic trends for the upcoming years. Some design themes include Amplified Craft, Main Character Energy, Serene Futurism, and Time to Go Dark. Amplified Craft leans into an art-centered and expressive design that feels personable yet vibrant. Main Character Energy uses bold colors and prints to convey a loud aesthetic. Serene Futurism centers around pastel but bright colors, with an emphasis on movement. Time to Go Dark embraces dark colors and edgy concepts (Browning, 2023). Utilizing these graphic trends can help visualize women's footwear by emphasizing ideas of futurism, strength, and movement.

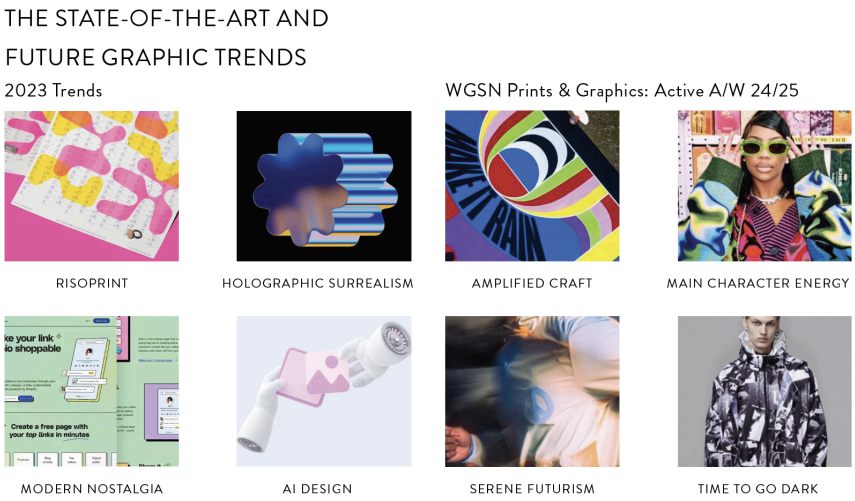


Fig 14: Current and Future Graphic Trends

State-of-the-art and Future Logo/Branding Applications

Logos and branding is used throughout product design, but brands' current logos do not best express current trends, given that logos of prominent brands used today use logo design that is based off of the market of when the company originally designed their logos, not reflecting the current market. However, the application and use of these logos do contain patterns that can be mentioned. As seen in Figure 14, logo and branding in snowboard footwear products today is kept to a minimum, with small logos of the company placed in seams or adhered to the edges of a product. Information regarding the product is seen to be used as graphic elements, like information on pull tabs of boots or the tongue of a boot. The use of these logos is minimal and non-intrusive. 2024 logo trends, outlined in a Wix article published in 2023 identify a few different logo styles that the company predicts will trend in 2024. Some design trends include Liquid Metal a 3D-looking logo with reflective, metal-like properties, Less is More (still) explaining how minimalism will still be in, Organized Chaos where organic shapes and lettering are used to create a friendly, independently owned look, and intentionally flawed, the use of chaotic shapes and lines as part of graphic communication (Goldstein, 2023).

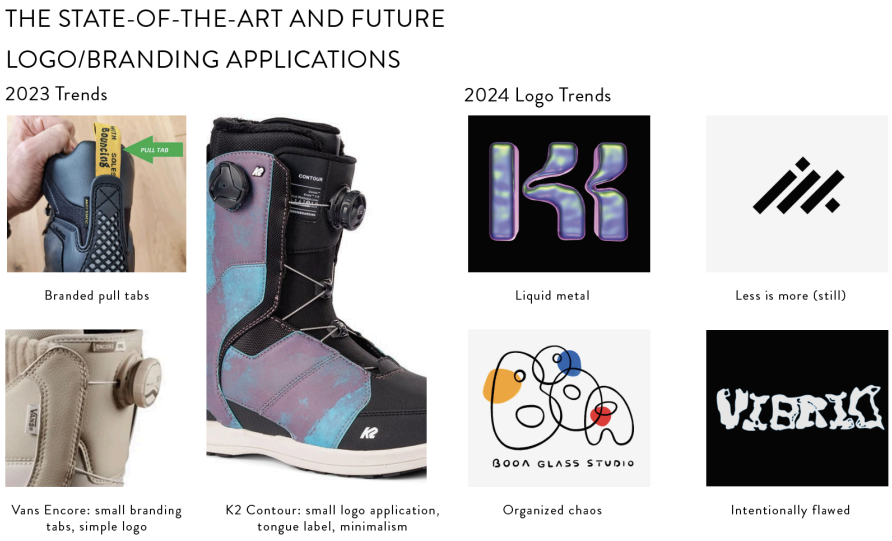


Fig 15: Current and Future Logo/Branding Applications

Physiological Research

Some helpful findings for designing footwear for snow sports include physiological information about female snowboarders. An article on both skiing and snowboarding by Jeffrey A. Ross explains how downhill ski injuries are often caused by fatigue (Ross, 2010). Another study on the "Comparison of Physical Characteristics and Performance Among Elite Athlete Snowboarders" found that "physical fitness is a performance-determining factor in snowboarding, but women's performance levels were reflected more" indicating that there may be indications of more similar general fitness levels among men than women, so "fitness plays a greater role in women's events" (Platzer, et al., 2009). This information is important for snowboard boot design because a boot that can prevent fatigue in the lower leg and foot can provide a safer experience for riders. And, since women have a lower general fitness level, it is increasingly important to design for fatigue in women's footwear.

Something to consider with women athletes is that their cycle can affect the way they perform. An article on the differences between men and women concerning balance found that women have increased length and thickness of plantar fascia during ovulation. This plus decreased postural sway and tremor indicates that sex hormones can affect balance. So, it is important to pay attention to cycles since hormone levels have a play in lower extremity injuries (Haneul, et al., 2018). These articles can help inform design, prioritizing designing for a female athlete's health by considering how fatigue and balance can be solved in a product.

Biomechanical Research

In the "Biomechanical Analysis of Snowboard Riding Motions", the journal article dissects common motions in snowboarding: Neutral, front turn, and back turn. This article identifies what muscle groups are used during each motion (Lee, et al., 2016). During frontside turns for regular riders, the article found that the "right vastus intermedius muscle, the right

biceps femoris muscle, the right gastrocnemius muscle, and the right anterior tibial muscle were shown to be major activated muscles" and for backside turns, the "right vastus lateralis muscle, the right vastus intermedius muscle, the left biceps femoris muscle, and the right anterior tibial muscle" were major muscle groups used (Lee, et al., 2016). This can be helpful in knowing which muscles to support when designing for fatigue prevention.

An article on the "Evolution of Laterality in Snowboard Basic Position" found that while over 90 percent of participants are right-footed and right-handed, 66% of total participants indicated that they lead with their right foot (goofy stance). This means that there are significantly more people who ride goofy with the right foot forward than is typical for those who are right-rooted (normally right-footed people will board with the left foot forward). This article goes on to state how the lateral stance an athlete has on a board in general affects the postural control of an individual, making it harder for anyone to maintain balance in typical snowboarding stances (Staniszewski, et al., 2016).

Another article on the biomechanics of jumps for ski jumps found that athletes with more valgus knee alignment had worse performance for imitation jumps and squats. And, valgus knee alignment is more common in females than males (Russell, 2006). And while having valgus knee doesn't cause flat feet, people with valgus knee tend to have flat feet in order to compensate for the misaligned knee (University of Rochester Medical Center). Designing soles for flat feet can help create footwear that prioritizes performance and fatigue prevention.

Psychological Research

Understanding the psychological nature of snowboarders is also important when designing for this athlete group. A study on the "Differences in sensation seeking between alpine skiers, snowboarders, and ski tourers" found that snowboarders scored significantly higher in the thrill and adventure-seeking category, and also the experience-seeking category (Kopp, et al.,

2016). With this in mind, a second article analyzes injury trends and found that out of 690 injury cases, only 144 were snowboarders with only 36 percent of those females. This indicates that females are less likely to get injured while snowboarding, meaning we could infer that while snowboarders, in general, are seeking adventure, females may play it more safe in terms of risk-taking (Ozen, et al., 2018).

Phase 2: Exploration

Methods User/Consumer Information

Different methods will be used to collect data and gain information surrounding female snowboard footwear. Methods that will be used to collect user and consumer information will include surveys and multiple performance testing plans. The survey will ask general questions to female snowboarders about their experiences with snowboard footwear to get a better understanding of the athlete. To identify the current state of sizing and thermoregulation, performance tests will be conducted. The first performance test will be a 3D foot scanning test to identify female snowboarder foot geometries and to discover any variability or insights. For female-specific fit, we need to collect data on what brands are currently doing to build footwear and boots to be designed for females. For this, 3D scans will identify Boot liner geometry. Photos will be collected to zone wear marks of lift-related boot wear. Temperature tests will be taken to identify affects of the Boa system on thermoregulation. Heel lockdown will also be identified in inches based on current boot liners and a new proposed system. Lastly, we will also need to run tests of comparing the current market item to new proposed technology.

Questions for Consumer Study

Questions were created to send to the target consumer/athlete. These questions were framed to understand and gain better reference for the preferences and needs of the athlete. The questions asked were:

1. How many years have you been snowboarding?
2. What skill level would you consider yourself
3. What type of snowboarding do you like to do?
4. What routes do you frequent at a ski resort?
5. How often do you snowboard?
6. What Brand/model of snowboard boots do you use?

7. Do you wear Apres boots? If so, what brand/model? If not, what shoes do you wear before or after snowboarding?
8. How many seasons do my snowboard boot last for?
9. For each question, rate 1-5 how you feel about each statement
    a. My snowboard boots are comfortable
    b. My snowboard boots keep my feet warm
    c. My snowboard boots fit properly
    d. My feet never go numb in my snowboard boots
    e. My feet never lose circulation in my snowboard boots
    f. I have great heel lockdown in my snowboard boots
    g. I have an easy time taking off my boots
    h. Lacing up my snowboard boots provides proper fit
    i. When I lace my snowboard boots, they keep their fit all day
    j. When I change out of my snowboard boots, I know my feet will be warm in my apres boots/shoes
10. Rate the following question:
    a. At the end of my snow day when I change out of my snowboard boots into apres boots or other shoes, I am looking for:
        i. my feet to be warm
        ii. my feet to breathe
        iii. my feet to be supported with cushioning
        iv. my feet to be comfortable
        v. my feet to be dry
        vi. good traction in snow/ice
11. Please elaborate on any specific issues you have with snowboard boot comfort.
12. Please elaborate on any specific issues you have with snowboard boot fit.

