Women's Fastpitch Softball: Ankle Sprain Preventing Footwear and Protective Batting Gloves

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Introduction

My name is Kylie Everill. I'm a current master's student in the University of Oregon's Sports Product Design program, with a Bachelor of Science in Kinesiology. Throughout my undergraduate career, I competed on my school's fastpitch softball teams, earning a third-place finish in a collegiate national championship, obtained multiple MVP and 1st team awards, and a professional league tryout invitation. My history with injury was what cut my softball career short – but is also what started my career as a designer. Specializing in biomechanics, personal training, and coaching, and having a knack for out-of-the-box problem solving led me to pursue this degree in Sports Product Design.

Golden Circle

I am a function forward designer with experience in biomechanics, fashion design, coaching and collegiate athletics. I have a passion for creating products that allow athletes to reach their highest potential through injury prevention and performance innovations.

Clifton Strengths

My top five strengths from the Clifton Strengths Finder are as follows, with definitions summarized (Gallup, 2022).

Individualization: intrigued with the unique qualities of each person, passionate about meeting people at different stages of their process and seeing ways to improve things for each individual rather than adopting a one-size-fits-all approach.

Empathy: able to intuitively share others' perspectives, connect to and understand people's stories and experiences, capable of anticipating the needs of others.

Ideation: fascinated with ideas, innate ability to connect the dots between seemingly disconnected phenomena.

Strategic: able to quickly spot patterns and potential downfalls, easily create progress in alternative ways, capable of seeing solutions that many cannot.

Positivity: contagiously enthusiastic, able to bring energy to projects where it may be difficult to muster, making everything a little bit more exciting.

Thesis Project Alignment

This thesis project aligns with my strengths and golden circle in many ways - my individualization highlights the specialized needs of each sport-specific movement for each player's biomechanics; my empathy allows stories and experiences from each athlete I work with to integrate into my design; my ideation gives me ample room to play with solutions that may not be apparent to the existing market; my strategic skills allow me to design new ways around long-standing problems; and my positivity brings a bit of excitement and passion to the project and those involved in it, even if they're unfamiliar with the project space.

Softball is a traditionally underrepresented sport, as its products often follow behind its male counterpart, baseball, through the "shrink and pink" method. This project will support my career in the industry by giving me a highly specified, culturally significant, and biomechanically sound product that sets me apart from many sport product designers without my background and experience. Additionally, moving through the entire design process at this depth, from research, design, testing, branding, and creating a high fidelity, functional prototype, is a rare experience and will improve my understanding of each stage in the industry.

The purpose of this design thesis is to discover and implement innovative ways to solve two major problems in women's fastpitch softball: hand and finger injuries – specifically those suffered by a batter being hit by a pitch; and ankle sprain – the most frequent injury in the sport overall. This exploration seeks to create a solution in the form of a fastpitch softball cleat, and a set of batting gloves to let athletes continue to be their best, on and off the field.

Design Statement

What if we could lessen the impact of injury in women's softball and allow players to stay in the game?

Fastpitch Softball: An Overview

History

To talk about the sport of softball, you must dive into its history. It is agreed that the sport was derived from general baseball rules in 1887, in Chicago, Illinois (Britannica, 2022). The frigid winter forced players indoors, and George Hancock created what began as indoor baseball – played with a larger, softer ball and a smaller field (Encyclopedia, 2022). Iterations of the game continued to be played, with names like diamond ball, kitten ball, indoor-outdoor, and eventually, softball. Many sets of rules were instated throughout the years in multiple cities, but in 1933, the Amateur Softball Association of America was created as the first recognized committee for national softball rules (Britannica, 2022).

As an extension of the original sport, slowpitch softball has been altered to cater to a more casual game that integrates a slow, high arcing pitch to the batter. Fastpitch softball pertains to the form of the game that is played with a high-speed, horizontally level pitch delivered from the pitcher to the batter.

Gameplay

Basic gameplay involves two 9 to 10-player teams switching from defense to offense each inning, for seven innings. There are multiple strategies for winning, but the main goal is to score more runs than the other team by the end of the game. Runs are scored by the offensive team by hitting a pitched ball and running from base to base until they reach home plate, counting as a run. The defense's job is to prevent the offense from getting from base to base, by catching the hit balls before they touch the ground or beating the offensive runner to the base with the hit ball (Van Kleek et al., 2021).

Environment

Competitive softball is traditionally played on a regulation softball field, with a dirt infield and grass outfield. The dirt infield is comprised of sand, silt, and clay (InfieldMix, 2022). A nicely kept field is hard to come by as different infield dirt mixes need specific amounts of water, turnover, and compaction to stay at the desired hardness. If not properly maintained, the dirt can easily become too soft in high-traffic areas such as the batter's box, pitching mound, and along the base paths, or can become too hard along the center of the field, causing dangerously uneven playing surfaces. The outfield grass is a similar situation. If not maintained, thick or dead patches of grass can create an uneven playing surface. Proportions and measurements for the field are shown in figure 1, from the NCAA Regulation Rules Book (Van Kleeck et al., 2021).

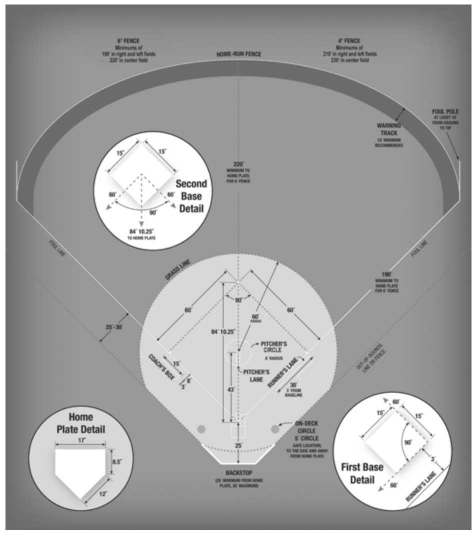


Figure 1: NCAA Softball Regulation Field (Van Kleeck et al., 2021)

Product Rules & Regulations

Rules considering the use of product in games are limited, as the leading committees' intent is to keep the sport accessible and safe and continue to grow its participation. In NCAA competition, equipment must be "commonly available to the public… reflect a positive image of the game… [and] must be worn properly and as designed" (Van Kleeck et al., 2021).

Target Athlete

The target athlete for this project is a highly competitive women's fastpitch softball player, 14 to 34 years of age, with a strict need to stay healthy. These women are going all out for every play, are passionate about staying in the game, supporting their team, and performing at the highest level. Unfortunately, the time these athletes have is limited. Professional leagues haven't stayed consistent, and many organizations shut down over the pandemic. College softball hosts the biggest stage for the sport, but only allows 4 years for these athletes to perform. Travel ball teams give an opportunity for middle and high school ages to get into the college recruiting sphere as quickly as possible. This level of competition comes with immense pressure to earn or keep a scholarship or a salary, maintain the closeness of their teammates and coaches, and to feel like they are pulling their own weight. Injuries can lead to trouble long term and having them occur mid-season can also severely limit opportunities. For these athletes, every moment counts.

Market Size

The market size of this demographic is small when compared to larger sports, however, the dedication to the sport at this level is a guarantee that there will be a strong following for a successful product in the space. It's also helpful that the sport is growing in the United States, especially since its return to the 2020 Summer Olympics (NCAA, 2022), (NFHS, 2022).

Numbers for DI and DII athletes have increased by an average of 100 athletes per year from 2014 to 2020, while DIII numbers have increased by about 250 per year. For the 2022 season, there were 6,704 DI athletes, 6,419 DII athletes, and 8,354 DIII athletes (NCAA, 2022). In high school sports, softball was the 5th most popular girls' sport throughout 2018-2022, with 340,923 total athletes in 15,454 schools that sponsor the sport (NFHS, 2022). With 69 countries having softball teams, it's estimated that there are at least 1,380 professional athletes on international rosters (Lombardo, 2020). This gives us roughly 365,000 highly competitive athletes in the sport of fastpitch softball.

Athlete Skills

One highly competitive softball player can perform, train, and look entirely different than another. Part of the uniqueness of the sport is that each player can have different strategies for success in the same game and on the same team.

In terms of defense, there are nine positions – one catcher, one pitcher, four infielders, and three outfielders. For most of the game, the catcher is in a squatting position behind home plate. Extreme endurance, flexibility, strength, control, and speed from this low position are required for success. A pitcher performs the duties of starting each play by pitching the ball to the batter. A traditional softball pitch involves a windmill action of the throwing arm, while the opposite foot jumps forward. The other foot is known as the drag foot, as it must maintain contact with the ground until the jumping foot contacts the ground again. As the pitch is released from their hand, the pitcher turns into another infielder and is responsible for similar duties. An infielder's skills generally involve extreme reaction time, quick, lateral sprints, diving, sliding, jumping, quick transitions and always having their head on a swivel. Usual outfielders' skills include high-speed sprints, diving, sliding, jumping, extreme agility, and athleticism.

