Sensory Feedback and the Elite Athlete:

Harnessing Sensation though Sports Apparel
to Influence Priming in Elite Basketball Athletes

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Project Overview

Harder, better, faster, stronger. As the demands of elite athletes continue to escalate, the field of sports performance optimization is tasked with devising strategies that allow athletes to train longer, compete harder, and recover faster. Over the years, the bulk of performance optimization has focused on building athletes' strength, speed, and resilience through aerobic and anaerobic training methodologies, supplemented with proper nutrition and sport-specific coaching. This framework, integrated into all aspects of elite sport, places emphasis on the direct correlations of physiology and biomechanics to athletic performance. In recent years, the field of performance optimization has shifted its focus to other aspects of sports science such as recovery, in order to facilitate performance improvements when an athlete is not competing or training. Consequently, the sports recovery product market has since exploded, growing from a global market value of $6.4 billion in 2018 to $8.7 billion in 2020, with a CAGR of 8.2% through 2027 (Grand View Research, 2020). While the sports recovery market has become widely successful and saturated in a short amount of time, the majority of products in this sector are designed for direct, physical recovery from intense exercise. These products focus on reducing muscle soreness, decreasing acute inflammation, and cushioning tired feet. While research supports these types of recovery modalities as a means of reducing the symptoms of physical fatigue, they only scratch the surface of opportunity given emerging understandings of both recovery and performance.

Groundbreaking insights have emerged regarding the interaction between mental and physical performance, recovery, and priming. As each of these three phases of a performance regimen inform one another, the neural (mental) and muscular (physical) experiences of the athlete are inextricably linked. Emerging research showcases a deep-rooted connection between the central nervous system and cardiovascular, digestive, and respiratory systems that strongly influence athletic performance and recovery. This project aims to explore this connection through innovations in performance footwear and apparel design.

At the nexus of this concept is the sensory system. The influence of sensory stimulation on the neuromuscular system and deeper regulatory systems within the body is an emerging topic in the field of sports performance. Evidence suggests that targeted sensory stimuli impact the most innate systems of the body, such as the autonomic nervous system and cardiovascular system, in previously unperceived ways. Sensory stimulation of various kinds has proven successful in clinical applications, most specifically in disabled and disordered populations (Chen et al., 2012). The utilization of sensory stimuli as a means of performance optimization in recreational and elite athletes has only recently emerged as a promising and untapped opportunity for sports product innovation (Chen et al., 2012).

The intense environment of elite-level basketball offers an opportunity to explore the concept of sensory stimulation through sports product design. The landscape of elite basketball is both physically and mentally grueling as athletes are tasked with intense aerobic and anaerobic workloads, frequent travel and tournament schedules, and the unceasing pressure to maintain peak performance. Men's basketball is unique because of the intensity and exposure players experience at the high school and junior levels, as well as the high volume of games in which these young athletes compete. For the upper echelon of rising basketball stars, pressure and intensity of games only increases as they enter the collegiate arena, another stop on the tenuous “pipeline to pro.” These young athletes must maintain peak physical form, focus, and consistency in order to build value and earn a place in the NBA draft. From a young age, athletes have their sights set on joining a team in the NBA - the pinnacle of professional basketball. For the typical high school senior playing on a team, the odds of achieving this are .03%, or 3 in 10,000 (O'Shaughnessy, 2011). Many budding players adopt a “ball is life” mentality to overcome these slim odds, dedicating their high school and collegiate experiences to basketball. Countless hours are spent working tirelessly in the gym and weight room in hopes of gaining an edge and ultimately making it to the league.

The overarching approach to training and performance optimization in this environment focuses on the concrete, physical aspects of performance, maximizing athletes’ time in the gym to facilitate visible gains (Sabato et al., 2016). Only recently have the deeper pressures of top-tier basketball come to light, with athletes at the collegiate and professional levels starting to share their challenges with mental health and its effect on performance (Pinto, 2018). The unearthing of this neglected yet critical aspect of sports performance optimization parallels the previously mentioned connection between mental and physical well-being.

This landscape of elite basketball, in which the link between neural and muscular performance has been generally overlooked, provides an excellent opportunity for product innovation. By utilizing the power of the sensory system and its influence on both neural and muscular systems (and the link between the two), sports products can deliver performance benefits from untapped aspects of an athlete’s body. By utilizing the power of sensory stimulation and its influence on the neuromuscular, autonomic, and cardiorespiratory systems within the body, a new class of sports product can deliver significant performance benefits to athletes.

Origins of Basketball

In December 1891, James Naismith, a physical education teacher in Springfield, Massachusetts, nailed two peach baskets to the walls of the YMCA gymnasium and introduced his students to the game of basketball (Logan, 2020). Naismith, in an attempt to devise an indoor sport to keep the collegiate football and lacrosse athletes active during the winter months, designed the game to be “easy to learn, easy to play” and most of all “appeal to (the students’) play instincts” (Springfield College, 2020). Naismith consciously adapted elements of preexisting games such as the passing of American rugby, the goal system of lacrosse, and the dimensions of a soccer ball to create a game that was easily adopted and enjoyed (Springfield College, 2020). He defined a system of rules, known today as the thirteen original rules, and nailed them to the gym bulletin board (Logan, 2020). Before long, news of the novel “basketball” spread to other YMCA communities, where students eagerly adopted the winter-friendly activity. Soon, high schools and colleges followed suit, and in 1905, basketball was officially recognized as a winter sport (Springfield College, 2020).

Fig. 1. James Naismith with early basketball equipment (History.com, n.d.).

Colleges around the United States fielded teams for inter-collegiate competition, further developing the game style and level of play. The late 19th and early 20th century featured a variety of rules committees and associations governing over the fledgling sport. In 1915, the Ameteur Athletic Union took over the responsibilities of YMCA basketball and collaborated with the NCAA to establish a joint rules committee, later named the National Basketball Committee (Logan, 2020). This unifying body helped to establish consistent rules of play on a national scale. The early era of basketball was rooted in recreation and off-season conditioning for collegiate athletes. The dynamic, competitive nature of the game allowed the sport to propagate throughout the U.S. and quickly evolve into an established professional sport.

Rules & Environment

Organized basketball is played on an indoor hardwood court. The court is typically made of maple, a dense wood that is resistant to splintering, protected by several coats of varnish (Basketball.org, 2019).

Rules as per the International Basketball Federation (FIBA), 2020):

The goal of basketball is to score more points than the opposing team at the end of the determined game duration (FIBA, 2020). The two teams, composed of 5 players each, must score points by shooting the ball in the opposing team's basket, which is located at opposite ends of the court (FIBA, 2020). Regulation size NBA and collegiate courts measure 94' x 50', while high school and middle school courts measure 84' x 50'(FIBA, 2020). The rim of the hoop is elevated 10' from the ground (FIBA, 2020). The game is typically played in quarters of 8, 10, or 12 minutes, depending on the level of play (FIBA, 2020). The only exception to this is collegiate men's basketball, which is played in 20 minute halves (FIBA, 2020). Each team has 24 seconds to shoot the ball, which is dictated by the shot clock located above the basket (FIBA, 2020). A basket is worth two points unless it is shot outside of the 3-point line, in which case it is worth 3 points (FIBA, 2020). Free throws are awarded after a foul is committed during the act of shooting the ball (FIBA, 2020). Once a player begins dribbling, they cannot stop or pick up the ball, and they have only two steps once they pick up the ball to either pass or shoot (FIBA, 2020).

Evolution of the Sport

As the level of play advanced and technique, gameplay, and strategy were continually refined, basketball gained significant momentum and popularity. The first NCAA Men's Basketball Tournament was held in 1939, an event that has since evolved into the spectacle we now know as March Madness (Logan, 2020). The modern frame of professional basketball was established by the founding of the unified National Basketball Association in 1949 (Logan, 2020).

The formation of the NBA spurred the birth of another ceremonious event in basketball lore: The Draft. Since the establishment of the league, top collegiate prospects and international talent have endured the strategic, high-stakes mayhem that decides their professional athletic career (Burleyson, 2018). The Draft is notorious for wild-card scenarios, starting from the usage of territorial picks in the 1950s in which teams could forego a first round pick to elect a local talent and override the order of the draft (Burleyson, 2018) . Since then, the Draft has utilized coin flips, lotteries, and weighted lottery systems to establish a sense of fairness (and spectacle) with the signing of new NBA talent.

Fig. 2. An emotional moment at the NBA Draft for Markelle Fultz and family as he is drafted #1 in 2017 (Nordeman, 2017).

Making it to the NBA

The most contentious aspect of this process is the eligibility of the players themselves. As both collegiate and youth basketball have evolved in their speed, intensity, and skill, the idea that players must attend college before going to the league has been widely scrutinized (Burleyson, 2018). In the 1960s and 70s, the NBA required that draftees be at least four years removed from high school, a controversial policy that reached the Supreme Court in Haywood v. the NBA in 1971 (Burleyson, 2018). This case led the NBA to abolish the 4-year rule, allowing many underclassmen and high school players to be eligible for the draft (Burleyson, 2018). A flood of straight-to-the league stars occurred in the period between 1995-2005, in which greats such as Kevin Garnett, Tracy McGrady, Kobe Bryant, and Lebron James signed contracts directly out of high school (Burleyson, 2018). This era came to an end when the league instituted a new policy in 2005: the “one-and-done” rule (Burleyson, 2018). This policy established a minimum age of 19 and one year removal from high school, aiming for the middle ground of the previously enacted regulations (Burleyson, 2018). The institution of “one-and-done”, however, significantly changed the landscape of college basketball, as elite players would commit to only one season, mainly for exposure, before declaring for the Draft (Burleyson, 2018).

In recent years, NBA Commissioner Adam Silver has hinted at plans to change the age limit to 18 and remove the one-and-done policy, once again opening opportunities for high school athletes to go professional (Burleyson, 2018). The eligibility of prospective star athletes fuels the high-stakes spectacle of the NBA Draft. As the skill of these young players evolves each year, restrictions on age and eligibility face scrutiny. Therefore, players must strategize and adapt to best position themselves in the ultra-competitive “pipeline to pro.”

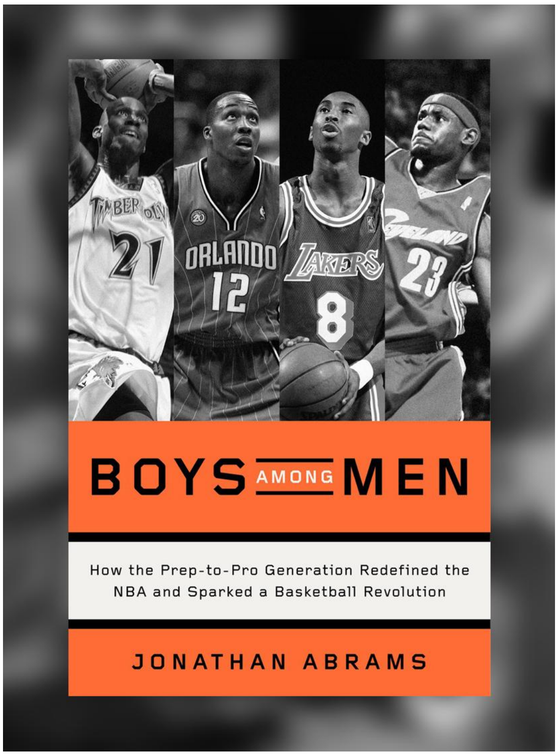

Fig. 3. Elite players that opted out of college are highlighted in the novel Boys Among Men (Abrams, 2016).

One of the dominant strategies for achieving success in elite basketball is to compete in AAU leagues and tournaments. The Ameteur Athletic Union, or AAU, was one of the earliest associations to embrace and promote high-level youth basketball. They hosted annual National Championships for both men’s and women’s basketball throughout the early 20th century, one of the earliest organizations to do so. The AAU was closely linked with Olympic and collegiate athletics prior to the passing of the Ameteur Sports Act in 1978, which established a national Olympic committee for each sport (Active, 2020). From this point on, the AAU focused its efforts on youth sports, specifically basketball. From 1980-1989, the number of basketball age group championships doubled from 6 to 13, and participation skyrocketed (Active, 2020). Since then, AAU basketball has become synonymous with elite talent, college scouting, and scholarships, drawing thousands of young athletes to tournaments each year (Amateur Athletic Union, 2017).

Today's AAU is regarded by many as a "necessary evil." Though criticized by greats such as Steve Kerr and Kobe Bryant, AAU is one of the best opportunities for elite youth players to extend their season through the spring and summer, face high-profile talent, and showcase their skills to scouts at tournaments (McDaniel, 2017). In the past, basketball athletes would transfer to one of the prep schools around the country that had the resources, facilities, and coaching to house national-caliber basketball programs, in hopes of getting noticed by college and professional scouts. Today, with new restrictions on high school transfers, a new model has emerged for budding basketball stars to fast-track themselves to the League. Athletes forgo the traditional high school experience and join basketball academies that heavily prioritize training, exhibition tournaments, and scouting opportunities over foundational high school education (McDaniel, 2017). Though openly criticized in the media and basketball community, these academies offer budding stars the chance to fast-track their way to Division I offers and ultimately the league. For rising stars, the AAU environment mimics that of collegiate and professional basketball, increasing the number of games played, elevating and expanding the talent pool, and improving exposure for nationwide recruiting.

Fig. 4. Top-tier AAU athletes showcase their talents in the Nike-sponsored EYBL Circuit.

Market Value of Basketball

Elite level basketball, its athletes, products, and teams, are a market in and of themselves. Professional, collegiate, and even AAU basketball (despite the organization's status as a nonprofit), are each designed to generate revenue. The AAU has amassed a $12 million budget surplus, holds $14 million in assets and generated upwards of $20 million in revenue as of 2018 (Nonprofit Metrics LLC, 2020). Within the organization, talented athletes are used as a marketing tool to drive increased participation, sponsorships, and media exposure. As AAU basketball continues to grow in its scope and impact, this market of young, elite talent continues to catch the eye of investors and promotes this trend.

The NCAA serves as a testimony to the growing value of young star athletes. As of 2019, the Kentucky Wildcats Men's Basketball team, a decorated and prominent collegiate program, was valued at $334.2 million, followed by Kansas at $319.5 million (Beaton, 2019). Perennial competitors at the March Madness Tournament including Louisville, Duke and UNC boast team values comfortably exceeding $150 million, shown below in Figure 5 (Beaton, 2019). If the players competing on these top teams were offered a fair market value based on team revenue, they would receive average annual salaries between $500k and $1.5 million (Gaines, 2015). The spectacle of the NCAA Tournament and explosive, exciting nature of collegiate basketball allows the NCAA to amass significant funds for the organization and participating schools. These athletic programs rely on recruiting and showcasing top-tier players to generate revenue, an opportunity threatened by one-and-done athletes dedicating only one year to a team before entering the professional arena.

The valuations of 176 major college basketball programs based on what each would be worth on the open market, based on revenues, expenses and other factors.

SEARCH

RANK	TEAM	2016 VALUATION	2015 VALUATION	% CHANGE
1	Kentucky	$342,607,000	$244,274,000	40.3%
2	Louisville	$320,112,000	$301,316,000	6.2%
3	Indiana	$277,834,000	$243,797,000	14.0%
4	Duke	$190,266,000	$203,910,000	-6.7%
5	Kansas	$181,447,000	$258,191,000	-29.7%
6	Wisconsin	$178,896,000	$206,881,000	-13.5%
7	Ohio State	$177,892,000	$240,390,000	-26.0%
8	Maryland	$154,629,000	$123,917,000	24.8%
9	Syracuse	$153,942,000	$203,920,000	-24.5%
10	North Carolina	$143,015,000	$221,604,000	-35.5%

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The 176 teams selected were major conference programs plus other additional notables, including those that have made the tournament in recent years; The rankings reflect current valuations according to 2016 financial information.
Ryan Brewer, Indiana University-Purdue Columbus

Fig.5. Market valuations of top college basketball programs 2015-2016 (Beaton, 2019).

Athletes are eager to sign contracts with professional teams and at last be properly compensated for their efforts on the court. The NBA is well-known for brokering massive contracts for star athletes, doling out hundreds of millions of dollars to basketball's brightest stars. NBA team valuations as of 2020 have increased 600% over the last decade, with the average team valued at $2.1 billion (Forbes, 2020). Average league revenue per team for the 2018-2019 season was over $290 billion, with average earnings of over $60 million, and as high as $178 million in the case of the Los Angeles Lakers (Forbes, 2020). These ample values are somewhat expected for the world's premier professional basketball league, however, the growth in year-over-year valuations continues to outshine other leagues such as the NFL and MLB. As the level of talent entering the league continues to increase, the values of team, media, and individual athletes involved in the league will continue to grow.

Athlete Profile & Performance Factors

Athletes competing at the elite AAU, collegiate, and professional levels follow a blueprint that prioritizes strength, agility, and aerobic fitness. Achieving success as a basketball athlete requires maintaining peak performance for months at a time, through tournaments, travel, and a busy game schedule. To manage this load and intensity while remaining injury-free, focused, and competitive is essential to advancing as a top-tier player. Stress, fatigue, and injury are challenges that the best players are able to overcome in their careers.

Fig. 6. Team USA Basketball athletes do their best to manage extensive travel and recover properly (Bishop, 2012).

Basketball is a team sport with intense intermittent aerobic and anaerobic demands involving running, jumping, and frequent directional changes. A study done by McInnes et al. demonstrated that a basketball player experiences approximately 1000 movement pattern changes in a single game, changing direction every 2.4 seconds (Drinkwater et al., 2008, 568). Various studies demonstrate mean work intensities that exceed the lactate threshold and mean heart rate values between 85-95% of HRmax, depicted below in Figure 8 (Stojanovic et al., 2018).

Study	Playing level/location/sex/*n*	Comparison groups	Total time (%)		Live time (%)	
			<85% HR_{max}	>85% HR_{max}	<85% HR_{max}	>85% HR_{max}
McInnes et al. [2]	National Basketball League/Australia/M/8	All players	35.0	65.0	25.0	75.0
Matthew and Delextrat [10]	University Sports Association/UK/F/9	All players	19.6	80.4	6.9	93.1
Ben Abdelkrim et al. [7]	National Championship/Tunisia/M/18	All players			24.7	75.3
Ben Abdelkrim et al. [6]	National Championship U19/Tunisia/M/38	International			23.1[a]	76.9[a]
		National			30.4	69.6
		Man-to-man			26.7	73.3
		Zone games			27.8	72.3
Hůlka et al. [8]	National Championship U18/Czech Republic/M/32	All players			36.9	63.1
Vencúrik and Nykodým [21]	Second National Championship/Czech Republic/F/8	PG, SG			27.0	73.0
		SF, PF			27.3	72.7
		C			20.5	79.5
		All players			24.0	76.0
Vencúrik et al. [22]	First National Championship/Czech Republic/F/10	PG, SG			29.1	70.9
		SF, PF			22.8	77.2
		C			25.3	74.7
		All players			25.7	74.3

PG point guard, *SG* shooting guard, *SF* small forward, *PF* power forward, *C* center, *M* male, *F* female, HR_{max} maximal heart rate, *U* under

[a]Significant difference between comparison groups

*Fig. 7. Work Intensity and HR during basketball match-play (*Stojanovic et al., 2018).

Fitness

Cardiovascular endurance is essential for maintaining competitive intensity throughout the game, scoring on fast breaks, and facilitating recovery between intense bouts of jumping and sprinting. According to Drinkwater et al., basketball players with greater aerobic fitness have a faster oxygen uptake and resynthesis of creatine phosphate, an essential process for anaerobic performance involving ATP (Drinkwater et al., 2008, 570). Observations of VO2max, or peak oxygen uptake, of elite under-19 and professional adult basketball players show average values of 52 ml/kg/min and 60 ml/kg/min, respectively (Abdelkrim et al., 2007). Drinkwater et al, in an analysis of elite and sub-elite junior Australian basketball athletes, found that national-level athletes had greater aerobic fitness than their state-level counterparts (Drinkwater et al., 2008, 570). Further studies demonstrate that aerobic fitness is necessary to recover between the short, repeated bouts of intense anaerobic work characterized by competitive basketball (Drinkwater et al., 2008, 571). Other evidence suggests that physical fatigue impairs motor control, cognitive functioning, and reaction time (Drinkwater et al., 2008, 572). The relationship between cognitive performance and fatigue is believed to follow an “inverted U” shape, in which performance decreases after reaching a point of optimal effort-induced arousal (Simek Salaj et al., 2008). Because a more aerobically fit athlete has a lower heart rate for a specific, absolute workload, it is likely that these athletes make quicker, more accurate decisions than less fit athletes (Simek Salaj et al., 2008). This consideration emphasizes the importance of aerobic conditioning for elite basketball athletes and their ability to maintain intensity and accuracy throughout the duration of a game.

While aerobic fitness is a key component for sustained intensity at the elite level, success in men’s basketball is largely dependent on explosive, sport-specific movements focused on scoring (Puente et al., 2017, 956). Elite junior Tunisian players were observed sprinting once every 39 seconds and jumping every minute, utilizing anaerobic power in short bouts interspersed with moderate- to low-intensity work (Stojanovic et al., 2018). Research by Abdelkrim et al investigating plasma lactate levels shows a considerable contribution from the anaerobic energy system, particularly towards the end of the second and fourth quarters of game play (Abdelkrim et al., 2007).

Table 1 Principal anthropometric and physiological characteristics of the subjects

Variable	All subjects (n = 38)	Guard (n = 8)	Forward (n = 18)	Centre (n = 12)
Age (years)	18.2 (0.5)	18.2 (0.2)	18.2 (0.5)	18.2 (0.5)
Height (m)	1.89 (0.05)	1.83 (0.04)*†	1.88 (0.04)‡	1.93 (0.03)
Body mass (kg)	80.3 (6.7)	76.2 (3.4)†	77.4 (5.1)†	87.2 (5.3)
Body fat (%)	8.2 (5.6)	6.1 (3.7)	7.8 (4.1)	10.4 (7.8)
Fat free mass (%)	91.7 (5.6)	93.9 (3.7)	92.2 (4.1)	89.6 (7.8)
BMI (kg/m^2)	21.7 (1.9)	22.7 (1.0)	21.8 (1.1)§	23.6 (1.8)
VO_2max (ml/kg min)	52.8 (2.4)	53.8 (1.9)	53.4 (2.3)	51.4 (2.4)

BMI, body mass index.
Data are mean (SD).
*Values are significantly different from those obtained by forward, $p<0.01$.
†Values are significantly different from those obtained by centre, $p<0.001$.
‡Values are significantly different from those obtained by centre, $p<0.05$.
§Values are significantly different from those obtained by centre, $p<0.01$.

Fig. 8. Physiological data of elite U-19 Tunisian basketball players (Abdelkrim et al., 2007).

The body composition and anthropometry of basketball athletes play a role in determining playing position and style. A study of body composition in elite level Greek basketball athletes calculated the average body fat percentage for elite under-22 athletes is 10.9+/-2.7, with guards averaging slightly lower values than centers and forwards (Gerodimos et al., 2005). Guards averaged 6'3" and 194lbs as compared to centers, who averaged 6'10" and 234lbs (Gerodimos et al., 2005). Documentation from recent NBA draft cycles shows similar anthropometric trends in top draft picks. Guards drafted in the first round averaged 6'3" with a 6'7" wingspan, 191lbs, and less than 6% body fat, while centers and forwards averaged 6'10" with a 7'3" wingspan, 233 lbs, and 7.3% body fat (Draft Express, 2020). The tasks of these positions and criteria for success vary, as guards are relied on for their agility, ball handling, and passing, while centers are responsible for rebounding and blocking shots close to the basket (Drinkwater et al., 2008, 567). Although body size plays a strong role in determining an athlete's position, the most valued attributes are the player's skill in combination with strength and agility.

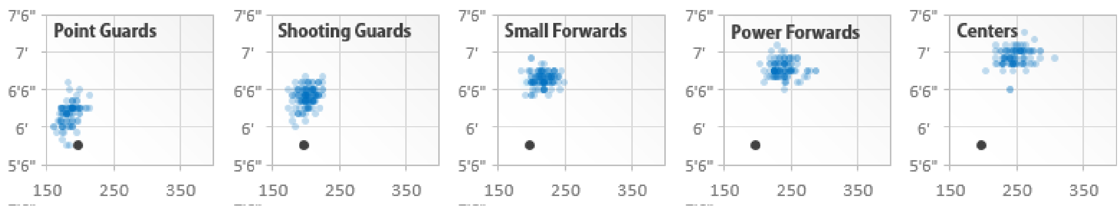


Fig. 9. Anthropometry of professional basketball athletes compared to the average male (SportChart, 2014).

Metadata of the NBA Draft Combine reveals clear strength and agility benchmarks for players seeking to be drafted. Players drafted in the first round averaged a vertical jump of 36.5" and 8.7 reps of the 185lb-bench press (Draft Express, 2020). A 1994 study collected data from over 300 Division I Men's Basketball players, drafted and undrafted, showing the average DI athlete at that time was able to bench press and power clean at least 100% of their body weight and squat at least 150% BW (Latin et al., 1994). Today, standout athletes at the collegiate level are able to achieve 40" vertical leaps and over 10 reps of 185lb bench press (Draft Express, 2020). As the level and intensity of the sport continues to evolve, athletes at the sub-professional level continue to push performance boundaries in the hopes of becoming a professional athlete. That said, there is a limit to how much strength training and conditioning an athlete can feasibly tolerate, and a balance between meaningful versus excessive hypertrophy. Though athletic programs place a strong emphasis on plyometrics and hypertrophy programming, other factors such as balance control play a role in an athlete's ability to change direction, accelerate, and jump efficiently.

Balance and Proprioception

Balance control, though often overlooked, is a key factor to agility and overall athletic performance (Han et al., 2015). Studies show that balance is strongly and positively associated with superior athletic performance and negatively associated with lower extremity injury (Han et al., 2015). Studies performed on active adult males show that heightened balance and proprioception are correlated to improvements in vertical jump performance (Simek Salaj et al., 2008). Postural sway (or poor balance control) in both youth and elite athletes correlates positively to ankle sprain susceptibility (McGuine et al., 2000). Furthermore, lower extremity injuries account for over 57% of total injuries in

NCAA Men's Basketball, with ankle sprains claiming nearly 25% of these injuries (Dick et al., 2007). As injury mitigation continues to be one of the primary challenges for the longevity and success of elite basketball athletes, understanding balance control may shed light on potential solutions.

Balance stems from the central nervous system (CNS) and its ability to integrate visual, vestibular, and proprioceptive feedback into coordinated muscular responses (Hrysomallis, 2011). While the vestibular system of the inner ear collects information about gravity, rotation, and acceleration, mechanoreceptors throughout the muscles, tendons, and joints provide information about limb and body position (Han et al., 2015). The combination of these sensory systems all contribute to balance, but researchers argue that proprioception, specifically of the ankle and plantar foot, is the most pertinent to dynamic balance tasks in elite sport (Han et al., 2015).

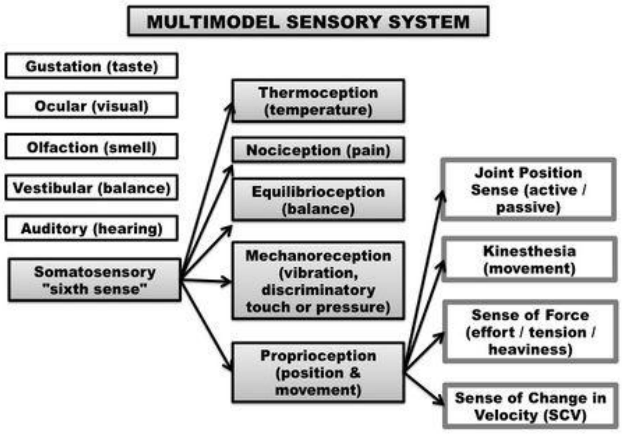


Fig. 10. An overview of the sensory systems within the human body (Physiopedia, 2020).

Proprioception can be enhanced by sport-specific and general training, and negatively impacted by fatigue and injury (Han et al., 2015). Active interventions such as the use of wobble boards, bilateral balance training, and Tai Chi are shown to improve balance in both athletes and non-athletes (Han et al., 2015). The trainability of proprioception and balance stems from neural mechanisms such as neuroplasticity, the ability of the neural networks of the body to reorganize, grow, and evolve based on external stimuli (Dobbs, 2018). Much like the concept of "muscle memory" of a sport-specific task, the brain refines and strengthens motor and neural pathways through repeated use (Dobbs, 2018). By harnessing this concept of neuroplasticity and its role in proprioception, we can target specific motor and neural pathways in order to facilitate improved neuromuscular synergy and consequently, performance. A growing understanding of the mind-muscle connection has spurred additional research into the nuances of mood, focus, and performance for elite athletes.

Mental Hardiness

Physical prowess and sport-specific skills are essential for athletes to reach elite levels of competition. In recent years, however, as the intersection between psychology and physical performance has come to the fore, performance specialists are focused more deeply on the mental aspects of elite sport (Chariton, 2019). Situation efficacy, mental toughness, and clutch performance are all key aspects that separate the good from the great. Both Kobe Bryant and Michael Jordan, known for their focus and obsession with winning, enlisted mental skills and expert George Mumford to direct them in the art of mindfulness (Fernandez, 2016). Mumford coached Jordan and the Chicago Bulls through their ‘95, ‘96, and ‘97 championship seasons, imparting onto them the art of stillness within the context of competition, before reuniting with Phil Jackson and the Lakers several years later (Fernandez, 2016). Mindfulness, more specifically defined as non-judgmental present-moment awareness, allows athletes to become aware of their thoughts and emotions without reacting to these internal stimuli (Chariton, 2019). In turn, by placing awareness on the present moment without judgment, athletes are better able to focus their energy on the task at hand without concern for the past or future. Studies suggest that athletes who practice mindfulness are better equipped to handle task-relevant external stimuli, thus leading to improved athletic performance (Chariton, 2019).

The concepts of mental strength (toughness and hardiness), self-efficacy, and anxiety are inextricably linked to high-stakes performance scenarios and can prove to be the difference-maker between a win and a loss. In European club championships between 1992 - 2000, winning teams displayed more tactical discipline, less turnovers, and more confidence and concentration than the defeated teams (Sindik & Adzija, 2013). Hardiness, a psychological skill rooted in self-belief, focus, and positivity in the face of stress, has been quantitatively linked to better basketball performance (Sindik & Adzija, 2013). The clear link between mental strength and improved performance is just one side of the coin. While focus and self-efficacy can enhance an athlete’s game, stress and mental fatigue have negative outcomes that manifest physically.

Stress, Injury, and HRV

Though stress is generally regarded as a psychological ailment, it manifests in a variety of ways both mentally and physically. Research consistently shows that stress is highly predictive of injury occurrence in athletes, regardless its cause (Sabato et al., 2016). One study of female collegiate gymnasts revealed that negative life stress accounts for 11-22% of injury variance, while another attributed a 70% greater chance of injury for high-stress youth soccer players (Sabato et al., 2016). The mechanism of stress-injury outcomes is a result of the body’s heightened stress response, in which muscle tension increases, the visual field narrows, and distractibility and self-consciousness are exacerbated (Johnson, 2011). Stress and anxiety drive the autonomic and central nervous systems to a state of reduced self-efficacy and impaired decision-making, while simultaneously taxing the cardiovascular and respiratory systems of the body (Paul & Garg, 2012). This is referred to as the sympathetic nervous response, also known as the “fight or flight” response (Harvard Medical School, 2011).

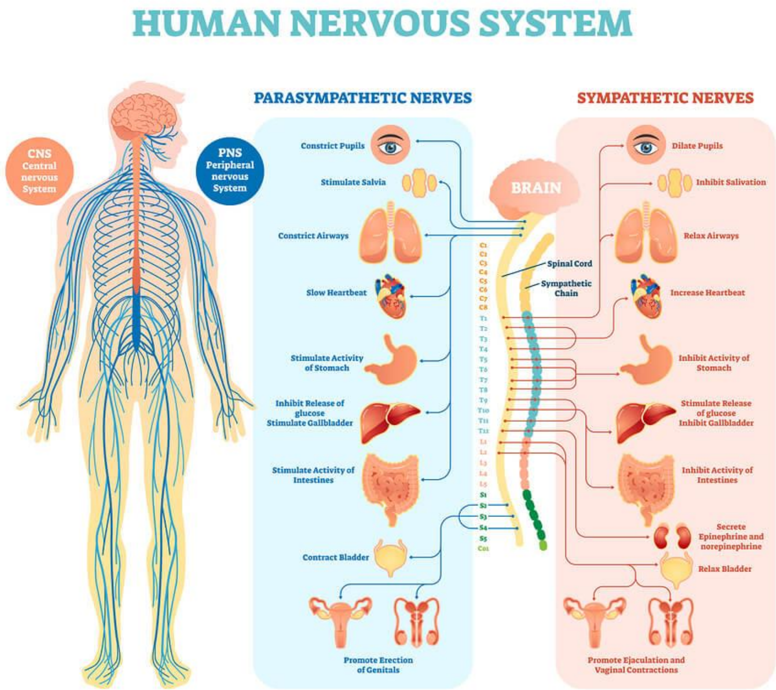


Fig. 11: An overview of the sympathetic and parasympathetic nervous systems

In a sporting environment that relies heavily on aerobic efficiency and rapid recovery, control of the cardiovascular and respiratory systems is necessary for optimal performance (Drinkwater et al., 2008). Heart Rate Variability (HRV) is currently regarded as the most reliable and quantitative assessment of autonomic nervous system functioning (Paul & Garg, 2012). Heart Rate Variability is the measure of the variation in time between each heart beat, and is regulated by the autonomic nervous system through the same mechanism as the sympathetic nervous response (Campos, 2017). The sympathetic nervous response works in contrast with the parasympathetic response, commonly known as the “rest and digest” response, to modulate and balance the body’s nervous system (Campos, 2017). Heart Rate Variability serves as a quantifiable metric for analysing the nervous response of the body and determining if an individual is negatively impacted by stress (Campos, 2017). A high HRV indicates an optimal balance between sympathetic and parasympathetic responses, and a general state of resiliency and health, while a low HRV is correlated with chronic stress, anxiety, and even poor cardiovascular health (Paul & Garg, 2012).

A variety of stress management techniques exist in the growing world of sports psychology, which are largely focused on meditation and breathing (Paul & Garg, 2012). These psychological coping mechanisms are trainable skills and include positive self-talk and mindfulness practices designed to induce a relaxed state in both the body and mind (Paul & Garg, 2012). At their core, these practices are designed to induce the parasympathetic response, the aforementioned “rest and digest”, to facilitate recovery and a return to a more balanced state.

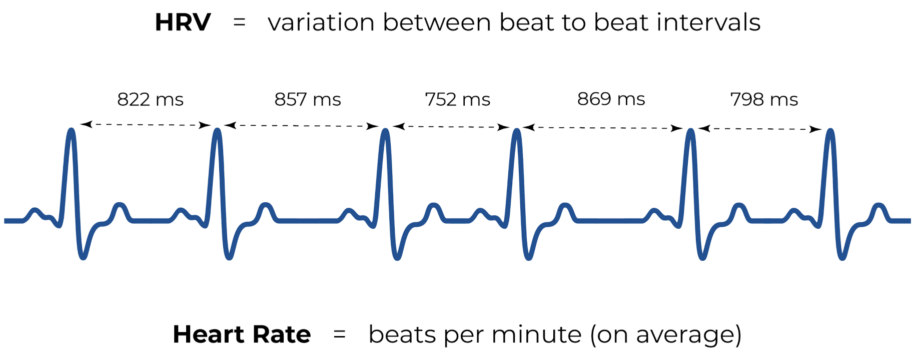


Fig. 12. How to calculate Heart Rate Variability.