13. Please elaborate on any specific issues you have with foot circulation, numbness, and thermoregulation.
14. If applicable, please list any other issues you have with your boots
15. If applicable, please list any other issues you have with your apres boots.
16. For each question, rate 1-5 how you feel about each statement.
    a. I feel like my snowboard boots were specifically designed for females/female needs
    b. I feel like my snowboard boots are just men's boots with small changes
    c. I like the design/aesthetic of my snowboard boots
    d. I like the color options available for snow footwear on the market
    e. I find that I am usually colder than my male snowboarding counterparts

From this set of questions, insights were recorded concerning different users' opinions on their current snow gear experiences. (see Appendix G). Some key insights gathered: Almost all of the women surveyed used a snowboard boot with a Boa Lacing system. The median amount of seasons that snowboard boots last for was 3-5 seasons. Some specific insights include an individual identifying a specific hot-spot pressure point to avoid. It was also mentioned that Boa's lacing system needs adjustments after a few hours. As for Apres boots, the main complaint was a lack of outsole traction. With this information, we can try to focus efforts on improving fit and function without re-inventing the Boa. There were mixed responses towards topics of the loss of circulation, heel lockdown, and numbness, which should be explored further through discussions with more athletes.

Performance Testing Plans

Three competitor products will be purchased secondhand, preferably from Burton, DC, Ride, and/or Vans. These 3 boots will be from different brands or from other available boots that are size 7 women's. These will be implemented in test 1.

Test 1: Reverse Engineer a Last

For brand measurements, we need to obtain a few different brands of snowboard boots and get an idea of what shapes are currently used for designs using 3D scanning.

Steps:

1. Purchase 3 used boots with boot liners. Source scanning equipment.
    a. Sourced boots: Van's Encore, Ride Sage, Solomon Ivy?
    b. Scanning platform, 3D scanning app, scanning socks.
    c. Purchase molding material (paster, vaseline, plastic, measuring materials, and PLA filament
2. Line boot shell with plastic
3. Fill boot with plaster
4. Take boot cast out of the shell
5. 3D scan plaster cast
6. Edit 3D scan in Rhino using the boots purchased as measurement reference. This boot last will be mad using informative data of the sample boots
7. Create a mold in 3D
8. 3D print mold
9. Re-cast using plaster in the 3D printed mold
10. Use this boot shell last for prototyping

Test 2: Foot Scans

Female foot data collection:

To get a good idea of what female snowboarders' needs are, data collection of 3D scans of female snowboarder feet will be collected. This may require a human subject release form.

1. Survey created including questions such as:
    a. Size in regular shoes

    b. Size snowboarding boots you wear
    c. Brand of boots you wear
    d. Age
    e. Ethnicity/Race
    f. What type of snowboarding do you do/how often do you snowboard
    g. Gather basic goot measurements using a Brannock device
2. Have participants wear a disposable sock liner and a knee-high sock
3. Acquire 3D scanning equipment:
    a. Scanning platform, 3D scanning app, scanning socks.
4. Have participant wear scanning sock.
5. Place Foot on acrylic footstand (provided by Susan)
6. Scan the foot using scanning app.
7. Make mesh in Rhino.
8. Compare measurements of instep and other geometries.

Test 3: Wear Survey

For wear marks, we can map wear patterns of mainly lift-related wear on boots.

1. Create survey with file-drop abilities.
2. Collect images from people who wear snowboard boots.
3. Categorize zones based on most frequent wear areas.
4. Visualize data with wear map.

Test 4: Temperature Collection

For Boa-related temperature issues, we can chart skin temperature through a skin temperature sensor while participant is wearing the sensor.

5. Obtain boot and sensor
    a. Ride Sage

   b. Skin Temperature Sensor from Vernier
6. Have participant wear sensor with sensor end taped to the top of the foot
7. Sensor is started.
8. Participant puts sock on, and puts boot on.
9. Boa is overtightened. Wait 5 minutes.
10. Boa is loosened and tightened moderately. Wait 5 minutes.
11. Temperature chart is saved and exported.

Test 5: Lockdown test

For ankle lockdown success, control boots' lockdown give would be recorded.

12. Obtain boots
13. Have participant wear only boot liner, but lace as they normally would
14. Give around ankle is recorded in inches.
15. Baseline is averaged from these tests.

Test 6: Product Wear test

To compare current market solutions to new solutions, wear test includes…

16. Boot is worn on the mountain with control (not modified) and test (modified).
17. Tester puts on system
    a. Tester is asked which lacing system provides better lockdown (with similar Boa use on both sides).
18. Tester rides on lift with system 2x
    a. One using Shell Guard
    b. One not using Shell Guard
19. Tester rides down slope with system 2x
    a. With Boa systems similarly tightened

b. With Boa systems tightened based on needed amount for heel lock down.

20. Observations are recorded:
    a. Does the shell shield provide coverage on area used for lifted comfort?
    b. Does system provide better initial heel lockdown?
    c. Is heel lockdown affect ride?
    d. Does difference in boot tightening affect cold feet?

How will data be analyzed?

Test 1: The boot scans will be overlaid with the participant's foot scans to see the differences in areas in geometries. This can be done in Rhino.

Test 2: Feet measurements will be recorded in a spreadsheet, and 3D scans will be averaged to create the average female snowboarder last.

Test 3: Wear marks will be recorded to establish highest-wear zones.

Test 4: Temperature data will be recorded. Slope will be analyzed, and differences in slope for the segments of time will identify differences in thermoregulatory ability based on Boa compression.

Test 5: Lockdown from current boots will be recorded in inches. New technology will be compared to current lockdown slack.

Test 6: Product wear tester's technology observations will be recorded based on user's experience.

Test Results and Interpretation

Test 1: Last making and data from this test provided geometric information in prototyping the snowboard shell. (See appendix J for making process).

Test 2: 5 scans were collected for athlete foot geometry information. This information supplemented the design process and is paired with demographic info from published journals.

Test 3: The tongue, inside side panel, and toe box are areas that receive the most wear on snowboard boots.
Test 4: This test provides evidence that over tightening your Boa reduces your ability to thermoregulate.
Test 5: The average slack for a boot liner is 1.5-3 inches, based on three boots tested.
Test 6: New proposed system works better overall than old system. Test boot provided better lockdown, better coverage for lift comfort, less tight Boas and warmer feet and the control boot. (See Appendix H)**.**

SWOT: Snowboard boots

SWOT analyses were performed on various competitor product components to better fully understand the different components of snowboard boots and apres boots. SWOT analyses were performed based on the component of the footwear since many different brands have similar technology with similar strengths and weaknesses (see Appendix A-F).

For snowboard boots, identified strengths include heat technology, rubber soles for traction women-specific calf design, and heat molded liners. Weaknesses include the Boa system's breakage: if it breaks, your day on the slopes is over because there isn't a quick repair method. Another weakness is that heat systems only really work well if there is some heat to begin with from the user. Also, EVA soles currently don't have many added benefits. Opportunities include heat mapping based on women's feet, traction based on women's pressure points on the foot, simple die-cut EVA insole improvements, and better heat management. Threats include newer and better lacing systems that adjust tension in specific locations and adjustable insulation.

For snowboard boot liners, strengths include liners on the market that are multi-layered and lined with fur, heat-molded liners for better fit, and made-to-size liners for fit. Weaknesses

include no recorded data on lofted vs. compressed insulation innovation for snowboard boots, the fact that closure systems for liners are only adjustable if the outer layer is opened, and closure systems are just okay at helping with ankle lockdown. Opportunities include different insulation methods for lofted vs. compressed insulation, new patterning methods for foot zoning, and the creation of external access for adjusting the liners. Current threats include new insulation technology that could improve products, liner-specific companies that have more time and resources for technology, and the cost of construction for liners.

For Snowboard boot's exterior lock-down, some strengths include the fact that snowboard boots have greater walking comfort than ski boots, that snowboard boots generally have good traction technology implemented, that there is midsole innovation with zoning, and that heat reflective foil is used for warmth. Weaknesses include that typical EVA is cut for the footbed with no added benefits, and that there isn't much innovation in this space. Opportunities include more zoning, lugs designed for female injury prevention, and a design for snow mitigation for when the snow gets stuck in the lugs and bindings. Threats include aesthetic preferences of athletes over function and skateboard culture including on boots and midsoles.

Baseline Product

Figure 8: Ride's Sage Women's Boot

The proposed baseline product is Ride's Sage Women's boot. This snowboard boot uses a single Boa system, has various technologies to aide the rider's circulation and thermoregulation:

- HEAT REFLECTIVE FOIL: Redirects heat underneath the foot and in the toe to help keep in the toasty warmth while charging up last chair.
- JADE LAST: Performance designed, women's specific fit.
- INTUITION™ PLUSH FOAM LINER: Medium-density foam delivers the ultimate plush feel for all day comfort.
- INTERNAL J BARS: Superior ankle and heel hold with added support.