Offensively, athlete skills can be divided into hitting actions and baserunning actions. During hitting, athlete skills include a short reaction time, rapid rotation of the upper body and back leg during the swing, precise control and accuracy of the hands, hips, legs, and bat, and the ability to derive power from the ground underfoot. While baserunning, skills needed are forward sprint speed, turning sprint speed for multi-base hits, agility to avoid tags or collisions, sliding, diving, jumping, abrupt stopping, and omnidirectional cutting.

Physiological Research

The importance of softball physiology is high, although the amount of research done in this specific area is minimal. In a study performed by Kathryn A. Cardwell in 2022, it was found that "softball is primarily composed of low intensity activities, like standing or walking, with intermittent periods of high intensity activity (e.g., sprinting, bat swings, high intensity throws). The cumulative effect of these high intensity activities across game durations of two hours or greater, compact tournament schedules and environmental factors may amplify neuromuscular fatigue". The specificity of the movements and timelines in this sport cause an inherent need for physiologically efficient equipment. I plan to apply the findings from Cardwell's study to ensure each part of the intended design adheres to the needs of the athlete in every moment of play.

Biomechanical Research

Ankle Injuries

Physiological aspects of the game combine with the physics of sprinting, sliding, diving, stopping, and cutting on dirt, grass, and bases, making ankle performance imperative to success and safety. Ankle sprains often come out on top of the injury list. In NCAA teams from 2015-2019, ankle sprains were the most common injury overall – in competition and practice time combined (Veillard et al., 2021). In a study compiling emergency room visits from 2010 to 2019 involving softball players, foot and ankle injuries were most frequently caused by sliding into base (51.5%, 95% CI = 47.0–55.2%) and typically resulted in a sprain or strain (65.5%) (Lee et al., 2022). In another study, Wasserman et al found at the high school level from 2004-2014, 16.9% of injuries during competitions occurred while sliding. When analyzed by player position, ankle sprains were the most common injury for high school base runners (34.1%), outfielders (14.2%), and pitchers (14.1%) as well as for collegiate base runners (21.6%). From data pulled from NCAA and high school softball from 1988-2004, "a total of 9% of game injuries occurred due to contact with a fixed base, and of these, 43.3% resulted in ankle ligament sprains. In addition, 7.8% of all game injuries resulting in 10+ days of activity time loss were ankle ligament sprains. Sliding injuries accounted for 23% of all game injuries" (Marshall et al., 2007). Figures 5-8 show a cohesive view of injury data from these reports.

This data shows that there is a need for better training and encourages the advancement of equipment. It's clear that improvements need to be made for softball players to stay healthy and continue to play throughout the season. Looking into the prevention of ankle sprain in the most vulnerable actions and positions, like contact with bases, during baserunning, pitching, and playing in the outfield, will be imperative for the success of this project.

Structural limitations of the ankle are difficult to test, as it is obviously unethical to initiate an ankle sprain under laboratory conditions. There is one study, however, that was testing for other lower body mechanics where a participant suffered an accidental ankle sprain. Fong et al. discovered the key biomechanics that leave the ankle susceptible to an inversion ankle sprain in their study in 2009:

For the successful normal trials, the ankle was externally rotated and slightly inverted at foot strike. Such orientation enhanced a flat foot landing with a maximum contact surface between the foot and the ground. For the injury case, the ankle was more internally rotated (or less externally rotated) at foot strike; this was suggested to be a vulnerable orientation for sustaining ankle sprain injury.1 However, in contrast to the hypotheses in previous studies, dorsiflexion instead of plantar flexion was found… In this case report, right after landing, the dorsiflexed ankle started plantar flexing at 0.06 seconds, shifted the center of pressure to the forefoot, and lifted the rearfoot. While the forefoot was in touch with the ground and supported the body, the rearfoot drifted to the lateral side; this was a pivoting internal rotational motion. Such motion swung the ankle joint center to the lateral aspect and deviated it from the application point of the ground-reaction force, as indicated by the center of pressure position (Fong et al., 2009).

These findings are incredibly helpful to design around, as this supplies quantitative data for the biomechanical limits of the ankle joint in each plane which is generally impossible to calculate. To prevent ankle sprain, these biomechanical limits must be integrated into the security, stability, and overall performance of the cleat to be designed. Figures 2-4 show compiled data from plantar pressure sensors, model-based image matching, and marker-based motion analysis.

	Normal Trials (N = 3)	Injury Trial (N = 1)	
At foot strike			
Plantar flexion/dorsiflexion	−14°[a]	−11°[a]	
Internal/external rotation	−21°[a]	−14°[a]	
Inversion/eversion	9°	15°	
During stance		Phase I[b]	Phase II[b]
Maximum plantar flexion	15°	1°	−15°[a]
Maximum internal rotation	−6°[a]	−5°[a]	10°
Maximum inversion	35°	41°	48°
Maximum plantarflexion velocity	730 deg/s	370 deg/s	93 deg/s
Maximum internal rotation velocity	320 deg/s	138 deg/s	271 deg/s
Maximum inversion velocity	638 deg/s	632 deg/s	272 deg/s

a Negative value means dorsiflexion and external rotation, respectively.

b Phase I is the preinjury phase, from 0.06 to 0.11 seconds. Phase II is the injury phase, from 0.11 seconds onward.

Figure 2: Phase breakdown of joint angles during normal and injury trial (Fong et al., 2009)

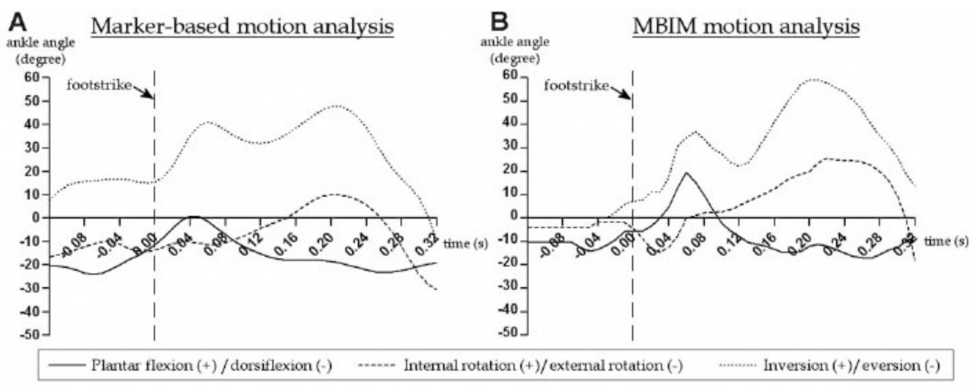


Figure 3: Timeline of ankle joint angles (Fong et al., 2009)

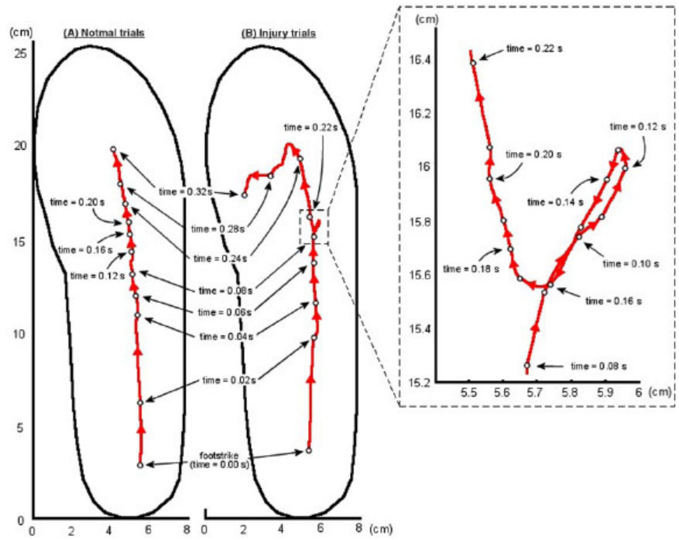


Figure 4: Plantar pressure sensor analysis from normal and injury trials (Fong et al., 2009)

Some research has been done to quantify ankle injury between high and low top shoes. A study performed by Weijie Fu, et al, shows that there were no significant differences in maximal ROM or angular velocity in ankle inversion for either type of footwear. However, EMG results from the testing showed that there was a significant increase in activation time from stabilizing muscles in the lower leg while wearing the high-top shoe – thus potentially increasing further injury if not corrected in time. (Fu et al., 2014). This project will focus on creating a structure that allows proprioception to exceed current high-top silhouettes and perform well under muscle activation times.

Potential negative impacts of bracing or taping mechanisms were explored. In a study of women's soccer athletes, Malloy et al discovered that "females with less ankle dorsiflexion flexibility exhibited greater peak knee abduction moments… greater peak knee abduction angles… and less peak knee flexion angles" during the trial. These changes in normal biomechanics can lead to improper joint loading and further injury for proximal structures such as the knee and hip. Maintaining dorsiflexion in this project is essential in keeping natural movement of the ankle joint and surrounding body structures.