The interplay of stress, injury, and HRV as key, linked factors in elite-level basketball performance suggest that injury mitigation and optimal performance can be successfully achieved through modulation of the parasympathetic stress response.

The vagus nerve, the longest and most complex cranial nerve of the body, is heavily involved in the parasympathetic nervous response (Encyclopaedia Britannica, 2020). The nerve links the heart, gut, lungs, and neck with the brain and modulates heart rate, blood pressure, breathing rate, as well as digestion and inflammation responses (Medical News Today, 2017). These physiological mechanisms directly impact mood, stress, and recovery regardless of the cause, and can be used as a tool to help athletes balance the sympathetic and parasympathetic systems within their own bodies. Looking deeper, it is clear that the physiological and psychological factors and their outcomes are not independent of one another, and thus should not be treated as such.

Performance & The Nervous System

The existing landscape of performance optimization separates physical and mental performance as independent disciplines, with distinct approaches and protocols. The compilation of research and the emerging understanding of the parasympathetic nervous system, however, establishes a concrete link between these two fields. Though the modern scope of sports product and training has generally overlooked this link, Traditional Chinese Medicine (TCM) emphasizes the interconnectedness of the mind, body, and spirit through *qi* (chi), or life energy (Wang, 2020). Practices within TCM, the world's oldest codified system of medicine, aim to balance the flow of *qi* within the body to heal and enhance its functions (Wang, 2020). A key principle of TCM is the importance of the complex connections between seemingly unrelated areas and systems of the body, and how stimulation of these can influence both physical and mental health (Wang, 2020).

In the ancient practice of reflexology, physical pressure is applied to specific zones on the feet, hands, or ears to relieve stress, pain, or acute ailments (Isik et al., 2014). Reflexology is based on the principle that reflex points on the foot correspond to 'mapped target organs' throughout the body, and stimulation of these reflexes will have a direct impact on the target organ (Chen et al., 2019). The effects of reflexology, namely foot reflexology, on stress and performance, are supported by empirical evidence. A study on the effect of foot reflexology in healthy individuals showed that foot reflexology decreased pulse rate and increased HRV parameters, indicative of an improvement in balance between the parasympathetic and sympathetic response and an increase in vagal activation (Isik et al., 2014). A separate study on collegiate soccer players tested the effects of foot reflexology on recovery from repeated sprint drills, and found that parasympathetic activation was improved in the reflexology group (Chen et al., 2019). These findings align with others findings that suggest reflexology improves sympatho-vagal balance after intense anaerobic work (Chen et al., 2019).

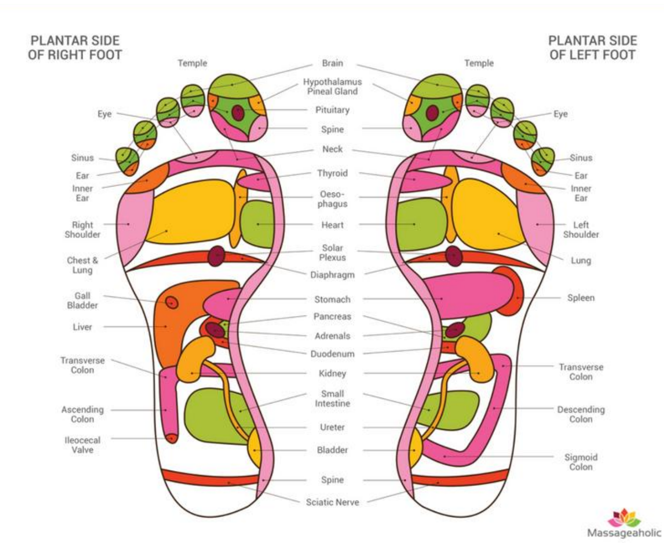


Fig. 13. Foot Reflexology Chart (Massageaholic).

Acupressure, a related but separate practice, utilizes pressure to stimulate nerves throughout the body, relieving ailments that may seem unrelated to the target area. Acupressure aims to improve the flow of blood, lymph and metabolic energy, or Qi, through gentle stimulation of pressure points (Science Daily, 2020). A study of the effect of acupressure on VO2 in a group of healthy, young men revealed that VO2 post-treatment increased 10% from baseline, while the placebo group remained unchanged. The study suggests that the acupressure treatment decreased stress levels and thus improved energy utilization for the test group (Ahmedov & Filiz, 2018). This finding strongly supports the link between sensory stimulation practices, stress relief, and enhanced performance. The evidence gathered from these studies as a whole suggest that targeted foot reflexology is a valuable tool for both mental and physical recovery in elite athletes and may pose further performance benefits. These ancient techniques showcase the influence of sensory stimulation on the complex neuromuscular and regulatory systems of the body. Though thousands of years old, these practices hinge on the same core principles as newfound research on HRV and the autonomic nervous system. By drawing from the foundation of Traditional Chinese Medicine, supplemented with the research and techniques of modern neuroscience, we can innovate the landscape of performance-optimizing sports product.

Product Market

Priming

Athlete priming has been largely unexplored in the sports product market, though the concept itself is well-known in the realm of sports science and performance optimization. Priming in the context of sports can refer to the physical activation of the muscular or cardiovascular systems, as well as the mental preparation or visualization an athlete may perform before competing. All of these practices aim to prepare the body for the upcoming task by providing a representation of the stimuli or environment prior to competition. Priming can be used to enhance or change motor skill execution, alter thought patterns, or elicit new behavioral responses.

Proprioception, with its links to balance, injury mitigation, and improved performance, has begun to be addressed by innovators such as Naboso and their widely available textured insoles. The brand's insoles ($50) and exercise mats ($110) feature a patented texture that stimulates the mechanoreceptors of the plantar foot to enhance proprioception (Steinberg et al., 2016). Other textured insoles in the market are geared towards non-slip rather than sensory stimulation, and the majority of tactile or sensory oriented products are designed for individuals with sensory disorders. Barefoot Science Insoles ($84.99) use a modular insert within the insole that is purported to increase arch height and strengthen the foot over time (BarefootScience, 2020). The company cites internally-sponsored studies to back this claim, and the product is the only of its kind currently available.

Figs. 14-15. Naboso Performance Insoles, Exosuit Exo1 Posture Shirt.

The market for proprioception-enhancing garments is generally limited. One recent innovation comes from London-based company Exosuit, who recently introduced a shirt that combines compression with patented PowerFlex structures integrated into a shirt. The structures gently adhere to the skin at key areas to provide tactile feedback not unlike kinesiotape, enhancing the athletes body awareness and posture (Exosuit, 2020). This approach draws from compression, taping, and proprioception research to provide a unique product that is endorsed by a variety of athletes in Great Britain.

A variety of products designed to stimulate or activate muscles has recently entered the market. The PowerDot ($199) , a wireless, bluetooth-enabled electronic myostimulation (EMS) device, dominates the emerging EMS market. EMS uses electrical impulses to actively contract muscles without activating the central nervous system. This allows users to achieve strength, endurance, and recovery goals that were previously only accessible through physical therapy (PowerDot, 2019).

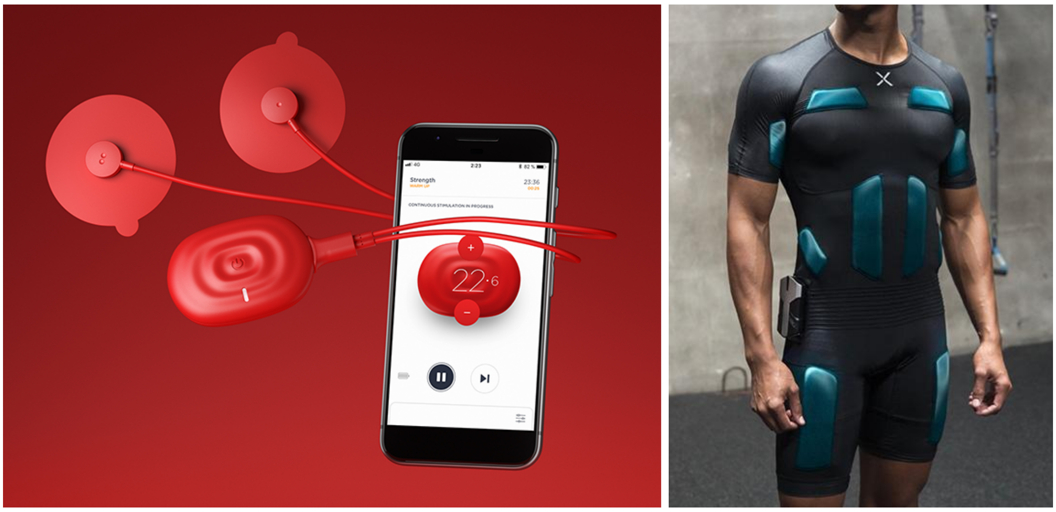


Fig. 16-17. PowerDot, Balanx Suit.

On the cutting edge of this technology are companies like Balanx, who have designed an EMS Training Suit ($799) that integrates stimulation nodes into a full-body garment. The nodes target muscle groups throughout the body and can be activated via smartphone app (BalanX Tech, 2020). Originally designed for astronauts to prevent muscle atrophy, studies suggest that the suit can improve aerobic and athletic performance, quantified by improvements in both VO2 kinetics and work efficiency (Perez et al., 2003).

Fig. 18-19. Agogie Performance Tights, Physiclo Shorts.

Other muscle activation garments use analog mechanisms to achieve this effect and a significantly lower pricepoint. Physiclo uses patented resistance technology integrated into tights ($125) and compression shorts to increase muscle activity by as much as 23%, while competitor Agogie uses a similar approach in their non-compression pants ($129). Both use technology akin to traditional resistance bands to increase the firing of muscles without overly taxing their energy stores. Resistance bands are widely used in physical therapy and specialized warm-up protocols for elite athletes, allowing them to target and “wake up” specific muscle groups prior to competition (Thomas, 2000). This product sector is still relatively small but poses a potential opportunity for growth.

Materials and Manufacturing

Acupressure Shoes

A variety of acupressure footwear exist that take a similar approach in construction and materials. The most common and relevant is the acupressure slide or slipper. It features a foam midsole and durable rubber outsole with hook and loop (Velcro) adjustable polyurethane strap that secures the foot to the footbed. The footbed is molded with approximately 40 small holes that are then filled with acupressure nodes. The nodes are either plastic or a durable gel material. In the case of the plastic nodes, a small spring embedded at the base of the node allows for a small amount of rebound when the user is walking to ensure comfort. The gel-based nodes are somewhat compliant and thus deform a small amount under pressure. The slides are assembled by cementing the midsole, outsole, and strap components together with contact cement.

Relevant Patents:
- KR200431316Y1 (Footgear and Insole for Performing Acupressure)
- KR100732496B1 (Shoes for Acupressure)
- JP3103838U (Shiatsu Slippers)

Textured Insole

Textured insoles enhance proprioception by stimulating the mechanoreceptors of the plantar foot. The premier textured insoles, by Naboso, are made using a flexible and durable latex-free rubber compound. The insoles, which feature an intricate pyramidal texture, are compression molded.

Relevant Patents:
- US20180243166A1 (Proprioceptor Stimulation Material)
- US8051582B2 (Medially or Laterally Textured Footbed)

Sensory-Motor Stimulating Garments (analog)

Several companies have produced garments that provide sensory stimulation and postural feedback to the body without the use of EMS. These garments are typically close fitting or compression fitting garments composed of elastomeric knit fabrics. Fiber content of these types of garments vary but are approximately 10% elastane and 90% polyester. These garments are manufactured using flat knit machines, and assembled using coverstitch and serger machines to maintain the stretchiness of the garment.

The postural control feature of these garments is achieved in two ways. One process is achieved by paneling or banding a textile with higher elastic tension on the target areas, serving as a sensory stimulator and posture reminder. The panels are elastomeric knits similar to the base material but with a different fiber content so that the user can differentiate between the two. The other process integrates thin silicone panels into the inside of the garment that gently adhere to the skin, offering an entirely different sensation to the user's sensory system.

Relevant Patents:
- US20190246709A1 (Sensory Motor Stimulation Garments and Methods)
- US9125442B2 (Sensory Motor Stimulation Garment and Method)
- US8677512B2 (Article of Apparel Providing Enhanced Body Position Feedback)

Resistance-Facilitating Garments

These products use resistance in the form of elastic bands to incite muscle activation of specific muscle groups, to increase the physiological load required to exercise or to facilitate targeted muscle activation. These garments are manufactured similarly to bodywear and compression garments, featuring a knit construction with a blend of elastomeric fibers such as elastane and synthetics such as polyester. This creates a comfortable and stretchy fit. The resistance is achieved through resistive elastic bands integrated into the garment, similar to rubber resistance bands used in training. The products are assembled like bodywear, using coverstitch machines to achieve a flat seam that allows for uninhibited stretch.

Relevant Patents:
- US5201074 (Exercise Suit with Resilient Reinforcing)
- WO9836652 (Aerobic Exercise Garment)

Colors and Graphics Trends

Athlete Priming

Products within the realm of athlete priming focus on energizing the body and preparing it to compete. These products use high energy colors such as deep red and burnt orange to deliver an exciting pre-performance product. Both colors and graphics reference muscles, blood circulation, speed, and power as influences. Accents of white, black, and grey are used to create eye-catching notes of contrast.

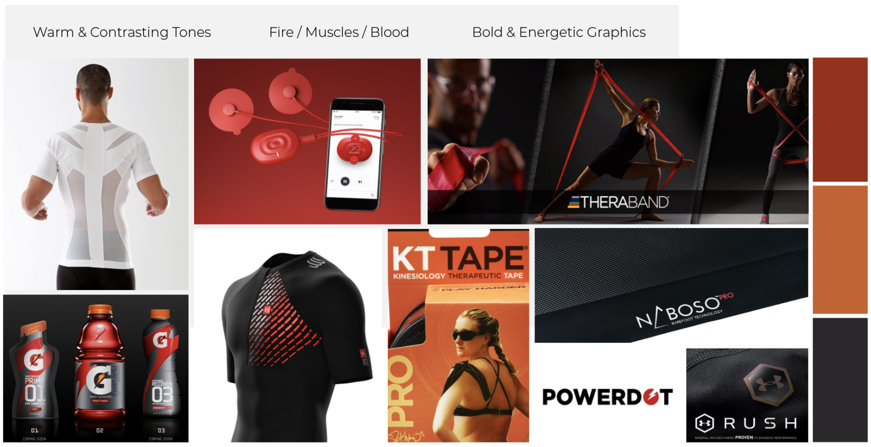
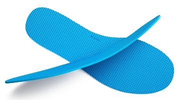


Fig. 20. Color & graphics of priming-oriented products.

Product	Strengths	Weaknesses	Threats	Opportunities
Naboso Activate Insole ($50) 	- Popular - Backed by science - Easy to manufacture	- Not sport-specific - Add-on to existing product - Niche consumer and exposure	- Emerging competitors - Not integrated into product	- Integrate into product - Resonate w/ basketball
Reflexology Slippers ($35) 	- Affordable - Accessible - Easy to manufacture	- Poor style - Primitive design - Not targeted to athletes	- Lots of similar products - More high-end options	- Elevate style - More advanced materials - Improve construction
Exo1 Men's Shirt ($125) 	- Liked by athletes - Performance-oriented - Clear concept	- Placebo effect - Designed for cricket athletes - Utilitarian style -Tactile sensation only	- Established competitors - Emerging competitors	- Basketball-specific - Increase neuromuscular Activity - Lower body solutions - Elevate style
Physiclo Resistance Tights ($125) 	- Backed by science - Patented technology - Athlete-oriented - Reasonable price	- Not fashion-forward - Resistance only	- Emerging competitors - Resistance band market	- Elevate style - Integrate tactile feedback

Professional Development

My "Strengths Finder" strengths of Achiever, Competition, Futuristic, Strategic, and Focus align well with the goals of my project. My "Achiever" strength, along with "Focus" will help me maintain stamina and productivity throughout the next phases of project development, keeping my end goal in sight. My "Competition" strength will help me design sports products that are superior to those in the existing market, using my "Strategic" strength to carefully consider market positioning and user experience. My final trait of "Futuristic" will inspire my design process as I bring my project vision to life. Together, these traits will allow me to showcase my skill as an innovator of cutting-edge sports product.

My strengths as an innovator are rooted in exploration of the nuances of the human body, challenging the status quo, and utilizing science to drive design. This project embodies these aspects of my strengths as well as my desire to work in footwear innovation. It is my goal to design a thought-provoking and visually inspiring collection that allows me to hone my strengths as a product innovator, a researcher, and 3D designer.

Industry Mentors

- Shannon Pomeroy (Nike Explore Team)

Shannon Pomeroy Wed, 18 Nov, 19:15
to me

Of course!

Send over the current state when you can and I can peruse over the holiday next week. Definitely focus on your portfolio first!

I'll chat with Ian, but we have a "strict" no Zoom calls rule next week so I don't have a one on one with him until the following Monday. I'll probably send him a quick note in the meantime.

- John Halliwill - He's great and works very, very closely with Chris below. Specializing in blood pressure changes in exercise and stressful conditions for athletes.
- Chris Minson - he came to mind first, because I know he loves his altitude research in crazy places. If I were to separate the two somehow I'd say Chris is a bit more interested in temperature than Dr. Halliwill.
- Andrew Lovering - this one is more of a lung guy and I'd say a bit more clinical actually. Sounds like you are going more heart rate anyway.

Might be some newer ones as well in the department! Share your thoughts and I'm sure they'll send you in the right direction. Right now it is hard for me to tell who might have the perfect expertise because your work is spanning a large spectrum (which I do love).

- Dr. Brad Wilkins (Gonzaga University)
- Ian Muir (Senior Director, Applied Performance Innovation Nike)
- Dr. Luke Patrick (Portland Trailblazers)
- John Halliwill (University of Oregon)
- Chris Minson (University of Oregon)

Conclusion

The product landscape for both priming and recovery generally emphasize physical, and more specifically muscular, improvements for the user. In-depth research of both the priming and recovery product markets show a greater opportunity for impact within the realm of priming. This market sector is less saturated with more opportunity for growth. Several relevant products utilize the more nuanced understandings of the body's regulatory systems to deliver performance enhancements. By tailoring these technologies and the science of sensory feedback to elite basketball players, we can deliver innovative sports products that enhance athletic performance and health in a holistic and profound manner.

PHASE II: Strategic Product Development

Table of Contents

Introduction

After an in-depth research process, a niche product opportunity was defined, aiming to utilize sensory stimulation to positively influence athletic priming in elite basketball athletes. While recovery remains an important part of performance science, the opportunity for innovation within the realm of priming proved to be more significant.

The second phase of this thesis project was dedicated to researching and developing functional goals for the product collection, founded in first-hand testing and analysis. The process draws from both objective and subjective data to define an innovative product proposal and design that will ultimately be developed into a functional prototype.

Detailed Swot Analysis

With this in mind, an in-depth examination of current products in this niche market was necessary to understand existing innovations and areas of opportunity. The SWOT breakdown below was developed by examining each component of existing benchmark products and defining strengths, weaknesses, opportunities, and threats to that components design. This helped to strategically map out potential design ideation paths.

The following research question was used to direct this process: How could we use the body's relationship to sensation and the science of neurology to design footwear and apparel that helps elite basketball athletes more effectively prime for competition?

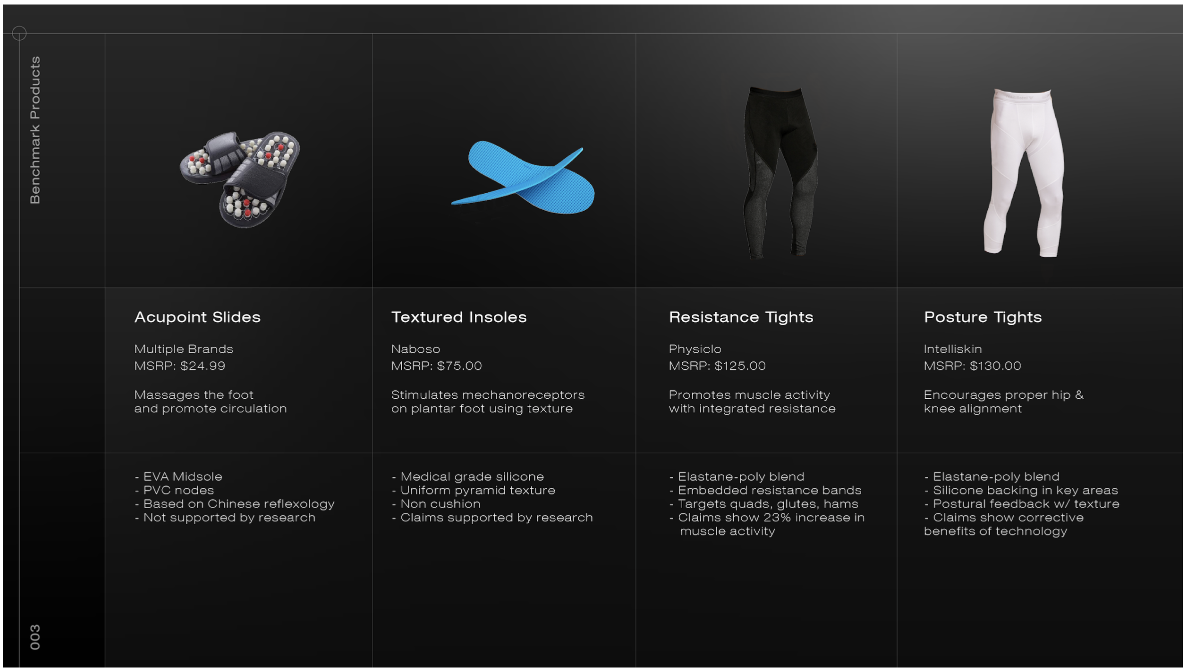


Fig. 21. Benchmark products.

1. Reflexology Slipper

FOOTBED	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Aesthetics	- clearly shows functionality	- not sophisticated -general eyesore, toy like - unlikely to be worn bc of aesthetics	- parametric design to elevate form - more sophisticated color palette - create unique and intriguing silhouette	- manufacturing is simple as is - need to maintain functionality
Reflexology mapping	- based off TCM reflexology maps	- “toy like” plastic nodes may not be best material - pvc plastic nodes can hurt the foot to new users	- unite TCM reflexology and mechanoreceptor science for new map -decrease size and/or increase fidelity/number of nodes for more balanced feel -create hierarchy between mechanoreceptor texture and acupressure	- balancing comfort and functionality - other products have tried to explore reflexology mapping -some people may not “believe in” reflexology as a functional tool

			function	
User experience	- adjustable nodes -color coding	- recommended to wear 15 min at a time because can cause pain	- decide whether nodes should be adjustable or not -be clear about use and intention for athlete -find better material choice for nodes	- function may be foreign or confusing to athletes - challenge convincing athletes to wear shoe -must be comfortable and feel good
Fit	- wide footbed fits most feet	- primitive, simple design - not tuned to nuances of foot -not geared towards athletics at all	- design from a last or foot scan -use understanding of ergonomics and footwear design to improve fit	-increased cost with more complex geometry - sports are not intended purpose of original product
Muscle Activation	- TCM supports activation of muscles and other bodily systems	-only focused on the plantar aspect of foot	- integrate textured insole with reflexology footbed	-adjustability -discomfort -compensatory muscle activation
Walkability	- can help to stimulate reflex points	- recommended to wear 15 min at a time because can cause pain	-find comfortable materials solutions -conduct user testing to understand athlete preferences	-pain or discomfort -determining appropriate duration to wear -ability to remove elements

STRAP/UPPER	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Aesthetics	- similar to sports slide	- not interesting, already been done - purely functional	-eliminate strap all together -explore other silhouettes such as slippers -draw inspiration from high fashion	- cost will increase -athlete preferences -balancing functionality with style
Reflexology mapping	-somewhat secures foot to footbed	- only forefoot gets constant contact w footbed	- create enclosure of entire foot that follows principles of TCM	-finding balance of comfort and function of upper -less research on other parts of the foot in relation to TCM

user experience	- adjustability is familiar to user - lightweight and packable - easy on & off	- unsophisticated and dated	-explore other types of adjustability systems that are more elegant design solutions	-creating simple system that workks for all foot types -dont want to look clinical -athlete preferences
Fit	- easy to modify fit using velcro	- overly simple, not ergonomic design	-use last to create more ergonomic upper form	-cost -variety in foot morphology and comfort preferences
Muscle activation	- not relevant	- heel is not secured, can impact muscle activation	- ensure heel is secured as well to create more uniform fit -whole foot contact and activation	-creating a comfortable solution
Walkability	- easy to change into	- slide promotes shuffling, not secure -not for sports	- create more secure upper for pre-game movements -analyze warm up protocol to understand needs	-creating something comfortable enough yet easy to change in and out of

MIDSOLE	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Aesthetics	- simple, understated	- boring, not interesting	-draw inspiration from nature and TCM - draw design language	-cost of manufacturing -importance of midsole aesthetics
Reflexology Mapping	-not relevant	- uniform platform midsole of same density	- integrate footbed into midsole	-cost
UX	- stable and uniform	-not conducive to sport activity	- design for more athletic movements -reduce stack height	-athlete preferences
Fit	- wide and stable platform	- simple and primitive shape is not very ergonomic	- use a last to create ergonomic midsole shape	-other products on market dedicated to ergonomic fit
Muscle activation	- not relevant	- EVA attenuates some impact - thickness reduces ground	- decide whether to improve impact attenuation or let it be a tool for muscle	-comfort during extended wear

		feel	activation	
Walkability	- EVA durable enough for sustained wear	-not designed for walking	-design for more athletic movements -reduce stack height -design off last -explore minimalist shoes as inspiration	-established market of ergonomic slides that are cheap and accessible -comfort during extended wear

OUTSOLE	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Aesthetics	- simple, goes with midsole	- not “sexy” or innovative -low quality	- draw from design language of TCM, integrate with midsole - Opportunity to tell a story	-cost of tooling -may not be important to function of shoe in many settings
Reflexology Mapping	- not relevant	-not relevant	- could mimic design language of reflexology elements	-not relevant
UX	- familiar style to other slides	-generally overlooked and boring	-design more interesting outsole that athletes connect with in some way	-of minimal importance to the athlete -variety of surfaces to be used on
Fit	-flat, stable, slight grip enhancement	- not designed for athletic purposes	-examine foot morphology to understand wear patterns and placement of outsole components such as flex grooves and pivot points	-variety of foot shapes
Muscle Activation	-not relevant	-not relevant	-not relevant	-not relevant
Walkability	- added grip -improved durability	- not advanced or considered design -not suited for sports	- research what surfaces shoe will most likely be used on - examine wear patterns to design more considered outsole	determining what surfaces this will be used on (marking vs non marking), may differ widely

2.Textured insoles

MATERIAL	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Aesthetics	- bright, energetic colors -uniform color -sleek and simple	- not visible from inside shoe -limited color selection -might not match team colors	- color customization - more clear and exciting branding on product	-manufacturing and cost -athlete preferences -balancing function with aesthetics
Walkability	- thin enough to be worn inside shoes	-not a standalone product -material could rip, tear over time	-integrate into outsole to create a more holistic product	-cheaper as an insole rather than full product
Fit	- flexible -low profile	-no arch support -might not work for wider feet	-create more 3D type of form that matches with curves of foot -have it wrap around foot	-wide variety of shoe shapes and foot shapes
Mechanoreceptor mapping	- durable material ensures effectiveness in long term	-changing mapping requires new mold design	-research materials options	-creating new molds -finding material both flexible and durable
Muscle activation	-thin material allows for maximum range of motion and activation	- material by itself may not be protective enough on sports surfaces	-find way to integrate into a shoe used for sports surfaces	-injury risk if material is too thin

TEXTURE DESIGN	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Aesthetics	- clean and elegant pyramid texture	- only stimulates mechanoreceptors, not reflexology points	-integrate hierarchy of both reflexology points and mechanoreceptor texture	-Naboso patented texture

			-tell a story with design	
Walkability	- easy to add to existing footwear	- sometimes can feel harsh on foot at first	-conduct user testing to ensure comfort and proper use	-sensation may not be liked by some athletes -does it need to be removable?
Fit	- variety of sizing -can be trimmed to fit even better	-different shaped feet or different arch heights may need different fit	-explore ways to integrate this into well-fitting shoe options -allow for integration with orthotics	-creating organic feel for variety of foot shapes -catering to athlete preferences -retrofitting with other footwear
Mechanorecepto r Mapping	- patented design specifically for activating mechanorece ptors	-does not take into account reflexology, only focused on mechanoreceptor s	-integrate reflexology map into product	-new molds and product, complete redesign -existing reflexology patents
Muscle Activation	- research supports texture improving muscle activation	- no interaction with other parts of the foot except for plantar aspect	-explore ways to activate other parts of the foot such as ankle more directly -include the whole foot	-overload or discomfort of foot -ability to manufacture successfully

TEXTURE PLACEMENT	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Aesthetics	- uniform design send strong branding message	- boring -very small to the eye	-tell a story with texture placement, make interesting to the eye -more clearly show why texture is places in certain areas	-dont want it to look clinical -do not diminish functionality for looks
Walkability	- enhances ground feel -improves balance	-sometimes texture can feel harsh on foot, especially low contact areas like arch	-refine placement areas to high contact zones such as ball of foot	-sensation may not be liked by athletes -foot morphology may differ a lot
Fit	-uniform	-different foot	-research foot	-ensuring both

	design allows functionality for all foot sizes and shapes	shapes may have slightly different mechanoreceptor placement	morphology -create zoning system that works for majority of feet	comfort and function
Mechanoreceptor Mapping	- studies prove efficacy of product enhancing balance/ Proprioception etc.	- research shows different types of mechanoreceptor on different parts of foot - does not relate to reflexology TCM at all	-research types of mechanoreceptors to better understand how to stimulate each kind -integrate TCM reflexology system into mapping	-make sure combination of reflexology and mechanoreceptor doesn't diminish functionality of each one
Muscle Activation	- stimulation of mechanoreceptors activates muscles	-doesn't directly warm up or interact with muscles of foot and ankle	-find a way to integrate activation of other parts of the foot - resistance training -balance training	-dont want to fatigue foot before competition -need to explore best way to involve lower leg in an elegant way

3. Physiclo Resistance Tights

FABRIC	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Aesthetic	- look like regular leggings -wicking technology -breathable	-not cutting edge fabric, more mid range -no branding -fabric looks thick	-use high-end brands as inspiration -look into innovative knit technology -ensure appropriate thickness for sports competition	-cost will likely increase significantly with use of more high end materials and mfg -dont want to look like lululemon -need to define brand image clearly
Muscle Targeting	- general compression of fabric may enhance proprioception	-no dedicated proprioception technology integration	-integrate proprioception elements like silicone to unite ideas -use advanced knits to create tension systems that encourage specific muscle	-kinesio tape similar and cheaper option -variety of anthropometric and biomechanics needs of athletes -creating understanding of

			movement patterns	purpose
Wearability	- elastane blend for body-hugging effect	-no mesh paneling for breathability -designed to be worn under shorts, limits ability to don/doff	-integrate mesh paneling -look at seamless knitting techniques -find way to remove easily for competition	-elegant solution to removing garment seems difficult -convincing athletes to wear garment

SILHOUETTE	S	W	O	T
Aesthetics	- looks like regular compression tights -can't see resistance elastic elements	- somewhat dated and simple design -full length tights not in style for men	-elevate silhouette to more cool, modern, high-end -¾ length more appropriate	-a million types of leggings on the market -creating desirable aesthetic for male athletes
Muscle Targeting	- lower body muscle activation is essential to athletic performance	-only targets upper leg	-integrate knee and calf aspects into tights -use both resistance and proprioception technology	-athlete preference and activation needs may differ greatly
Wearability	- easy to wear as compression garment under shorts	-full length silhouette hard to remove from underneath uniform	-create a better way to remove tights prior to game -create way to wear over uniform as a warm up garment	-removing tights or elastic -comfort for athlete balanced with function -understanding locker room environment and access to clothes etc.

ELASTIC	S	W	O	T
Aesthetics	- not visible, hidden by exterior fabric	- looks generic because elastic is hidden	-create more interesting geometry for elastic	-do not want to look clinical or wack -balance functionality with aesthetic -convincing athletes to wear the product

Muscle Targeting	- targets key muscles for explosive movements (hips, glutes, quads)	- doesn't target lower leg (calf, ankle etc) - design to fatigue muscles rather than activate	- integrate resistance into lower leg aspect of tights	-dont want to fatigue the athlete -different needs or resistance weights for different athletes
Wearability	-low profile -light weight	-must be worn as base layer, could pose issues for athletes in uniform -cannot remove elastic from garment	-devise way to remove elastic from garment prior to competition	-needs to be comfortable -some athletes may not like sensation -finding way to remove and adjust elastic

4. Intelliskin Posture Tights

FABRIC	S	W	O	T
Aesthetic	- simple, sporty, goes with everything	- no branding, somewhat generic	-elevate materials choice -integrate branding into garment in subtle elegant way	-athletes may like simplicity of garment -dont want to impede on sponsorship agreements
Muscle Targeting	- tension of fabric encourages efficient movmt and proper form - different knits used to induce feelings that encourage movement patterns	- no resistance elastic integration, limits effectiveness of muscle activation	-find way to integrate resistance bands into garment -allow athletes to customize resistance areas and level of tension	-do not want garment to look clinical or over the top
Mobility	- articulated pattern design with sports in mind	-lots of seams which could become abrasion points	-explore seamless construction, advanced knits to eliminate seams	-seamless construction will be expensive -don't diminish fit for fabric selection
Breathability	-mesh paneling in high-sweat areas for improved breathability	-silicone overlays could impede breathability	-conduct sweat mapping to ensure high sweat areas are appropriately	-will seamless construction allow for functional mesh paneling

			ventilated -integrate more mesh	-research finishes and technology for breathability

CONTACT PTS	S	W	O	T
Aesthetic	- not visible from exterior of tights	- athlete may not know why they are there	-find way to subtlety reference areas of contact points	-other products have integrated similar technology -kinesio tape is cheaper alternative
Muscle Targeting	- targets key muscles in core and hips for athletic improvements	-is shape and size optimized for proprioception	-look into discriminability of diff shapes and sizes of contact points	-existing patents -will athletes like this sensation? -longevity of contact points is unknown
Mobility	- low profile so doesn't impede movement	-added layer of contact points may negatively influence perception of mobility	-use muscle movement patterns to map contact points to flow with movements	-might feel annoying to athletes -large contact points may not fit contours of body
Breathability	- silicone elements only used where necessary	-silicone is not breathable at all -silicone sensation may change when sweaty	- explore other materials options -use silicone dots or pattern to allow for breathability	-sticky sensation of contact points may reduce perception of breathability

SILHOUETTE	S	W	O	T
Aesthetic	- simple and sporty -unbranded so no sponsorship conflict	-generic, looks like any other compression tights -lack of branding Lots of visible seams (somewhat dated look)	- use new mfg technologies to elevate silhouette -use subtle branding	-sponsorship conflicts w branding -athlete aesthetic preferences may differ or change
Muscle Targeting	- ¾ length targets upper leg and calf	-no resistance elements	-integrate resistance elements into ¾ length tights	-muscle targeting designed for pre-competition only, find way to

			-find way to include calf and knee	remove it for the game -comfort is of utmost importance
Mobility	- lightweight and low profile	-flat lock seams may become uncomfortable	-minimize seams in abrasion areas -explore seamless construction	-need to balance resistance elements with proper mobility and biomechanics -do not want athletes to compensate for resistance
Breathability	- lots of mesh integrated	-none really	-conduct sweat mapping and movement research to understand breathability needs	-mesh can be flimsy and may not work with intended functionality

Product Testing

After exploring areas for improvement from a strategic analysis standpoint, it was important to gather feedback directly from athletes and conduct testing to establish a baseline of performance. To measure priming in a consistent and accurate way, I developed a unique protocol to test each product's influence on static balance, dynamic balance, and agility.