Proposed Platform Technology

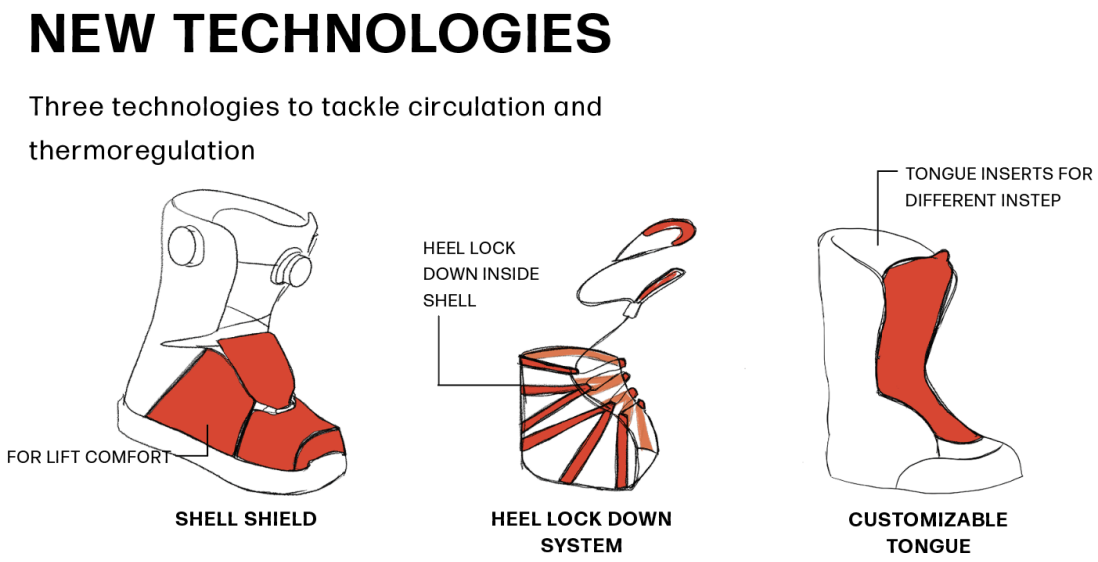


Figure 16: Three introduced platform technologies

Three platform technologies are introduced to tackle circulation and thermoregulation. The Shell Shield provides lift comfort, allowing for snowboarders to sit on the lifts and use the

Shell Shield to balance their board on top of their boot to better distribute the weight of the board. This provides better and more even pressure on the foot to better ensure that the rider's strapped foot doesn't fall asleep. The Heel lockdown system provides specific ankle and heel security in the boot to keep the ankle from lifting while riding. This is so that the user can combat over tightening of the Boa system that contracts around the dorsal of the foot and the calf. With the introduction of a heel-specific tightening system, athletes can reduce general boot Boa tightening that can lead to circulation being cut off. Customizable Tongue inserts also can help reduce over tightening of the Boa system by providing better fit. The customizable tongues will specifically target the variability of feet in general to provide a better customizable fit.

Final Testing

Fig 17: example of wear mapping data sample.

Wear Mapping

With the final patterning, the shell shield and Cut-Tex Pro cover and extra 77% wear-mapped area previously exposed to damage (see fig 17).

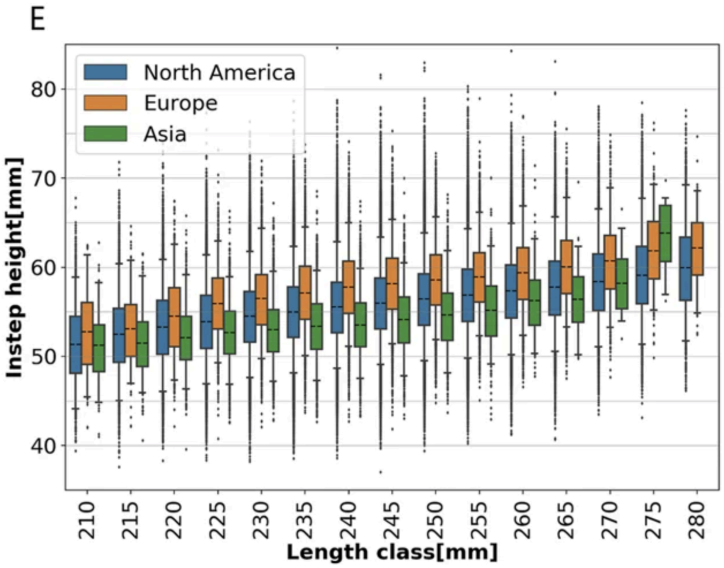


Figure 18: Instep height across North America, Europe, and Asia (Jurca, et. al, 2019).

Instep Insert

Personal 3D foot scanning was conducted across four size 7 snowboard athletes. Due to the small athlete sample size, further research was required to provide valid evidence of trends. Thus, an analysis of 1.2 million foot scans was utilized to gain better insights on women's fit.

In an analysis of 1.2 million foot scans from North America, Europe and Asia, instep heights for women are visualized in box plots showing Q1, 2, and 3 in color for each country. Using sample size 7 and reference for this project, the Inter Quartile Range falls between 50 and 60mm for all geographical locations. For a 10mm range, about three quartiles can be captured for each country. With 2mm dense EVA plus 3mm open cell foam small, 5mm dense EVA foam medium, and 10mm dense EVA foam large instep inserts, the new boot covers around 75% of instep heights (see fig 18).

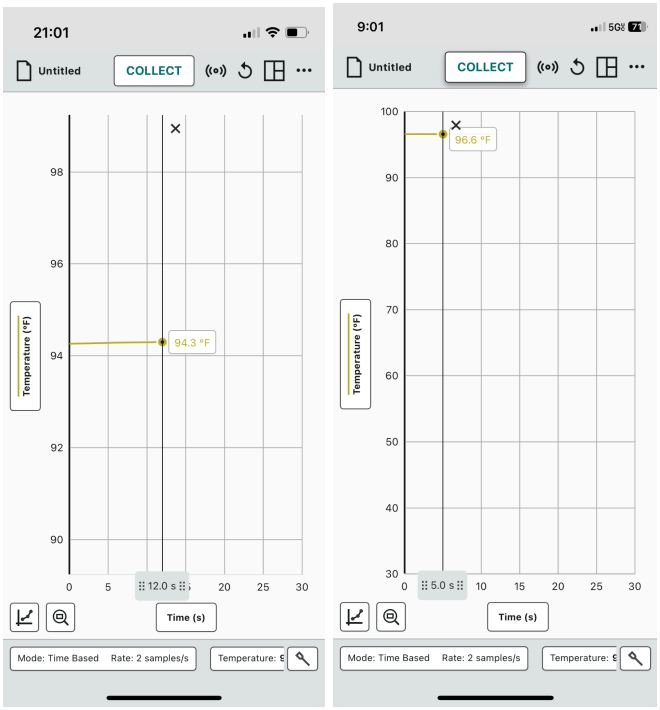


Fig 19: Image of athlete #3's skin temperature, with control on the left and test on the right.

Skin Temperature Test

A skin temperature test was conducted comparing the prototype heel lock boot to a control boot, re-using the same testing format as the skin temperature 6. Findings include an increased warmth of 1-3 °F (see fig 19). 3 athletes tested the control and test product over a 25-30 minute period. Most athletes felt other side affects in the control boot compared to the test boot, such as numbness in the foot.

Conclusion

Through new design features and skin temperature data collection there is substantial evidence that over tightening a Boa lacing system and reduce an athlete's ability to thermoregulate, and alternative tightening methods should be prioritized to target the ankle and

heel lockdown. Through wear mapping, locations on boots that experience much chair lift related wear are identified. Utilizing 3D scanning and 3D scanning journals, average instep heights and be identified to best design for fit.

Phase 3: Design Direction

Materials and Manufacturing

Materials and manufacturing are important in realizing proposed designs and creating an accurate looks-like model. All of the proposed materials and manufacturing methods aren't feasible for creating a looks-like prototype by hand, and alternative making methods will need to be taken to create a looks-like snowboard boot. Knowing this, Figure 20 shows the different actual materials and manufacturing processes for all the parts and pieces of the snowboard boot.

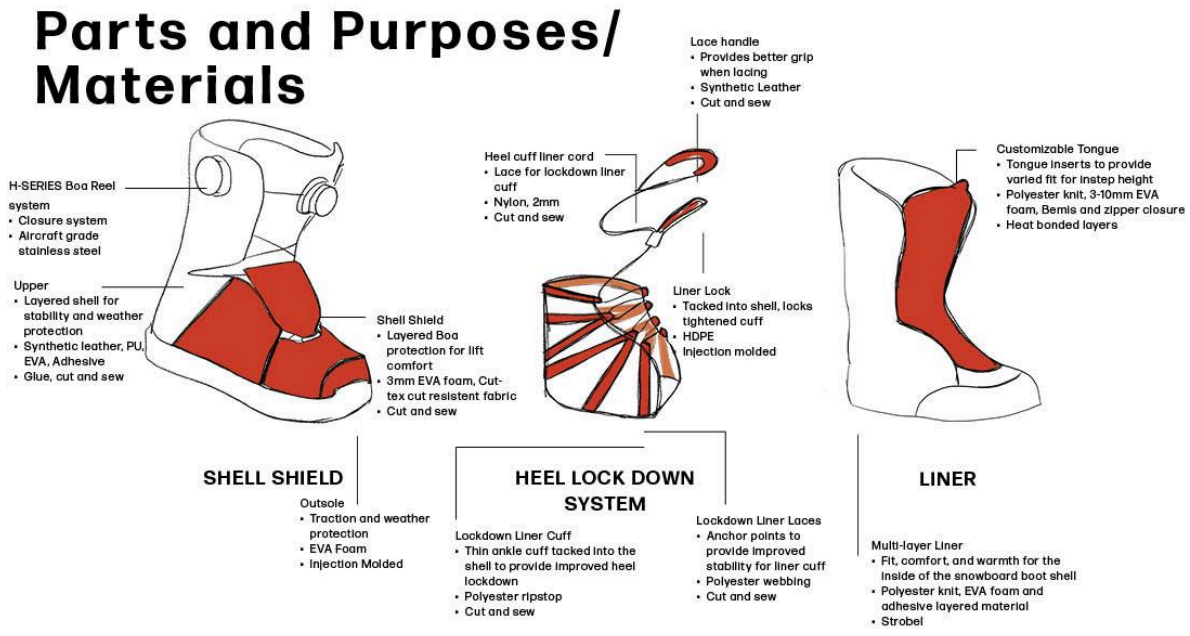


Figure 20: Materials and Manufacturing

Psychographic Profile and Demographic Information

The psychographic profile is a way to understand who the user is, what they value, and what they are like. This user has a work hard, play hard mentality and balances life with enjoying

nature. There's a willingness to go out of one's way to enjoy the outdoors. They are resilient, adventurous, carefree, playful, and competitive. They believe that the human experience is doing things that make you feel alive.