Hand/Finger Injuries

When you calculate pitch speed, pitch spin, and overall movement from the batter, there are many forces at play when it comes to softball hitting. While batting gloves are often worn to prevent blisters and improve grip on the bat, the hand is generally left unprotected from the ball, aside from a layer or two of fabric.

From 2004-2015, injuries sustained to the hand and fingers in high school and collegiate softball batters were most frequently caused by being hit by a pitch, and in collegiate softball, hand and finger injuries accounted for 16.8% of all in-game injuries, deeming it the second most injured body part during NCAA competition (Wasserman et al., 2019). It is concluded in this study that "further examination of ways to protect batters from pitches […] is needed". During the 2015-2019 seasons, hand and wrist injuries surpassed the concussion, deeming it the most frequently injured body part reported in NCAA softball competition (Veillard, 2021). From 2009-2015, 1123 ball-contact injuries were reported in NCAA sports, for an overall rate of 3.54/10 000 AEs. Women's softball had the highest rate of 8.82/10 000 AEs in NCAA sports (Fraser et al., 2017). Figures 5-8 show a cohesive view of injury data from these reports.

This is seen as a confirmation of the validity of the thesis and will serve as the basis for improvement.

Table 6. Most Common Game and Practice Injuries Resulting in 10+ Days of Activity Time Loss, Women's Softball, 1988–1989 Through 2003–2004

Body Part	Injury Type	Frequency	Percentage of Severe Injuries	Most Common Injury Mechanism
Games (24.8% of all injuries required 10+ days of time loss)				
Knee	Internal derangement	142	22.6	No contact
Ankle	Ligament sprain	49	7.8	Other contact*
Finger(s)	Fracture	41	6.5	Other contact†
Hand	Fracture	39	6.2	Other contact‡
Other		358	56.9	
Total		629		
Practices (22.0% of all injuries required 10+ days of time loss)				
Knee	Internal derangement	93	15.0	No contact
Ankle	Ligament sprain	41	6.6	Other contact§
Shoulder	Tendinitis	34	5.5	No contact
Other		451	72.9	
Total		619		

*Indicates contact with fixed base.
†Indicates contact with batted ball.
‡Indicates hit by pitch, contact with the ground, or contact with a fixed base.
§Indicates contact with the ground.

Figure 5: Most Common Injuries with 10+ Days of Activity Time Loss, 1988-2004 (Marshall et al., 2007)

Table 5. Most Common Game and Practice Injuries, Women's Softball, 1988–1989 Through 2003–2004*

Body Part	Injury Type	Frequency	Percentage of Injuries	Injury Rate per 1000 Athlete-Exposures	95% Confidence Interval
Games					
Ankle	Ligament sprain	260	10.3	0.44	0.38, 0.49
Knee	Internal derangement	221	8.7	0.37	0.32, 0.42
Head	Concussion	151	6.0	0.25	0.21, 0.29
Upper leg	Muscle-tendon strain	130	5.1	0.22	0.18, 0.26
Lower leg	Contusion	81	3.2	0.14	0.11, 0.17
Shoulder	Muscle-tendon strain	72	2.8	0.12	0.09, 0.15
Finger(s)	Fracture	71	2.8	0.12	0.09, 0.15
Patella	Patella or patella tendon injury	56	2.2	0.09	0.07, 0.12
Unspecified†	Unspecified	56	2.2	0.09	0.07, 0.12
Hand	Fracture	45	1.8	0.08	0.05, 0.10
Knee	Contusion	40	1.6	0.07	0.05, 0.09
Upper leg	Contusion	40	1.6	0.07	0.05, 0.09
Lower back	Muscle-tendon strain	38	1.5	0.06	0.04, 0.08
Shoulder	Tendinitis	38	1.5	0.06	0.04, 0.08
Shoulder	Subluxation	37	1.5	0.06	0.04, 0.08
Hand	Contusion	35	1.4	0.06	0.04, 0.08
Thumb	Fracture	34	1.3	0.06	0.04, 0.08
Thumb	Ligament sprain	34	1.3	0.06	0.04, 0.08
Pelvis, hip	Muscle-tendon strain	32	1.3	0.05	0.04, 0.07
Finger(s)	Contusion	29	1.1	0.05	0.03, 0.07
Finger(s)	Ligament sprain	28	1.1	0.05	0.03, 0.06
Nose	Fracture	26	1.0	0.04	0.03, 0.06
Patella	Subluxation	26	1.0	0.04	0.03, 0.06
Elbow	Contusion	25	1.0	0.04	0.03, 0.06
Practices					
Ankle	Ligament sprain	266	9.5	0.25	0.22, 0.28
Upper leg	Muscle-tendon strain	237	8.5	0.23	0.20, 0.25
Shoulder	Muscle-tendon strain	152	5.4	0.14	0.12, 0.17
Knee	Internal derangement	151	5.4	0.14	0.12, 0.17
Shoulder	Tendinitis	124	4.4	0.12	0.10, 0.14
Lower back	Muscle-tendon strain	121	4.3	0.12	0.09, 0.14
Unspecified†	Unspecified	119	4.3	0.11	0.09, 0.13
Pelvis, hip	Muscle-tendon strain	80	2.9	0.08	0.06, 0.09
Head	Concussion	77	2.8	0.07	0.06, 0.09
Patella	Patella or patella tendon injury	69	2.5	0.07	0.05, 0.08
Lower leg	Contusion	51	1.8	0.05	0.04, 0.06
Elbow	Tendinitis	45	1.6	0.04	0.03, 0.06
Finger(s)	Fracture	45	1.6	0.04	0.03, 0.06
Shoulder	Subluxation	42	1.5	0.04	0.03, 0.05
Nose	Fracture	37	1.3	0.04	0.02, 0.05
Elbow	Muscle-tendon strain	27	1.0	0.03	0.02, 0.04
Lower leg	Muscle-tendon strain	27	1.0	0.03	0.02, 0.04
Thumb	Ligament sprain	27	1.0	0.03	0.02, 0.04

*Only injuries that accounted for at least 1% of all injuries are included.
†"Unspecified" indicates injuries that could not be grouped into existing categories but that were believed to constitute reportable injuries.

Figure 6: Most Common Game and Practice Injuries, 1988-2004 (Marshall et al., 2007)

Most Common Injuries Associated With Position in Competitions in High School Girls' and Collegiate Women's Softball[a]

Position	HS RIO (2005–2006 Through 2013–2014)			NCAA-ISP (2004–2005 Through 2013–2014)		
	Most Common Injuries	% of Injuries Within Position	Most Frequent Mechanism of Injury for This Injury Within Position	Most Common Injuries	% of Injuries Within Position	Most Frequent Mechanism of Injury for This Injury Within Position
Base runner	Ankle sprain	34.1	Contact with bases	Ankle sprain	21.6	Contact with bases
	Concussion	12.5	Contact with another person	Concussion	9.4	Contact with another person
	Knee sprain	11.4	Contact with playing surface			
Batter	Hand/wrist contusion	14.0	Hit by pitch	Arm/elbow contusion	16.1	Hit by pitch
	Hand/wrist sprain	10.5	Hit by pitch	Hand/wrist contusion	12.1	Hit by pitch
				Hand/wrist fracture	11.3	Hit by pitch
Catcher	Concussion	15.2	Contact with another person	Concussion	21.2	Contact with another person
	Hand/wrist contusion	8.9	Contact with another person	Hand/wrist sprain	7.1	Contact with other playing equipment
				Hand/wrist contusion	7.1	Hit by pitch
Infielder	Concussion	15.2	Hit by thrown ball	Concussion	11.8	Contact with another person
	Ankle sprain	12.9	Contact with playing surface	Ankle sprain	10.1	No contact
Outfielder	Ankle sprain	14.2	Contact with playing surface	Concussion	11.5	Contact with another person
	Concussion	12.1	Contact with another person	Hip/thigh/upper leg strain	9.0	No contact
	Knee sprain	12.1	Contact with playing surface	Ankle sprain	9.0	Contact with bases
Pitcher	Ankle sprain	14.1	Contact with bases	Trunk strain	6.4	No contact
	Hip/thigh/upper leg strain	12.9	No contact	Concussion	5.5	Hit by batted ball
				Shoulder strain	5.5	No contact

Figure 7: High school and NCAA Injuries by Position, 2004-2014 (Wasserman et al., 2017)

Distribution of Injuries by Women's Softball-Specific Activities and Player Position[a]