As stated in this project's research section, sensory stimulation is shown to influence the systems of the human body in profound and significant ways. This study aims to assess whether specific stimuli administered through existing sports products influences priming in the test subjects/athletes. For the purpose of this study, priming is defined as preparation for competition, characterized by improved body control and muscle recruitment. Minimal research exists that examines priming for elite athletes, especially through the lens of sensory or tactile stimulation. Most studies of athletic products, including some of the baseline products to be examined in this study, examine the product use during exercise rather than before or after. Other related studies have no athletic influence or application, making this study unique in topic and aim.

The study design tasks subjects with a series of sports-related tests, much like the tests administered at a physical therapist or sports trainer's office, both with and without product intervention. The order of product intervention, including the control state (no intervention) are randomized to minimize data error as the test subjects become more familiar with the tests.

The objectives of the proposed study include:

- Assess whether products in the priming category aid performance when used in pre-performance scenarios:
    - Does a proprioceptive garment, when used pre-exercise, influence postural control, balance, or muscle recruitment?
    - Does a garment with resistance, when used pre-exercise, influence postural control, balance, or muscle recruitment?
    - Does a textured insole, when used pre-exercise, influence postural control, balance, or muscle recruitment?
    - Does a reflexology slipper when used pre-exercise, influence postural control, balance, or muscle recruitment?
- Do athletes feel more prepared to compete when they use any of the products in the priming category?

Products To Test

Testing was performed on the same products on which the SWOT analysis was conducted. These products were chosen because of their unique stimulation-oriented attributes as well as their accessibility to the consumer.

Parameters

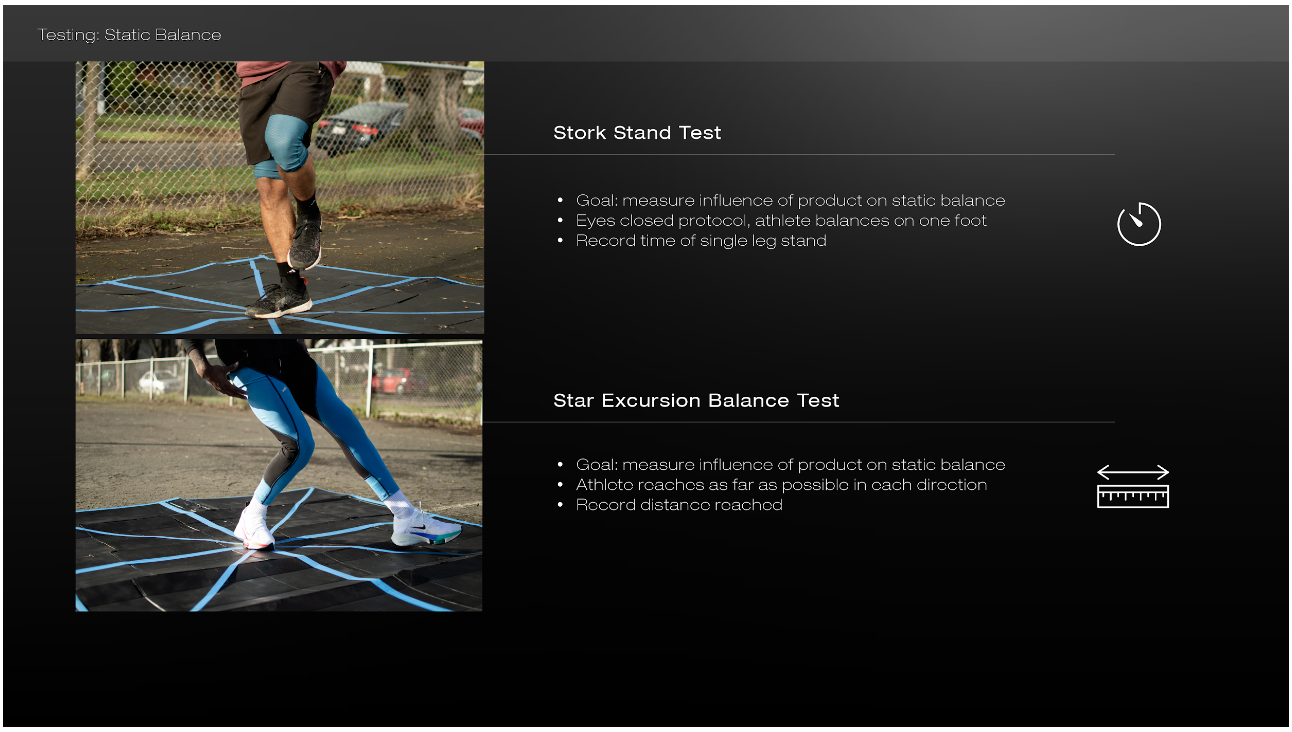
Location: Due to Covid-19 safety measures and the athletic nature of the tests to be performed, as well as weather considerations, the tests will be conducted at the covered basketball courts at Abernethy Elementary School at 2421 SE Orange Ave, Portland, OR 97214.

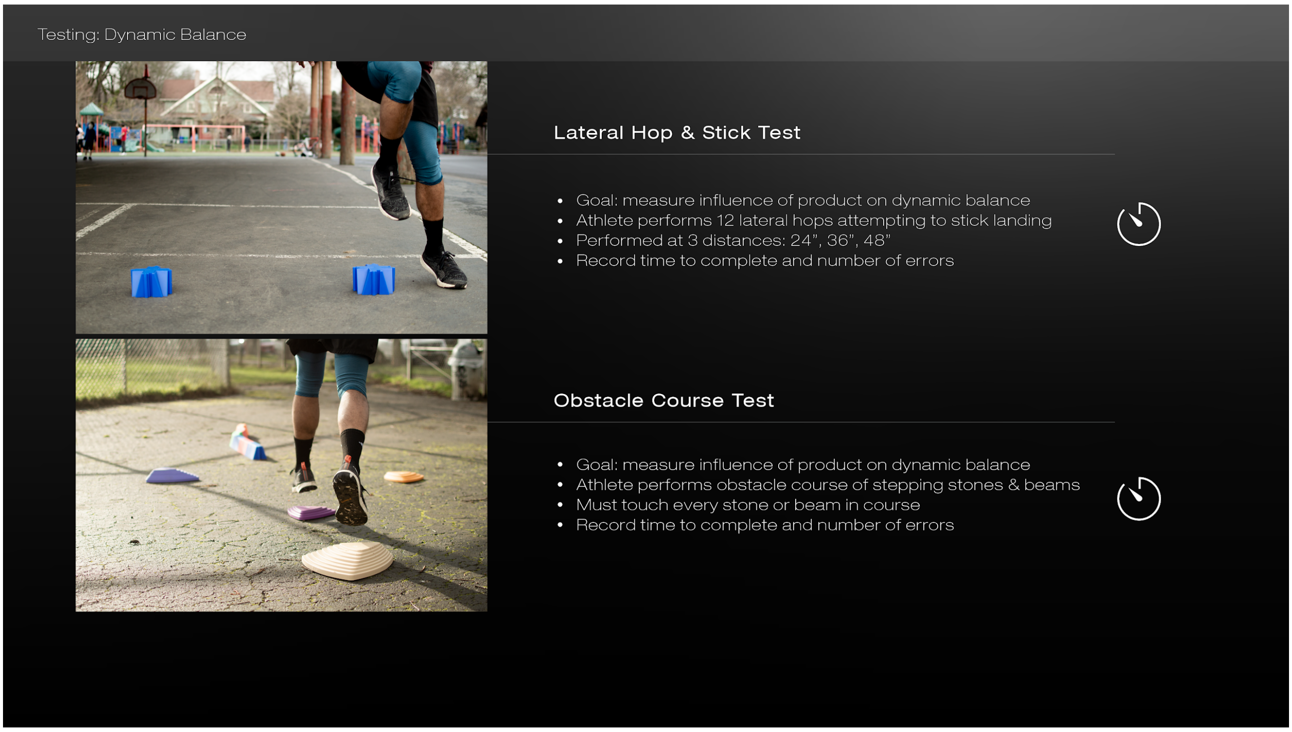
Subjects: Subjects include 3 males aged 22-26 who train regularly. 2 subjects competed in Division I Track & Field, all are experienced in basketball and strength training.

Timing: Subjects will be asked to participate in 2 visits lasting approximately 70 minutes in duration.

Fig. 22. Athlete testing overview

The tests performed in the empirical phase of priming tests were derived from common athletic assessment tests geared towards examination of body control and balance. The Standing Stork and Star Excursion Balance Tests are typical tests one would experience in an athletic trainer's office. The Lateral Hop & Stick is somewhat less common but is typically used in a sports setting to understand an athlete's dynamic balance control at a higher intensity. The second dynamic balance test, an obstacle course, was developed for the purpose of this study in order to examine agility and body control from another perspective.





Figs 23-24. Athlete testing details

Detailed Protocol

A. Warm Up (5 min)

Data Collected: None
Athletes will complete the following warm up while wearing their assigned product (see chart above)

- 10x forward walking lunge, 10x backwards walking lunge, 10x bodyweight squat, 90 sec brisk walking

B. Standing Stork (5 min)
Data Collected: Time (sec) of successful stand on both left and right feet
Step 1: Athlete will remove product and put on regular clothing
Step 2: Athlete will stand on one leg with their eyes closed in the stork position, tester will document the amount of time athlete can do so successfully
Step 3: Repeat on the other leg

C. Star Excursion Balance Test (5 min)
Data Collected: Distance (inches) reached in 8 directions on both left and right feet
Step 1: Athlete will stand on one leg in the middle of tape asterisk
Step 2: Prompted by tester, athlete will reach in each direction of the tape with their other leg as far as they can go without losing balance, tester will document distance reached
Step 3: Repeat on other leg

D. Lateral Hop & Stick (5 min)
Data Collected: Number of errors per 12 hops at 3 distances
Step 1: Two pieces of tape will be positioned parallel at 24” apart
Step 2: Athlete will stand on left leg on left side piece of tape
Step 3: Athlete will hop laterally from left leg to right leg, aiming to land on the right side piece of tape without losing balance, emphasising sticking the landing
Step 4: Repeat 12 times total (6 each side), tester will document the number of errors
Step 5: Repeat test with tape 36” apart
Step 6: Repeat test with tape 48” apart

E. Obstacle Course (5 min)
Data Collected: Time (sec) to complete, number of errors during test
Step 1: Athlete will be shown obstacle course
Step 2: Athlete will perform obstacle course as quickly as possible without losing balance, tester will document time to completion and number of errors observed

Consumer Feedback

In addition to the empirical testing protocol, athletes were tasked with completing a survey to provide subjective data about each product that was tested. This provided details about the fit and feel of the products, as well as perceived effects on performance. Shown below is the survey completed by the test subjects

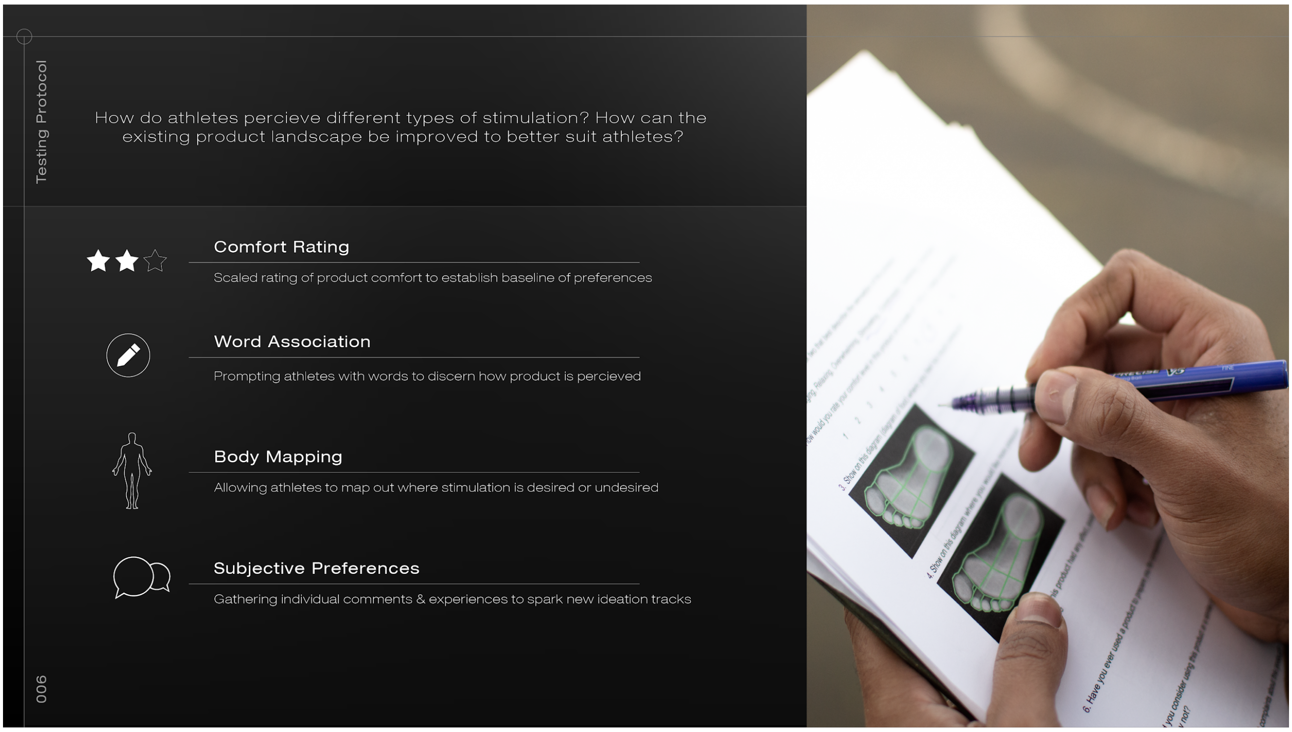


Fig. 25. Consumer research overview

A. Pretest Questions

1. Please share your height, weight, and age

2. Have you had any previous injuries?

3. Describe your athletic background and skillset

4. What does the phrase "pre competition priming" mean to you? What comes to mind?

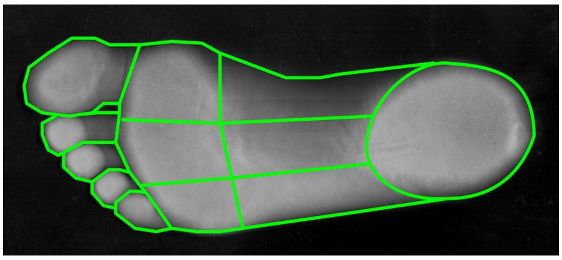
B. Question Set

1. Out of these words, pick two that best describe the sensation of this product: *Painful, Massaging, Relaxing, Overwhelming, Stimulating, Comfortable, Centering, Confusing*

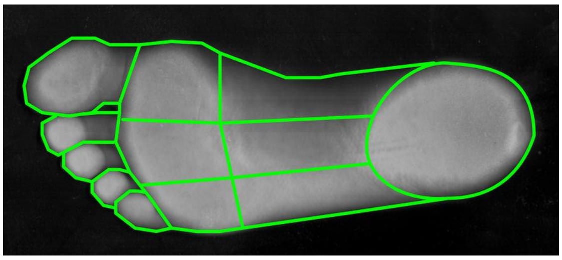
2. How would you rate your comfort level in this product on a scale of 1-10 (1 = least comfortable)

1 2 3 4 5 6 7 8 9 10

3. Show on this diagram (diagram of foot) where you feel too much pressure



4. Show on this diagram where you would like more pressure



5. Did you feel like this product had any affect, positive or negative, on your performance in the tests? Describe

6. Have you ever used a product to prepare you for competition or exercise? Explain

7. Would you consider using this product or a similar product before an athletic performance? Why or why not?

8. What are your biggest complaints about this product? What are your favorite aspects? (1-2 each)

Test Results

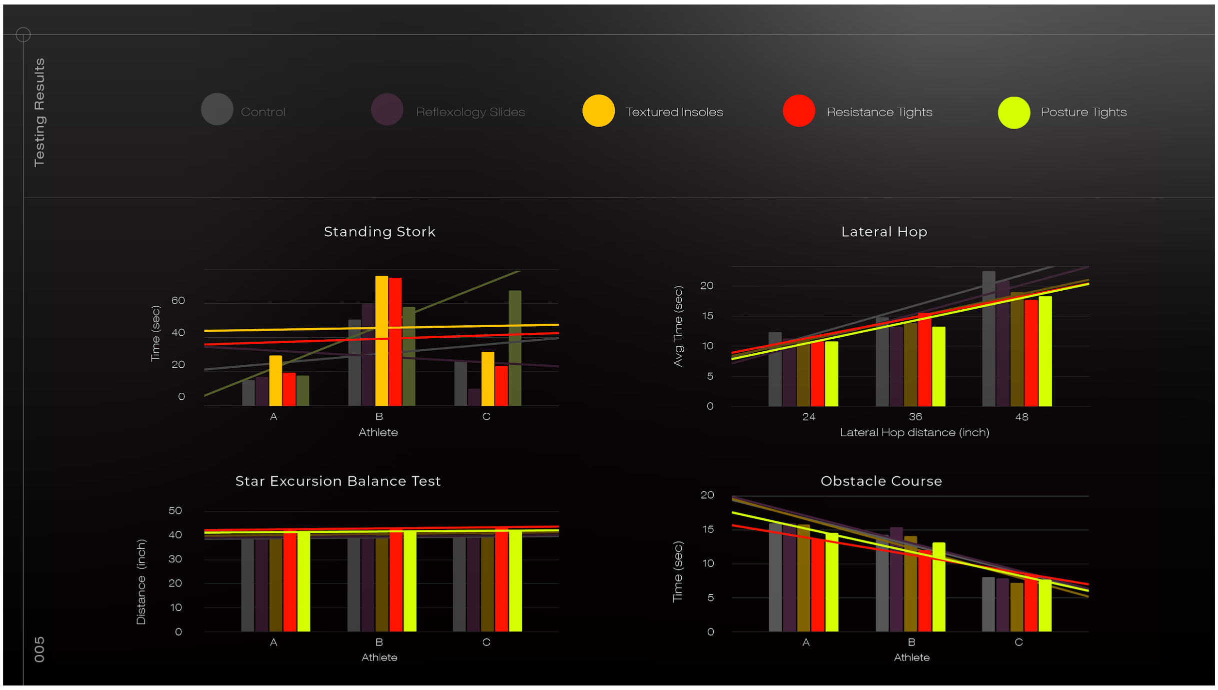


Fig. 26. Athlete testing results

The results of the empirical testing showed that objectively, the resistance tights and posture tights had the strongest positive influence on priming, followed by textured insoles. The reflexology slides were not consistently better than the control and thus were not considered as a viable product moving forward.

Fig. 27. Consumer research results

The results of the athlete survey showed that the textured insoles and posture tights were the most comfortable and had the most positive word associations of the group. The survey also revealed specific areas of improvement within each product.

The results of this benchmark testing was used to begin strategic ideation for a collection of products that enhance priming in athletes. Based on market research, athlete feedback, and strategic analysis, the following line plan was developed with the intent to bring innovative designs to this product market.

Fig. 28. Line plan overview

Ideation Planning

The next phase of the project required in-depth analysis of product weaknesses and potential solution paths. This process was informed by SWOT analysis, testing results, and athlete feedback. Below is a strategic ideation plan mapping out potential product solutions and innovations for each product component.

Product: Footwear for Priming	
Part: Footbed	
Problem identification	**Ideation Path**

SWOT/ Benchmark: Aesthetics	- parametric design - color selection - elevate materials selection
SWOT: Targeted Muscle Activation	- add texture element for mechanoreceptor activation - resistance training element - barefoot training simulation - balance training integration - weighted training element
SWOT/ Benchmark: Fit	- organic shape - proper foot encasement - construct off of last
Consumer: Comfort	- material selection for nodes: hard vs soft - node size & height - node distribution
SWOT: Reflexology mapping	- change node shape & material - combine reflexology with texture mapping
Part: Strap/Upper	
SWOT: Aesthetics	- design language to reflect function - future aesthetic
Consumer: Better fit on foot	- sock upper - overshoe - clog - add straps
Part: Midsole	
SWOT: Aesthetics	- reflect functionality - not clinical
SWOT: Fit	-low to the ground -zero drop - allow for toe splay - activate ankles - > proprioception? - properly protect and encase foot
Consumer: Flexibility	- eliminate midsole to create barefoot feel shoe - thin flexible midsole -auxetic midsole -segmented
Part: Outsole	
Outsole currently part of midsole	
Consumer: Grip	- multisurface grip - multidirectional -designed for athletic movements
Product: Garment for Priming	

Part: Use-Case	
SWOT: Define use case	- Leading up to competition - possible overlap into competition - under uniform (base layer) - over uniform (warm up) - hybridized with uniform -> must evolve from pre game to during game
Part: Fit	
SWOT: Define fit	- next to skin - hybrid integration with uniform - articulated fit - adaptive/ transformative
Part: Fabric	
SWOT: Aesthetic	- state of the art synthetic knit
SWOT: Maintain breathability of posture tights	- mesh panels - perforations - cut outs - wicking tech - minimize layering
SWOT: Targeted muscle activation	- resistance elements integrated - multi-tension knit - textured elements integrated - targeted compression - kt tape/postural type of integration: nonwoven bemis/interfacing, band overlays *adaptive resistance: - mechanical actuator: activated by biometric feedback (HR, breathing rate, HRV), activated by environmental changes (moisture, heat) - active textiles: reactive bacteria coating, heat activated auxetic materials, stress memory polymeric filaments
SWOT: Comfort	- premium compression elastane/poly blend - minimize excessive layering - targeted paneling thru body/muscle mapping - advanced knits - elastane blend
Part: Elastic Resistance	
SWOT: Aesthetics	- create more interesting design - use smaller brands - web like configuration - bemis overlays
SWOT/ Consumer: Muscle Activation	- targeted to hips - calves - combination of resistance and texture - kt tape inspiration

	- nonwoven bemis/interfacing - band overlays / underlays * see adaptive resistance
Consumer: Better fit in hips & groin	- reduce resistance in groin area
Consumer: Too intense resistance	- change type of resistance bands - thinner bands -adaptive resistance:
Part: Textured Contact Points	
SWOT: Improve Breathability	- use a pattern of texture that allows for air flow - use material for pattern that is breathable - printed pattern - adhered pattern - texture is knit into fabric as pattern - resin - thermoformed knit
SWOT: Maintain proprioception	- map key areas needed for proprioception - athlete feedback

Sourcing

The strategic ideation planning helped to narrow the project focus and more concretely define what materials and components would be necessary to continue on with functional prototyping. The next step in developing the project was to identify the essential product components and brainstorm potential sources to acquire the necessary materials.

Priming Shoe			
Part	**Performance Goals**	**Material**	**Where to Source**
Outsole	-multi- surface traction	- Molded Rubber	-3d printed mock up - molded with smooth on
Midsole	none	none	none
Upper	- breathability - flexibility	- engineered knit	- tin york - nike scrap - ryan anderuud - reclaimed materials

Textured elements	- foot stimulation	-molded silicone -applied texture	-printed onto material - 3d printed solid piece
Priming Garment			
Part	**Performance Goals**	**Material**	**Where to Source**
Base textile	- breathability - general compression -stretch	- 3d knit - elastane/poly blend	- mill end - tin york -ryan anderuud
Resistance Elements	- adaptive resistance -responsive to body heat/moisture	- programmed knit textile -performance knit	- mock up with 3d knit - get swatch from MIT
Proprioceptive texturing	- tactile surface texture for postural feedback	- resin -plastic -silicone -yarns	-3d printed onto textile - applied by hand or using stencil -woven into garment

Thesis Ideation Calendar

After defining the potential materials and ideation paths, a calendar was developed to define what methods of functional and aesthetic ideation would be used to design the products. The calendar was used as a tool to manage time and ideation processes in order to build a proof of concept. The ideation process for these products includes 2d and 3d ideation, industry insights, anatomy studies, and more.

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
2/7	2/8 **Midterm Preview**	2/9 **Midterm Prep**	2/10 **Midterm Prep**	2/11 **Midterm**	2/12 **Break (Speedhack)**	2/13 **Break**
2/14 **Break**	2/15 - Shoe: mind mapping exercise - Call with	2/16 - Garment: Silhouette & Muscle Mapping / texture placement	2/17 - Garment: Texture & ideation: (30 ideas, combo of sketch and	2/18 - Garment: Swatch mockups (laser cutting, sleeve idea,	2/19 - Garment: Work on 3d printed swatches, send to print	2/20 **Break**

	alex **Class**	Ideation (30 Ideas) - Order LED lights - reach out to mentors for follow ups	substance/parametric etc.) - Harvest materials from studio for swatches **Class**	prepare 3d print on textile swatches: 10-15 ideastotal, 5 swatches) - Call w/ Oksana, MIT mats	- Get materials ordered from ryan	
2/21 CLO3D Independen Study	2/22 - Garment: Narrow down concepts to top 3 -Order additional materials / electronics if needed **Class**	2/23 - Shoe: footbed functional ideation, identify core needs and explore through sketch (30 ideas)	2/24 - Shoe: Footbed / texture ideation (30 ideas, Combo of Form sketch and 3d proto/substance) **Class**	2/25 - Shoe: work on 3d print swatches (5 swatches) - Midsole & outsole ideation start	2/26 - Send swatches to print -Shoe: Midsole & Outsole Ideation (20 sketches, 10 crude protos)	2/27 **Break**
2/28 CLO3D Independen Study	3/1 - Shoe: entire underfoot unit ideation with surrogate materials and crude protos (10 -15 proto sketch hybrid)	3/2 - Shoe: Upper Ideation, sketch over last w diff views (40+ ideas)	3/3 - Shoe: refine upper ideation (10 ideas) to unite with rest of shoe concepts	3/4 - Shoe: Refine visual assets	3/5 - Garment and shoe: refine visual assets	3/6 **Final Review Prep**
3/7	3/8 **Final Review**	3/9	3/10 **Final Review**			

Aesthetic Direction

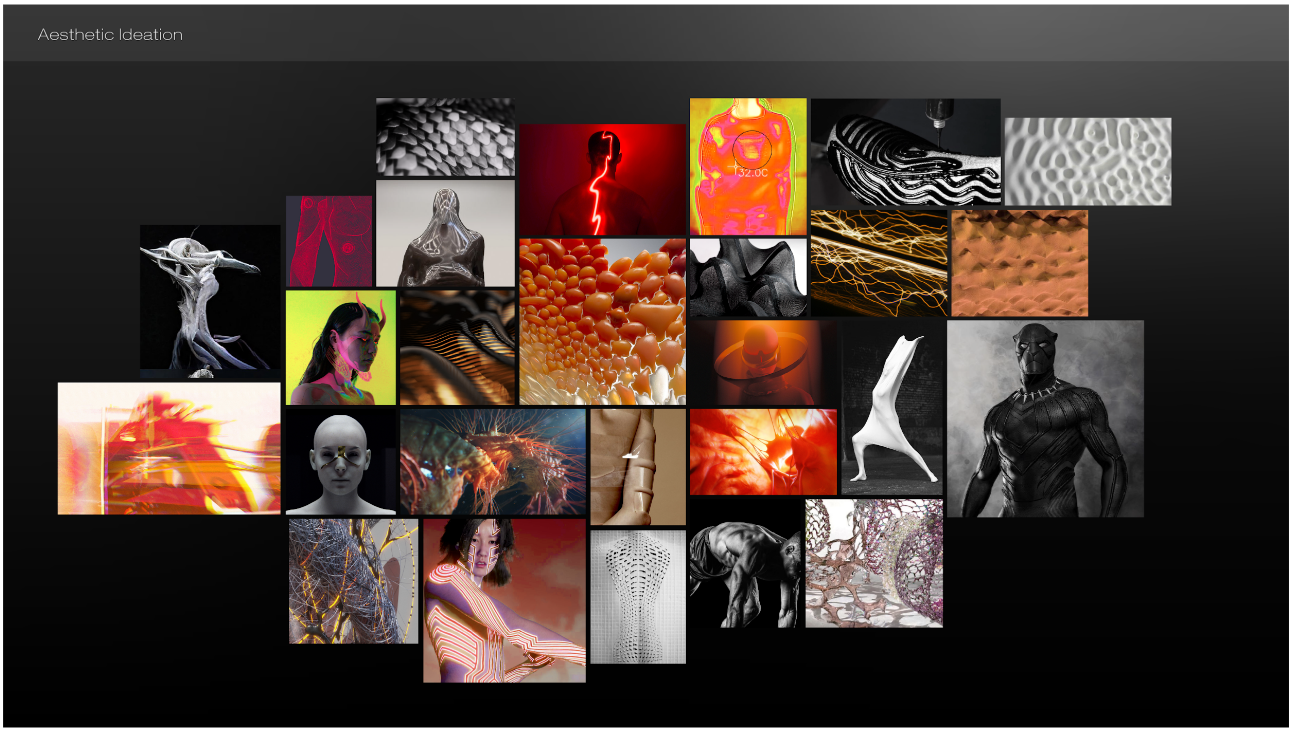


Fig. 29. Aesthetic moodboard

Fig. 30. Athlete imagery/moodboard

Ideation

With a clearly defined aesthetic direction and baseline product research, the ideation process was focused on designing against key goals. The overarching idea of awakening the neuromuscular system to properly prime the body to compete remained at the center of these goals. More specifically, improving muscle recruitment, activating neural pathways, and enhancing body awareness were concrete goals for product ideation and development. Based on research, the key methods creating these product attributes was to integrate muscular resistance and haptic/texture feedback into the products.

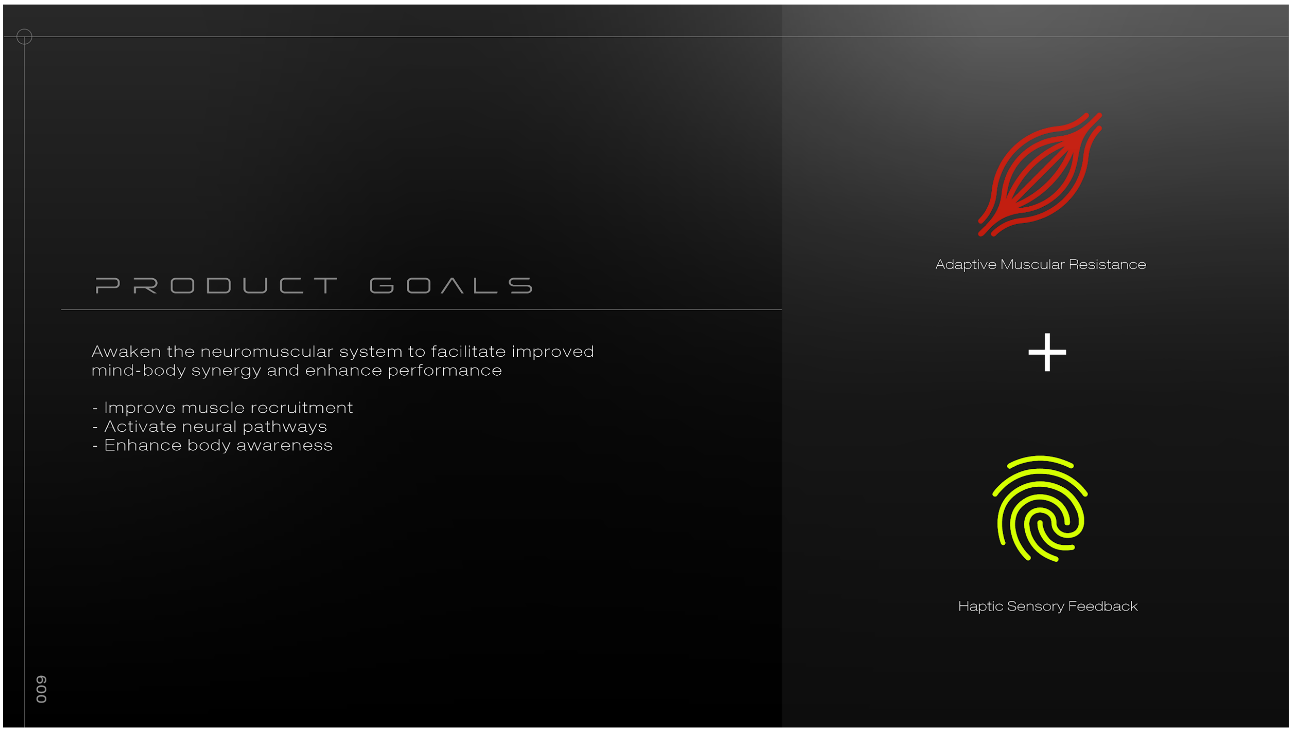


Fig. 31. Product goals overview

When taking into consideration the use-case scenarios of products in an elite basketball setting, it became clear that an athlete's pre-game rituals did not typically include changing out of base layer garments to put on a uniform, and most athletes used the same shoes for before and after competition. Therefore it did not make sense to provide athletes with products that could only be used before competition but not during.

This sparked a new path in the ideation plan for the project - developing a garment and shoe that would appropriately prime the athlete before competition yet adapt to their needs as the body became sufficiently warmed up. Thus the idea of integrating "adaptive" muscular resistance and textural feedback became an essential aspect to creating a product that was truly in tune with the mind and body.

Technology Integration

A key facet in developing the concept of an adaptive garment was research regarding responsive materials & textiles. Innovations in responsive design showcase materials ranging from textiles to architectural facades that change shape or deform based on environmental factors such as heat and light. These technologies, though not universally market-ready, are a shining example of the possibilities for the future of sports product design. Based on research in this field, two key technologies were identified as the most promising integrations into this thesis project.

1. Shape Memory Polymers

Shape memory polymers (SMPs) are a type of "programmed" or "active" polymer that changes shape when contacting a specific stimulus (Behl & Lendlein, 2007). These polymers are programmed through mechanical deformation coupled with a stimulus such as heat and light, thus creating a material that responds to its programmed stimulus. Heat, moisture, and light are common stimuli programmed for SMPs, though other stimuli such as electromagnetic waves have been used. Thus far, SMPs are regarded as a promising innovation in the design of medical devices, aeronautics, and smart textiles (Behl & Lendlein, 2007).