Demographic information includes:

- Female
- Ages 15-35
- Intermediate skill level
- Typically goes to a ski area/ski resort to snowboard

Typically for snow sport athletes, there is a high level of athlete engagement into product and purchasing decisions. For this demographic of athletes, the investment into personal snow sport gear means that the user tends to be more selective in what products they buy, and may typically try on product in person, do research online, or a combination of both purchasing methods.

Moodboard

The moodboards incorporate various graphics, colors, and visuals that this user demographic may be drawn to (see appendix I). Using inspiration from crafts, ceramics, and artwork, the athlete moodboard map explores various other interests that could inspire this athlete. Athlete mapping helps display what current snowboarders in the demographic's age range may wear either on or off the slopes. This moodboard displays these athletes' styles, and visualizes where middleground can be found generally between different styles. Other

moodboards show environmental influence, showcasing different colors and textures that these athletes may interact with along with inspiration from ceramics. Finally, the last moodboard distills a few different key images used for their movement, color, and environmental influence.

Branding

This collection will be called Terracotta. The name Terracotta refers to clay in its fired state. Terracotta metaphorically equates how clay can be both soft (from the earth) and hard (when fired), and how snowboard boots have both soft (snowboard boot liner) and hard (snowboard boot shell) components. Terracotta also contains ideas of warmth through its color and manufacturing process. In addition, Terracotta refers to the Terracotta warriors which are historic art pieces in China. These warriors are suited up for war. When athletes go to the mountains to snowboard, their actions of putting on their boots and gear feels akin to suiting up for war. Terracotta's brand colors include Burnt Brown, Red Glaze, Soft Redstone, and Black. These colors emphasize warmth, earth, playfulness, and boldness. The metaphorical aspects of the branding tie into the product, athlete, and goals of circulation for women's snow footwear. The logo design for Terracotta displays a simple image that abstractly represents a snowboarding half pipe and pot (Figure 21).

Figure 21: branding

Sketches

Sketching is used in the ideation process to identify visual forms and lines that best describe the product, brand, and goals while also targeting the user and demographic. After exploring a few different visual form ideas (fig. 22), further exploration was required. While many of the sketches were visually appealing, they didn't speak to the user and demographic. More playfulness and movement were required to best express the demographic's playful nature. The final sketch was landed upon because of its expression and movement, using curved lines to showcase freedom and adventure (figure 23).

Figure 23: Ideation Sketches

.Figure 23: Final Sketch

Outsole Inspiration

While tread is not a main feature for tackling circulation, it is still an important factor for snowboard boot design because of the environment that the athletes will be in. Inspiration for tread design included tread blocks, grooves, and ribs found on snow tires (SimpleTire*, 2022*). Tread blocks on snow tires are raised rubber sections that touch the ground. Shapes for the outsole lugs mimicked shapes that are similar to those found on snowboard tires (fig 24). Grooves are channels around the circumference of the tire to help drain water. These channels are deeper than non-snow tires to better interact with snow and water. Ribs are "the raised rubber sections that run around the circumference of the tire to help improve steering in snow, on ice covered surfaces and wet roads" (SimpleTire*, 2022*). Both grooves and ribs are utilized on the midsole so that snowboard athletes using the snowboard boot can have traction tailored to the elements that they may find themselves in while in ski areas. Final outsole design incorporated these elements (fig 25).

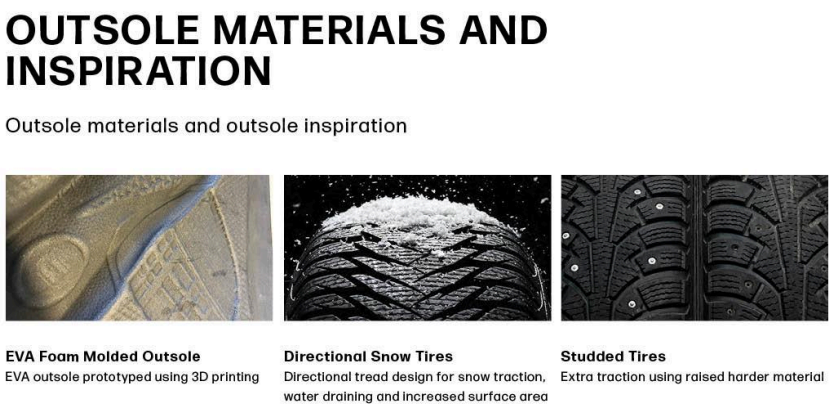


Figure 24: Tire Inspiration

Figure 25: Outsole design

Looks-like Prototyping Process

The looks-like prototyping process included 3D printing, last making, upper design, and hardwear design, and assembly (see appendix J).

Final Product

Figure 26: Final Product Design

Features and Benefits

Figure 27: Features and Benefits

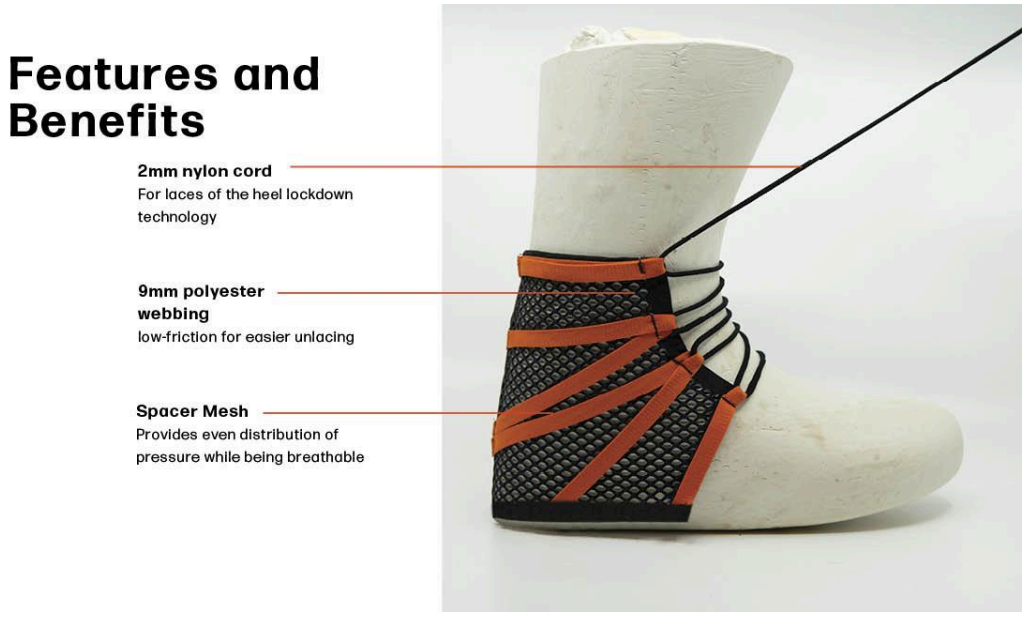


Figure 28: Features and Benefits part 2

Figure 29: Features and Benefits part 3

Final Photography

The final photography includes an athlete featured in ski areas where the athlete would frequent. Detailed shots, action shots, and close-up design shots are showcased in the final photography (see appendix K).

About the Designer

Golden Circle

My mission is to enable people to connect with the outdoors, allowing individuals to cultivate meaningful experiences in nature. I create thoughtful designs that prioritize the intended user's needs. My designs focus on the people behind the sport, not just the sport itself. They allow users to develop respect for nature and foster a deep connection between the two.

Top 5 Strength Finder's Strengths

1. Strategic: I am talented in the Strategic theme. I create alternative ways to proceed. Faced with any given scenario, I can quickly spot the relevant patterns and issues (Gallup).
2. Individualization: I am intrigued by the unique qualities of each person. I have a gift for figuring out how people who are different can work together productively (Gallup).
3. Relator: I enjoy close relationships with others. I find deep satisfaction in working hard with friends to achieve a goal (Gallup).
4. Intellection: I am characterized by my intellectual activity. I am introspective and appreciate intellectual discussions (Gallup).
5. Input: I have a craving to know more. Often I like to collect and archive all kinds of information (Gallup).

These strengths as an innovator will support the project. Being strategic will allow for streamlined problem-solving when issues arise. Individualization will allow me to utilize test

athletes and participants to develop my thesis. My Relator skills can be helpful when talking to mentors. Intellection can be a helpful trait when discussing issues with prototypes and current products on the market.

Project Goals

My thesis aligns with my strengths because working on this project will improve female athletes' experience on the mountains. Having working and functional gear allows people to spend time outdoors without the fuss of ill-fitting and improper gear. This project allows me to explore women-focused design and experience designing and prototyping footwear. With two footwear projects in my portfolio, I will feel more equipped to pursue footwear in my design career.

Mentor

My project mentor for this project is Ali Leach, a Footwear Designer at Burton. Ali has expertise in designing snowboard boots.

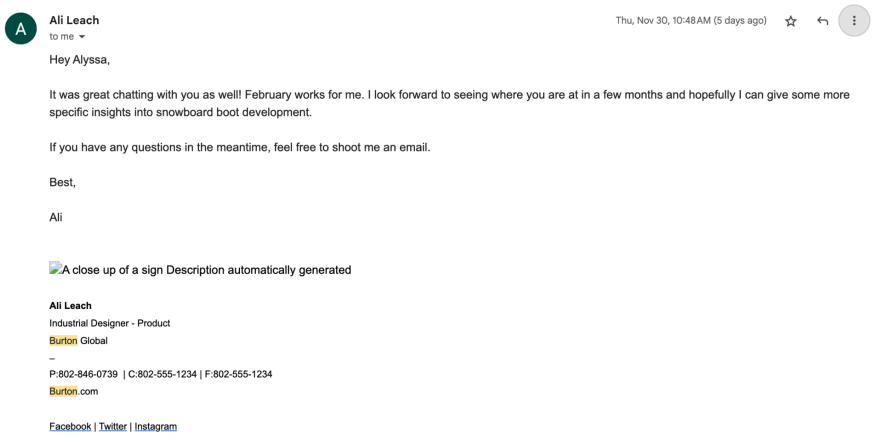


Fig. 30: Email Confirmation.