	Overall		Competitions		Practices	
	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)	Injuries Reported (%)	National Estimate (%)
Activity						
Base Running	141 (9.33)	3873 (9.58)	86 (13.50)	2698 (15.00)	55 (6.29)	1175 (5.23)
Batting	165 (10.92)	3660 (9.05)	91 (14.29)	2035 (11.32)	74 (8.47)	1625 (7.24)
Conditioning	51 (3.38)	1832 (4.53)	3 (0.47)	102 (0.57)	48 (5.49)	1730 (7.71)
Fielding	172 (11.38)	4452 (11.01)	76 (11.93)	1814 (10.09)	96 (10.98)	2638 (11.75)
General Play	165 (10.92)	3970 (9.82)	38 (5.97)	1110 (6.17)	127 (14.53)	2860 (12.74)
Chasing/diving	97 (6.42)	3254 (8.05)	57 (8.95)	2202 (12.25)	40 (4.58)	1053 (4.69)
Pitching	148 (9.79)	3921 (9.70)	74 (11.62)	2022 (11.25)	74 (8.47)	1899 (8.46)
Catching	103 (6.82)	2307 (5.71)	51 (8.01)	1166 (6.48)	52 (5.95)	1141 (5.08)
Running	85 (5.63)	2646 (6.54)	27 (4.24)	995 (5.53)	58 (6.64)	1652 (7.36)
Sliding	49 (3.24)	1490 (3.69)	32 (5.02)	1123 (6.25)	17 (1.95)	367 (1.63)
Throwing	173 (11.45)	4436 (10.97)	40 (6.28)	1054 (5.86)	133 (15.22)	3382 (15.06)
Other/unknown	162 (10.72)	4591 (11.35)	62 (9.73)	1660 (9.23)	100 (11.44)	2931 (13.05)
Position						
Base runner	92 (6.09)	2890 (7.15)	59 (9.26)	2072 (11.52)	33 (3.78)	819 (3.65)
Batter	88 (5.82)	1960 (4.85)	49 (7.69)	899 (5.00)	39 (4.46)	1062 (4.73)
Catcher	182 (12.05)	4595 (11.36)	75 (11.77)	2060 (11.46)	107 (12.24)	2535 (11.29)
Corner Infielder	211 (13.96)	5617 (13.89)	80 (12.56)	2493 (13.86)	131 (14.99)	3124 (13.91)
Middle Infielder	261 (17.27)	7216 (17.85)	110 (17.27)	3504 (19.49)	151 (17.28)	3712 (16.53)
Outfielder	359 (23.76)	9654 (23.88)	136 (21.35)	3673 (20.43)	223 (25.51)	5982 (26.64)
Pitcher	235 (15.55)	6142 (15.19)	101 (15.86)	2719 (15.12)	134 (15.33)	3423 (15.25)
Other/unknown	83 (5.49)	2358 (5.83)	27 (4.24)	562 (3.13)	56 (6.41)	1796 (8.00)

Figure 8: Softball Injuries by Activity and Position, 2014-2019 (Veillard et al., 2021)

Psychological Research

The growth of softball has led to an incredible period of human performance in the sport. Unfortunately, this often comes with added pressure. In recent years, light has been shed on the dark side of high-level athletes – especially in women's sports and their deep-rooted connection to societal, coach, parent, and personal stressors. In the last few years, there have been several tragedies in the community. Within the first 4 months of 2022, three female NCAA athletes committed suicide, all relating to pressure from their sport. In an interview with Arizona softball coach Caitlyn Lowe, she explains that a lot of her players equate their self-worth with their success on the softball field, especially if they feel they aren't "pulling their weight" (Doss, 2022).

The chance of being injured is a frequent fear for many athletes. Erika J. Hunt found in her thesis that ankle taping, regardless of whether the athlete had recently suffered an ankle injury, had suffered one in the past, or didn't have one at all, experienced an improvement in emotional and psychological conditions when having the extra security in the form of athletic tape.

> Psychological perceptions ranged from feelings of increased confidence, increased strength, decreased anxiety for injury or re- injury, mental preparation prior to performance, part of pre-performance routines, and even part of superstitious behaviors. The results supported previous research that also found a relationship between the use of adhesive ankle tape, even if not injured, and superstitious

behaviors, as well as emotional responses experienced through the rehabilitation and recovery from injury (Hunt, 2005).

This research is helpful in validating that the use of an ankle injury preventing cleat is useful for every athlete, let alone the ones most susceptible to injury or reinjury of the ankle. Improving ankle stability will directly improve mental health and in turn, improve performance in the sport.

Athlete Insights

User research will be performed through an online survey of softball athletes. It will begin by determining their age, and the highest or most recent level of play the athlete participated in. Afterwards, the following questions will be asked:

General Mental/Injury Questions

1) Have you suffered an injury during the season that you had to play through? If so, what happened? If there were multiple events, what was the most impactful?
2) How did the injury effect your mental health for the rest of the season, and afterwards?

Cleat/Ankle Questions

1) In your competitive career, have you sprained your ankle? If you could guess, how often has it happened?

2) What were you doing when it happened?
3) Do you wear an ankle brace during play or practice? If so, do you wear it all the time for prevention, or more for recovery when you need it?
4) What do you feel current softball cleats lack? Do you have any strong likes or dislikes, or have a favorite cleat?
5) If you had a PERFECT cleat, what would it allow you to do?

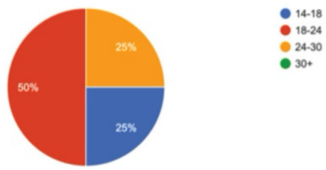
Hand HBP Questions

1) In your competitive career, have you been hit in the hand by a pitch? If so, what was the resulting injury? How long was your performance hindered?
2) What is your main complaint with batting gloves?
3) Do you wear your batting gloves while running the bases?
4) Do you wear any other protective offensive gear? Ankle guards, hand guards, baserunning mitt, mouth guard, elbow guard, etc. Why or why not?
5) If you had a PERFECT batting glove, what would it allow you to do?

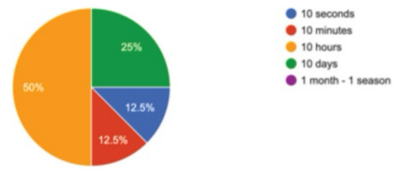
Initial Survey Results

Results from the online survey are included below in figure 9, showing demographics, experience with injury, product use, and opinions on current product (Everill, 2022). Although results are in early stages, it is interesting to note the high rate of injury in ankle sprains and being hit in the hand by a pitch, as well as the prevalence of mental health impact of an injury, both experienced themselves, or in another teammate.

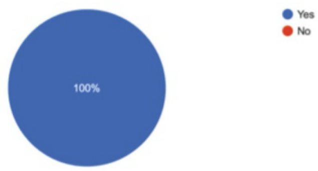
What is your age?
8 responses



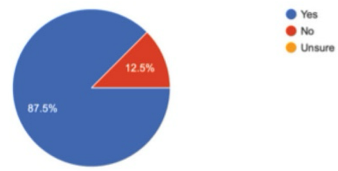
How long did you stop playing because of this injury?
8 responses



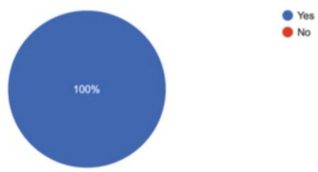
Have you suffered an injury during the season that you struggled to play though?
8 responses



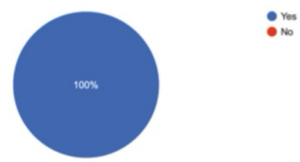
Did your injury negatively affect your relationship with your team, coaches, or parents?
8 responses



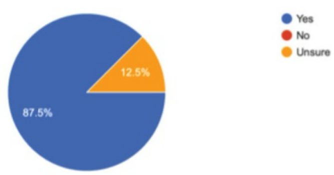
Did your injury negatively impact your mental health or your self-confidence?
8 responses



Did you ever have a teammate suffer an injury during the season that they struggled to play through?
8 responses



Did this teammate's injury seem affect their relationship with your team, coaches, or their parents?
8 responses



Did this teammate's injury seem to affect their mental health or their self-confidence?
8 responses

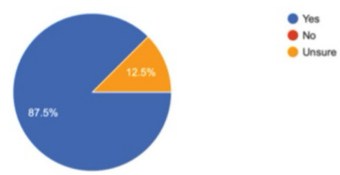


Figure 9: Fastpitch Softball Athlete Insight Survey (Everill, 2022)

Footwear Competitor Product Research

Softball Cleat Components – Jobs and Materials

Softball cleats are commonly comprised of an upper and outsole, with midsoles being more common within the last 5-8 years. This section, along with figure 10, serves as a breakdown of a softball cleat piece by piece, with the purpose and materials of the piece included.

The main upper of the cleat allows for the foot to be secured to the shoe, offers stability, enables functional movement, prevents overarching movement, and offers protection from external forces. It may be made from woven, flat knit, or diamond knit polyester, often glued to a 2mm PU open cell foam padding layer, backed with a polyester tricot knit. The interior of the upper may consist of a cotton/polyester blend jersey knit lining (Motawi, 2018).