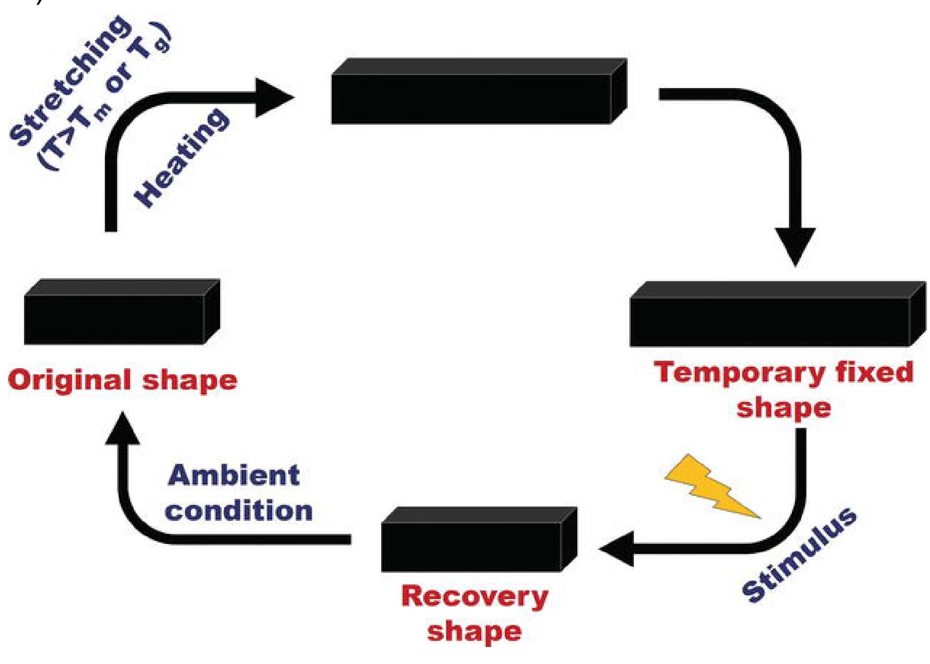


Fig. 32. Programming process of Shape-Memory Polymers

The Self-Assembly Lab at MIT, a cross-disciplinary studio of architects, biologists, chemists, and more, has harnessed the power of SMPs to develop "active textiles," moving the needle forward with regard to responsive sportswear. These active textiles feature traditional yarns woven or knit with SMPs in key areas to create targeted deformation of the garment (Tibbits, 2017). The distribution, orientation, and weave of the SMPs within the garment dictates endless possibilities of an activated state.

This opens the door to the possibility of developing a garment with active and responsive resistance. Rather than a garment with constant muscular resistance (and subsequent fatigue), a garment could provide light resistance as a means of activation that becomes passive as the body becomes sufficiently warmed up. Using heat and moisture as potential stimuli for the activation of the textile could allow the athlete to wear the garment both before and during competition as it adapts to their body.

Fig. 33. Adaptive garment developed by the Self-Assembly Lab at MIT

2. Metamaterials & Origami

The overarching theory of metamaterials is that the mechanical properties of the material are defined by its structure rather than its composition (Sandalow, 2020). Innovation in the field of metamaterials has shown increased interest in origami (paper folding) and kirigami (paper cutting) as a means of creating functional tessellations with unique structural properties. Specific fold styles and tessellations such as the Ron Resch and Miura Ori folds have intriguing auxetic and deployment behaviors that have been integrated into load damping systems, self-deploying structures, and more.

Inspired by the integration of origami into engineering, I was motivated to utilize a variable texture or tessellation in the project to provide a type of responsive texturing that would enhance proprioception. By developing a metamaterial inspired by origami and harnessing the responsive attributes of the SMPs, it is theoretically possible to create a responsive texture that adapts to the body's activity.

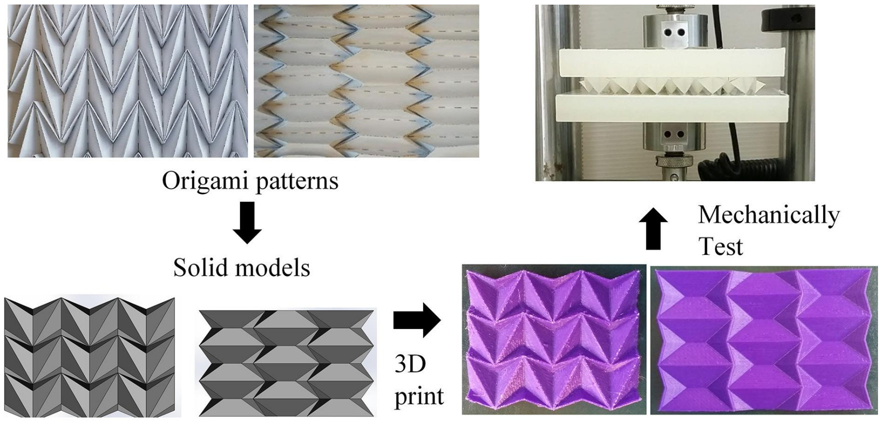


Fig. 34. Application of origami as a load-damping metamaterial

Garment

Ideation for the garment began with anatomical studies of the body in motion, taking into account the specific muscles used in basketball and the myofascial chains connecting these muscle groups. In designing a next-to-skin garment, it was important to consider the comfort needs of the athlete, such as thermoregulation, as well as interfacing with other gear. During this process, I kept in mind the potential innovation opportunity of integrating active textiles in order to create adaptive resistance.

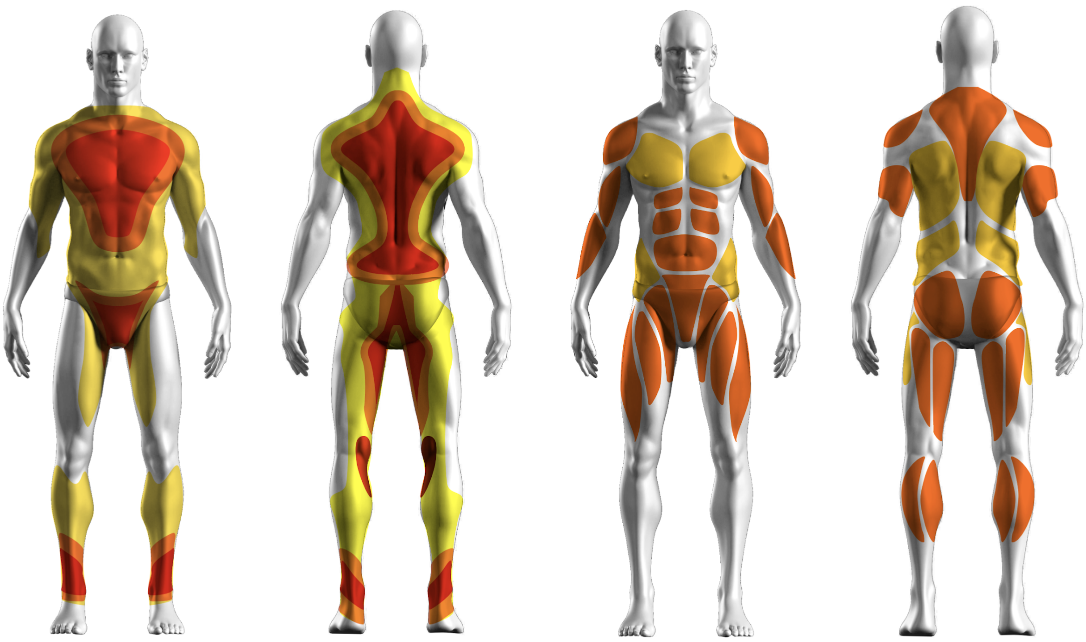


Fig. 35-36. Sweat map of the active male body, Primary (orange) & Stabilizing (yellow) muscles used in basketball

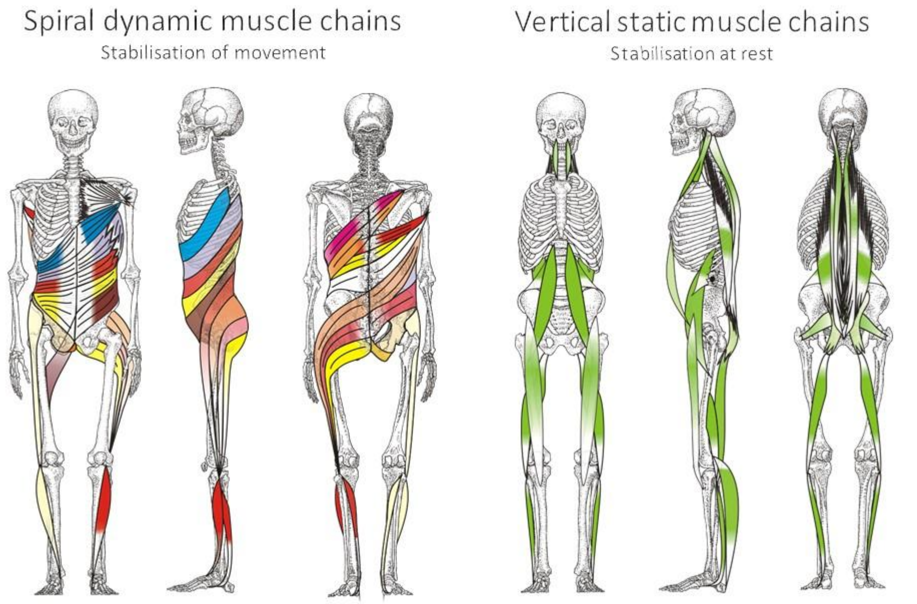


Fig. 37. Muscle chains of the body

The fascia, and more specifically myofascia, of the body is a network of connective tissue that encapsulates every muscle in the body much like a scaffolding system. It is never completely lax nor completely tense, and constantly adapts to maintain a smooth transfer of energy throughout the body. (Skoyles, 2018) The muscle chains in the figure above are visualizations of the kinetic pathways created by fascia that facilitates the flow of energy between muscles. In my ideation process, I drew from these kinetic pathways to properly map resistance and postural elements onto the athlete's body.

Fig. 38. Ideation with elastic on athlete test subject

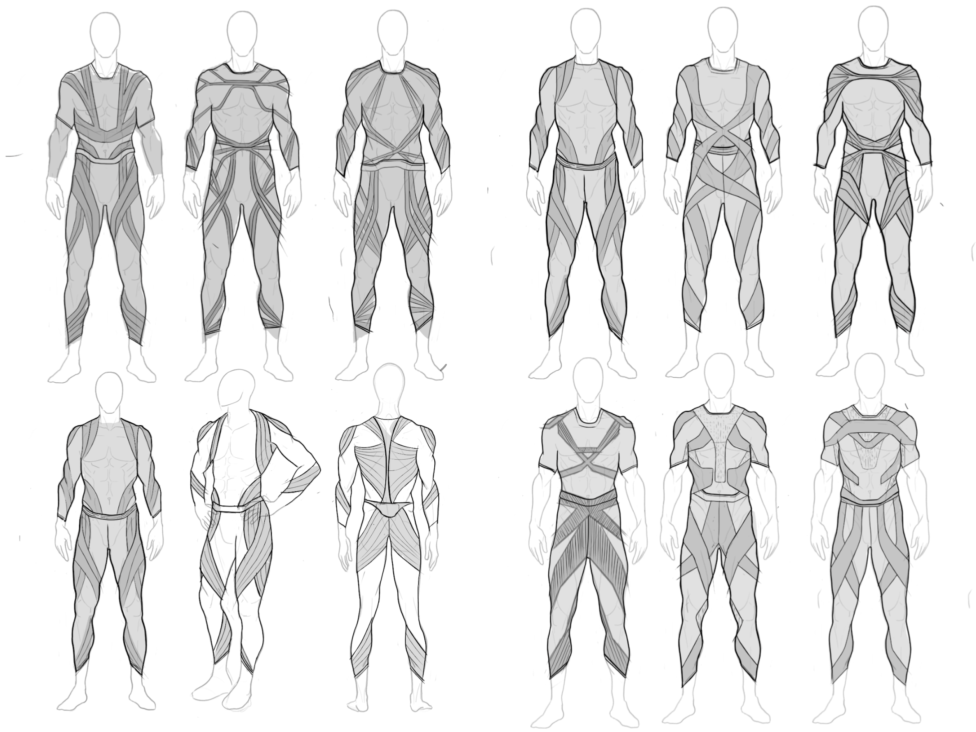


Fig. 39. Aesthetic Ideation targeting kinetic chains

Refining the functional prototypes, I defined key areas on the athlete's body that required resistance and cross-referenced these patterns with the muscle and fascial studies conducted at the start of the ideation process. Texture applied to the interior of the garment in key areas can be added to aid in joint positioning feedback.

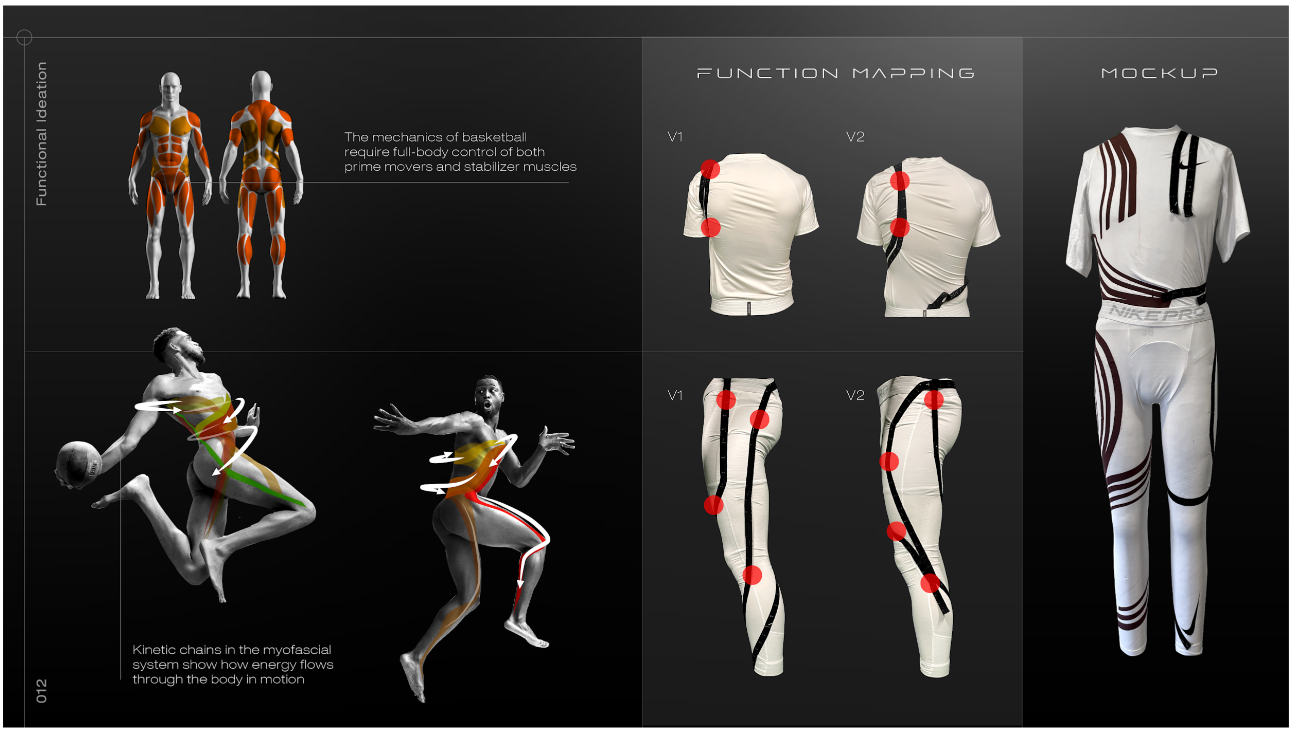


Fig. 40. Functional ideation process of garment

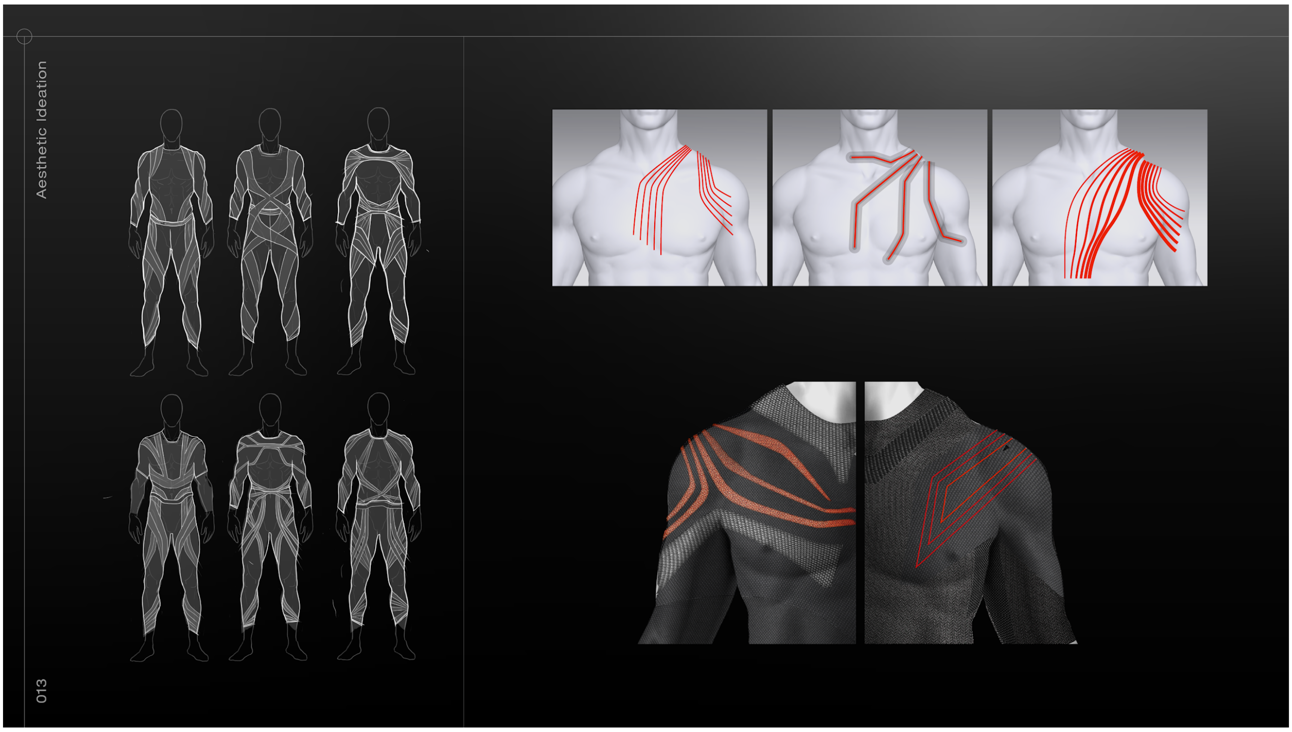


Fig. 41. Aesthetic ideation process of garment

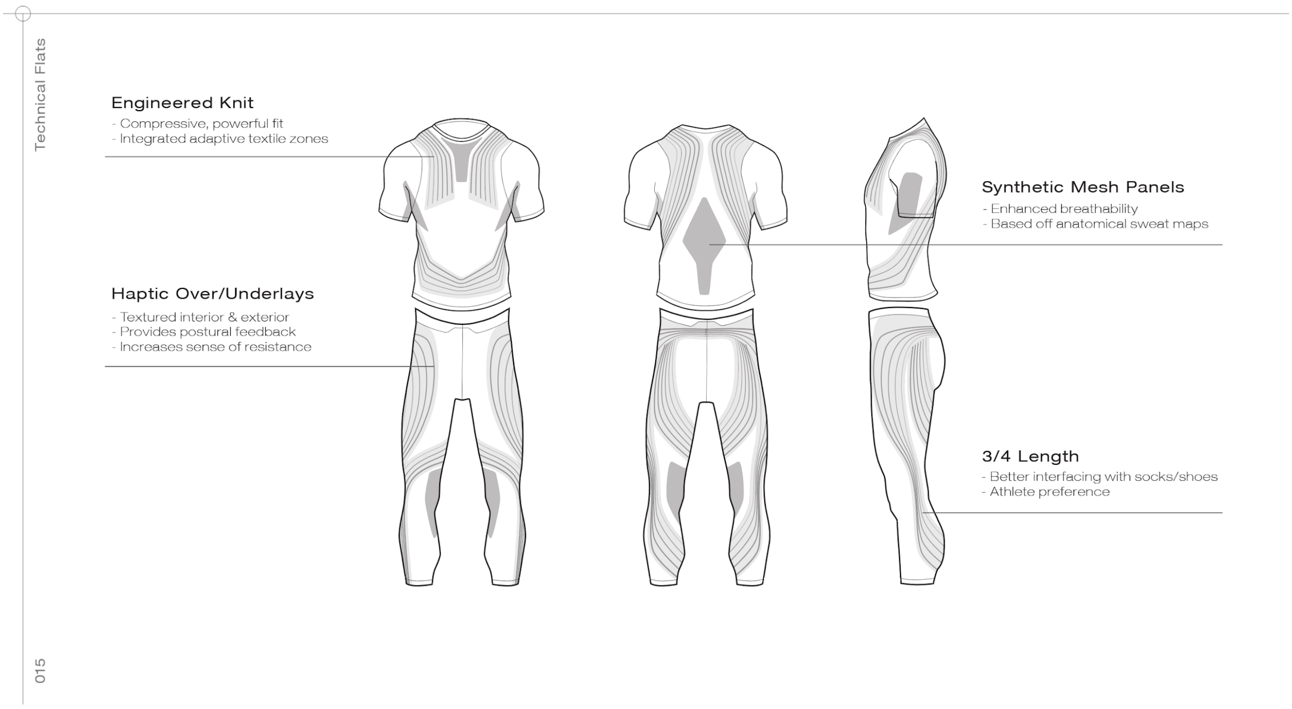


Fig. 42. Technical drawing of garment with callouts

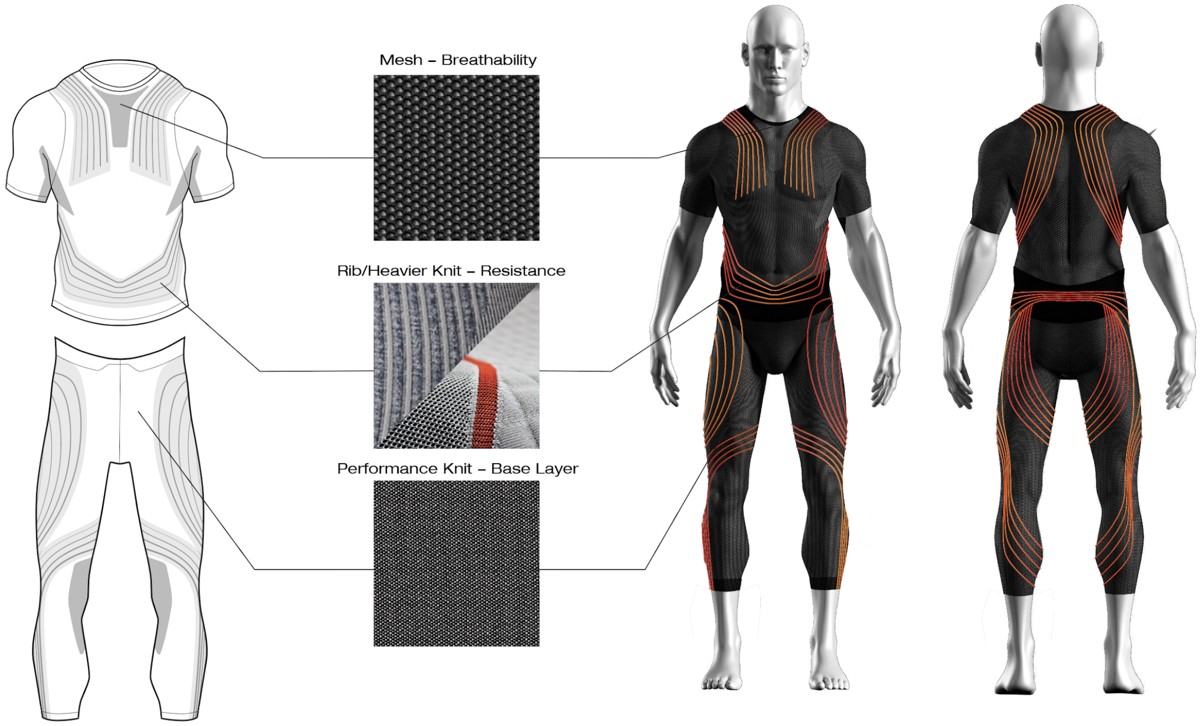


Fig. 43. Rendering and flat of garment with swatches

The finalized garment is constructed of an engineered knit with a breathable mesh in high-sweat areas. The key functional zones, defined by my functional ideation, feature a knit integrated with SMPs to provide adaptive resistance as the body is warming up. Around the joints, a subtle texture is applied to the interior of the garment to enhance positional feedback.

Footwear

The ideation process of the footwear portion of the collection was inspired by the technology overviewed previously in the Ideation section. Research revealed significant correlations between texture and enhanced positional awareness, as well as the use of elastic taping to enhance proprioception. I focused my ideation efforts on integrating my research and technology innovations into the footbed and upper of a performance basketball shoe, with the goal of providing both priming and performance to the athlete.

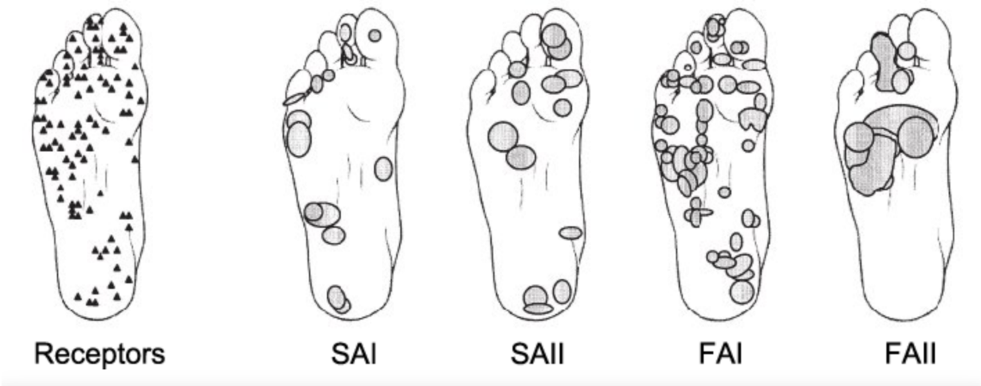


Fig. 44. Distribution of mechanoreceptors in the plantar foot

The footbed of the shoe was particularly important to the goal of priming due to the large array of mechanoreceptors located on the plantar aspect (bottom) of the foot. These mechanoreceptors aid in both static and dynamic balance by notifying the body of acute changes in pressure, skin stretch, and texture (Robbins et al., 1995). In this portion of my ideation, I focused on integrating a variable or responsive texture into the footbed of the shoe, inspired by my research in origami and metamaterials. I prototyped variable textures using kirigami and origami tessellations to find the appropriate texture shape and deployment style.

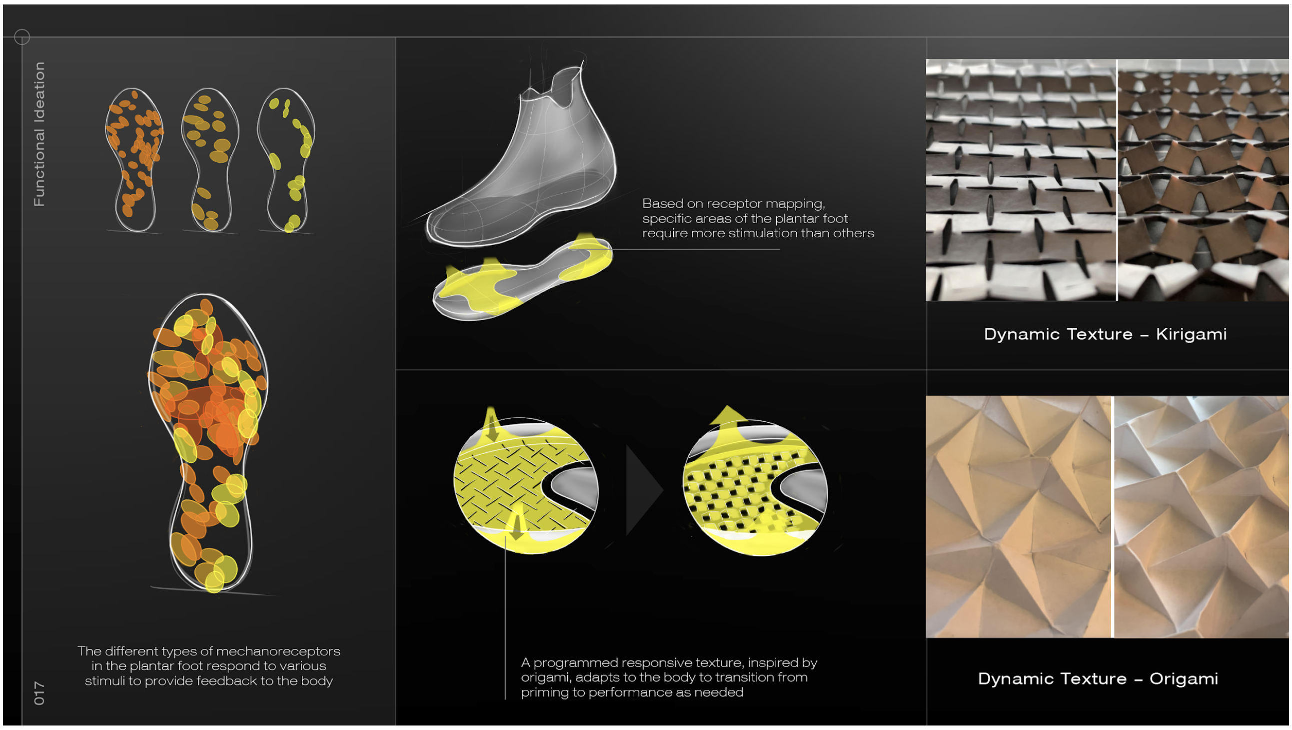


Fig. 45. Ideation process of footbed design

For the upper of the shoe, I primarily focused on integrating SMP active textile zones to provide light resistance and enhance positional awareness through tactile feedback. I drew inspiration from ankle taping, as studies show it enhances positional awareness regardless of whether the tape restricts motion or not (Robbins et al., 1995). The tape provides external reference to ankle position, improving the athlete's perception of their body in movement and in space.

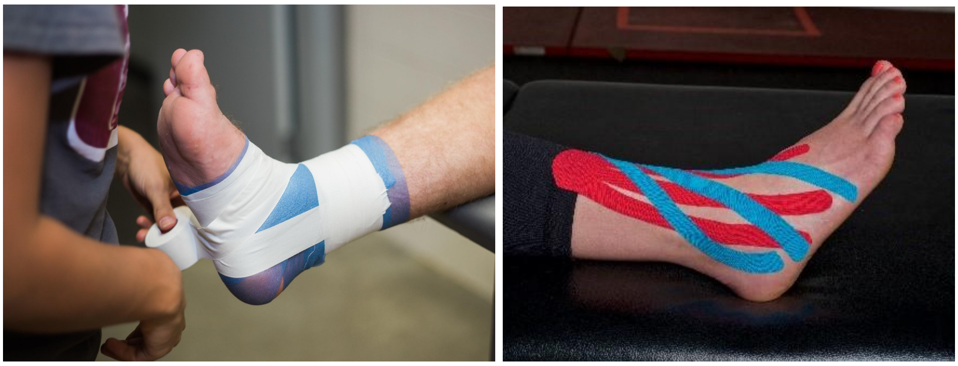


Fig. 46. Ankle taping methods

Ideation using elastic applied to socks, much like my functional ideation process with the garment, provided feedback for elastic placement. This ideation was performed on the athlete, who was tasked with performing dynamic movements so as to gather more accurate, sport-specific feedback. It was my intention that these areas could be integrated with SMPs to provide light resistance and feedback just like the garment.

Fig. 47. Dynamic Foot Studies With Elastic

Following these studies, I marked on a last the key areas to target with these resistance elements in order to mock up a more refined prototype. Rough sketching over the last was refined as an aesthetic direction took shape and the rest of the shoe was designed.

Fig. 48. Rough and refined sketching on shoe last

The compiled research and ideation of the upper shows a refined mockup and the key influencing factors in its development: ankle taping, anatomy studies, and elastic ideation.