Appendix A

SWOT for Boot and upper

SWOT

Snowboard Boots

Strengths

- Heat technology
- Rubber soles for traction
- Women specific Calf design
- Heat molded liner

Weaknesses

- Boa system: If it breaks the day is over, has to be adjusted as you ride, can cause discomfort on pressure points
- Heat system only really works if there is heat to begin with
- EVA sole has no added benefits

Opportunities

- Heat mapping based on women's feet
- Traction based on women's pressure points on the foot
- "Lockdown lacing" is their current lacing system. This portion can be iterated
- Simple "die cut EVA insole"
- "Heat reflective foil" to reflect heat back into the boot

Threats

- New and better lacing system that can adjust tension in specific locations
- Adjustable insulation?



Appendix B

SWOT for Lock-down

SWOT

Snowboard Exterior Lock-down

Strengths

- Greater walking comfort than ski boots
- Generally good traction technology implemented
- Mid sole innovation with zoning
- Heat reflective foil for warmth

Weaknesses

- Typical EVA cut foot bed
- Not much innovation in this space

Opportunities

- More zoning
- Lugs designed for female injury prevention
- Design for snow mitigation w/ snow getting stuck in lugs and bindings but also grip on metal and ice surfaces

Threats

- Aesthetic preference over function
- Skateboard culture influence on boots/midsoles

Appendix G

Results From Survey (Insights)

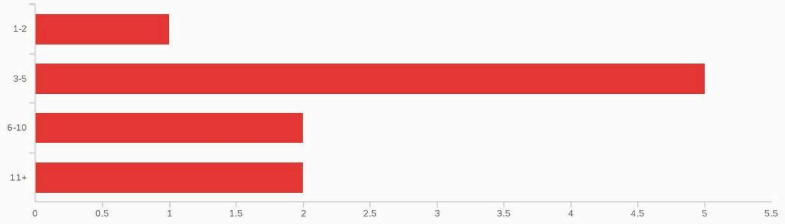
Q9 - What Brand/model of snowboard boots do you use?

Brand:	Model (optional):	Type of Lacing system:
Ride	Hera	Double boa
Burton	Step On	Boa
Burton	Felix	BOA
Salomon	N/A	Boa
Ride	Cadence	Boa
Vans	N/A	Boa
thirty-two	N/A	single boa
Roxy	N/A	Boa
Thirty-Two	N/A	Boa
Burton	Sapphire	N/A
Vans	Hi-Standard Pro X Benny Urban Boot	Lacing and Side boa

Q10 - Do you wear Apres boots? If so, what brand/model? If not, what shoes do you wear before or after snowboarding?

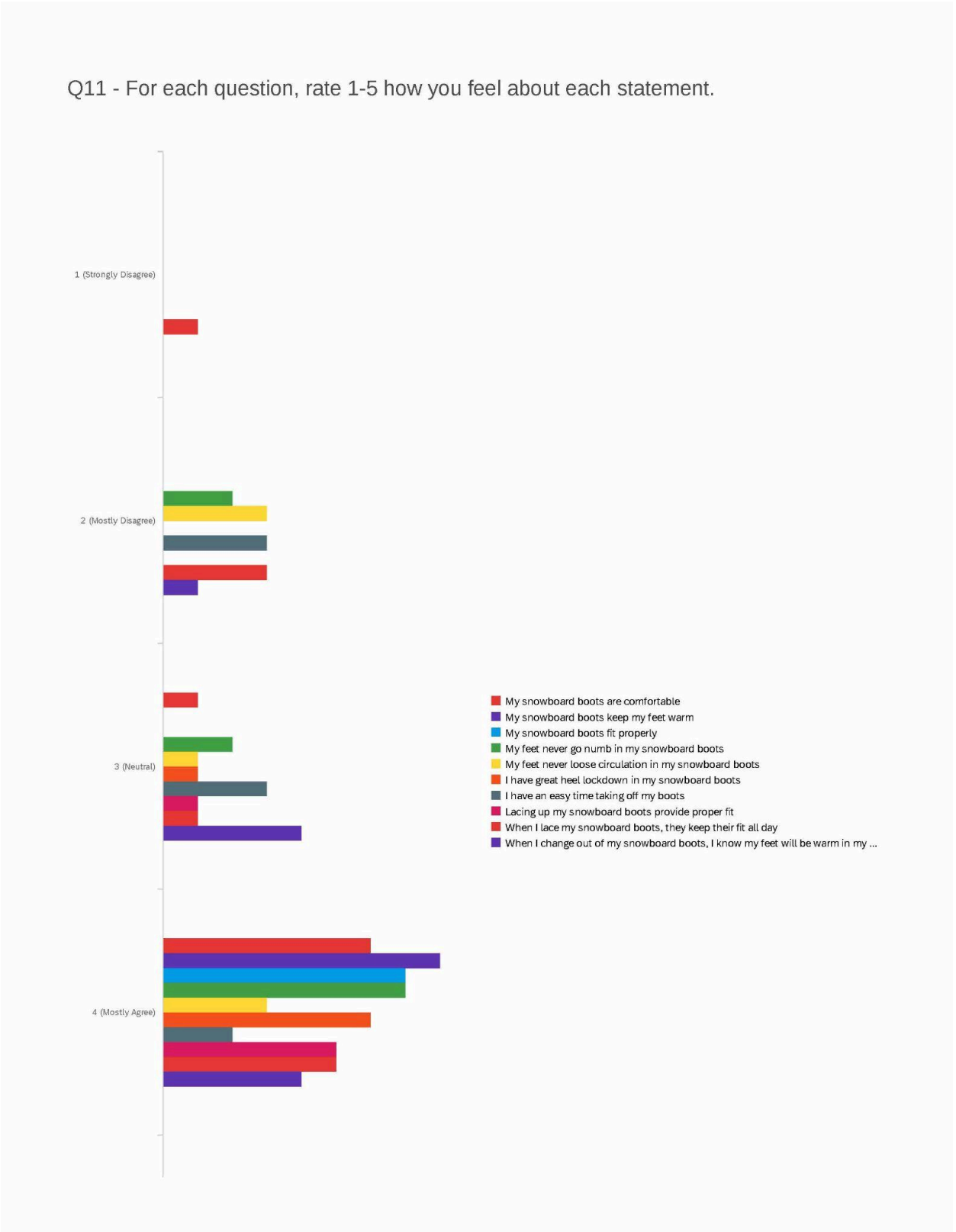
Do you wear Apres boots? If so, what brand/model? If not, what shoes do you...
Columbia facet 75 low, Blundstones high top, crocs, vans mte skate highs
No?
Hiking boots
Crocs
The North Face thermoball slippers
Yes, The North Face
Sneakers
No
Birkenstocks/uggs
No

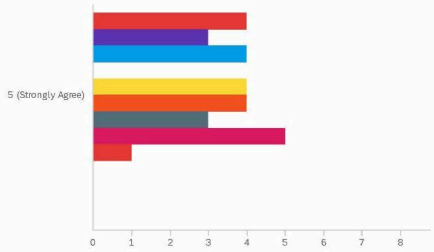
Q12 - How many seasons do my snowboard boot last for?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	How many seasons do my snowboard boot last for?	1.00	4.00	2.50	0.92	0.85	10

#	Field		Choice Count
1	1-2	10.00%	1
2	3-5	50.00%	5
3	6-10	20.00%	2
4	11+	20.00%	2
			10


Q11 - For each question, rate 1-5 how you feel about each statement.
1 (Strongly Disagree)
2 (Mostly Disagree)
3 (Neutral)
4 (Mostly Agree)
My snowboard boots are comfortable
My snowboard boots keep my feet warm
My snowboard boots fit properly
My feet never go numb in my snowboard boots
My feet never loose circulation in my snowboard boots
I have great heel lockdown in my snowboard boots
I have an easy time taking off my boots
Lacing up my snowboard boots provide proper fit
When I lace my snowboard boots, they keep their fit all day
When I change out of my snowboard boots, I know my feet will be warm in my ...