The tongue of the cleat gives support for the top of the foot, cushioning from the lacing system, ease of donning and doffing and allows the upper to fit comfortably around the foot. It is often made of the same materials as the upper, while many cleats opt to add a thicker PU open cell foam pad, and an optional branded finger pull tab made of a polyester or cotton/polyester blend webbing (Motawi, 2018).

Toe caps are incorporated into softball cleats due to the excessive toe drag that happens in the sport. Toe caps allow the cleat to be substantially more durable at the most vulnerable part of the shoe and offers protection from external forces. It is made of a molded TPU shell and adhered to the upper, and sometimes the outsole (Motawi, 2018).

The lacing system of a cleat offers lockdown, stability, and comfort, and enables donning and doffing. The laces themselves are made of a polyester or cotton/polyester blend closed loop woven cording. The lacing/upper interface is frequently made of stamped and coated steel eyelets, or a TPU film adhered to the upper (Motawi, 2018).

The collar of a cleat is there to provide stability, comfort, and security in the shoe. The exterior is commonly an extension of the upper, or an extension of the upper lining. An additional thickness PU open cell foam is often added between layers to increase support and comfort in the ankle (Motawi, 2018).

The heel cup of a cleat is imperative to stability, security, and overall movement. Because it is shaped to the convex curve of the heel, it allows your foot to be fully encased in the shoe, while allowing enough flex to don and doff when the lacing system is loosened. The heel cup is generally made of a molded TPU, adhered to the inside of the upper layers. It is common to include an extra layer of PU open cell foam to protect the foot from the rigid plastic, as it needs to create resistance to overarching movement in the shoe (Motawi, 2018).

The midsole offers fatigue reduction, protection from external forces such as bases, uneven playing surfaces or another player's foot, and cushioning from the directed pressure of the cleat spikes. It is generally made of a hot-pressed EVA foam with a usual Asker C 50-60 hardness (Motawi, 2018).

The outsole of a softball cleat can also be called the cleat plate. It is responsible for attaching the cleat spikes to the shoe, offering controlled directional flexion, protection from the external forces as mentioned with the midsole, and stability. The cleat plate or outsole is made of an injection molded TPU (Motawi, 2018).

The final components of the cleat are the cleat spikes. The main objective of the cleat spikes is to offer traction over the varying surfaces of the softball field. They are made of die cut stainless steel and are directly over molded into the cleat plate in the injection molding step (Motawi, 2018).

Figure 10: Cleat Components (Everill, 2022), (Mizuno, 2022)

Cleat Manufacturing

The upper pattern is designed, graded, and cut. Next, adhesion of TPU films, molded pieces, foam pads, interfacing, or visual effects are added to their respective pieces. Each piece of the upper is sewn together, often around the collar and eyestay area, and the tongue is attached. Now the upper is placed onto the last and is sewn together, usually with the traditional strobel method. The footbed area of the shoe is then shaped and smoothed down in preparation for the midsole. The midsole is traditionally hot pressed and then glued to the upper. The outsole containing the over molded cleat spikes is also glued to the midsole and can extend to glue to the upper at the toe. The finishing of a cleat includes lacing the shoelace cording and applying a paint touch-up to disguise parting lines, glue marks, or other imperfections (Motawi, 2018).

Baseline Products

The Mizuno Sweep and Swift lines are a staple in any fastpitch dugout. The "Mizuno brand is known to offer the best value for the money comparing to other brands", according to many athletes, coaches, and parents (Mizuno Review, 2021). The Mizuno Sweep 6 Mid is one of three state-of-the-art softball cleats that feature a mid-top silhouette, said to offer more ankle support for the wearer. It is sold at $120 (Mizuno, 2022).

Because the target athlete is often sponsored through their college team or an endorsement deal, it is important to include the brand with the most sponsorships in this field. Nike sponsors a large percentage of university athletics and professional teams and athletes, and their standard cleat offered is the Nike Hyperdiamond Elite, retailing at $90 (Nike, 2022).

Baseline SWOT Analysis

The baseline products are broken down into piece-by-piece SWOTs in figures 11-14 to inform design decisions.

Figure 11: SWOT Analysis of Mizuno Sweep 6 Mid (Everill, 2022), (Mizuno, 2022)

Figure 12: SWOT Analysis of Mizuno Sweep 6 Mid (Everill, 2022), (Mizuno, 2022)

Figure 13: SWOT Analysis of Nike HyperDiamond (Everill, 2022), (Nike, 2022)

Figure 14: SWOT Analysis of Nike HyperDiamond (Everill, 2022), (Nike, 2022)

Batting Equipment Competitor Product Research

Batting Glove Components – Jobs and Materials

A batting glove's overall purpose is to protect the batter from friction, impact, vibration, and abrasion. The following section breaks down each piece of the palmar and dorsal sides of the glove, along with figure 15.

The base layer of the palmar side of a batting glove provides protection from vibration and force from the bat, protection from the friction of the batter's grip on the bat's handle, and protection from the ground while sliding during baserunning. It is made of a durable material, often goatskin, sheepskin, or synthetic leather, measuring less than 1.6mm (Rawlings, 2022).

Many gloves include a pad on the palmar side of the glove, protecting the ulnar/palmar side of the hand. This pad is specifically placed to protect the area most frequently exposed to high vibration and impact of the bat when making contact with the ball – the pisiform, triquetral, hamate, and 5th metacarpal bones. It is often made of an open cell PU foam encased in the same material used in the palmar base layer (Rawlings, 2022).

The finger gussets of a glove are responsible for comfort, full hand ROM, and breathability. They are made of a polyester blend, two or four-way stretch jersey knit (Rawlings, 2022).

Wrist straps are the main source of security for the batting glove. They can also provide some stability in wrist motion and protection from vibration and impact from the bat, as they are generally thicker and more structured than the rest of the glove. They are composed of an outer polyester knit layer adhered to an open cell PU foam and backed with another layer of polyester knit. The closure is achieved with a hook and loop strip sewn into the strap. Many wrist straps also integrate a sewn in, molded TPU tab to stiffen the strap above the hook and loop closure, creating a stronger closure and improving donning and doffing (Rawlings, 2022).

Most batting gloves are made with a split on the ulnar side, extending about two inches distal to the wrist strap. This parting in the glove opens at different degrees to create a better fit, improve ease of donning and doffing, and expels wrinkling and bunching that can occur from tightening the wrist strap (Rawlings, 2022).

The dorsal side of the glove has a base layer that provides breathability and protects from abrasion and impact from external forces like the ball, the ground, or another player. The dorsal base layer is usually made from a polyester/spandex single or double knit (Rawlings, 2022).

Most gloves have some sort of dorsal overlay to improve zonal abrasion resistance, durability, impact protection, or improved flexibility. A strategically perforated TPU film is frequently used to slightly improve all these qualities. To improve flexibility and impact protection, a glove will commonly have panels of knit polyester spacer mesh (Rawlings, 2022).

Figure 15: Glove Components (Everill, 2022), (Rawlings, 2022)

Batting Glove Manufacturing

The glove manufacturing process starts with tanning and pre-stretching the leather. The glove pattern is cut, including the leather stitch holes. Next, any TPU films, overlays, hook and loop strips, or external pads are sewn or adhered to the flat pattern pieces. Assembly varies greatly depending on the patterning of the glove, but a traditional method is to sew together by connecting the finger gussets to the front, then the back of the glove with the thumb attached last. The trim inside of the flap on the ulnar side of the hand is attached, then the rest of the wrist edge of the glove is sewn into the wrist strap piece (How It’s Made, 2017).

Baseline Products

The Rawlings Workhorse is a generally trusted batting glove and is a staple in many dugouts. It is known for its durability, comfort, grip, and blister protection. They recently developed a women's specific fit of the glove in 2021. The women's version includes a dorsal pad for protection from pitches. It retails at $39.95 (Rawlings, 2022).

The EvoShield hand guard, retailing at $59.95, is the state of the art for batter hand protection (EvoShield, 2022). It's incredibly effective at protecting from the hit by pitch, however, it complicates game transitions. In the game of softball, there is a strict time limit between pitches. As soon as the pitcher, batter and catcher are in position for the next pitch, the pitcher has 15 seconds to deliver the pitch (Van Kleek, 2021). With the combination of hitting and baserunning, the use of these protective devices can be difficult. There is frequent use of elbow guards and ankle guards in hitting, and players have been able to adapt just enough to get this equipment off in time but adding one more piece could be severely detrimental to the speed of the game. The goal of including this product as a baseline is to achieve the same level of protection while integrating it into a glove.

Baseline SWOT Analysis

The baseline products are broken down into piece-by-piece SWOTs in figures 16-18 to inform design decisions.