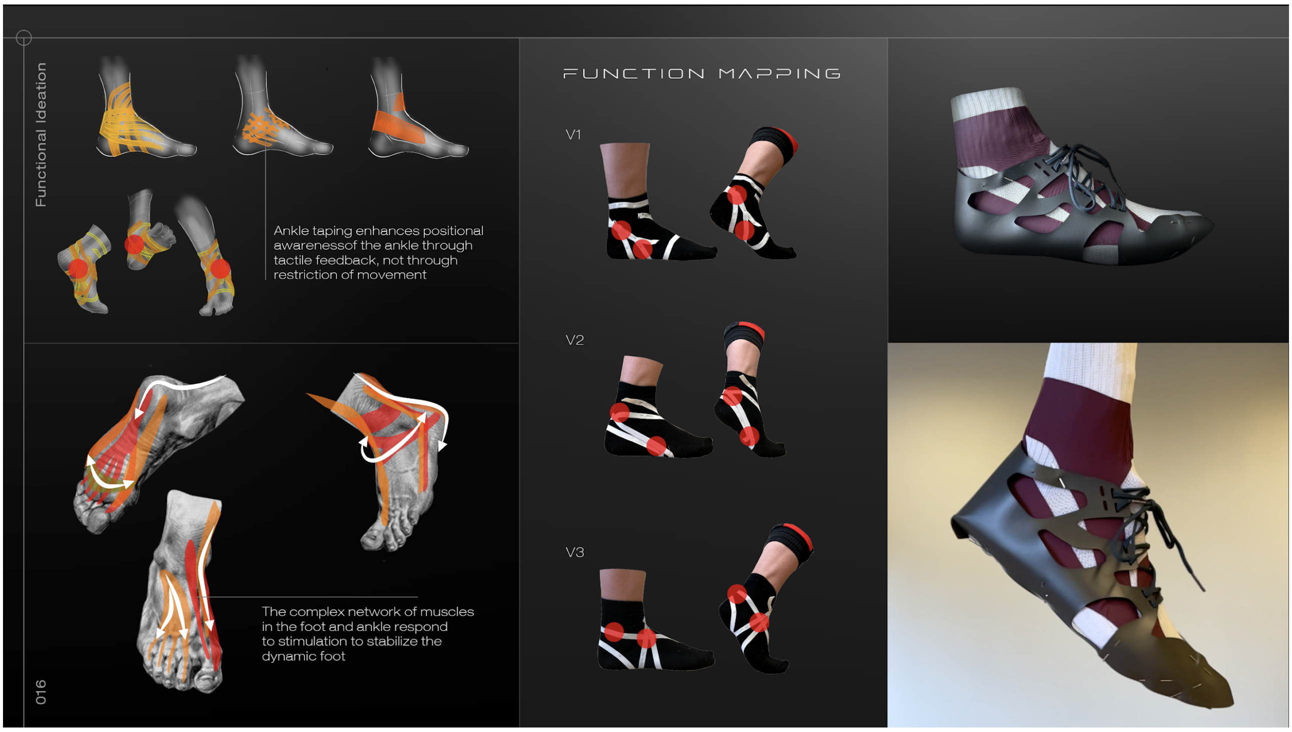


Fig 49. Ideation process for upper design

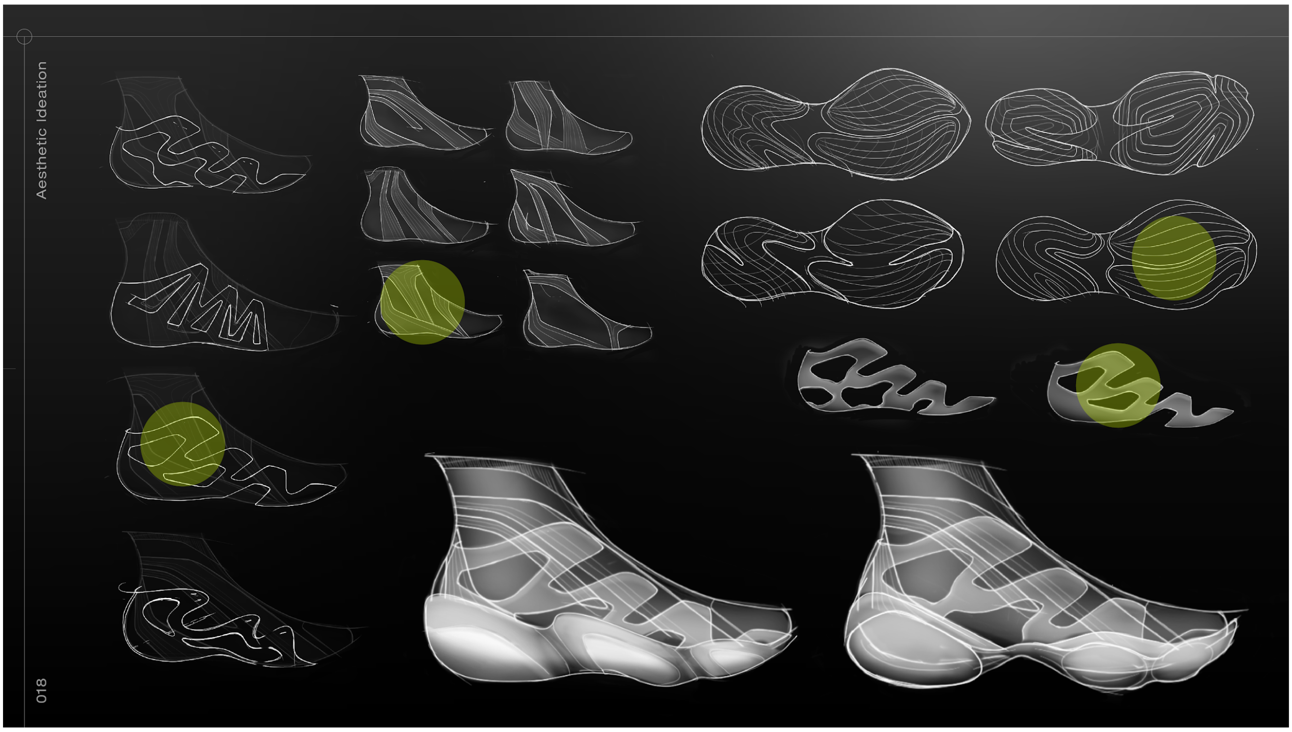


Fig. 50. Aesthetic ideation for shoe

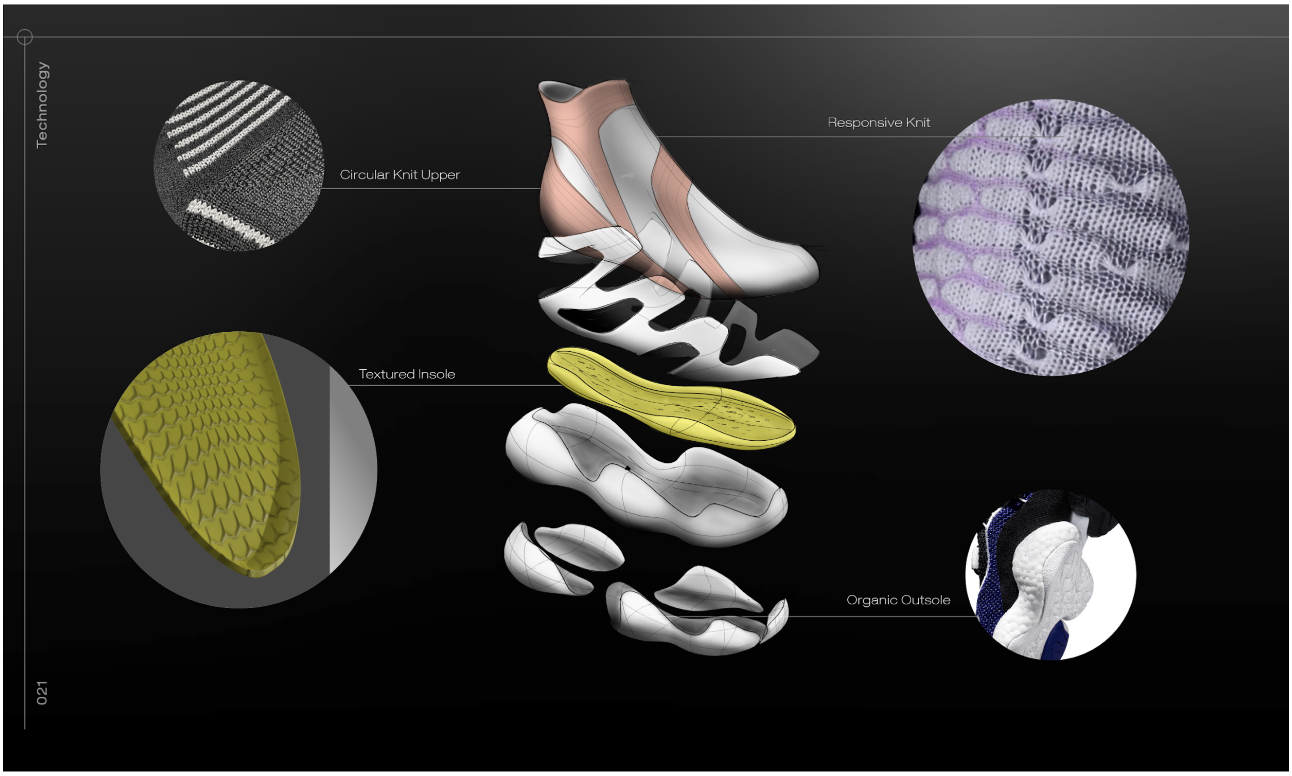


Fig. 51. Exploded view showing key elements of shoe design

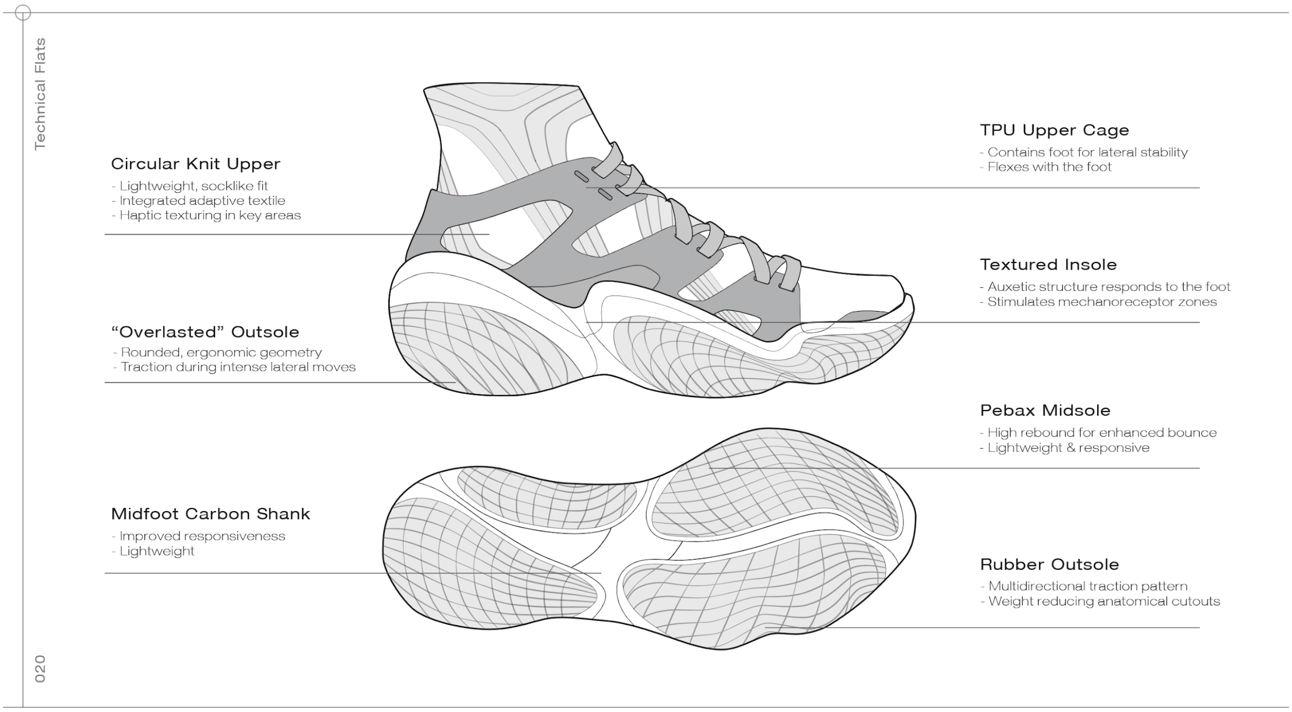


Fig. 52. Technical drawing of shoe with callouts

The finalized shoe features a circular knit upper with integrated SMP zones, overlaid with a TPU cage for proper foot containment. Within the shoe, a textured footbed inspired by the Ron Resch triangle tessellation provides variable texture to the foot. The midsole is a high-rebound pebax foam with a durable rubber outsole for traction on-court.

Fig. 53. Rendering of final shoe concept

Testing & Validation

The testing and validation protocol for the completed garments will be performed using a FLIR thermal imaging camera in order to assess whether the product activates muscles and warms up the body more than traditional compression garments. The FLIR camera gives a clear visual reference to compare the products for this preliminary validation. We anticipate a 10% increase in muscles activation and neuromuscular priming, measured by the change in temperature between control and test subject thermal imaging.

PHASE III: Product Creation & Launch

Overview

This final phase of the Graduate Thesis Project involved developing & delivering a functional prototype & compelling consumer experience to potential users. Given the 10-week allotted time frame, I chose to focus my efforts on developing the apparel component of the project. The line plan of this project has been distilled to include a ¾ length tight, compression top, & shooting sleeve specific to basketball.

Technologies

The previous phase of the project, two specific technologies were pinpointed as the most feasible and functional to apply to this garment. These technologies aim to facilitate two primary functions: muscular resistance and proprioceptive feedback. First, adaptive textiles with integrated shape-memory polymeric yarns allow fabrics to change shape in response to external stimuli. This technology can be applied to create adaptive resistance, in which SMP yarns integrated into a fabric tighten and loosen to provide resistance when the body needs it, and diminishes as the body becomes sufficiently primed. Next-to-skin texturing, vetted and used primarily in clinical applications such as physical therapy, is shown to improve joint awareness and proprioception. This technology has not yet been widely utilized in the sports product arena but is extremely promising.

Body Mapping

The myofascial studies completed in Phase II informed the body mapping of the two specific technologies, adaptive resistance and next-to skin texturing. The figures below show the complete body mapping of each of these technologies, as well as a combined body map .

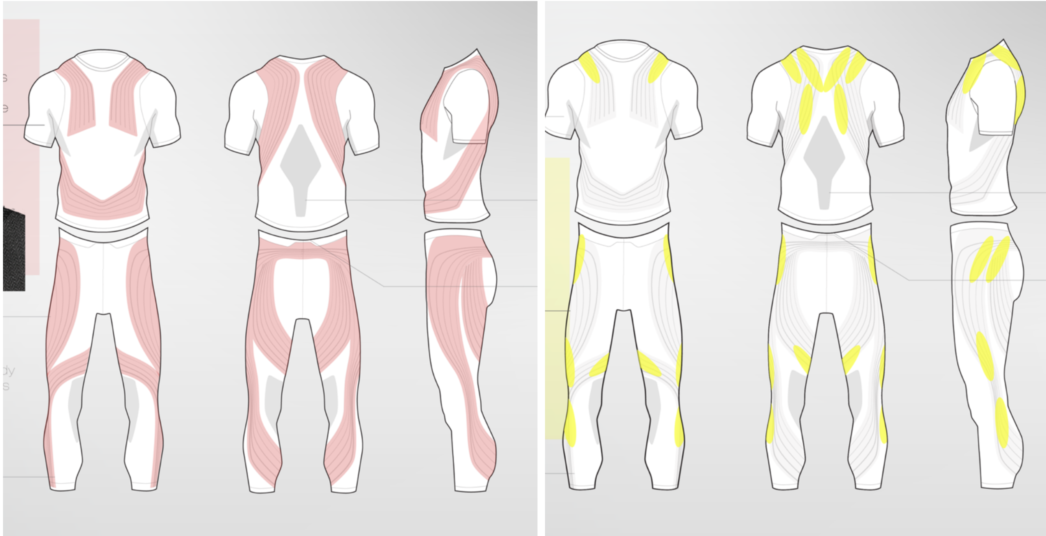


Fig. 54. Body mapping of adaptive resistance (red) and next-to-skin texturing (yellow)

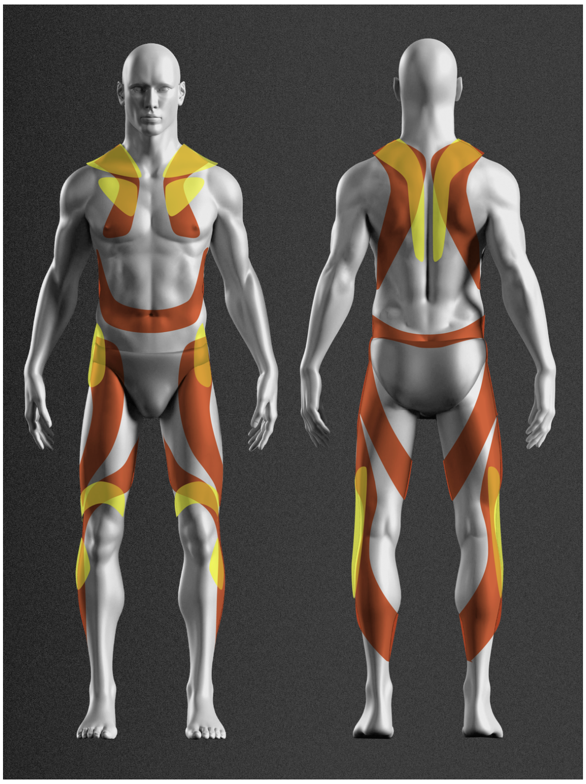


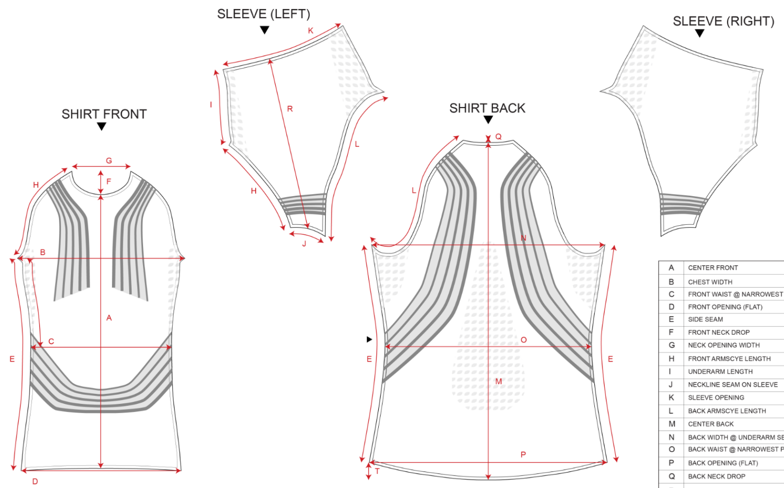
Fig. 55. Combined body mapping of adaptive resistance (red) and next to skin texturing (yellow)

Manufacturing

The intended construction of the garment is an engineered knit with shape memory polymer yarns integrated into the knit construction. The following documents show preliminary knit zoning to be communicated to a knit factory on flatbed knitting machines. Below is a mockup of a technical knit package that would be delivered to the factory.

GARMENT DIMENSIONS

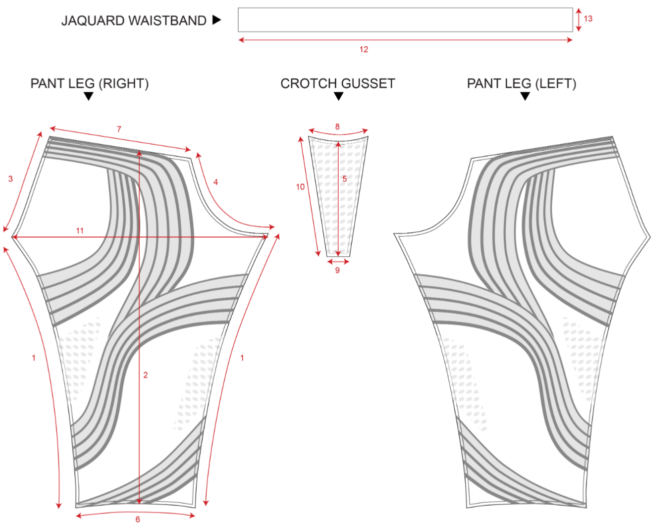
MEN'S ENGINEERED KNIT COMPRESSION TOP



A	CENTER FRONT	24"
B	CHEST WIDTH	14.5"
C	FRONT WAIST @ NARROWEST POINT	12.25
D	FRONT OPENING (FLAT)	14"
E	SIDE SEAM	19"
F	FRONT NECK DROP	2"
G	NECK OPENING WIDTH	5"
H	FRONT ARMSCYE LENGTH	9"
I	UNDERARM LENGTH	7"
J	NECKLINE SEAM ON SLEEVE	3"
K	SLEEVE OPENING	11"
L	BACK ARMSCYE LENGTH	14.25"
M	CENTER BACK	29.5"
N	BACK WIDTH @ UNDERARM SEAM	20.25"
O	BACK WAIST @ NARROWEST POINT	18"
P	BACK OPENING (FLAT)	20.75"
Q	BACK NECK DROP	0.25"
R	SLEEVE LENGTH	15.25"
S	WAIST PLACEMENT FROM UNDERARM SEAM	8"
T	BACK HEM DROP	1.5"

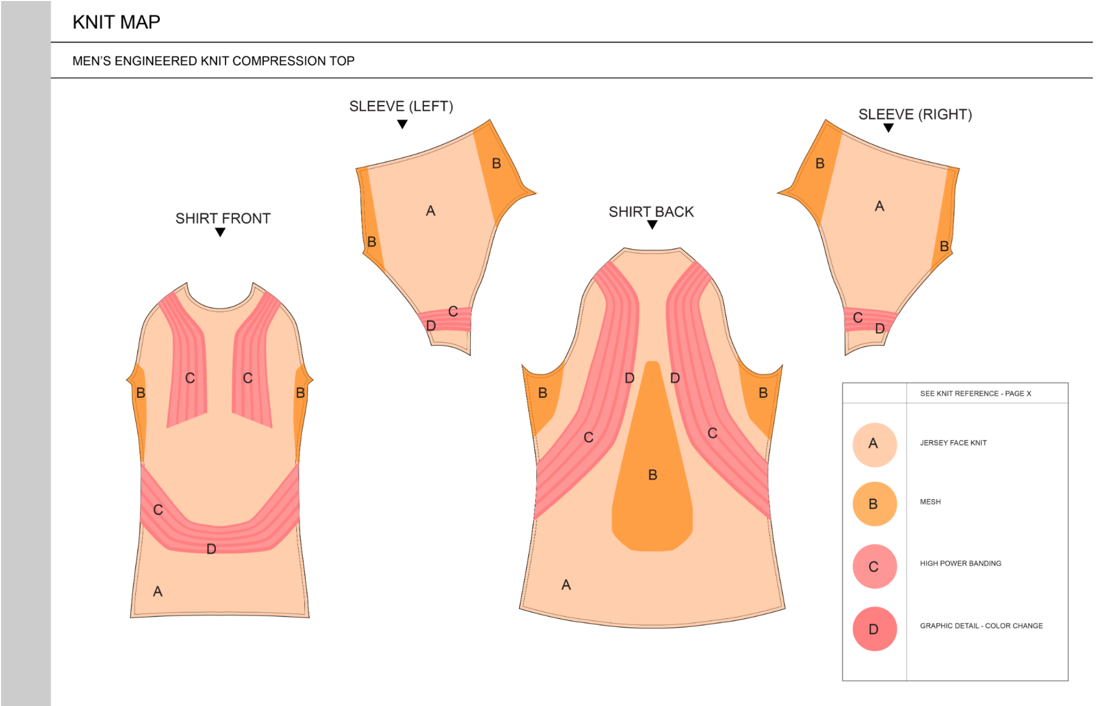
GARMENT DIMENSIONS

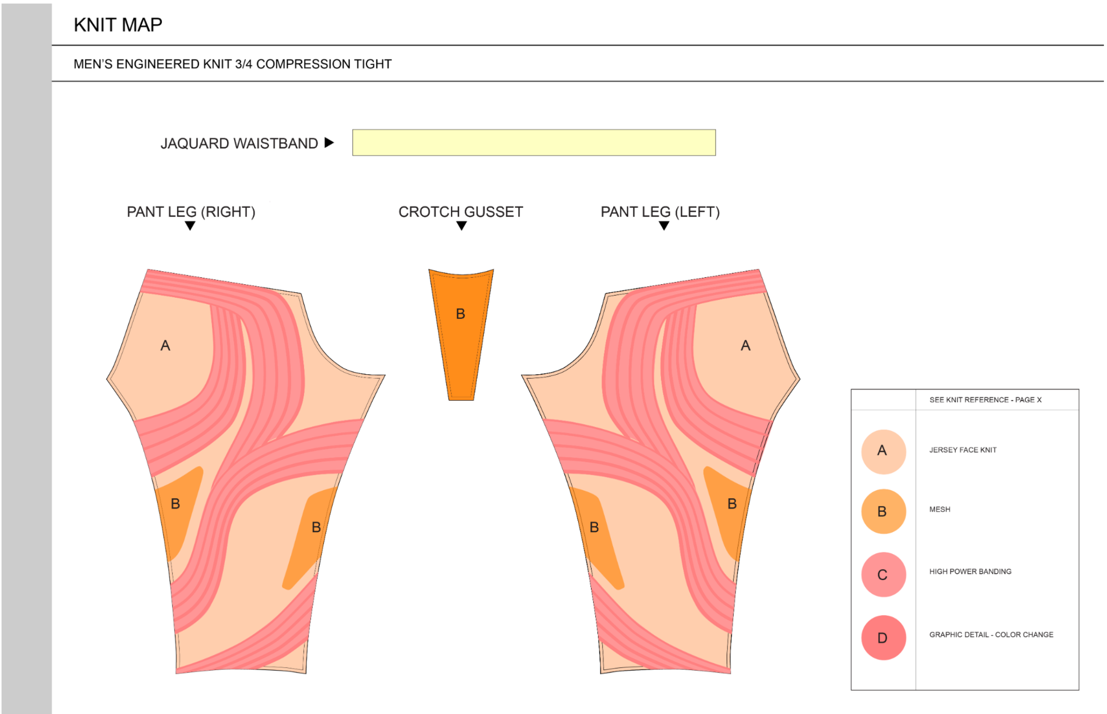
MEN'S ENGINEERED KNIT 3/4 COMPRESSION TIGHT



1	INSEAM	24"
2	OUTSEAM	29.5"
3	BACK CROTCH (NO WAISTBAND)	9"
4	FRONT SEAM (NO WAISTBAND)	10.5
5	CENTER FRONT CROTCH LENGTH (NO WAISTBAND)	9.5"
6	LEG OPENING	10"
7	WAIST	12"
8	CROTCH GUSSET TOP	5"
9	CROTCH GUSSET BOTTOM	2"
10	CROTCH GUSSET SIDE LENGTH (NO WAISTBAND)	10.25"
11	THIGH OPENING CIRCUMFERENCE @ CROTCH SEAM	21.5"
12	WAISTBAND LENGTH	28"
13	WAISTBAND WIDTH	2"

Figs. 56-57. Technical flat knit pattern pieces





Figs. 58-59. Color-coded knit schematic

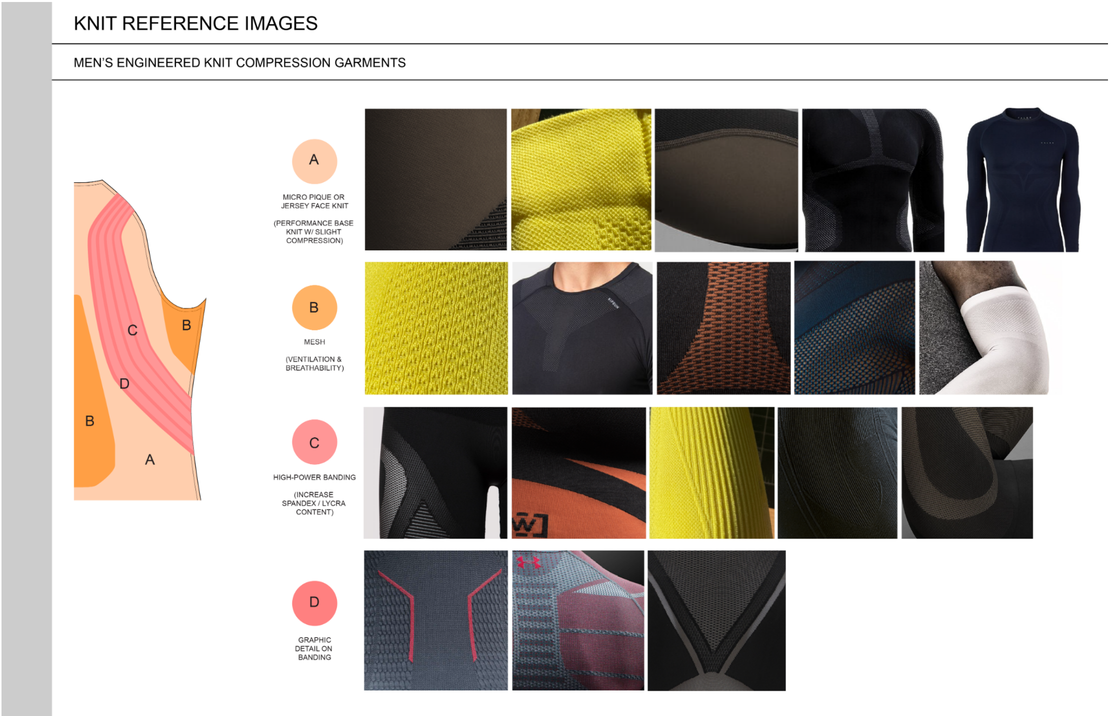


Fig. 60. Engineered Knit Reference Images

Prototyping

The prototyping process focused on the application of texturing on the interior of a garment and achieving a proper compression fit for the garments in general. The methods used in this prototyping phase included 3d printing directly onto fabric, as well as using heat transfer vinyl with 3d puff properties.

Fig. 61. Prototype samples of next to skin texturing

To achieve proper fit and compression on the athlete's body, multiple fittings and rounds of prototyping were needed. Challenges included fitting the chest and armscye properly, as well as reducing bunching at the back of the neck.

Figs. 62-63. Prototyping to improve garment fit

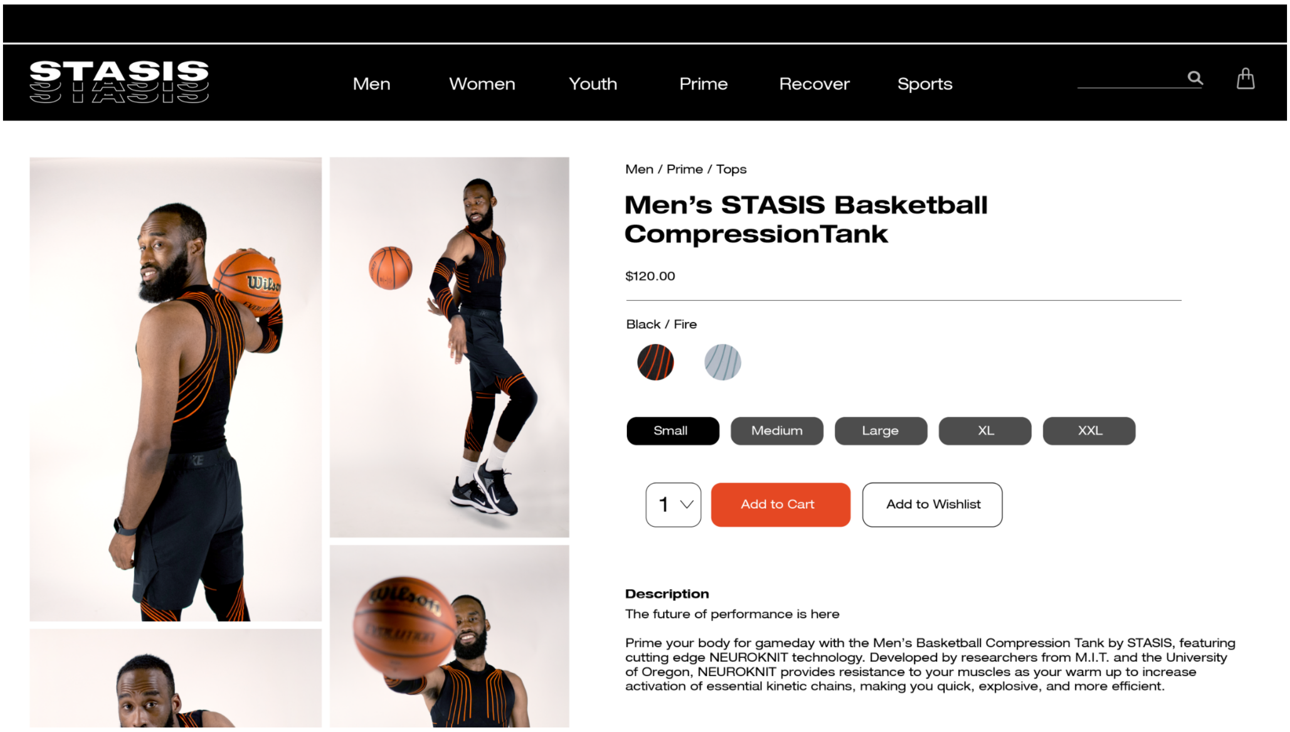
Final Prototypes

Figs. 64-67. Final garment prototypes on fit model

Packaging

Packaging and ecommerce mockups for this product balance existing design language and familiarity with new & playful features. The website keeps in line with existing sports product ecommerce sites, in which the product is showcased in an athletic setting, while the unique technology within the garment is featured in the copy below.

Packaging mockups depart from traditional sports packaging in order to showcase the unique technology of the product and set the brand apart from others in the market. The resealable packaging features a clear window in which the consumer can see the specialized adaptive yarns directly on the product. On the reverse, information about this cutting-edge technology is shown to help the consumer understand why this product is unique and innovative.

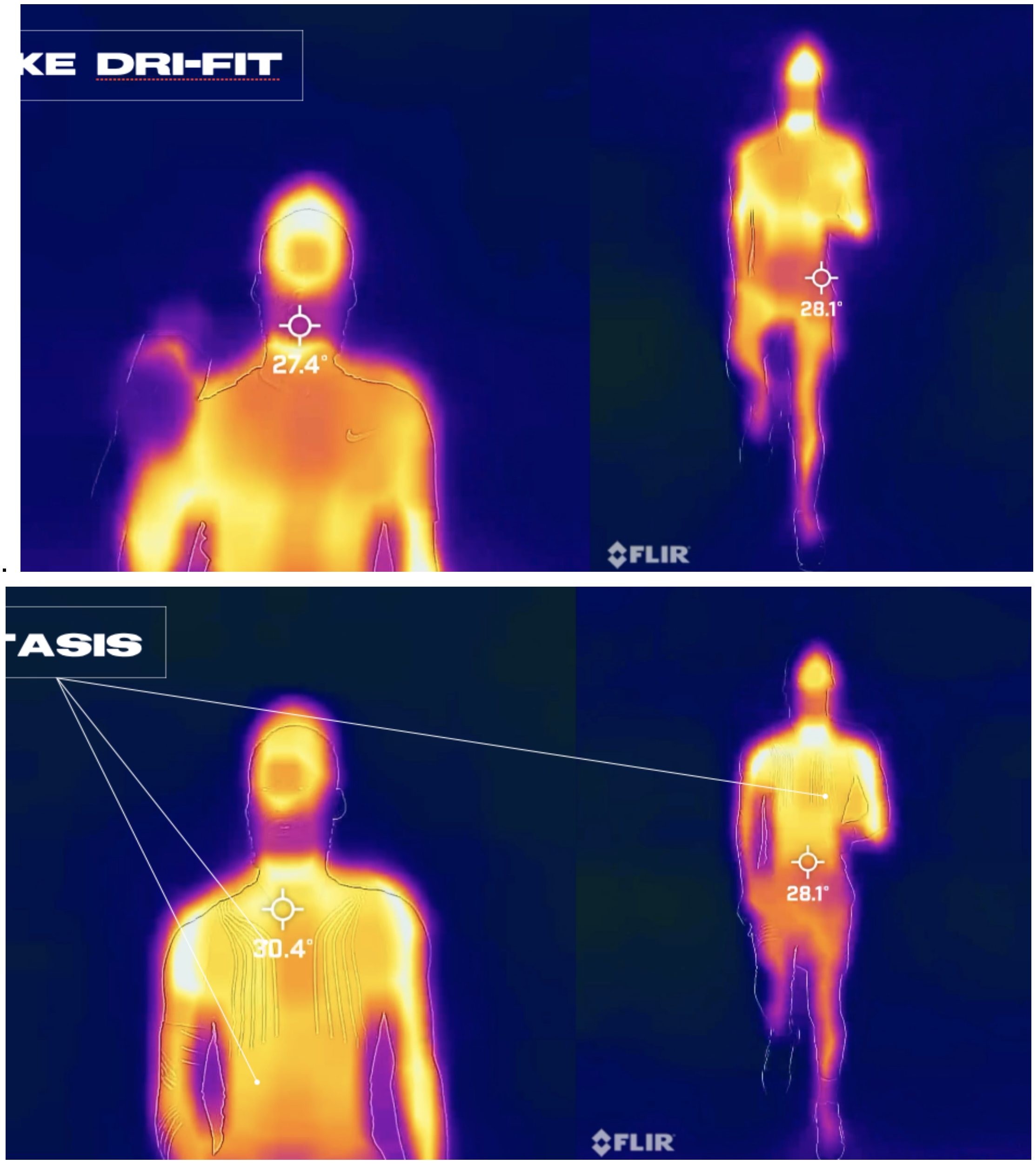


Figs. 68. Ecommerce mockup

Figs. 69. Packaging mockup

Validation

Using the FLIR thermal imaging camera, I assessed the performance of the STASIS garment collection as compared to Nike Dri-Fit compression, a popular current choice for basketball athletes. The results show a 2 degree increase in temperature in the trunk of the body, with markedly increased activation in the pectoral and abdominal areas, key zones for muscle stabilization and posture control. This calculates as approximately 7% increase in muscle activation, close to the anticipated 10%, but more tests are needed to achieve further validation.