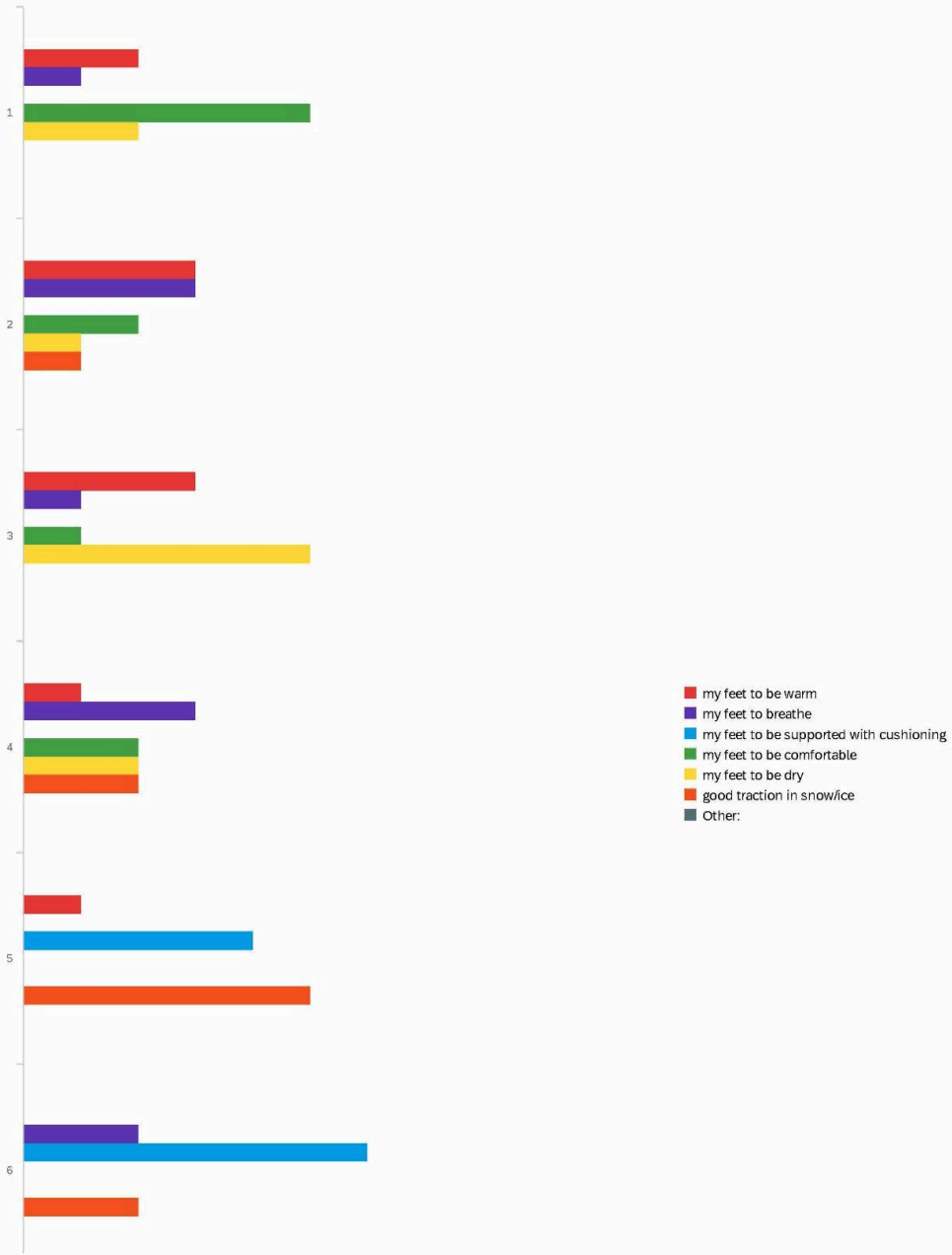


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	My snowboard boots are comfortable	3.00	5.00	4.27	0.62	0.38	11
2	My snowboard boots keep my feet warm	4.00	5.00	4.27	0.45	0.20	11
3	My snowboard boots fit properly	4.00	5.00	4.36	0.48	0.23	11
4	My feet never go numb in my snowboard boots	2.00	4.00	3.45	0.78	0.61	11
5	My feet never loose circulation in my snowboard boots	2.00	5.00	3.73	1.21	1.47	11
6	I have great heel lockdown in my snowboard boots	3.00	5.00	4.27	0.62	0.38	11
7	I have an easy time taking off my boots	2.00	5.00	3.45	1.16	1.34	11
8	Lacing up my snowboard boots provide proper fit	3.00	5.00	4.36	0.64	0.41	11
9	When I lace my snowboard boots, they keep their fit all day	1.00	5.00	3.18	1.19	1.42	11
10	When I change out of my snowboard boots, I know my feet will be warm in my apres boots/shoes	2.00	4.00	3.33	0.67	0.44	9

#	Field	1 (Strongly Disagree)	2 (Mostly Disagree)	3 (Neutral)	4 (Mostly Agree)	5 (Strongly Agree)	Total
1	My snowboard boots are comfortable	0.00% 0	0.00% 0	9.09% 1	54.55% 6	36.36% 4	11
2	My snowboard boots keep my feet warm	0.00% 0	0.00% 0	0.00% 0	72.73% 8	27.27% 3	11
3	My snowboard boots fit properly	0.00% 0	0.00% 0	0.00% 0	63.64% 7	36.36% 4	11
4	My feet never go numb in my snowboard boots	0.00% 0	18.18% 2	18.18% 2	63.64% 7	0.00% 0	11
5	My feet never loose circulation in my snowboard boots	0.00% 0	27.27% 3	9.09% 1	27.27% 3	36.36% 4	11

#	Field	1 (Strongly Disagree)	2 (Mostly Disagree)	3 (Neutral)	4 (Mostly Agree)	5 (Strongly Agree)	Total
6	I have great heel lockdown in my snowboard boots	0.00% 0	0.00% 0	9.09% 1	54.55% 6	36.36% 4	11
7	I have an easy time taking off my boots	0.00% 0	27.27% 3	27.27% 3	18.18% 2	27.27% 3	11
8	Lacing up my snowboard boots provide proper fit	0.00% 0	0.00% 0	9.09% 1	45.45% 5	45.45% 5	11
9	When I lace my snowboard boots, they keep their fit all day	9.09% 1	27.27% 3	9.09% 1	45.45% 5	9.09% 1	11
10	When I change out of my snowboard boots, I know my feet will be warm in my apres boots/shoes	0.00% 0	11.11% 1	44.44% 4	44.44% 4	0.00% 0	9

Q16 - Rank the following based on this question: At the end of my snow day when I change out of my snowboard boots into apres boots or other shoes, I am looking for:



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	my feet to be warm	1.00	5.00	2.60	1.20	1.44	10
2	my feet to breathe	1.00	6.00	3.40	1.62	2.64	10
3	my feet to be supported with cushioning	5.00	6.00	5.60	0.49	0.24	10
4	my feet to be comfortable	1.00	4.00	2.00	1.18	1.40	10
5	my feet to be dry	1.00	4.00	2.70	1.00	1.01	10
6	good traction in snow/ice	2.00	6.00	4.70	1.10	1.21	10
7	Other:	7.00	7.00	7.00	0.00	0.00	10

#	Field	1		2		3		4		5		6		7	
1	my feet to be warm	20.00%	2	30.00%	3	30.00%	3	10.00%	1	10.00%	1	0.00%	0	0.00%	0
2	my feet to breathe	10.00%	1	30.00%	3	10.00%	1	30.00%	3	0.00%	0	20.00%	2	0.00%	0
3	my feet to be supported with cushioning	0.00%	0	0.00%	0	0.00%	0	0.00%	0	40.00%	4	60.00%	6	0.00%	0
4	my feet to be comfortable	50.00%	5	20.00%	2	10.00%	1	20.00%	2	0.00%	0	0.00%	0	0.00%	0
5	my feet to be dry	20.00%	2	10.00%	1	50.00%	5	20.00%	2	0.00%	0	0.00%	0	0.00%	0
6	good traction in snow/ice	0.00%	0	10.00%	1	0.00%	0	20.00%	2	50.00%	5	20.00%	2	0.00%	0
7	Other:	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	100.00%	10

Q13 - Do you have any specific issues you have with snowboard boot comfort?

Do you have any specific issues you have with snowboard boot comfort?
One of the ride emblems on the lateral side near ankle sits right under my ankle binding strap. This creates an uncomfortable pressure point. And when my binding is too tight I go numb. But when I back off the bindings I don't have any issues
No
Small hot spot by fifth toe where the bindings snap in
Not anymore, now my boots have double BOAs which help with heel lockdown
stiff and awkward heel-to-toe transition but that's expected. Sometimes tightening the BOA to ensure a good fit results in my snow pants/fasteners to press uncomfortably between the boot interior and my pants on top of my shin
No
no
I have Solomon's and so they fit pretty well! I went to a couple stores to get fitted and these were the ones that felt the best with heel lock, secureness, and comfort. At first the toes were at the top of my boots and I was concerned but they fit great on the mountains. Heard boot fit was most important so invested in that
tight and not super comfortable to walk around the resort in
hard to walk when not in snowboard
Getting my feet in and out

Q14 - Do you have any specific issues with snowboard boot fit?

Do you have any specific issues with snowboard boot fit?
Before the ride hera's i had a difficult time getting a good heal lock. Would tighten my bindings to a point where I would get a tingling sensation and would have to stop in the middle of the run. Also the toe box of my old boots(Burtons) created a pressure point on the lateral side of my where your pinky toe joint is
No
None
No
Doesn't fit/lockdown my heel perfectly
I would say the only thing with my double boa system is I do have to tighten it every so often after a couple runs
no
i have wide feet and high arches
no
No

Q15 - Any specific issues you have with foot circulation, numbness, and/or thermoregulation?

Any specific issues you have with foot circulation, numbness, and/or thermo...
The here's are super comfortable. Only wish these boots were a little bit warmer. It's a lighter weight boot and isn't the warmest of the bunch for night boarding in the pnw
Sometimes I use feet heating pads
None
Sometimes in pinky toes
Foot goes slightly numb occasionally
No
no
I think it took a little time to know to make the first lace looser and make the boa tight to not cut off circulation
no
No
No

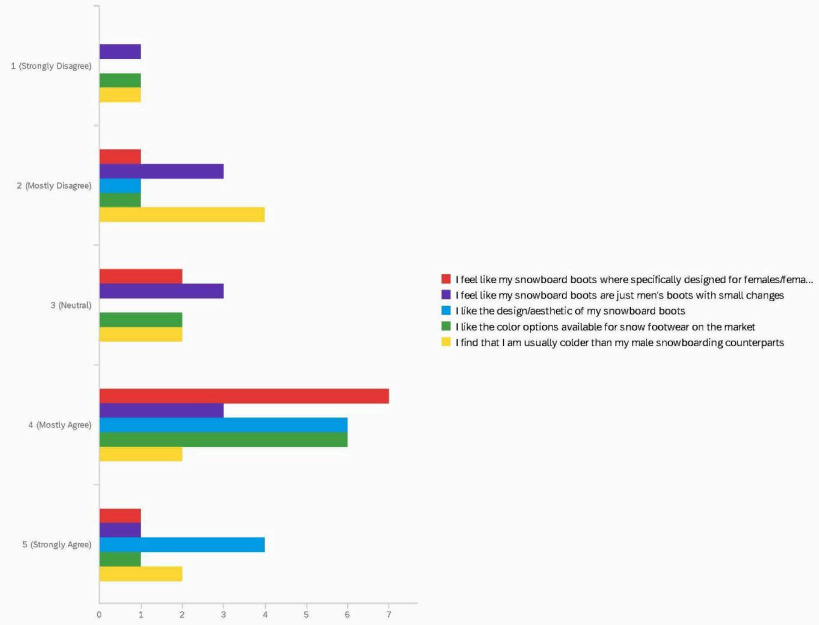
Q17 - If applicable, please list any other issues you have with your snowboarding boots.