Figure 16: SWOT Analysis of Rawlings Workhorse (Everill, 2022), (Rawlings, 2022)

Figure 17: SWOT Analysis of Rawlings Workhorse (Everill, 2022), (Rawlings, 2022)

Figure 18: SWOT Analysis of EvoShield Hand Guard (Everill, 2022) (EvoSheild, 2022)

Key Patent Research

The patent search in terms of softball specific footwear and batting glove technology is limited, offering many opportunities for design. In terms of creating footwear and batting gloves, there are multiple innovations that can be applied from adjacent industries.

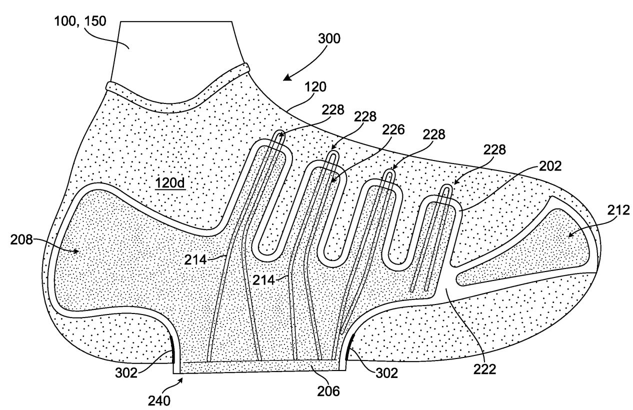


Figure 19: US9861161B2 (Meschter et al., 2015)

A key footwear related patent to stay away from includes Nike's Flywire Technology. This patent claims the use of "footwear components made from lightweight textile structures (e.g., including circular knitted structures made from natural or synthetic fibers) that are selectively supported at various areas to provide desired local characteristics (such as stiffness or support), as well as to methods of making such components and articles of footwear containing such components" (Meschter et al., 2015). The summary of the invention is described as followed:

> Some aspects of this invention will utilize and/or begin with an upper base member that defines a single foot-insertion opening and an otherwise enclosed volume (e.g., a sock or sock-like structure, optionally one produced by a circular knitting process and/or having one end closed off by a seam). Additionally, some aspects of this invention relate to footwear upper structures that are selectively supported (e.g., by pressed on support members or reactive polymeric materials, as will be described in more detail below) and may be incorporated into footwear structures in relatively easy and simple manners. More specifically, some aspects of this invention relate to footwear upper structures, e.g., of the types described above, that may be incorporated into a foot structure without the need for attachment of a strobel member, without the need for a bottom seam, and/or without the need for forming a heel stitch or other stitching, etc. Thus, the upper base member may be a continuous structure that extends uninterrupted around a plantar support surface of the foot (e.g., without a seam or strobel member under the foot). Such advantageous features of some examples of this invention can substantially

reduce the time and/or labor involved in finally forming an upper and/or engaging an upper with a footwear sole structure. (Meschter et al., 2015)

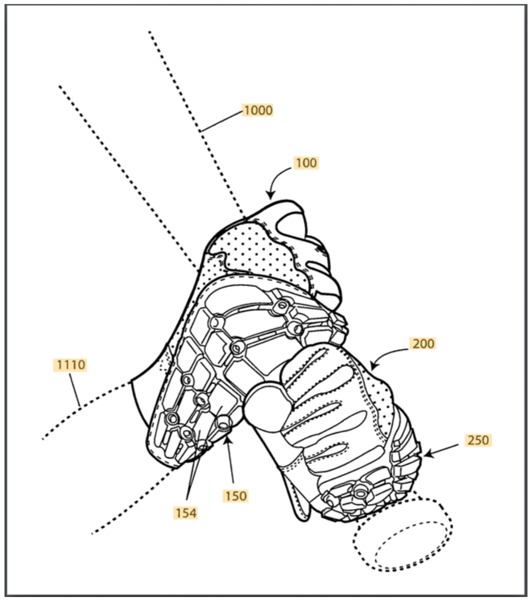


Figure 20: US8256028B1 (Ibon et al., 2012)

A patent to be aware of for the batting glove is from XProTex, a baseball batting glove company:

The invention comprises a unique protective system of a design of a matched pair of batting gloves with one matched pair designed for a right-handed batter and one matched pair designed for a left-handed batter. For each matched pair of batting gloves, impact and shock absorbing material is incorporated onto selected portions of the exterior of the glove where the grip on the bat causes the hand to be most exposed to a pitch thrown at the batter. The specific one of the matched set of gloves for a right-handed or left-handed batter has impact and shock absorbing material incorporated onto the exterior of the glove which covers the area where the pinkie finger and its metacarpal bone on the hand are located, and pinkie finger bones proximal bone, middle bone and distal bone are located and also covers the area of the hand where the metacarpal bones and are located. In addition, another unique feature of the present invention is that impact and shock absorbing material extends so that they extend over the exposed area of the wrist which is aligned with the pinkie finger and includes carpal bones which are the hamate, triquetrum, pisiform, and lunate and further extends over a portion of the ulna bone which is aligned with the pisiform and lunate bones of the wrist and connect the wrist to the forearm. (Ibon et al., 2014)

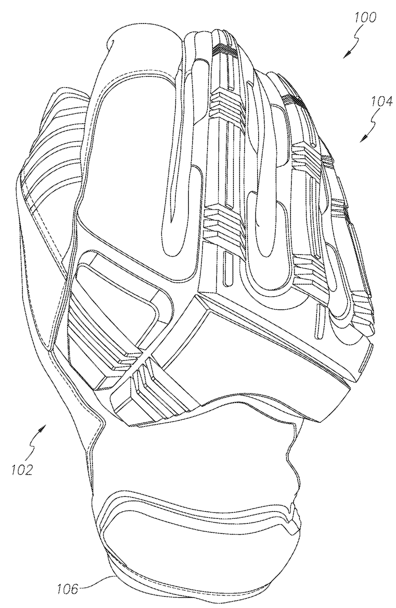


Figure 21: US20190357612A1 (Safford, 2019)

Impact protection is a prevalent aspect of work gloves, with new and improved testing protocols coming out of the industry. Mechanix Wear is a strong leader in the industry, with the patent for their M-PACT line comprising of a varied durometer thermoplastic layer on top of a foam layer:

The protective glove may include a least one finger guard. The at least one finger guard may be connected to a knuckle guard. The at least one finger guard and the knuckle guard may be surround by a flange. The at least one finger guard, the knuckle guard and the flange may be integrally formed of a thermoplastic rubber, e.g., a soft or medium soft durometer thermoplastic rubber. An outer layer of the glove may underlie and may be secured to the at least one finger guard and the knuckle guard. The outer layer of the glove may be formed of a knitted mesh fabric. For example, the knitted mesh fabric may be made of 94% nylon and 6% spandex. A sponge layer may underlie and may be connected to the outer layer of the glove. The sponge layer may be formed of an open cell foam and may be coextensive with the outer layer of the glove. A second layer may underlie the sponge layer. For example, the second layer may be made of tricot. A foam layer may abut the second layer and may be positioned between the second layer and an inner layer. The foam layer may consist of an EVA foam. The inner layer may be made of tricot. The foam layer may be encased by a combination of the second layer and the inner layer. The foam layer may include four extensions and a main body, and the foam layer may be at least coextensive with the knuckle guard. In addition, the foam layer may extend 1-5 mm beyond a periphery of the knuckle guard. The at least one finger guard further may include a proximal flexure zone, and the four extensions may extend to a distal end of a proximal flexure zone that separates the at least one finger guard from the knuckle guard. The foam layer may be between 2 mm and 4 mm thick, e.g., 3 mm thick. (Safford, 2019)

Color, Graphics & Logo Applications

In terms of sport, softball remains very “safe” in its designs, colors, and overall aesthetics. Historically, softball follows baseball closely, in rules, and strategy, and the same goes with trend. Much of the research in this area revolves around the use of personalization of product, adding names, numbers, custom colors, and team graphics onto equipment.

Color in softball is often a controversial topic, as there are many rules, both recorded and unspoken, around this topic (Van Kleek et al., 2021). The overarching theme is to match your team. Differentiating yourself in a visually aggressive way is thought to be cocky and can often be detrimental to team and coach chemistry. In recent years, however, there’s been a surge of personality in both baseball and softball. Neutrals and team colors still take the precedent, though full spectrum and iridescent shades are making a strong presence in equipment, footwear, and accessories (DeMarini, 2022), (Easton, 2022), (Wilson, 2022). Additionally, most high-level athletes will play on multiple teams throughout the year, from high school play during spring, travel team play in the summer, fall, and winter, or being traded between professional teams. This creates an opportunity to be more creative with colors, as their teams may be different colors and they frequently use the same equipment year-round.

For this design thesis, I plan to use neutral colors, like black, white, and beige as base colors. To continue to push the sports’ culture, I plan to utilize the up-and-coming athlete’s personalized aspect of color, by combining pops of color that work with common team colorways.