Figs. 70-71. Validation testing using FLIR thermal imaging

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Appendix A - Patent Landscape

Weighted Blankets:

- US9833509B2 (Bioceramic Compositions and Biomodulatory Uses Thereof)

US009833509B2

(12) **United States Patent**
Vissman et al.

(10) **Patent No.: US 9,833,509 B2**
(45) **Date of Patent: Dec. 5, 2017**

(54) **BIOCERAMIC COMPOSITIONS AND BIOMODULATORY USES THEREOF**

(71) Applicant: **Multiple Energy Technologies LLC**, Washington, PA (US)

(72) Inventors: **Shannon Vissman**, Upper St. Clair, PA (US); **Francisco Jose Cidral-Filho**, Washington, PA (US); **Francisco de Paula Moreira**, Florianópolis (BR); **Steven Midttun**, Boca Raton, FL (US)

(73) Assignee: **MULTIPLE ENERGY TECHNOLOGIES LLC**, Washington, PA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/702,467**

(22) Filed: **May 1, 2015**

(65) **Prior Publication Data**

US 2015/0335742 A1 Nov. 26, 2015

Related U.S. Application Data

(60) Provisional application No. 62/115,567, filed on Feb. 12, 2015, provisional application No. 62/064,939,
(Continued)

(51) **Int. Cl.**
B32B 1/02 (2006.01)
A61K 41/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***A61K 41/0052*** (2013.01); ***A61K 33/00*** (2013.01); ***A61K 33/08*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B32B 1/02; Y10T 428/1352; A41B 1/00; A61K 33/00; A61K 33/08; C04B 33/04; A61N 5/0613; A61M 21/02
See application file for complete search history.

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(Continued)

Primary Examiner — Marc A Patterson
(74) *Attorney, Agent, or Firm* — Wilson Sonsini Goodrich & Rosati

(57) **ABSTRACT**

The subject matter described herein is directed to articles, compositions, systems, and methods of using and preparing bioceramic compositions and to the bioceramic compositions. A bioceramic composition of the disclosure radiates infrared energy or rays and can be used in the treatment of various conditions.

15 Claims, 51 Drawing Sheets

- US20040225049A1 (Composition for Far Infrared Irradiation with Excellent Antistatic Property and Fiber and Textile Product Both Containing the Same)

US 20040043209A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2004/0043209 A1**
Schnurer et al. (43) **Pub. Date: Mar. 4, 2004**

(54) **POLYMERIC FIBER COMPOSITION AND METHOD**

(76) Inventors: **John H. Schnurer**, Yellow Springs, OH (US); **Robert Michael Klein**, Los Angeles, CA (US); **David Dru Horinek**, Camarillo, CA (US)

Correspondence Address:
Rachele Wittwer
IRELL & MANELLA LLP
Suite 900
1800 Avenue of the Stars
Los Angeles, CA 90067 (US)

(21) Appl. No.: **10/396,131**

(22) Filed: **Mar. 24, 2003**

Related U.S. Application Data

(60) Provisional application No. 60/366,237, filed on Mar. 22, 2002.

Publication Classification

(51) **Int. Cl.**[7] **B32B 5/16**

(52) **U.S. Cl.** **428/327**; 428/328

(57) **ABSTRACT**

The present invention generally relates to specific combinations of active particles, forming a powder, that may be combined with carrier materials such as resins to produce fibers for textiles, films, coatings, and/or protective or insulating materials. The specific mixture of particles and materials may be carefully engineered to impart unique and valuable properties to end products including integration with optical energies, heat, and other electromagnetic energies. Resultant compositions may interact with light in the visible spectrum and optical and electromagnetic energy beyond the visible spectrum.

- US20200238045A1 (Therapeutic Blanket)

US 20200238045A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0238045 A1**
Pacheco (43) **Pub. Date: Jul. 30, 2020**

(54) **THERAPEUTIC BLANKET**

(71) Applicant: **CapeAble Sensory Products, LLC**, Winona Lake, IN (US)

(72) Inventor: **Marna G. Pacheco**, Winona Lake, IN (US)

(73) Assignee: **CapeAble Sensory Prodcuts, LLC**, Winona Lake, IN (US)

(21) Appl. No.: **16/845,545**

(22) Filed: **Apr. 10, 2020**

Related U.S. Application Data

(63) Continuation-in-part of application No. 15/701,762, filed on Sep. 12, 2017, now Pat. No. 10,617,158, which is a continuation-in-part of application No. 14/693,958, filed on Apr. 23, 2015, now abandoned.

(60) Provisional application No. 62/001,445, filed on May 21, 2014.

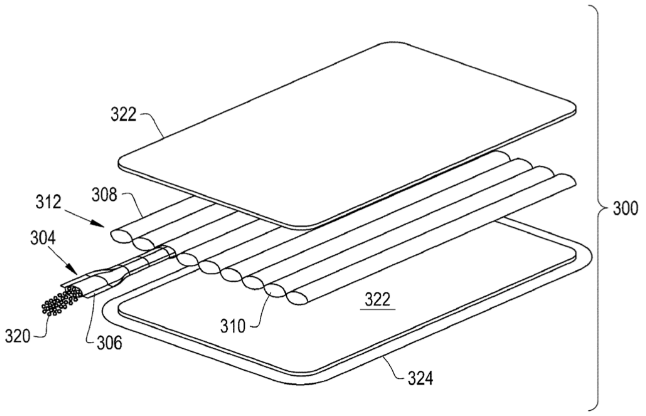
Publication Classification

(51) **Int. Cl.**
A61M 21/00 (2006.01)
A47G 9/02 (2006.01)
A47G 9/00 (2006.01)
A61M 21/02 (2006.01)

(52) **U.S. Cl.**
CPC ***A61M 21/00*** (2013.01); ***A47G 9/0223*** (2013.01); *A61M 2205/0205* (2013.01); ***A61M 21/02*** (2013.01); *A61M 2021/0022* (2013.01); ***A47G 9/007*** (2013.01)

(57) **ABSTRACT**

A therapeutic blanket including first and second outer layers that are attached together, and an internal matrix of generally equal sized cells. Each cell containing a measured weighted mass, the mass being held within the respective cell. The matrix being secured to the first and second outer layers along an outer perimeter of the blanket.



- US20200255791A1 (Layered Yarn and Weighted Blanket for Deep Pressure Therapy)

US 20200155791A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2020/0155791 A1
Hamm (43) Pub. Date: May 21, 2020

(54) LAYERED YARN AND WEIGHTED BLANKET FOR DEEP PRESSURE THERAPY

(71) Applicant: Kathrin Hamm, Nufringen (DE)

(72) Inventor: Kathrin Hamm, Nufringen (DE)

(21) Appl. No.: 16/193,792

(22) Filed: Nov. 16, 2018

Publication Classification

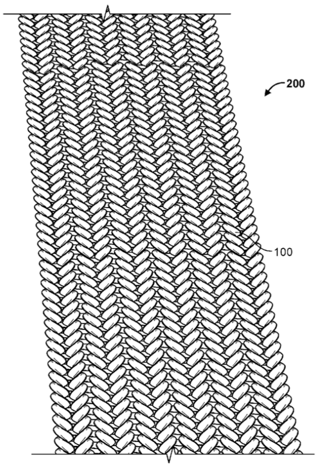
(51) Int. Cl.

A61M 21/02	(2006.01)
D04B 1/22	(2006.01)
D04B 31/00	(2006.01)
D04B 21/20	(2006.01)

(52) U.S. Cl.
CPC *A61M 21/02* (2013.01); *D04B 1/22* (2013.01); *A61M 2021/0022* (2013.01); *D04B 21/20* (2013.01); *D04B 31/00* (2013.01)

(57) ABSTRACT

Disclosed is a weighted material that is configured to effectuate deep pressure therapy to a person when a piece of the weighted material is used as a blanket over the person's body. A length of layered yarn is interlooped to form the piece of weighted material. The layered yarn includes an outer tube extending longitudinally from a first end to a second end. The outer tube defines a conduit extending longitudinally therethrough from the first end to the second end. A plurality of inner layers of material are disposed within the conduit and extend longitudinally from the first end to the second end. The interlooped length of yarn, by itself, is configured and sufficiently weighted to effectuate deep pressure therapy to a person when the blanket lies over the person's body. Various other systems and methods are also disclosed.



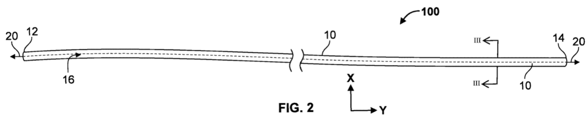


FIG. 2

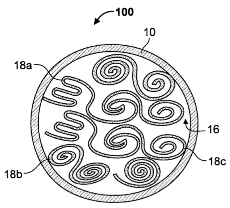


FIG. 3

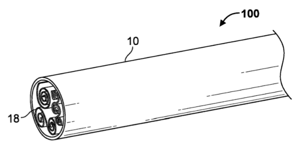


FIG. 4

- US20200196685A1 (Wearable Blanket with Distributed Weight System)

US 20200196685A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0196685 A1**
Williams (43) **Pub. Date: Jun. 25, 2020**

(54) **WEARABLE BLANKET WITH DISTRIBUTED WEIGHT SYSTEM**

(71) Applicant: **Tara Williams**, Danville, CA (US)

(72) Inventor: **Tara Williams**, Danville, CA (US)

(21) Appl. No.: **16/664,941**

(22) Filed: **Oct. 27, 2019**

Related U.S. Application Data

(60) Provisional application No. 62/783,191, filed on Dec. 20, 2018.

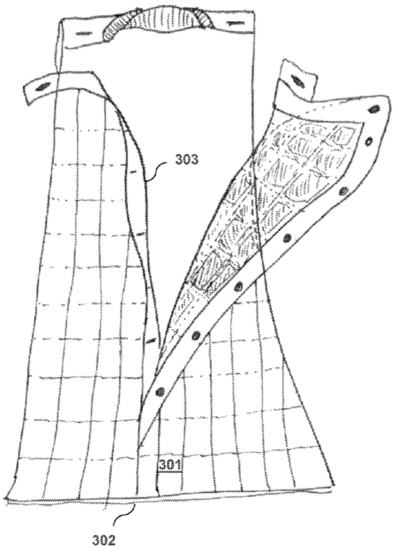
Publication Classification

(51) **Int. Cl.**
A41D 11/00 (2006.01)
A47G 9/02 (2006.01)
A47G 9/04 (2006.01)

(52) **U.S. Cl.**
CPC *A41D 11/00* (2013.01); *A47G 9/04* (2013.01); *A47G 9/0223* (2013.01)

(57) **ABSTRACT**

A wearable blanket with a distributed weight system for providing gentle and soothing weight on an infant's body without excessive pressure with optional swaddling wings that are removably attached to the wearable blanket. The wearable blanket has an array of subpanels containing weight or pressure-inducing material that can be adjusted to provide evenly distributed weight throughout the front panel of the wearable garment or create a weight gradient to provide more focused weighted support to particular areas of the wearable blanket depending on the physical or medical need of the wearer. The subpanels are compartmentalized and separated from one another to prevent undesirable movement or accumulation of weighed material and may include individual pouches or containers to hold the weight or pressure-inducing material that allows for customization and adjustment of any of a number of the subpanels that constitute the distributed weight system.



Footwear:

- USD621594S (Sandal)

US00D621594S

(12) **United States Design Patent** (10) **Patent No.: US D621,594 S**
Diaz (45) **Date of Patent: ** Aug. 17, 2010**

(54) **SANDAL**

(75) Inventor: **Juan Antonio Diaz**, Lake Oswego, OR (US)

(73) Assignee: **White Water Enterprises LLC**, Hull, MA (US)

(**) Term: **14 Years**

(21) Appl. No.: **29/357,291**

(22) Filed: **Mar. 10, 2010**

(51) **LOC (9) Cl.** **02-01**
(52) **U.S. Cl.** **D2/953**; D2/916; D2/951
(58) **Field of Classification Search** .... D2/916, D2/947, 949, 951, 952, 953, 957, 959, 960; D25/153, 156; 36/3 B, 22 R, 24.5, 25 R, 36/67 A, 59 C, 103
See application file for complete search history.

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D530,063	S	*	10/2006	Issler	D2/916
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D564,734	S	*	3/2008	Krompasick et al.	D2/916
D565,285	S	*	4/2008	Duffy et al.	D2/953
D571,087	S	*	6/2008	Dillenbeck et al.	D2/953
D574,134	S	*	8/2008	Petrie	D2/960
D577,184	S	*	9/2008	McMillan	D2/960
D578,279	S	*	10/2008	del Biondi et al.	D2/916

(Continued)

Primary Examiner—Celia A Murphy
(74) *Attorney, Agent, or Firm*—Sunstein Kann Murphy & Timbers LLP

(57) **CLAIM**

The ornamental design for a sandal, as shown and described.

DESCRIPTION

FIG. **1** is an upper perspective view of a sandal showing my design;

FIG. **2** is a lower perspective view of the sandal of FIG. **1**;

FIG. **3** is a bottom plan view of the sandal of FIG. **1**;

FIG. **4** is a top plan view of the sandal of FIG. **1**;

FIG. **5** is right side elevational view of the sandal of FIG. **1**;

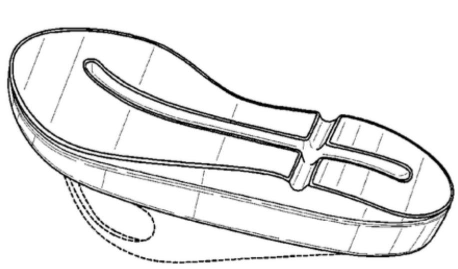
FIG. **6** is left side elevational view of the sandal of FIG. **1**;

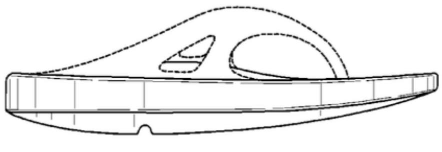
FIG. **7** is a front elevational view of the sandal of FIG. **1**; and,

FIG. **8** is a rear elevational view of the sandal of FIG. **1**.

Straps of the sandal are shown in broken line for illustrative purposes only and form no part of the claimed design.

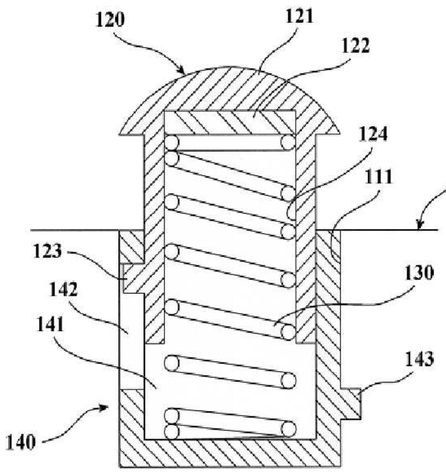
1 Claim, 4 Drawing Sheets

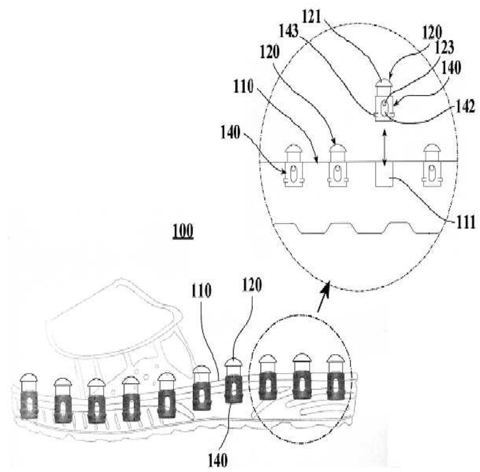




- KR200431316Y1 (Footgear and Insole for Performing Acupressure)

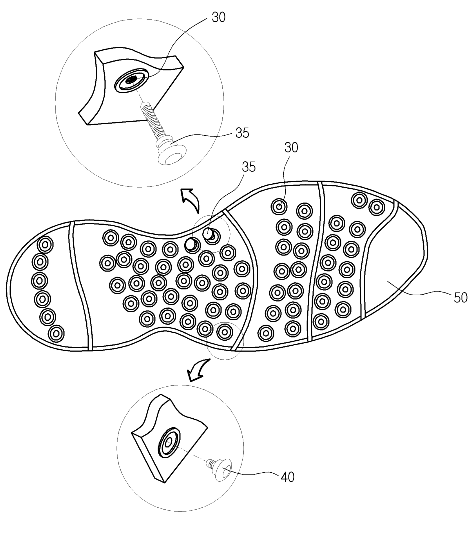
Abstract: The present invention relates to acupressure shoes and insoles, in acupressure shoes such as slippers, sandals, shoes, sneakers having acupressure function, a number of acupressure protrusions for acupressure the sole of the foot protrudes by the elastic force from the bottom surface. Therefore, the present invention provides continuous acupressure on the sole of the foot according to the weight or movement of the user, and the acupressure protrusion protruding by the elastic force stimulates the acupoints at any time when worn, thereby promoting blood circulation and releasing fatigue. It has the effect of acupressure, promotes blood circulation due to magnetism, helps the discharge of waste products in the body, and it contains nanosilver, which is hygienic to human body through sterilization and antibacterial action of harmful bacteria such as viruses, bacteria and fungi. In addition to causing the air flow by the lifting of the foot sole to minimize the area in contact with the bottom surface is excellent in athlete's foot prevention, and has the effect of easily controlling the size of the pressure on the sole.

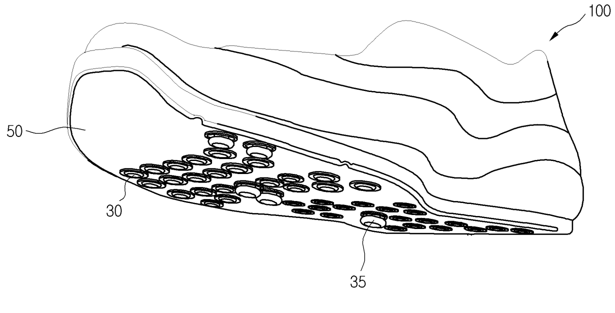




- KR100732496B1 (Shoes for Acupressure)

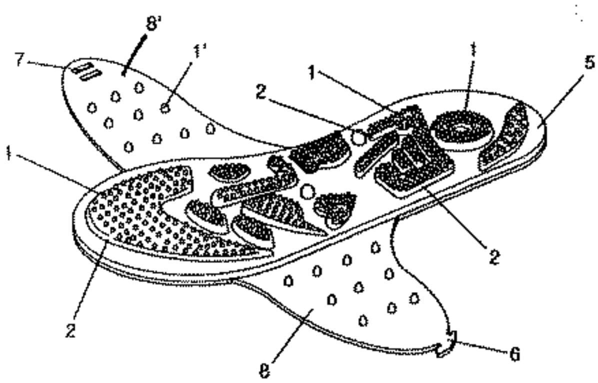
Abstract: The present invention drills acupressure hole in the sole of the shoe to correspond to the position of the foot reflexes and inserts a shiatsu rod into it so that effective acupressure can be achieved without direct stimulation to the sole for acupressure for activating the overall system function of the human body It's about shoes.Acupressure shoe according to the present invention is characterized in that it comprises a shiatsu hole formed in the midsole and the outsole, and a shiatsu rod fitted in the acupressure hole in a normal shoe composed of an upper part, an insole and an outsole part.Therefore, according to the present invention, the acupressure hole is inserted into the sole of the shoe and the acupressure rod is inserted therein to make the effective acupressure without applying a direct stimulus to the sole and at the same time the acupressure rod has excellent elasticity and resilience and excellent shock absorption ability. It is made of gel material, so there is no pain or discomfort even for a long time, and it has an excellent effect such that anyone can use it without any objection.

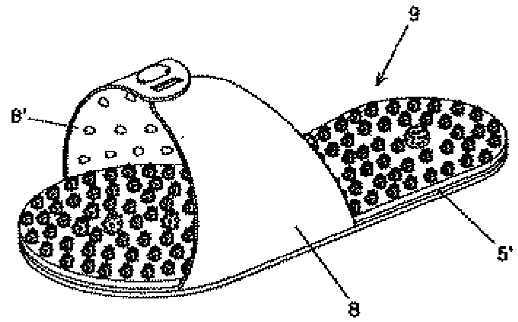




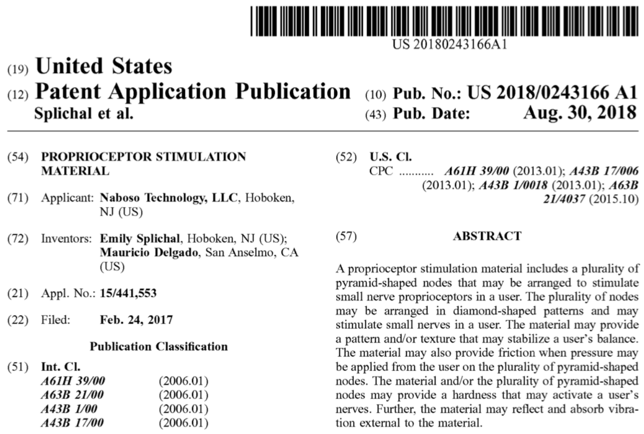
- JP3103838U (Shiatsu Slippers)

PROBLEM TO BE SOLVED: To provide a Shiatsu slipper which has been conventionally used, in which a Shiatsu which can be shiatsu is formed only on one surface of an inner bottom, and various Shiatsu tools cannot be selectively used, and various Shiatsu tools are used. There was the problem that one had to purchase individual shiatsu slippers in order to do so.
SOLUTION: An inner bottom 5 in which acupoint acupressure tool 2 provided with acupressure projection 1 and semicircular acupressure tool 4 provided with acupressure needle 3 are formed on each side, acupressure projection 1 ', coupling tool 6, and coupling tool through hole. 7 are provided, and a semicircular acupressure tool 4 provided with an acupressure needle 3 is formed on one surface of the inner sole 5 ', and a semicircular projection 10 is formed on the other surface. So that the semicircular acupressure tool 4 and the semicircular projection 10 can be selectively used, or the acupoint acupressure tool 2 provided with the acupressure projection 1 on one surface of the inner bottom 5 ″. A semicircular projection 10 was formed on the surface so that the acupoint acupressure tool 4 and the semicircular projection 10 could be selectively used.





- US20180243166A1 (Proprioceptor Stimulation Material)


US 20180243166A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2018/0243166 A1**
Splichal et al. (43) **Pub. Date: Aug. 30, 2018**

(54) **PROPRIOCEPTOR STIMULATION MATERIAL**

(71) Applicant: **Naboso Technology, LLC**, Hoboken, NJ (US)

(72) Inventors: **Emily Splichal**, Hoboken, NJ (US); **Mauricio Delgado**, San Anselmo, CA (US)

(21) Appl. No.: **15/441,553**

(22) Filed: **Feb. 24, 2017**

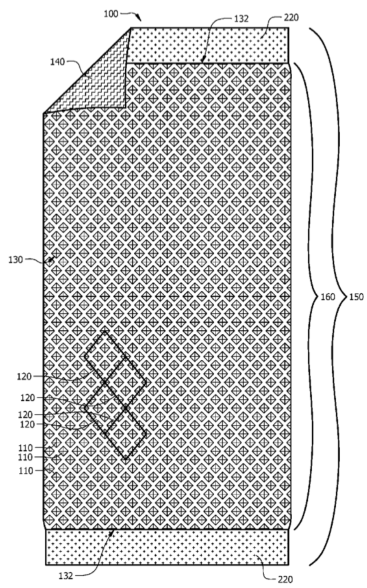
Publication Classification

(51) **Int. Cl.**
A61H 39/00 (2006.01)
A63B 21/00 (2006.01)
A43B 1/00 (2006.01)
A43B 17/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61H 39/00*** (2013.01); ***A43B 17/006*** (2013.01); ***A43B 1/0018*** (2013.01); ***A63B 21/4037*** (2015.10)

(57) **ABSTRACT**

A proprioceptor stimulation material includes a plurality of pyramid-shaped nodes that may be arranged to stimulate small nerve proprioceptors in a user. The plurality of nodes may be arranged in diamond-shaped patterns and may stimulate small nerves in a user. The material may provide a pattern and/or texture that may stabilize a user's balance. The material may also provide friction when pressure may be applied from the user on the plurality of pyramid-shaped nodes. The material and/or the plurality of pyramid-shaped nodes may provide a hardness that may activate a user's nerves. Further, the material may reflect and absorb vibration external to the material.



- US8051582B2 (Medially or Laterally Textured Footbed)

US008051582B2

(12) **United States Patent**
Nurse et al.

(10) **Patent No.: US 8,051,582 B2**
(45) **Date of Patent: *Nov. 8, 2011**

(54) **MEDIALLY OR LATERALLY TEXTURED FOOTBED**

(75) Inventors: **Matthew Anthony Nurse**, Lake Oswego, OR (US); **Mario A. LaFortune**, Tigard, OR (US)

(73) Assignee: **NIKE, Inc.**, Beaverton, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/829,519**

(22) Filed: **Jul. 2, 2010**

(65) **Prior Publication Data**

US 2010/0269244 A1 Oct. 28, 2010

Related U.S. Application Data

(62) Division of application No. 11/420,572, filed on May 26, 2006, now Pat. No. 7,765,719.

(51) **Int. Cl.**
A43B 13/38 (2006.01)

(52) **U.S. Cl.** .... **36/25 R**; 36/43; 36/144

(58) **Field of Classification Search** .... 36/25 R, 36/43, 144, 44, 140, 141, 143

See application file for complete search history.

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(Continued)

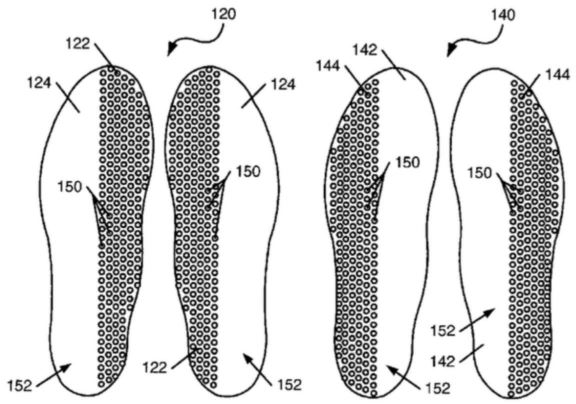
Primary Examiner — Ted Kavanaugh

(74) *Attorney, Agent, or Firm* — Banner & Witcoff, Ltd.

(57) **ABSTRACT**

Footbeds (e.g., in footwear, socks, etc.) for engaging a plantar surface of a wearer's foot include one of the lateral or medial sides having a smooth or substantially smooth feel or surface while the opposite side has a textured feel or surface, e.g., by providing plural raised areas that define the textured feel or surface. Depending on the location of the texturing (lateral side or medial side) and/or the type of ambulatory activity (e.g., running or walking), lower extremity movement during the activity may be affected, e.g., to reduce pronation, reduce maximum eversion, reduce rearfoot range of motion, reduce eversion velocity, reduce plantarflexion when pushing off during a step, reduce inversion at heel strike, reduce eversion range of motion, reduce maximum internal tibial rotation, to increase stability during cutting motions, etc.

24 Claims, 20 Drawing Sheets



- US8540654B2 (Therapeutic Massage Sock)

US008540654B2

(12) **United States Patent**
Davis

(10) **Patent No.: US 8,540,654 B2**
(45) **Date of Patent: Sep. 24, 2013**

(54) **THERAPEUTIC MASSAGE SOCK**

(76) Inventor: **Reginald J. Davis**, Cockeysville, MD (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 948 days.

(21) Appl. No.: **12/383,954**

(22) Filed: **Mar. 30, 2009**

(65) **Prior Publication Data**

US 2010/0249680 A1 Sep. 30, 2010

(51) **Int. Cl.**
A61H 7/00 (2006.01)

(52) **U.S. Cl.**
USPC **601/152**; 601/149

(58) **Field of Classification Search**
USPC 601/148–152; 602/13; 606/201, 606/202

See application file for complete search history.

(56) **References Cited**

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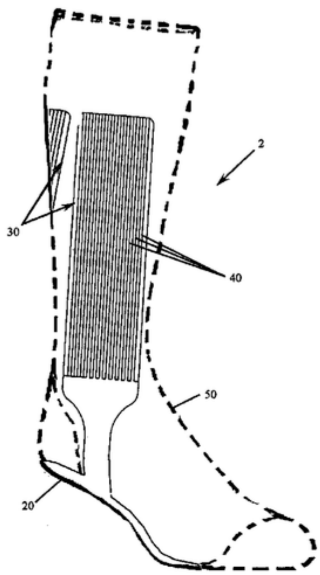
Primary Examiner — Justine Yu
Assistant Examiner — Raymond G Chen

(74) *Attorney, Agent, or Firm* — Ober, Kaler, Grimes & Shriver; Royal W. Craig

(57) **ABSTRACT**

A pneumatic or hydraulic massage sock including a unitary molded insole formed with one or more internal pump chambers for generating fluid pressure throughout the user's gait, and a plurality of interconnected compression pads each containing an array of fluid feed tubes. The compression pads fold up and around the foot and calf substantially enveloping them in a low-profile sock-like configuration. An outer shell is worn overtop to maintain the compression pads against the user's calf. The fluid feed tubes are in fluid communication with the pump insole to provide a self-compressive non-constricting deep-kneading, undulating (wavelike) pattern massage action up the leg in accordance with the full-length heel-to-ball-to-toe foot plant. The massage sock appears as a conventional sock so it can be worn with virtually any conventional pair of shoes. This provides effective unobtrusive relief for individuals with circulatory disabilities, diabetes, arthritis, etc.

14 Claims, 5 Drawing Sheets



- US20150359700A1 (Compressive Therapeutic Device)

US 20150359700A1

(19) **United States**
(12) **Patent Application Publication**
Davis et al.

(10) **Pub. No.: US 2015/0359700 A1**
(43) **Pub. Date: Dec. 17, 2015**

(54) **COMPRESSIVE THERAPEUTIC DEVICE**

(71) Applicant: **NIKE, Inc.**, Beaverton, OR (US)

(72) Inventors: **Carrie L. Davis**, Portland, OR (US); **Michelle L. Mishler**, Tigard, OR (US); **Lee D. Peyton**, Tigard, OR (US); **Eric S. Schindler**, Portland, OR (US); **Bradley W. Wilkins**, Aloha, OR (US)

(73) Assignee: **NIKE, Inc.**, Beaverton, OR (US)

(21) Appl. No.: **14/836,451**

(22) Filed: **Aug. 26, 2015**

Related U.S. Application Data

(63) Continuation of application No. 13/474,442, filed on May 17, 2012, now Pat. No. 9,144,530.

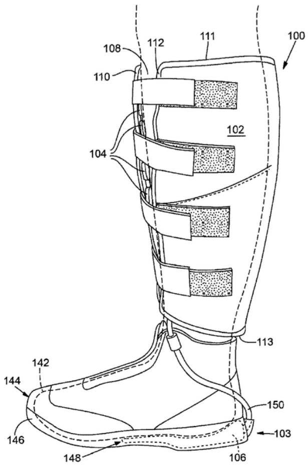
Publication Classification

(51) **Int. Cl.**
A61H 9/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61H 9/0085*** (2013.01); *A61H 2201/164* (2013.01); *A61H 2201/165* (2013.01); *A61H 2201/5002* (2013.01); *A61H 2201/5071* (2013.01); *A61H 2209/00* (2013.01); *A61H 2205/106* (2013.01)

(57) **ABSTRACT**

A device for compressing an extremity of a user includes a wearable support member operable to be worn on the extremity of the user. The device also includes a plurality of chamber members that are arranged across and coupled to the support member. The chamber members each have a respective chamber therein. The chamber is at least partially defined by a base wall that is disposed adjacent the support member, a side wall that is attached to and that extends away from the base wall, and a top wall that is attached to the side wall and that is spaced away from the base wall. Furthermore, a foot pump member is operable to be disposed underneath a foot of the user. The foot pump member is operable to change a pressure inside the chambers as a result of being stepped upon by the user.



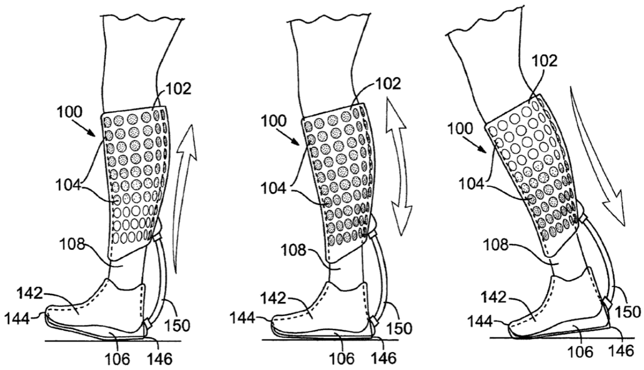


FIG. 6A FIG. 6B FIG. 6C

Sensory Garments:

- US20190246709A1 (Sensory Motor Stimulation Garments and Methods)

US 20190246709A1

(19) **United States**
(12) **Patent Application Publication**
Brown

(10) **Pub. No.: US 2019/0246709 A1**
(43) **Pub. Date: Aug. 15, 2019**

(54) **SENSORY MOTOR STIMULATION GARMENTS AND METHODS**

(71) Applicant: **INTELLISKIN USA, LLC**, WOODBURY, NJ (US)

(72) Inventor: **Timothy W. Brown**, Newport Beach, CA (US)

(21) Appl. No.: **16/392,498**

(22) Filed: **Apr. 23, 2019**

Related U.S. Application Data

(63) Continuation of application No. 13/559,507, filed on Jul. 26, 2012, now Pat. No. 10,264,828, which is a continuation-in-part of application No. 12/756,114, filed on Apr. 7, 2010, now Pat. No. 9,125,442, which is a continuation-in-part of application No. 12/551,420, filed on Aug. 31, 2009, now Pat. No. 9,119,707.

(60) Provisional application No. 61/534,815, filed on Sep. 14, 2011, provisional application No. 61/512,367, filed on Jul. 27, 2011.

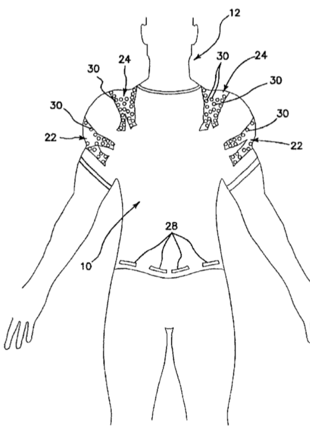
Publication Classification

(51) **Int. Cl.**
A41D 13/00 (2006.01)
A61F 5/02 (2006.01)
A41C 3/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A41D 13/0015*** (2013.01); ***A41C 3/0057*** (2013.01); ***A61F 5/026*** (2013.01)

(57) **ABSTRACT**

A garment includes a form-fitting shirt with an anterior portion and a posterior portion. The form-fitting shirt is fabricated from an elastomeric material. The garment includes a spine band and four shoulder bands, each shoulder band radiating from the spine band and extending over a respective shoulder region of the form-fitting shirt toward the anterior portion, and the four shoulder bands comprise two inner shoulder bands and two outer shoulder bands. At least one of the inner shoulder band and the outer shoulder band extending over each shoulder region of the form-fitting shirt has a first width at a first location on the anterior portion and a second width different from the first width at a second location on the anterior portion.