If applicable, please list any other issues you have with your snowboarding...
The top of the toe box my boot wearing out from me holding my snowboard on it on the lift
bindings loosen after 3-4 runs and need to be adjusted; not difficult with boa system
$200

Q18 - If applicable, please list any other issues you have with your apres boots.

If applicable, please list any other issues you have with your apres boots.
Not enough grip (Blundstones and crocs)... vans high tops has too many laces hard to put on quickly after boarding
Wetness and traction if theres a lot of snow
Comfortable, loose fit but not the best traction or protection to walk on snow/ice through parking lot or through a ski village/resort
none

Q21 - For each question, rate 1-5 how you feel about each statement.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I feel like my snowboard boots where specifically designed for females/female needs	2.00	5.00	3.73	0.75	0.56	11
2	I feel like my snowboard boots are just men's boots with small changes	1.00	5.00	3.00	1.13	1.27	11
3	I like the design/aesthetic of my snowboard boots	2.00	5.00	4.18	0.83	0.69	11
4	I like the color options available for snow footwear on the market	1.00	5.00	3.45	1.08	1.16	11
5	I find that I am usually colder than my male snowboarding counterparts	1.00	5.00	3.00	1.28	1.64	11

#	Field	1 (Strongly Disagree)	2 (Mostly Disagree)	3 (Neutral)	4 (Mostly Agree)	5 (Strongly Agree)	Total
1	I feel like my snowboard boots where specifically designed for females/female needs	0.00% 0	9.09% 1	18.18% 2	63.64% 7	9.09% 1	11
2	I feel like my snowboard boots are just men's boots with small changes	9.09% 1	27.27% 3	27.27% 3	27.27% 3	9.09% 1	11
3	I like the design/aesthetic of my snowboard boots	0.00% 0	9.09% 1	0.00% 0	54.55% 6	36.36% 4	11
4	I like the color options available for snow footwear on the market	9.09% 1	9.09% 1	18.18% 2	54.55% 6	9.09% 1	11
5	I find that I am usually colder than my male snowboarding counterparts	9.09% 1	36.36% 4	18.18% 2	18.18% 2	18.18% 2	11

Appendix H

Results From Tests (Insights)

PERFORMANCE TESTING GOALS

Bench Top

- Solve for performance needs of lockdown and Test methods of lockdown in competitor products
- Solve for thermoregulation needs of boots
- Solve for lift foot falling asleep

Test 1: Liner Lockdown ability

Liner's ability to provide heel lockdown can be quantified through targeted ankle slack in different boot and lacing styles.

Results: Of the three boot liners tested, a typical user can easily lace current boot liners with 1.5-3 inches of slack near the ankle location.

VALIDATION TEST

Testing validation for heel lock down and shell shield

Insights from in-situ testing:

- Right foot's boot tested the Heel Lock Down system, left foot was the test's control. Prototype maintained better or the same heel lock down, but control boot had to be overtightened to achieve this better performance fit. Control's foot was noticeably colder than prototype foot.
- Shell Shield provided needed coverage and protection of your boot on lift situation. Center of Boa lacings were covered properly, and goal of all major wear areas of the boot to be made of cut-proof material is met.
- Shield stayed in place yet was easy to remove when necessary.

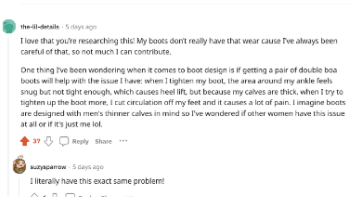
HEEL LOCKDOWN SYSTEM

Lacing system tacked to the inside of the shell to reduce heel lift and boa tightening

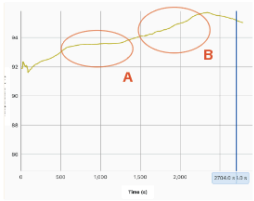
- Tested on the slopes, provided equal or better heel lockdown than control, with control boot boa lacing system tightened until heel lift was minimal
- Control foot was noticably colder, control foot fell alseep
- Lockdown system reduced heel slippage while also reducing boa tightness

INFORMATIVE TESTS

Wear Mapping
Looking at 20 different pairs of boots, areas of lift-related wear includes tongue, inside panel, and toe-box



Survey
40+ women in online forum also claim to have over tightening/circulation issues

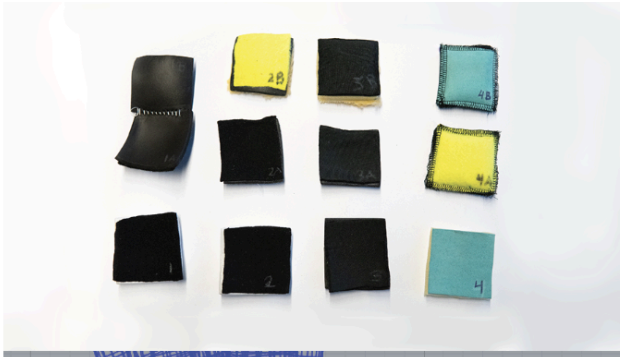


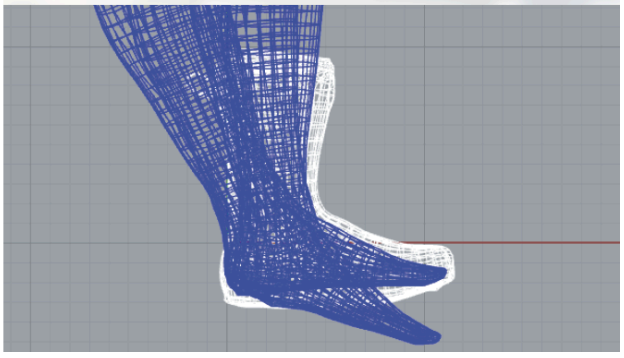
Skin Temperature Test
Skin temperature test shows that over-tightening your boa decreases rate of thermoregulation

TONGUE INSERTS FOR FIT

Tongue inserts for better fit... Think of Helmet pads that help your helmet fit!

- Different combos of padding for small, medium, and tall insteps
- Utilizing 3D scanning to obtain accurate female snowboarder feet geometry
- More data to be collected on instep heights
- This test is still ongoing





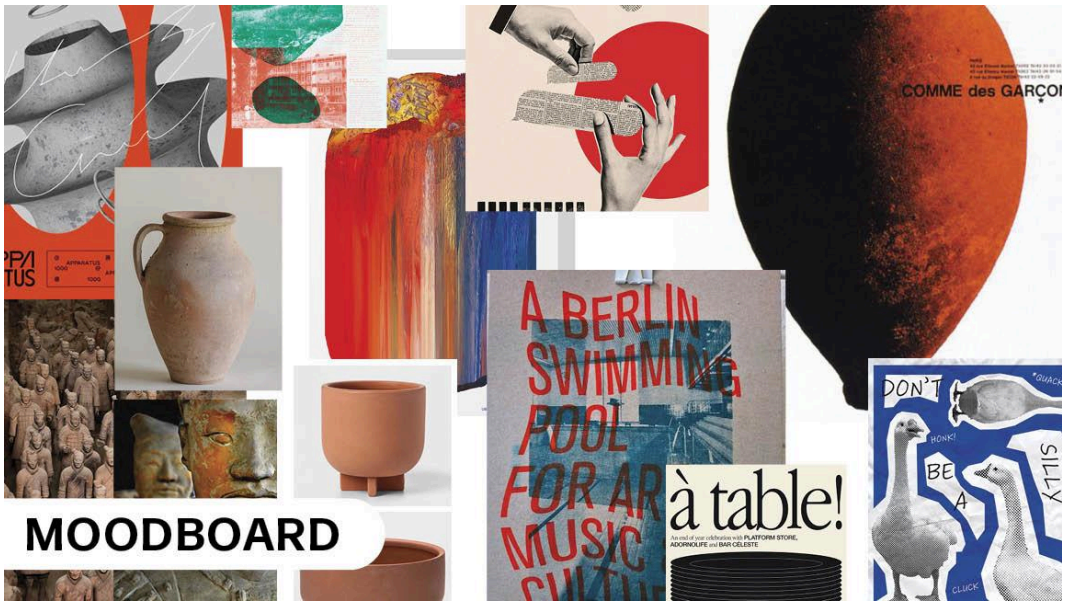
SHELL SHIELD

Toe and lace protection made of cut-resistant fabric (Cut-Tex Pro)

- Magnetic and fully detachable Boa lace protector
- Zoned protection on the toe-box, upper panel, and laced areas
- Cut-Tex Pro material following ANSI/ISEA 105-2016 standards