Figure 22: Intended color trends (Everill, 2022)

Softball product graphics in the past have been bold and monochromatic, often utilizing geometric designs. Like the color trends in the sport, graphics are getting more personalized and more adventurous, while also integrating understated ways to incorporate more color while staying cohesive with the team. WGSN graphic trends are also highly applicable here, with the trends “Creative Confidence” and “SenseScapes” making a stand in S/S 2024.

Creative Confidence describes surrealism, collage, optical illusions, graffiti inspirations, and illustrations of acceptance (Hudson, 2022). SenseScapes creates graphics of shape-shifting forms, natural and artificial crossover, and psychedelic iterations of nature (Kostiak, 2022). Examples are shown in figures 23-24.

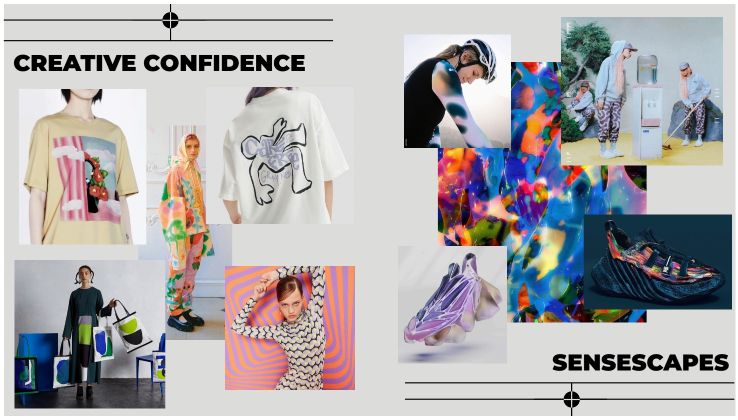


Figure 23: Imagery from Creative Confidence and SenseScapes (Hudson, 2022), (Kostiak, 2022)

Figure 24: Intended graphics trends (Everill, 2022)

Softball has historically enforced minimalism in its logo applications. It is difficult for companies to have pronounced logos on products, as it will detract from the cohesion of the team. For this reason, logos and branding tend to stay in a black, white, or tonal colorway, often featuring the most minimal form of the company's logo. Following future trends in branding and logos, I intend to design with an empowering but understated branding scheme.

Utilizing the graphic and color trends stated above, the branding will be able to be cohesive while being heavy on storytelling, acceptance, and encouragement.

Product Development

Glove Prototyping

The batting glove design was catered towards a minimal silhouette for enhanced bat grip and baserunning comfort. Softball pitch movement and swing analysis was performed to determine a predicted hand impact map for a right-handed hitter. To adapt to a left-handed hitter, the design would be inverted. A sheathing mechanism of 2mm Poron XRD impact attenuating foam was used throughout the glove in an overlapping pattern as shown in Figure 25. The glove's dorsal side is made up of two fabric layers - both of which have impact foam adhered to them. The staggered construction allows the foam pieces to glide across themselves when flexing and extending the fingers and hand, while still offering full coverage of the high-risk impact zones along the knuckles when gripping the bat. The front hand wristband foam is extended down the arm and around the wrist, culminating in an 85% coverage for the entire impact zone (Everill, 2024). For the glove to withstand the rough dirt, diving, sliding, grabbing for bases, and potential contact with another player's cleat spike, Dyneema embedded nylon stretch knit was used for the outer dorsal layer of the glove, topped with a Bemis abrasion resistant film at the high abrasion zones. The inner layer of the glove and the finger gussets in-between are made of a highly flexible nylon polyester jersey knit to ensure comfort throughout the entire time the player is at the plate and on the bases.

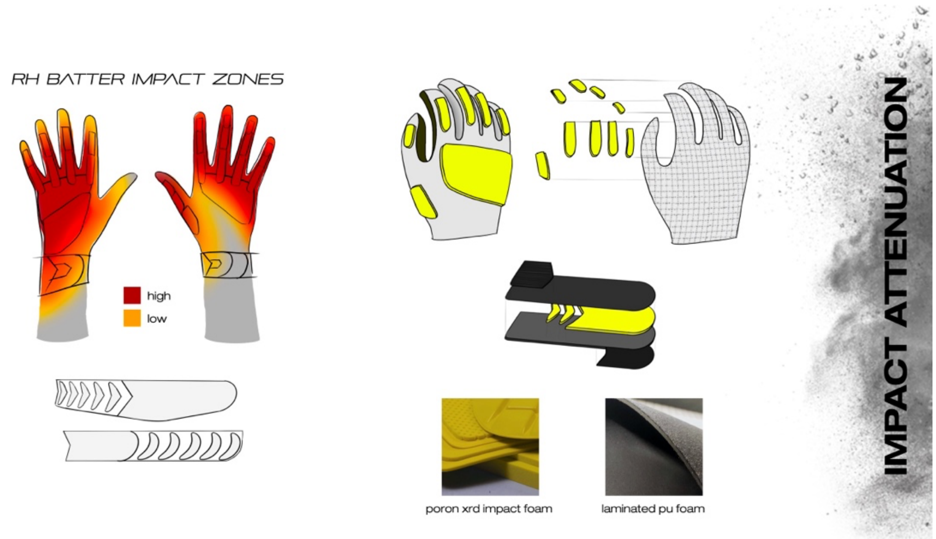


Figure 25: Glove Design (Everill, 2024)

Figure 26: Glove Design (Everill, 2024)

Cleat Prototyping

Softball movements were researched to determine the footwear needs of the athlete. Considering the omnidirectional movements of the sport, along with the need for highly proprioceptive inputs, and need for comfort, I explored internal heel counter shapes that would offer a better ground feel. The final shape, shown in figure 27, includes a lateral extension of the heel counter that connects the 5th metatarsal to the heel, strengthens the tripod of the foot on the side most needed to self-stabilize, while also controlling torsion. It's made of a firm but flexible TPU, with the base having a 2mm thickness that tapers to 1.5mm along the vertical extensions of the heel counter. They are thin and unobtrusive - they only exist to alert the body by sliding against your sock as you reach higher angles of movement. A custom last, shown in figure 28, was created by blending a cross training and American Football last, with incremental changes to the toe box width and height to allow for better grounding and range of motion. A mid top engineered knit serves as the base of the upper construction to increase feedback, range of motion, and to house the vertical extensions of the heel counter (Everill, 2024).

Figure 27: Extended Heel Counter (Everill, 2024)

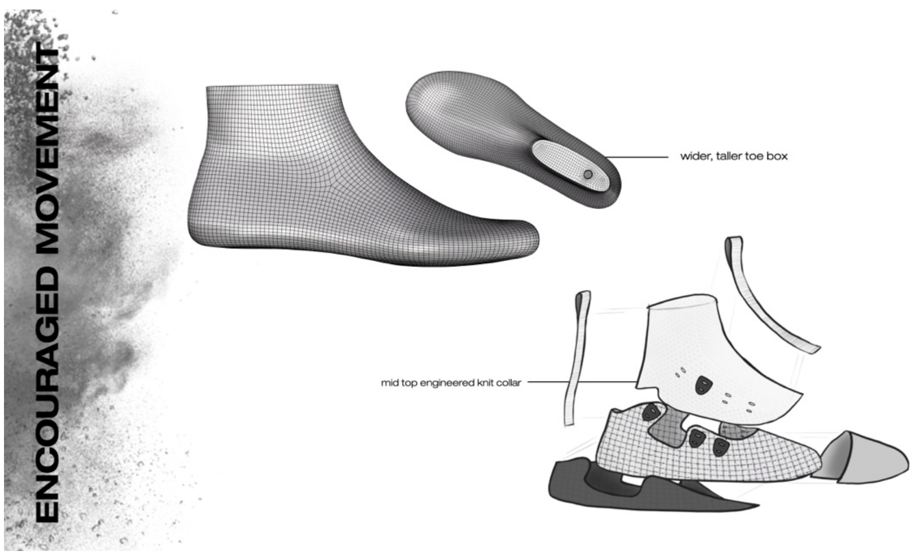


Figure 28: Last and Engineered Knit (Everill, 2024)

Impact zoning maps were created from both impact frequency and injury severity. To adapt the Poron impact foam into a footwear application and maintain coverage of these large impact zones, channels were created between the foam and the upper lining, and perforations were added to the raised ridges to improve air flow without sacrificing impact protection

(Figure 29). These ridges also add an extra mechanical impact protection to the already protective material. To protect the area around the toe, there is an external toe cap that has a dual purpose in abrasion and puncture resistance, as toe drag is a common movement in the sport, even required at the pitching position. Aside from the toe cap, the impact foam details are laminated with the Dyneema nylon knit along the portion of the foot closest to the ground, as shown in Figure 30 (Everill, 2024).