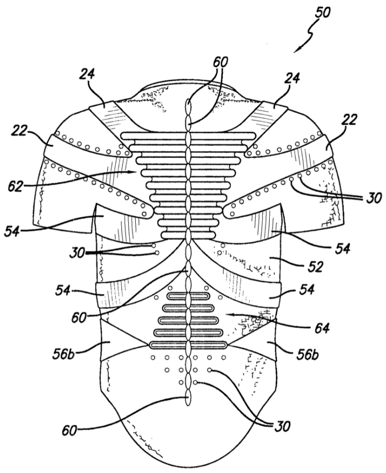


FIG. 12

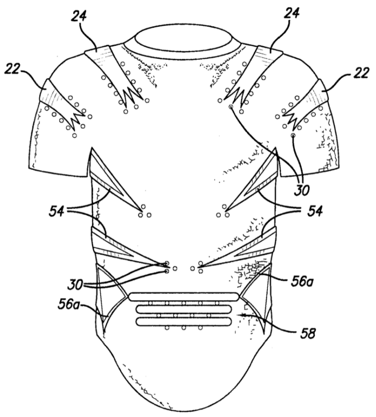
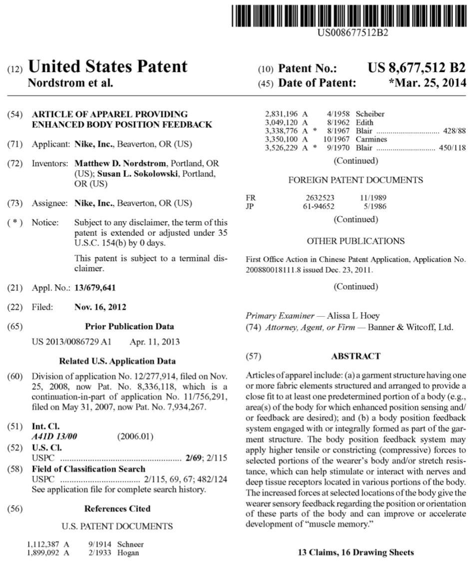


FIG. 13

- US8677512B2 (Article of Apparel Providing Enhanced Body Position Feedback)



US008677512B2

(12) **United States Patent**
Nordstrom et al.

(10) **Patent No.:** **US 8,677,512 B2**
(45) **Date of Patent:** ***Mar. 25, 2014**

(54) **ARTICLE OF APPAREL PROVIDING ENHANCED BODY POSITION FEEDBACK**

(71) Applicant: **Nike, Inc.**, Beaverton, OR (US)

(72) Inventors: **Matthew D. Nordstrom**, Portland, OR (US); **Susan L. Sokolowski**, Portland, OR (US)

(73) Assignee: **Nike, Inc.**, Beaverton, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/679,641**

(22) Filed: **Nov. 16, 2012**

(65) **Prior Publication Data**

US 2013/0086729 A1 Apr. 11, 2013

Related U.S. Application Data

(60) Division of application No. 12/277,914, filed on Nov. 25, 2008, now Pat. No. 8,336,118, which is a continuation-in-part of application No. 11/756,291, filed on May 31, 2007, now Pat. No. 7,934,267.

(51) **Int. Cl.**
A41D 13/00 (2006.01)

(52) **U.S. Cl.**
USPC **2/69**; 2/115

(58) **Field of Classification Search**
USPC 2/115, 69, 67; 482/124
See application file for complete search history.

(56) **References Cited**

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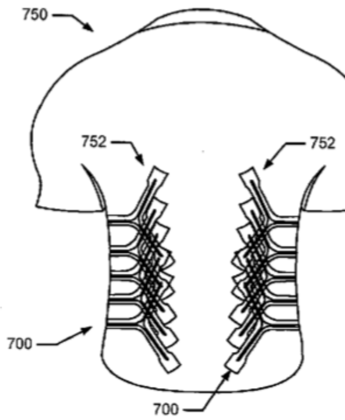
(Continued)

Primary Examiner — Alissa L Hoey
(74) *Attorney, Agent, or Firm* — Banner & Witcoff, Ltd.

(57) **ABSTRACT**

Articles of apparel include: (a) a garment structure having one or more fabric elements structured and arranged to provide a close fit to at least one predetermined portion of a body (e.g., area(s) of the body for which enhanced position sensing and/or feedback are desired); and (b) a body position feedback system engaged with or integrally formed as part of the garment structure. The body position feedback system may apply higher tensile or constricting (compressive) forces to selected portions of the wearer's body and/or stretch resistance, which can help stimulate or interact with nerves and deep tissue receptors located in various portions of the body. The increased forces at selected locations of the body give the wearer sensory feedback regarding the position or orientation of these parts of the body and can improve or accelerate development of "muscle memory."

13 Claims, 16 Drawing Sheets



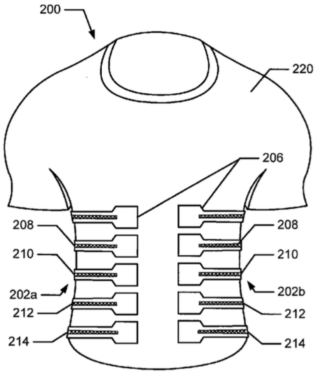


Fig. 2A

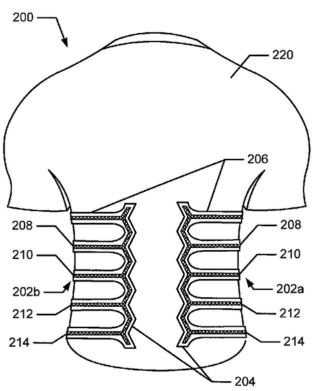


Fig. 2B

- US5201074 (Exercise Suit with Resilient Reinforcing)

US005201074A

United States Patent [19]
Dicker

[11] **Patent Number:** **5,201,074**
[45] **Date of Patent:** **Apr. 13, 1993**

[54] **EXERCISE SUIT WITH RESILIENT REINFORCING**

[76] Inventor: **Timothy P. Dicker,** 11359 Dornfield, Lakeview Terrace, Calif.

[21] Appl. No.: **814,508**

[22] Filed: **Dec. 30, 1991**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 712,459, Jun. 10, 1991, Pat. No. 5,109,546.

[51] **Int. Cl.**[5] **A41D 13/00**
[52] **U.S. Cl.** **2/70**; 2/69; 2/79; 2/227; 2/228; 2/239; 2/80; 482/105; 482/121
[58] **Field of Search** 2/70, 69, 79, 227, 409, 2/228, 239, 80; 482/105, 121

[56] **References Cited**

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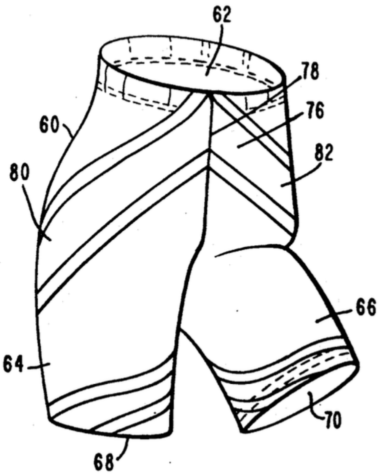
5,109,546	5/1992	Dicker	2/70

Primary Examiner—Clifford D. Crowder
Assistant Examiner—Gloria Hale
Attorney, Agent, or Firm—Cislo & Thomas

[57] **ABSTRACT**

An exercise suit which has a pair of stretchable pants (**20**) and a pull-over top (**44**) with a lower-body reinforcing segment (**38**) attached, in the middle only, to the pants and an upper-body reinforcing collar (**54**) attached, in the middle only, to the top. A leg band (**58**) encircles the legs (**24**), and side bands (**58**) are affixed to the reinforcing collar. The leg bands (**42**) grip the wearer's feet, creating a continuous loop from the waist to the feet. Hook-and-loop tapes (**40**) allow the reinforcing segment (**38**) to be adjusted in tension around the wearer's waist and similarly adjustable knee pads (**32**) cover the knees in the pants legs (**24**). The resilience of the suit and the looped bands create a resistance to movement which provides exercise to the wearer's muscles during physical activity. Exercise short pants (**60**) are also provided which provide elongatable resistive bands (**80, 82**) which meet at the vertical midline of the back of the short pants and spiral downwardly across the buttocks and around the backs of the thighs of the wearer to end at the leg openings. In an alternative embodiment, exercise short pants (**60'**) employ resistive bands (**80', 82'**) reversed back-to-front in location on the short pants as well as a low-back panel (**84**) in the shape of an upright "V" attached by elastic at the vertical midline of the back of the shorts and having first and second hook-and-loop tabs (**90, 92**) at the free ends thereof which mate with tabs (**94, 96**) on the sides of the waistband to provide adjustable resistance to motion.

10 Claims, 4 Drawing Sheets



- WO9836652 (Aerobic Exercise Garment)

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) **International Patent Classification** 6 :
A41D **A2**

(11) **International Publication Number:** **WO 98/36652**
(43) **International Publication Date:** 27 August 1998 (27.08.98)

(21) **International Application Number:** PCT/US98/01967

(22) **International Filing Date:** 3 February 1998 (03.02.98)

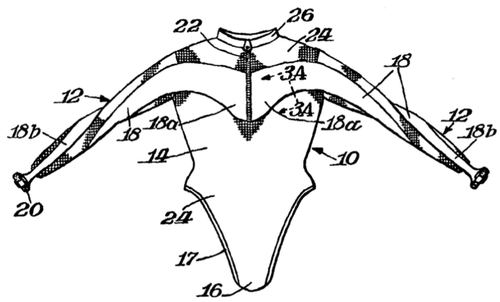
(30) **Priority Data:**
08/802,973 20 February 1997 (20.02.97) US

(71)(72) **Applicants and Inventors:** DICKER, Timothy, P. [US/US]; 6906 Foothill Boulevard, Tujunga, CA 91042–2780 (US). WILKINSON, William, T. [US/US]; Sunset Drive, R.D. #1, Salem, NJ 08079 (US).

(74) **Agent:** PEZZNER, Harold; Connolly & Hutz, P.O. Box 2207, Wilmington, DE 19899 (US).

(81) **Designated States:** AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.



(57) Abstract

An aerobic exercise garment includes a body section and limb sections. The garment includes a base fabric which incorporates elastic resistance band material having a direction of stretch. The elastic resistance band material is formed with a minimal number of pieces and is incorporated in the garment by securing the pieces together at locations which do not interfere with the direction of resistance.

Appendix B - Final Project Presentation

STASIS

STASIS

STASIS

SPORTSWEAR

APPAREL INNOVATION

GRADUATE THESIS

2021.06.10

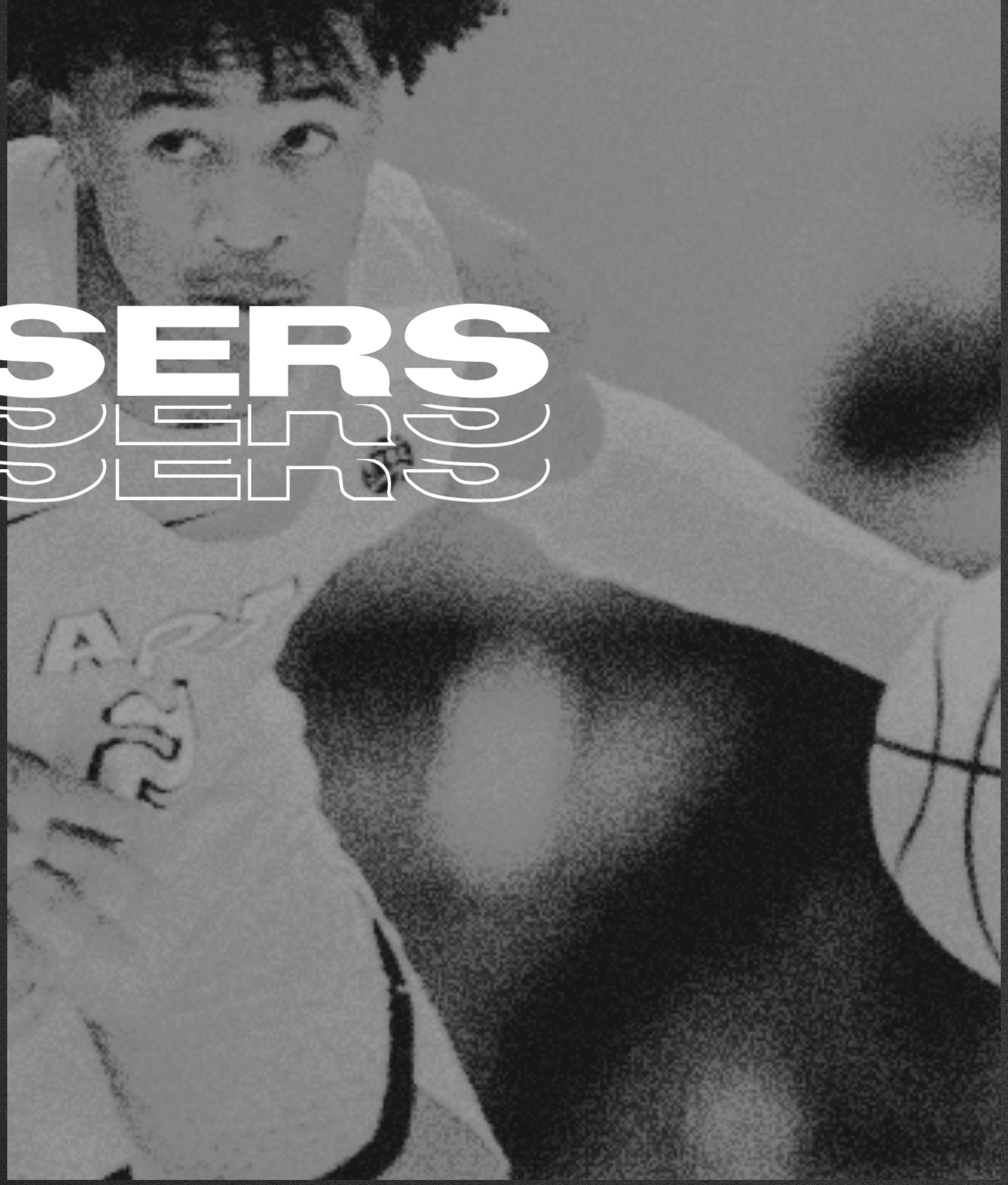
PROBLEM

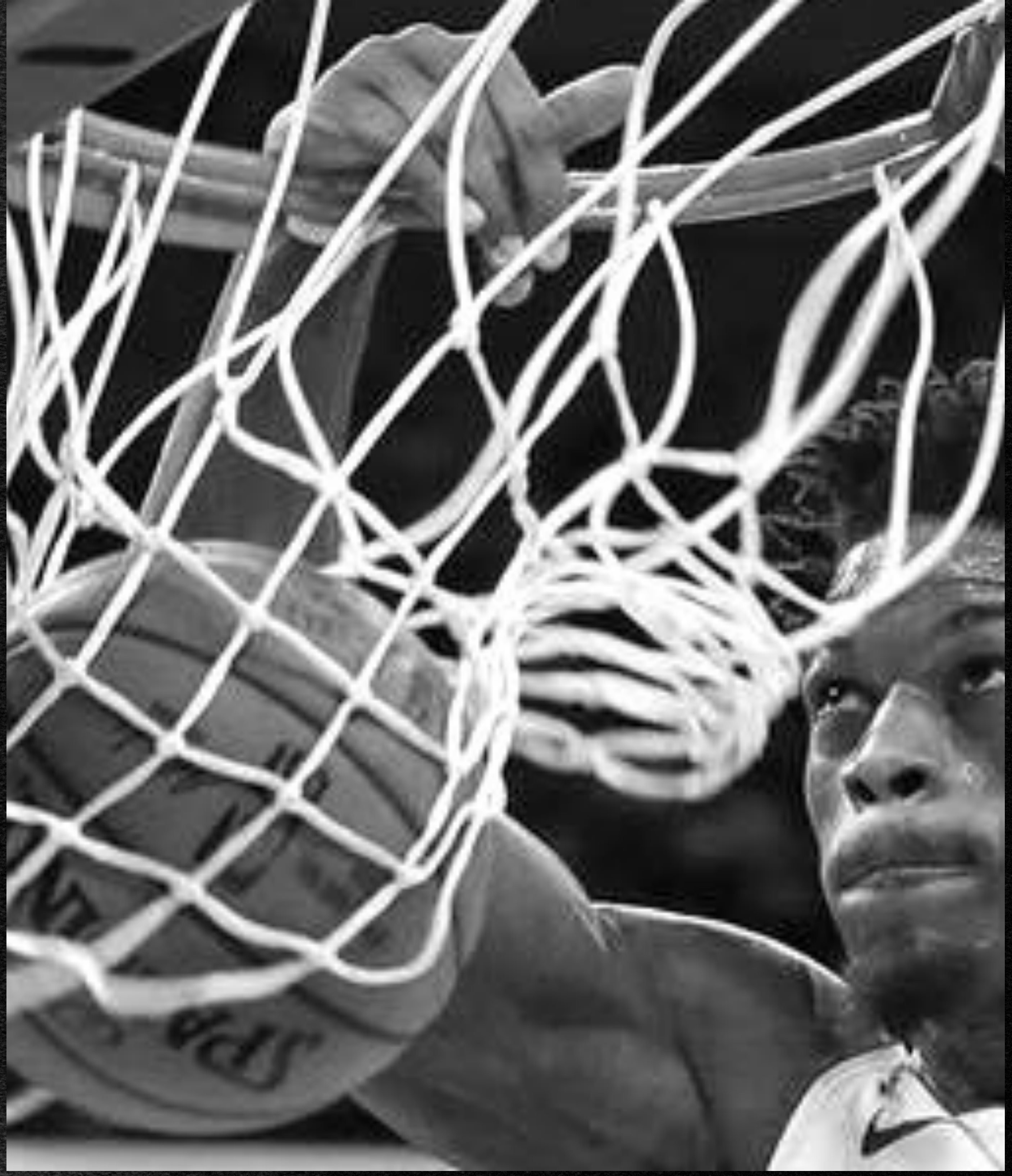
PROBLEM
PROBLEM

THE COMPETITIVE EDGE

In the demanding environment of elite basketball, a miss is as good as a mile. Players must fend off fatigue & injury while performing at peak aerobic & anaerobic capacities for months at at time

USERS





ELITE YOUTH

Ages 15–19

High school & AAU
Tournament-based competition

Growth spurts
Key phase for habit development
Movement & form mechanics

NCAA BREAKOUT

Ages 18–22

High stakes path to pro
Significant travel

Intense strength & conditioning
Pressure on larger stage
Fatigue as a student-athlete

PROFESSIONAL

Ages 21–35

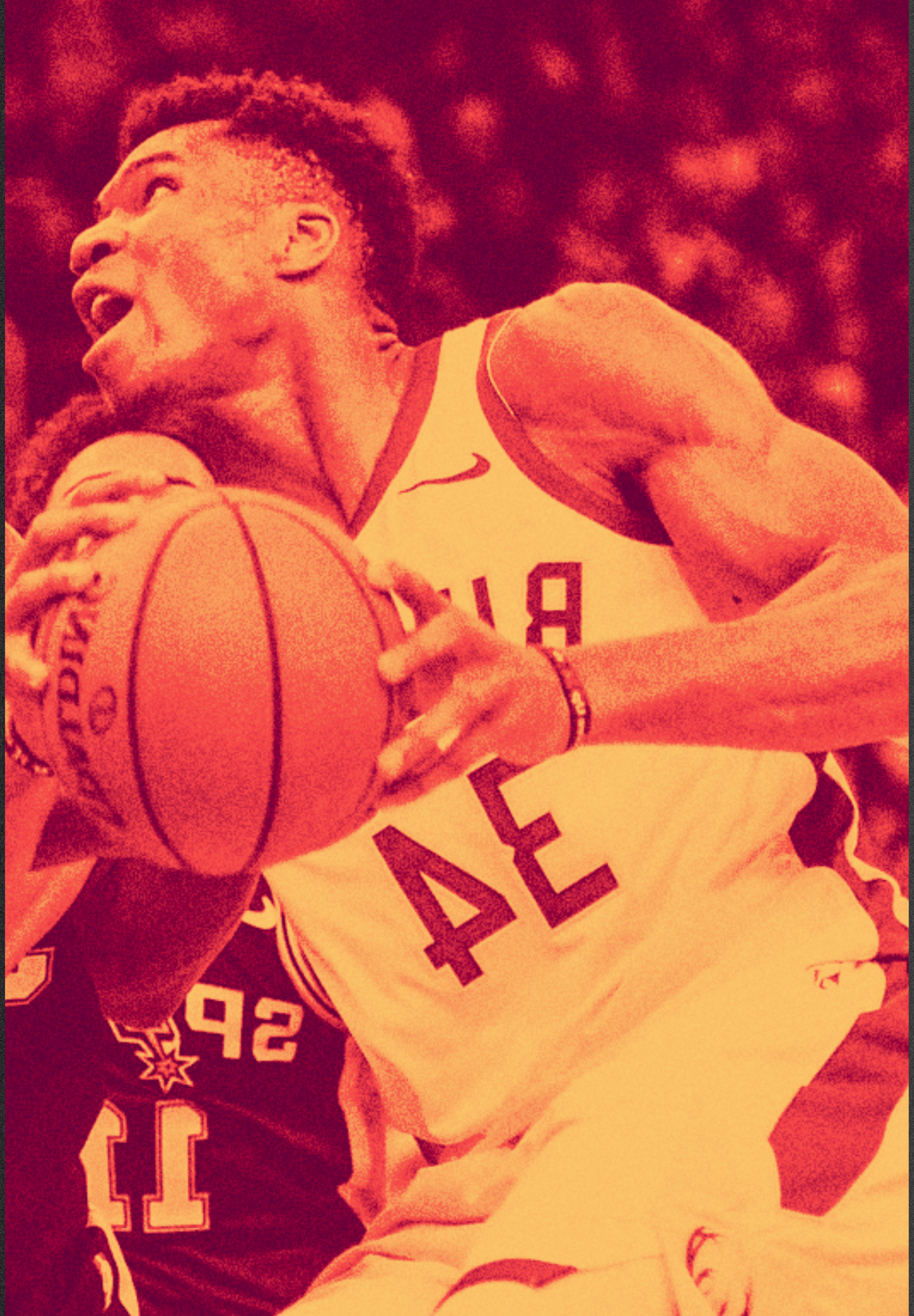
82-game season (minimum)
Weekly travel

Extremely physical gameplay
Must maintain peak from for 5+ months
Longevity & quality of career

OPPORTUNITY

PRIMING FOR SPORT

Currently, there are no wearable products designed to actively prepare the body to compete. While innovations in the sports recovery industry have defined a new niche, athletic priming remains largely unexplored



GOALS

Improve muscle recruitment

Reinforce neuromuscular pathways

Optimize movement patterns

FIELD RESEARCH

FIELD RESEARCH
FIELD RESEARCH

Research focused on studying what kinds of benchmark products & technologies impacted athletic performance in a controlled testing environment. This process measured:

BALANCE

MUSCLE ACTIVATION

AGILITY

BODY AWARENESS

FINDINGS

FINDINGS
FINDINGS

The data from field studies combined with secondary research revealed two main modes of priming that improved performance the most:

+

MUSCULAR RESISTANCE

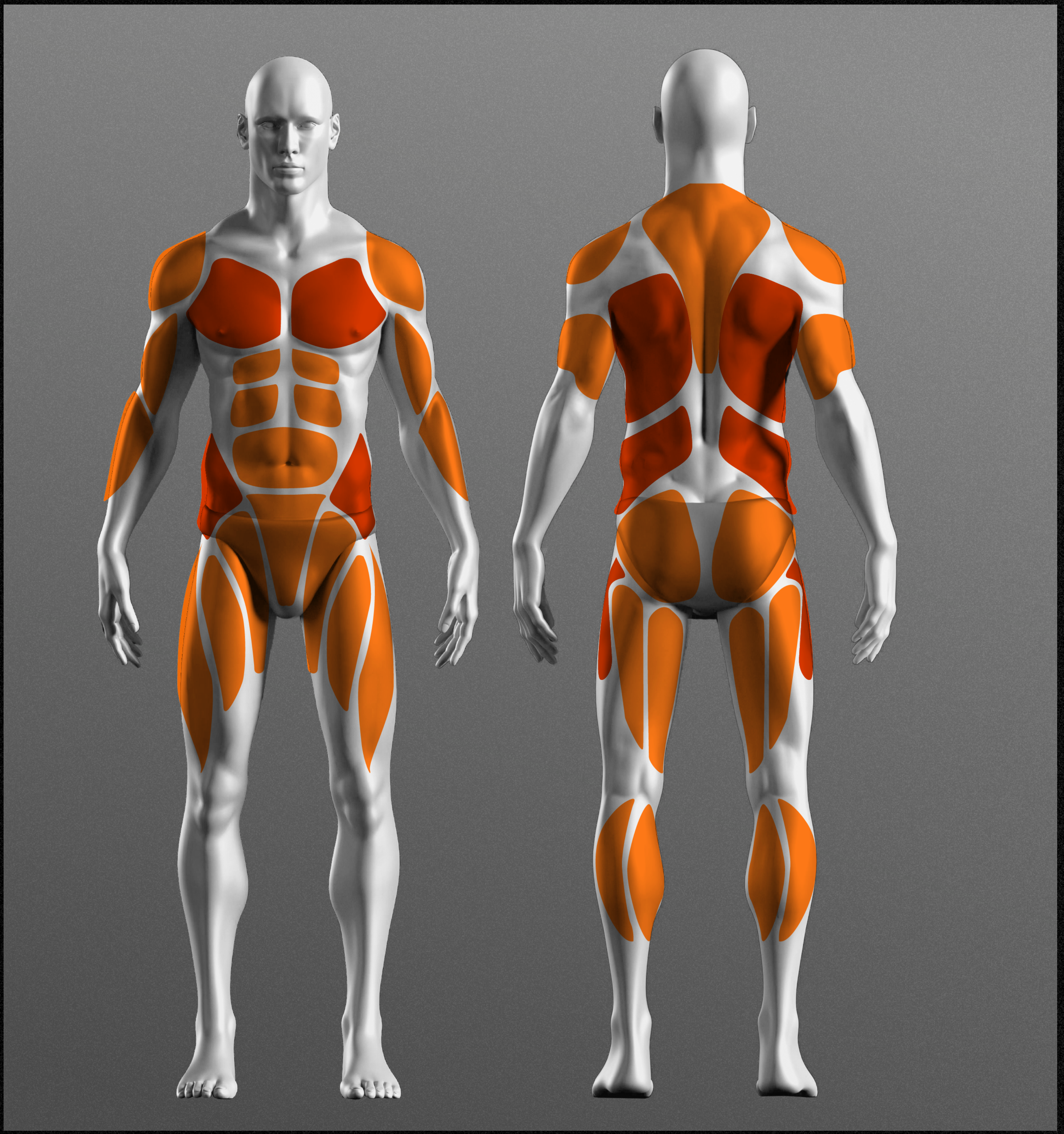
- Increases recruitment of individual muscle fibers
- Targets activation of sport-specific kinetic chains

PROPRIOCEPTIVE FEEDBACK

- Enhances body awareness & form
- Optimizes movement patterns

PROTOTYPING

PROTOTYPING
PROTOTYPING



FUNCTION MAPPING

Resistance elements placed on key intersections of stabilizing muscles, prime movers, & fascia can activate the kinetic chains of the body