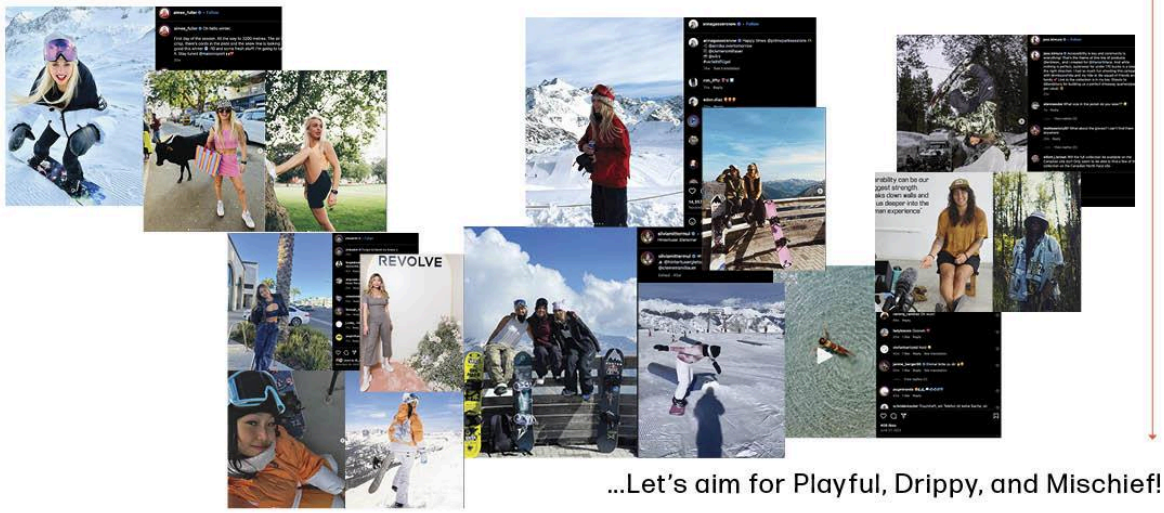
Appendix I

Moodboards

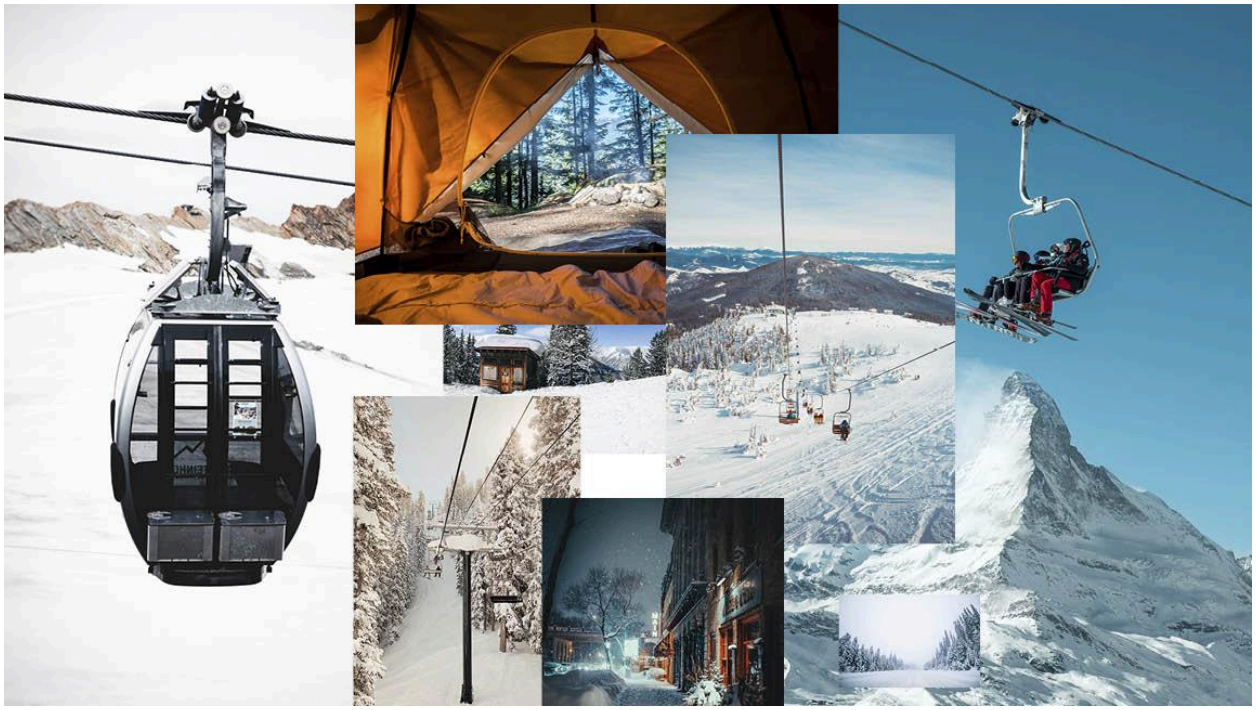


Athlete

Sweet/Fun/Playful ⟷ Drippy/Cool/Mischief



...Let's aim for Playful, Drippy, and Mischief!



Appendix J: Making Process

3D Printing

Prototyping for plastic and foam elements

- 3D printing for plastic hardware
- 3D printing using TPU to replicate EVA foam midsole/ outsole

LAST MAKING

Last for inside of the boot shell for pattern making

- Plaster molded last using Vans Encore women's boot as a mold
- 3D scan for 3D modeling a clean left and right last
- Tape up for patterning upper

LAST MAKING

Continued

- Re-modeled first cast in 3D to clean up shell last
- 3D printed mold for casting
- Plaster mold casted and then vacuum formed to achieve a shell boot shape out of HIPS plastic to replicate heat-formed snowboard boot manufacturing

UPPER DESIGN

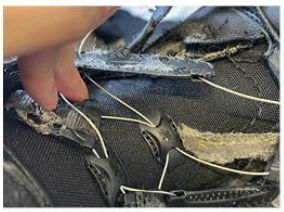
Upper design for looks like model

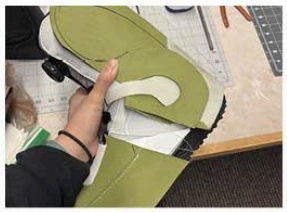
- Tested on the slopes, provided equal or better heel lock down than the control boot, with the control boot Boa lacing system tightened until heel lift was minimal
- Control foot was noticeably colder, control foot fell asleep
- Lock down system reduced heel slippage while also reducing Boa tightness

UPPER DESIGN

Upper design for looks like model

- Pattern prototyping and part harvesting for looks like model
- final stitching and layers order

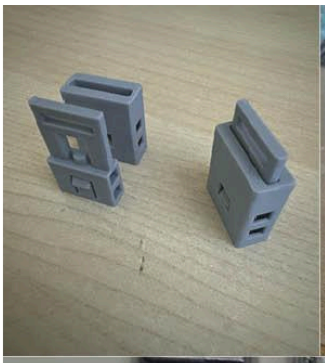


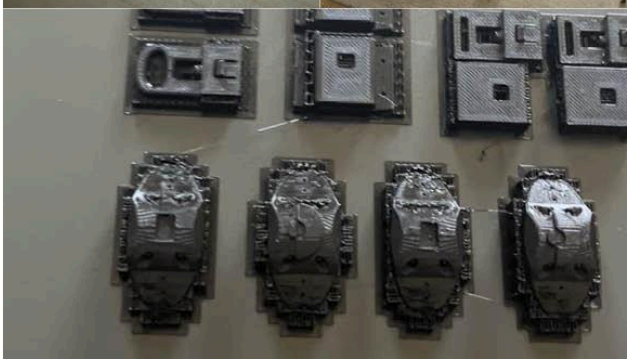


HARDWARE DESIGN

Using 3D printing

- 3D printed lacing system lock prototyping
- 3D printed Boa hardware prototyping





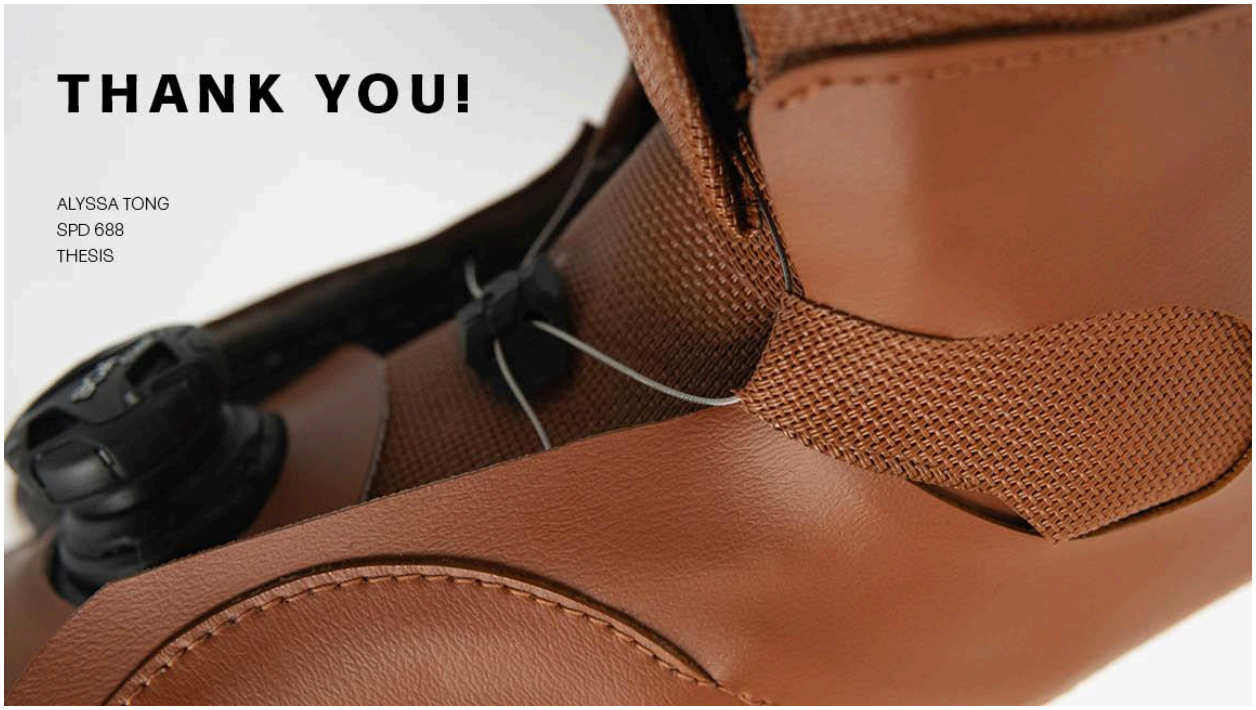
ASSEMBLY

Final assembly

- Layered assembly of vacuumed formed shell, heat formed eva foam, and PU leather
- Edge painting and finishing
- Final prototype assembly progress

Appendix K: Final Photography


SPORT


THANK YOU!
ALYSSA TONG
SPD 688
THESIS

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