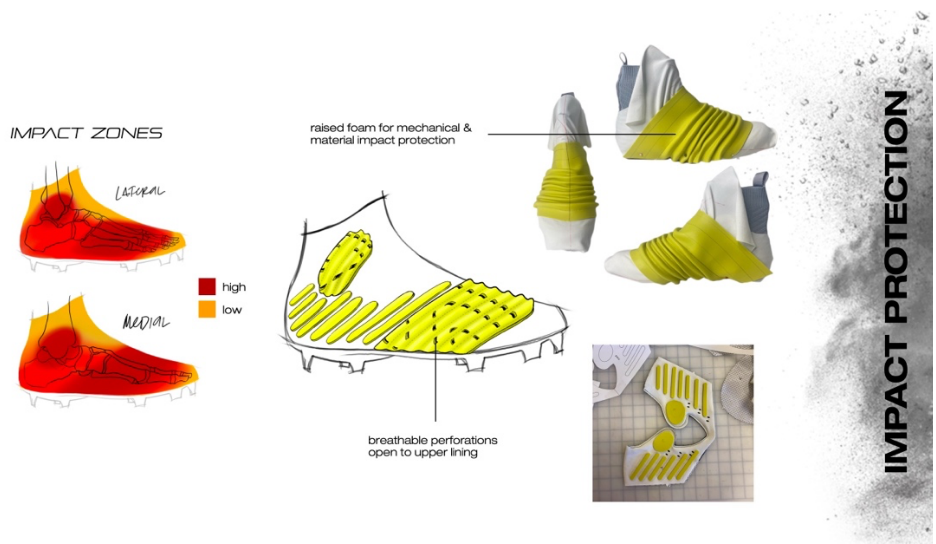


Figure 29: Cleat Impact Protection (Everill, 2024)

Figure 30: Cleat Abrasion and Puncture Resistance (Everill, 2024)

Batting Glove Testing

To improve upon the current products in terms of the project's design intent, certain metrics will need to be tested. The batting glove will need to prevent mechanisms of injury from being hit by a pitch.

Glove Testing Methods

Quantitative data to collect for the batting glove will include the level of impact protection and the coverage area of impact protection. Testing methods are described in the tables below.

Ball Drop Impact Attenuation Test

Phase	Procedure	Documentation	Data Collected	Time
Recruitment	Acquire baseline products, steel ball, enclosed testing environment, and gridded, measurable backplate			
Study Preparation	Set up product to be tested and slow-motion camera			5 min
Data Collection	Drop steel ball onto product being tested, repeat for all products	Slow-motion video	Measured height of bounce	30 min
Data Analysis	Analyze slow-motion video	Excel spreadsheet documentation of trial results	Calculated rebound height, direct inference of impact attenuation	3 hours

Perceived Force Test (ANSI/ISEA 138)

Phase	Procedure	Documentation	Data Collected	Time
Recruitment	Acquire baseline products, pressure sensitive film, and enclosed testing environment			
Study Preparation	Set up product to be tested and respective measuring tool			5 min
Data Collection	Drop steel ball onto product being tested, repeat for all products	Pressure sensitive film color change	Film color saturation and density	30 min
Data Analysis	Obtain high quality scans of pressure sensitive paper, match result data to respective video	Layout of pressure sensitive paper analyzed by color proportion/color change	Impact attenuation metrics	5 hours

Glove Testing Results

Results were averaged among each product and were calculated into a percent of improvement against the controls.

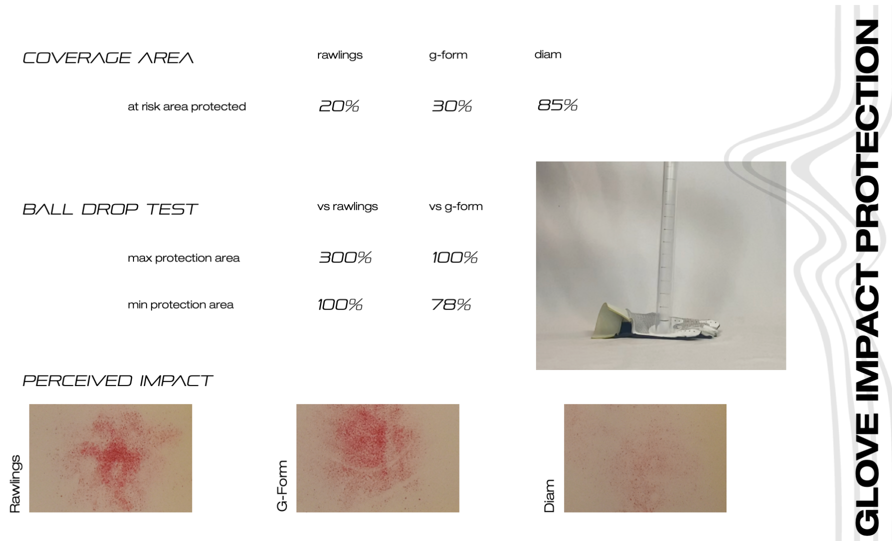


Figure 31: Batting Glove Impact Protection Testing Results (Everill, 2024)

Cleat Testing

To improve upon the current products in terms of the project's design intent, certain metrics will need to be tested. The cleat will need to prevent mechanisms of injury from ankle sprains and improve impact protection along the aforementioned areas.

Cleat Testing Methods

Quantitative data to collect for the softball cleat will include perceived stability, ROM, and impact protection. Testing methods are described in the table below.

Focused Movement and Weight Testing

Phase	Procedure	Documentation	Data Collected	Time
Recruitment	Identify participants, reserve field, acquire cameras			
Participant Consent	Inform participant of study risks, purposes, etc.	Study participant consent form	Participant consent or refusal of consent	5 min
Data Collection	Perform ROM testing without footwear	Goniometer readings recorded on excel spreadsheet	Natural, unrestricted ROM	5 min
Data Collection	Perform ROM testing with footwear to be tested	Goniometer readings recorded on excel spreadsheet	ROM influenced by testing cleat	5 min
Data Collection	Perform ROM testing with control footwear – what participant would wear to play softball (or plyometric/cross training if N/A	Goniometer readings recorded on excel spreadsheet	ROM influenced by trusted control footwear	5 min
Data Collection	Perform movement testing with control footwear	Slow motion video, photo with footwear	Video stills of joint angles throughout exercises	15 min
Data Collection	Perform movement testing with cleat to be tested	Slow motion video, photo with footwear	Video stills of joint angles throughout exercises	15 min
Data Analysis	Analyze ROM results	Excel spreadsheet	Calculated percentage difference of ROM between the bare foot, trusted footwear, and cleat to be tested	30 min

Data Analysis	Analyze slow motion video	Slow motion clips, video stills, illustrated highlights	Calculated joint angle ranges compared between footwear with each movement (+xdegrees of xflexion in xmovement, etc.)	8 hours

Specific movement testing involved the subject doing 30 body weight single leg squats on a Bosu ball, flat side up, with the tested cleat. Slow motion film captured the angle of the Bosu ball and time. Maximal displacement of the Bosu ball was recorded, as well as the time it took for the subject to maintain less than or equal to 2° of displacement for at least 2 seconds. These results were averaged to cumulate in a final score.

Ball Drop Impact Attenuation Test

Phase	**Procedure**	**Documentation**	**Data Collected**	**Time**
Recruitment	Acquire baseline products, steel ball, enclosed testing environment, and gridded, measurable backplate			
Study Preparation	Set up product to be tested and slow-motion camera			5 min
Data Collection	Drop steel ball onto product being tested, repeat for all products	Slow-motion video	Measured height of bounce	30 min
Data Analysis	Analyze slow-motion video	Excel spreadsheet documentation of trial results	Calculated rebound height, direct inference of impact attenuation	3 hours

Perceived Force Test (ANSI/ISEA 138)

Phase	Procedure	Documentation	Data Collected	Time
Recruitment	Acquire baseline products, pressure sensitive film, and enclosed testing environment			
Study Preparation	Set up product to be tested and respective measuring tool			5 min
Data Collection	Drop steel ball onto product being tested, repeat for all products	Pressure sensitive film color change	Film color saturation and density	30 min
Data Analysis	Obtain high quality scans of pressure sensitive paper, match result data to respective video	Layout of pressure sensitive paper analyzed by color proportion/color change	Impact attenuation metrics	5 hours

Cleat Testing Results

Results were averaged among each product and were calculated into a percent of improvement against the controls.

Figure 32: Cleat Stability and Proprioception Testing Results (Everill, 2024)

Figure 33: Cleat Impact Protection Testing Results (Everill, 2024)

Conclusion

As shown in figure 34, the batting gloves maintain a sleek silhouette, offer zoned abrasion resistance, and full coverage, effective impact attenuation that is visible through the perforations in the dorsal layer, adding assurance that the user is protected.

Figure 34: Final Glove Design (Everill, 2024)

As shown in figure 35, the cleat offers the rare combination of safety and agility, a visually striking protective layer and grounding internal components.

Figure 35: Final Cleat Design (Everill, 2024)

This collection offers my athlete a chance to make a difference in the game and their careers, allowing them to make the most of every moment on and off the field with their teams.

Figure 36: Full Collection (Everill, 2024)

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