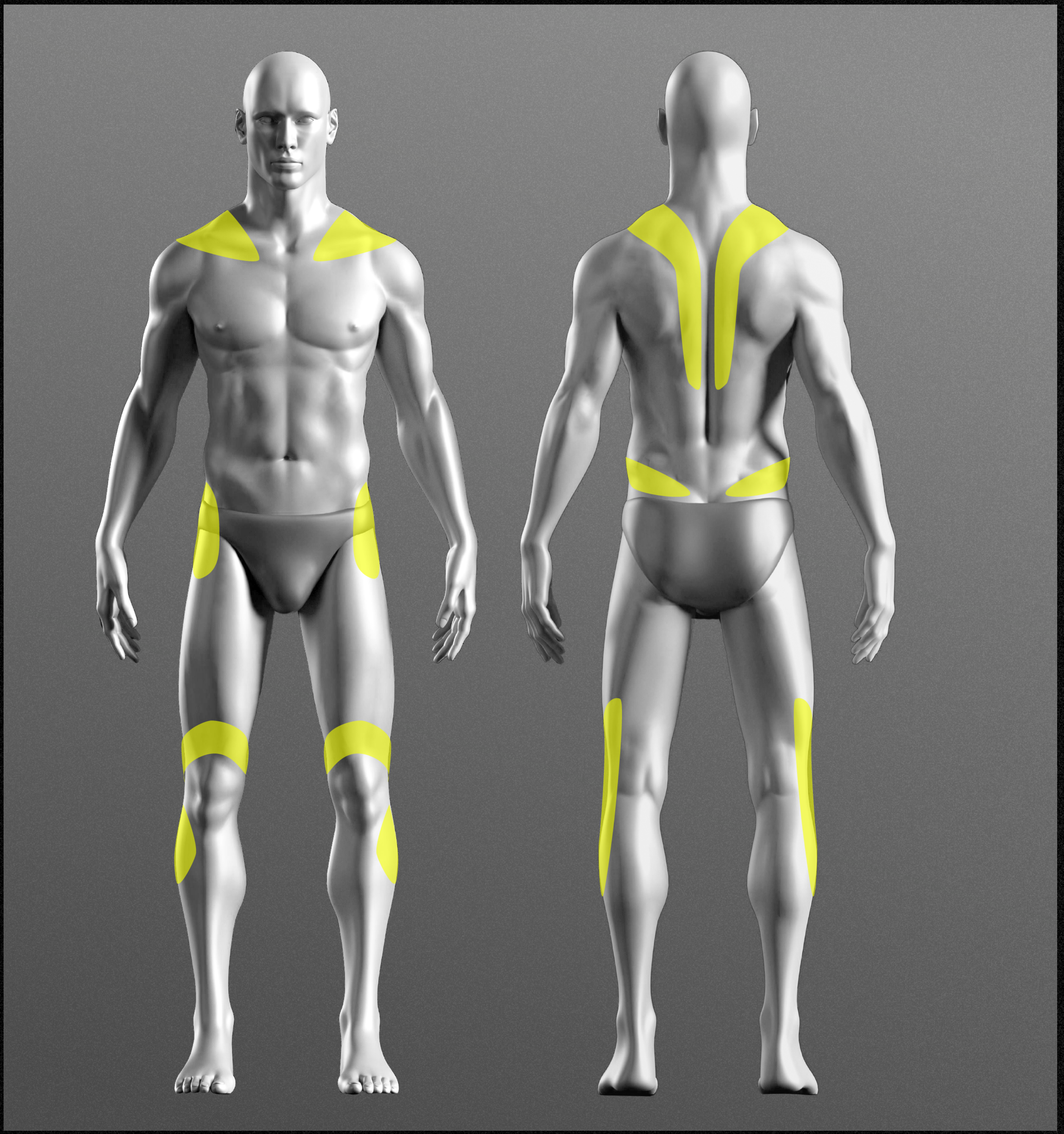
V1 V2 V3 Mockup

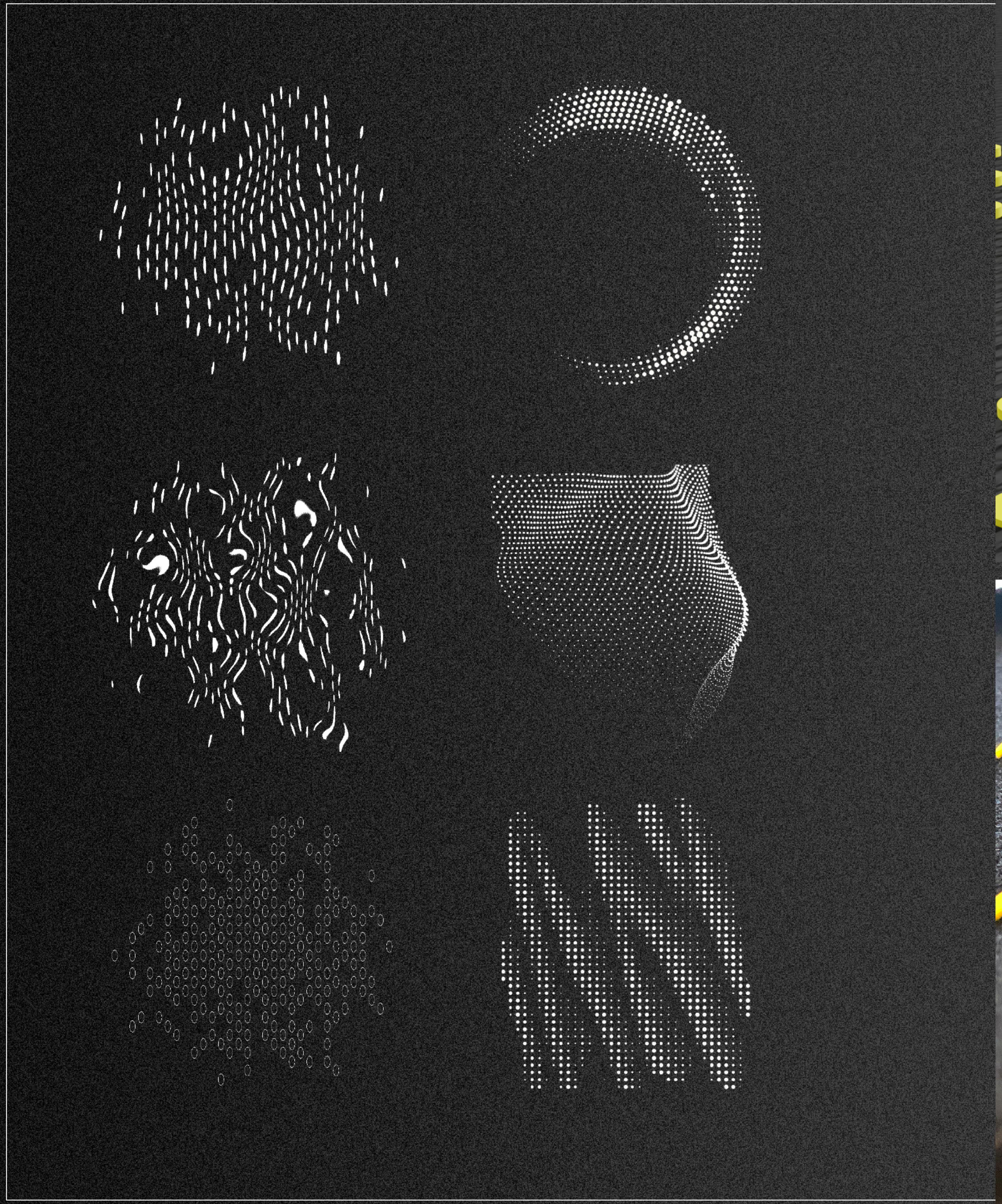
PROTOTYPING

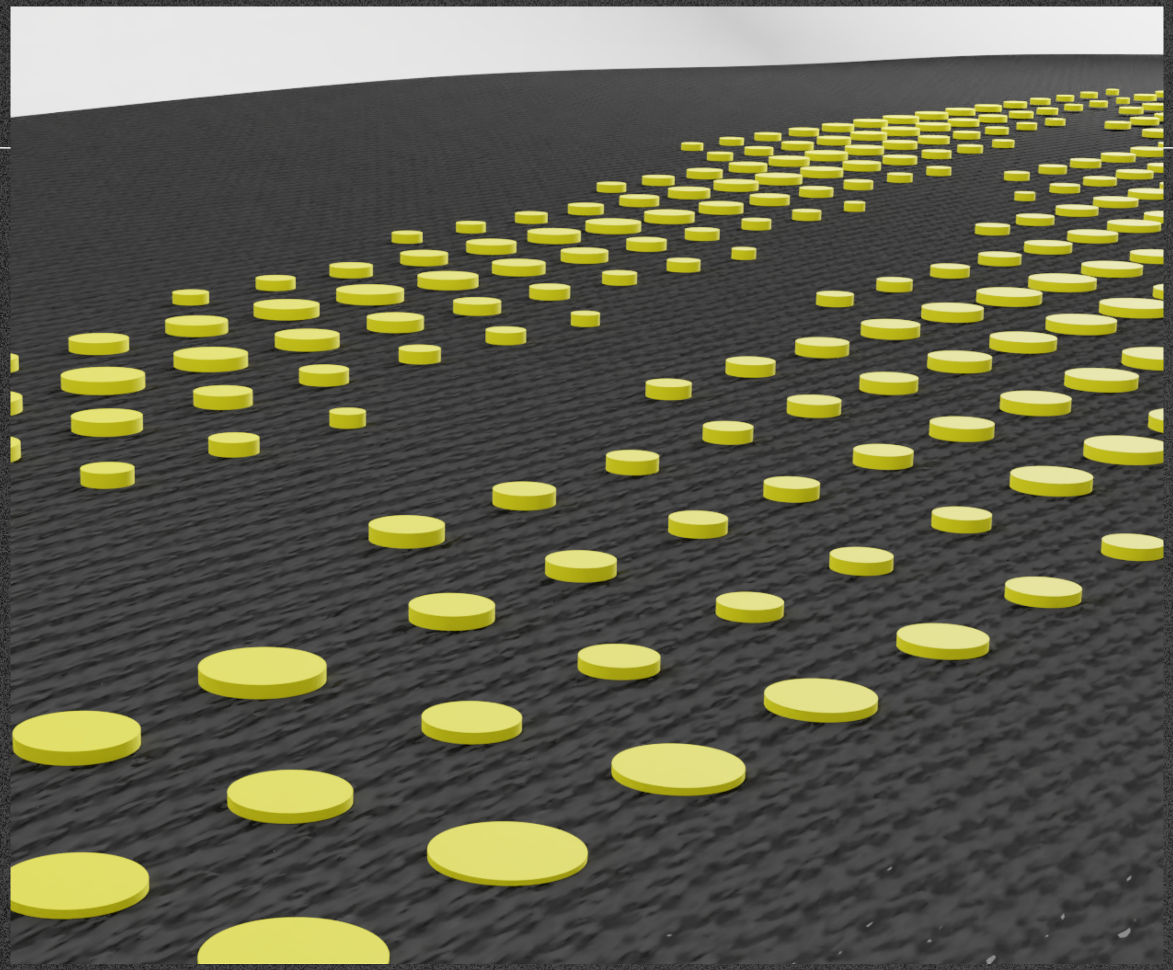
PROTOTYPING
PROTOTYPING

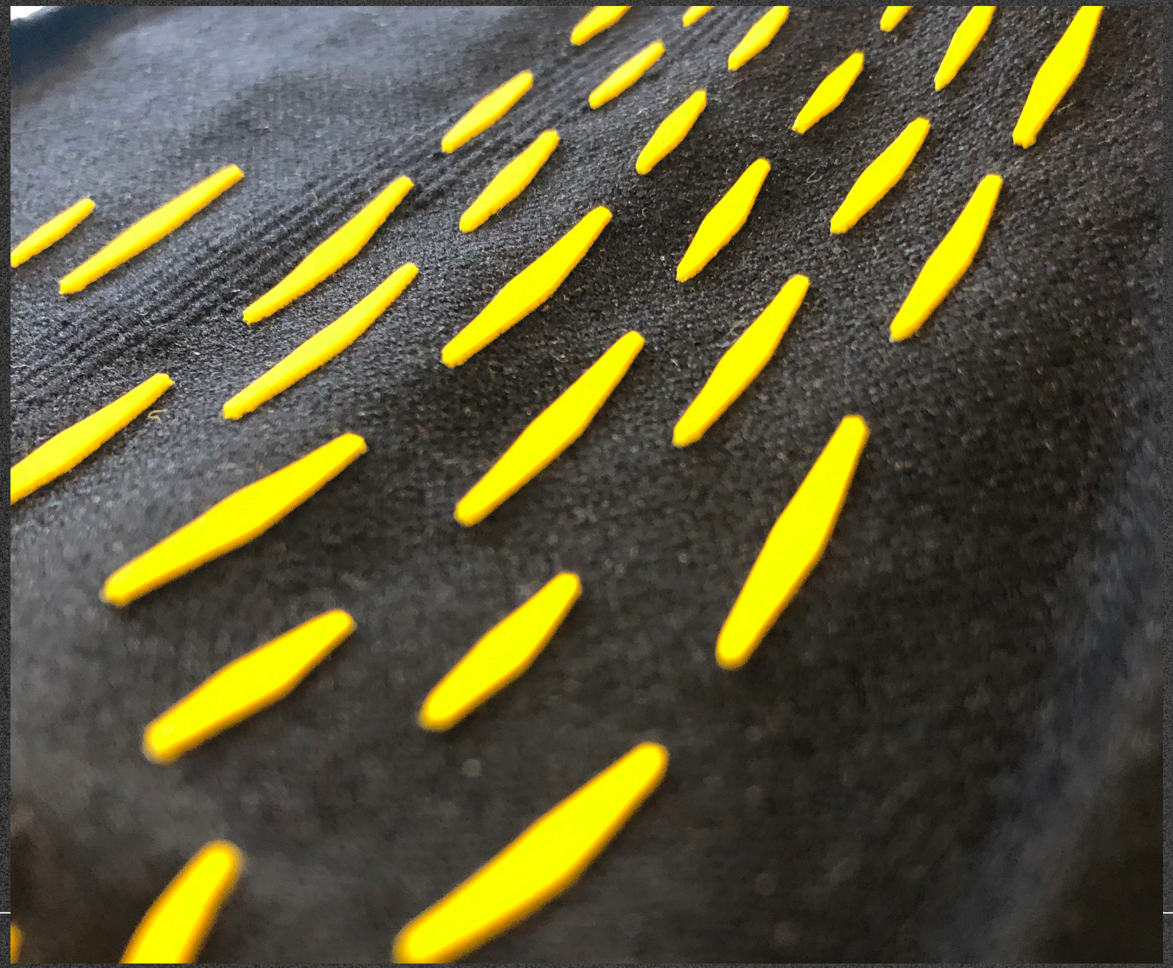
TEXTURE STUDIES

Targeting postural feedback zones at the intersections of joints, muscles, and fascia, helps activate the mind-muscle connection









BODY MAPPING

BODY MAPPING
BODY MAPPING

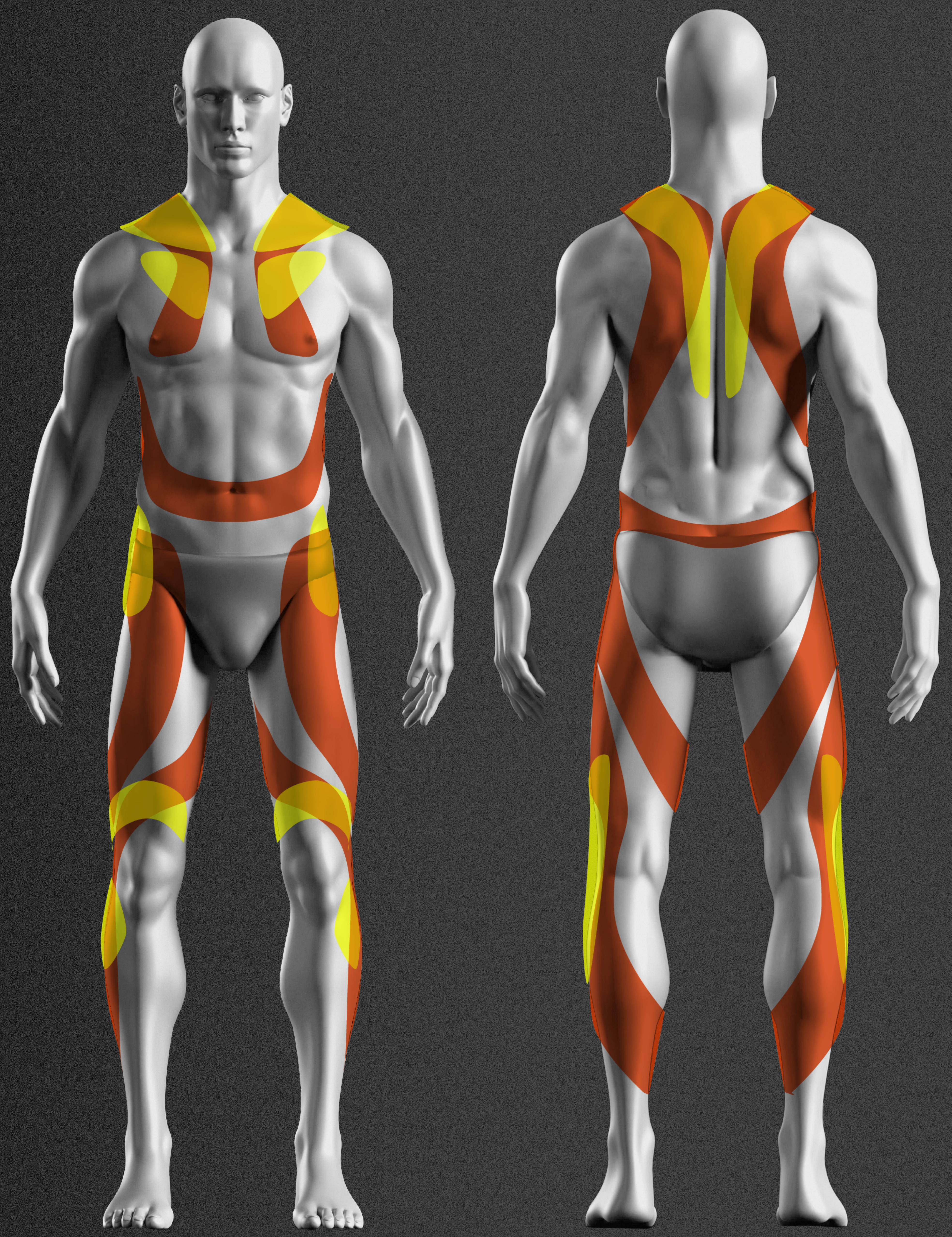
TARGETED RESISTANCE

- Zoned to provide resistance to sport-specific muscles
- Targets stabilizing muscles & prime movers
- Inclusion of entire kinetic/myofascial chain

NEXT-TO-SKIN TEXTURE

- Zoned to improve postural awareness & form
- Targets areas around joints
- Influenced by sport-specific movements & biomechanics

How do we develop a product with these features while providing a seamless & intuitive gameday experience?




ADAPTIVE TEXTILES
ADAPTIVE TEXTILES
ADAPTIVE TEXTILES
APPAREL INNOVATION
PROGRAMMABLE YARNS
The Self-Assembly Lab at MIT has developed responsive textiles using programmed yarns. The yarns change shape when contacting stimuli such as heat & moisture. Using this technology, garments can respond to the needs of the body.
GRADUATE THESIS
2021.06.10

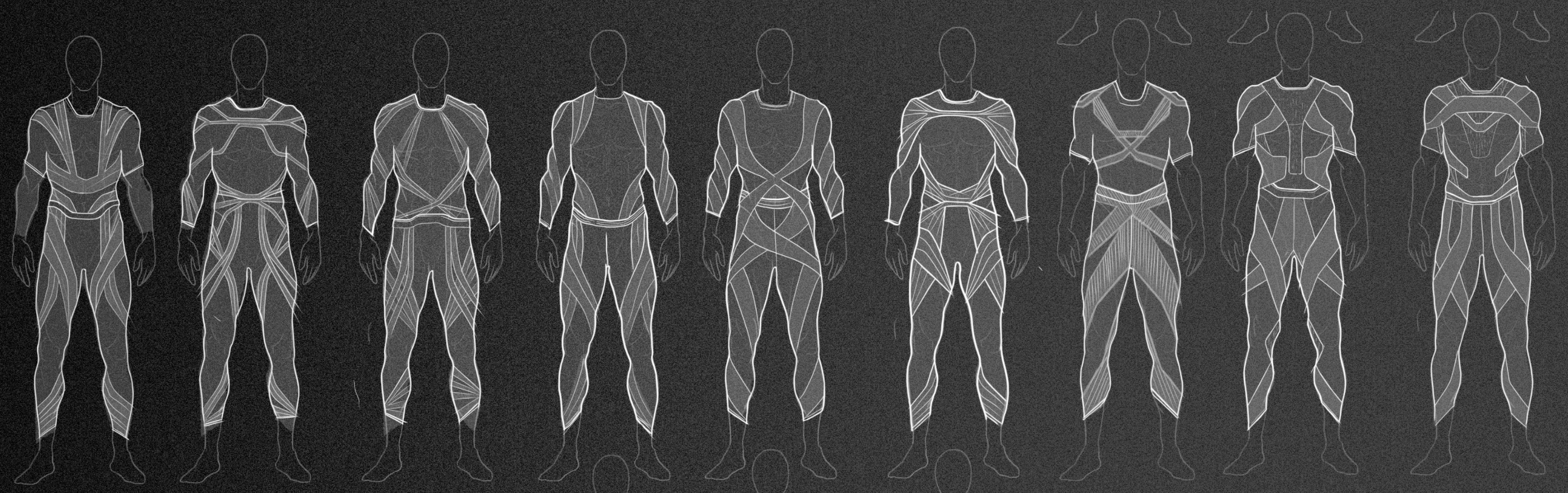
TEXTURED GARMENTS

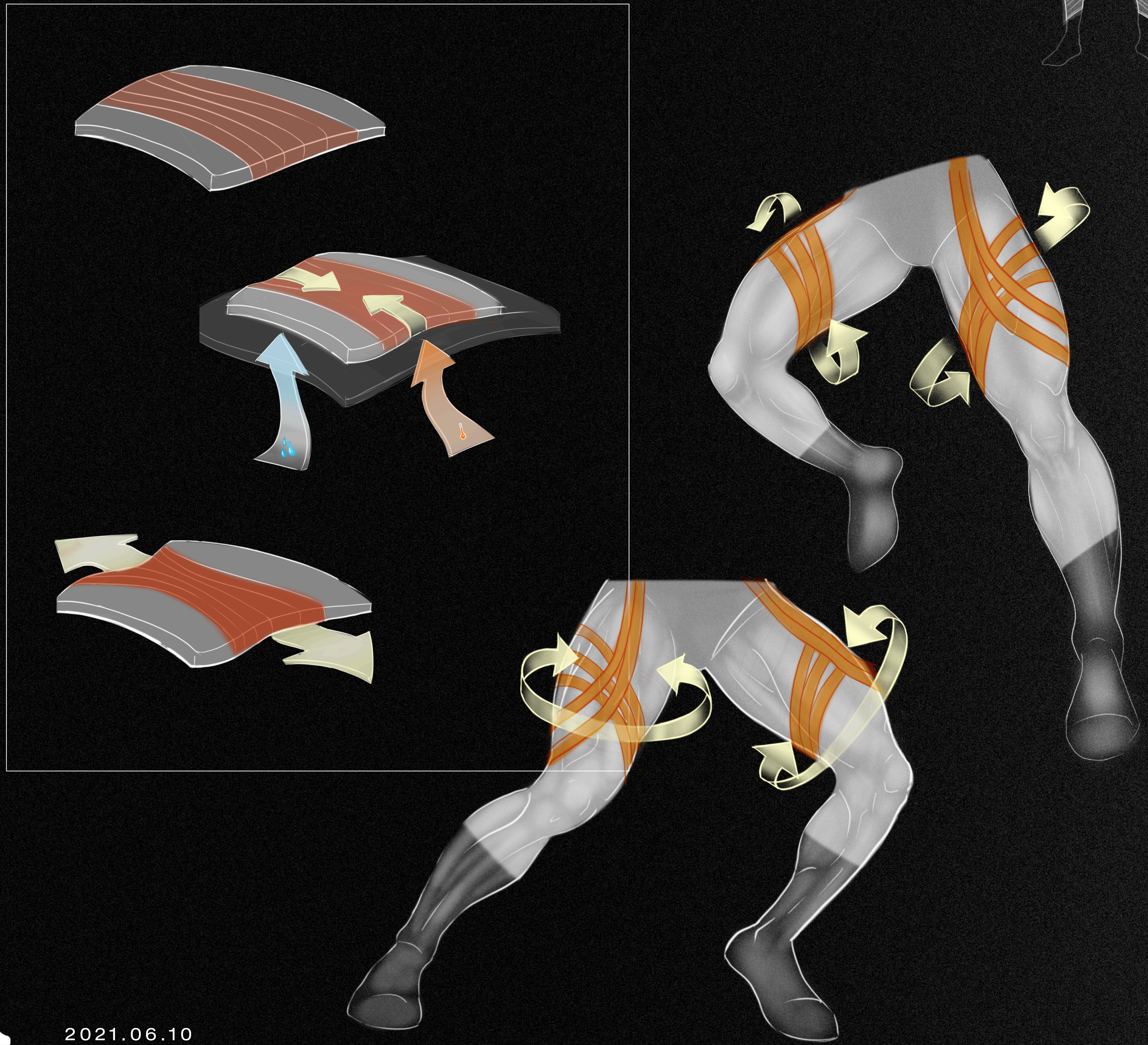
PROPRIOCEPTION

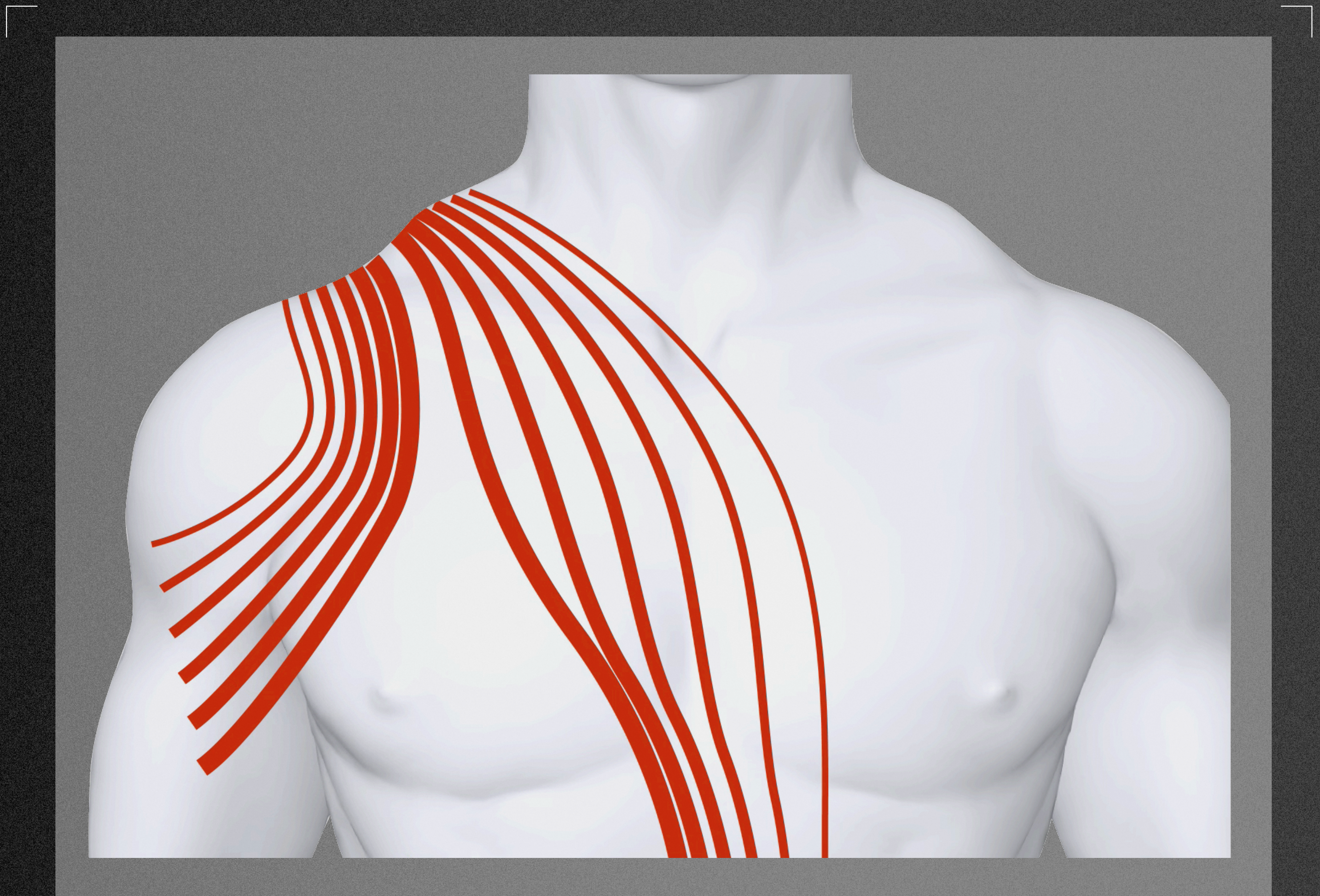
Next-to skin texturing is shown to increase activity of sensory receptors in the body, enhancing posture & balance through proprioception. Used primarily in clinical applications, this technology has proven to be a valuable innovation for performance sports product

IDEATION

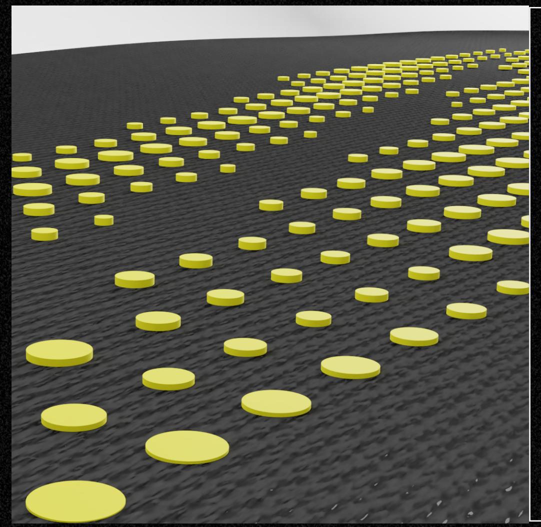
IDEATION
IDEATION







FEATURES

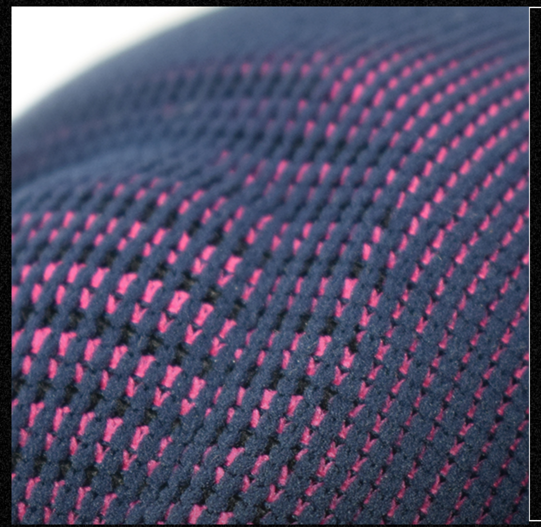


TEXTURED UNDERLAYS

- Applied texture on interior of garment
- Flexible matte silicone
- Provides postural feedback in key areas

ENGINEERED KNIT

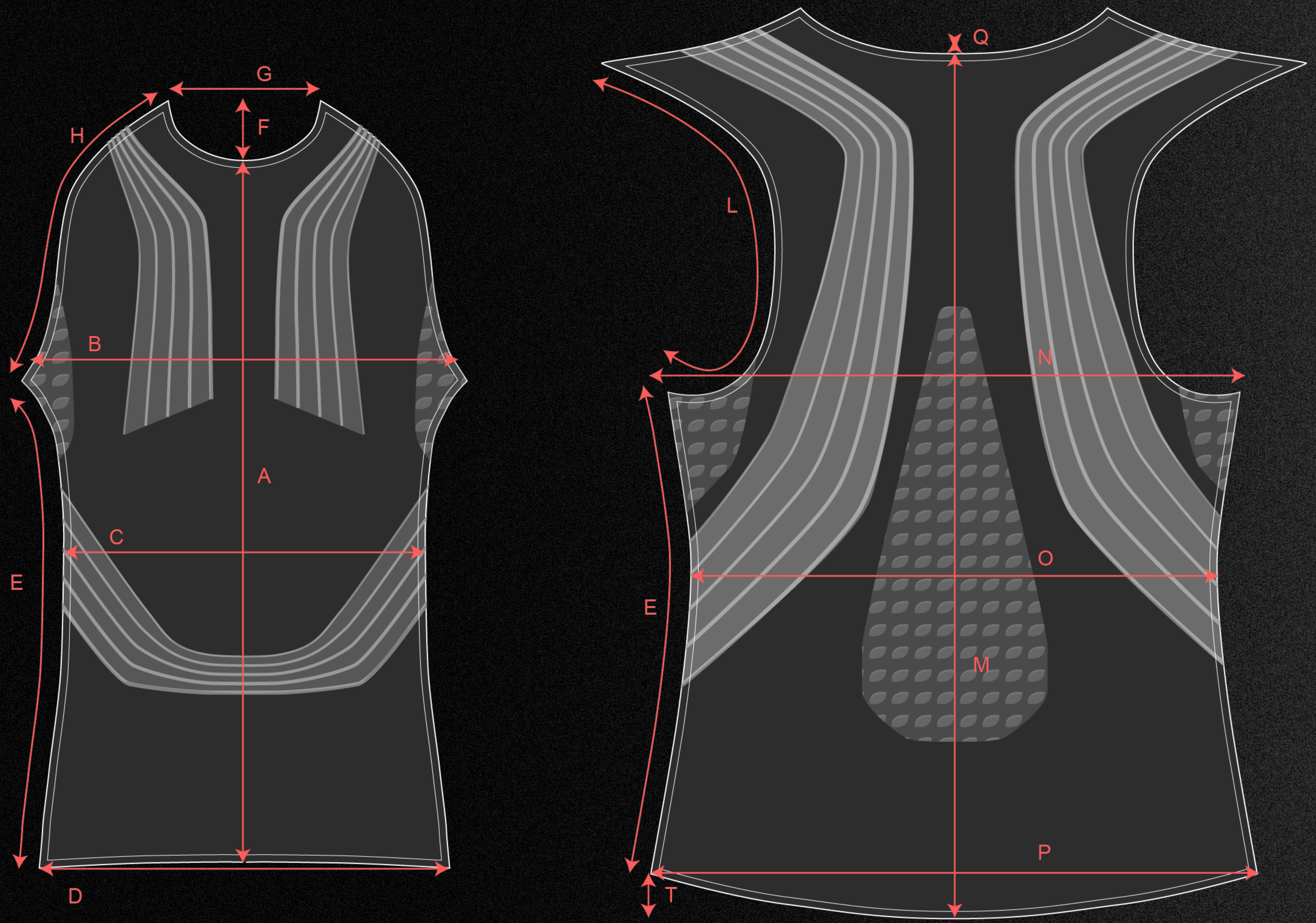
- Integrated mesh panels for breathability
- Seamless construction
- Compatible with basketball uniform

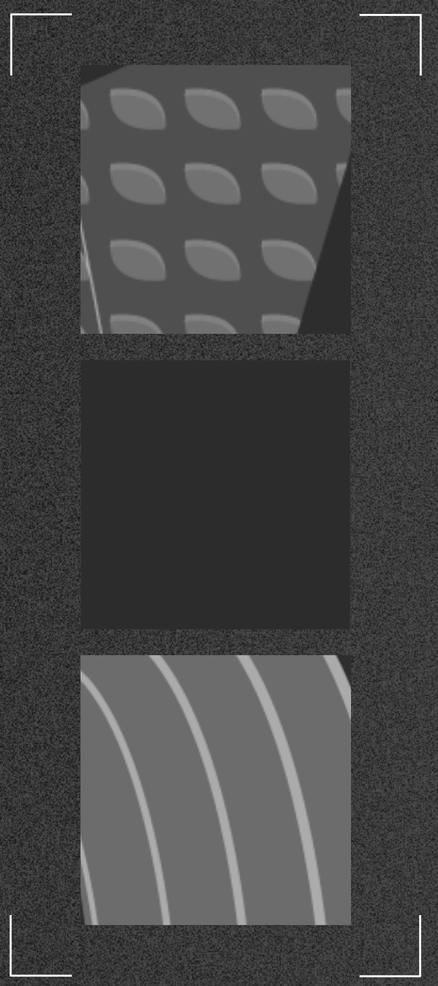


ADAPTIVE 'NEUROKNIT'

- Compressive, powerful fit
- Targeted resistance for key muscles
- Adaptive yarns change shape to adjust resistance

KNIT SCHEMATIC





Engineered mesh panels

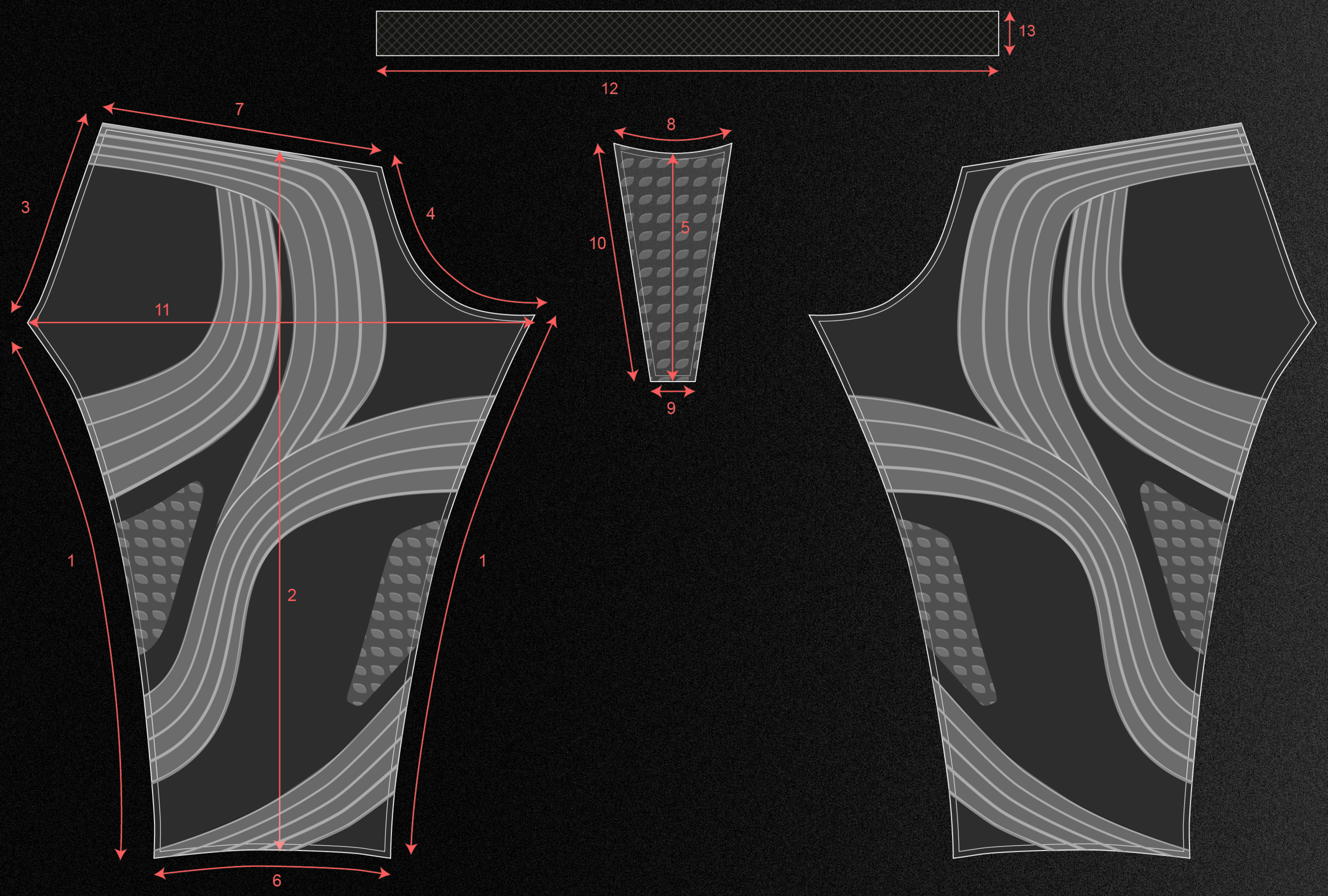
Engineered compression knit

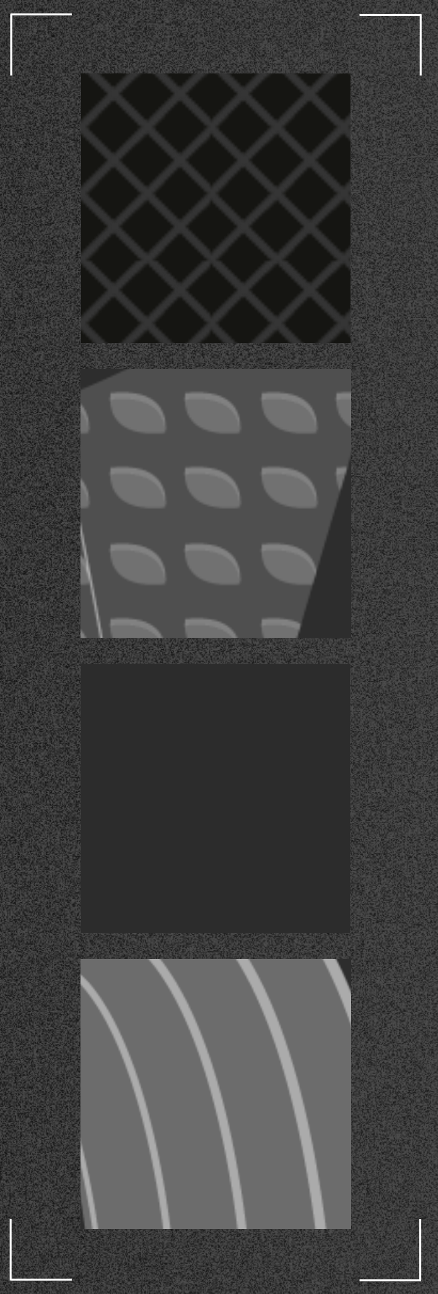
Adaptive NEUROKNIT

A	CENTER FRONT	24”
B	CHEST WIDTH	14.5”
C	FRONT WAIST @ NARROWEST POINT	12.25
D	FRONT OPENING (FLAT)	14”
E	SIDE SEAM	17”
F	FRONT NECK DROP	2”
G	NECK OPENING WIDTH	5”
H	FRONT ARMSCYE LENGTH	11”
J	SHOULDER SEAM	7”
L	BACK ARMSCYE LENGTH	16.5”
M	CENTER BACK	29.5”
N	BACK WIDTH @ UNDERARM SEAM	20.25”
O	BACK WAIST @ NARROWEST POINT	18”
P	BACK OPENING (FLAT)	20.75”
Q	BACK NECK DROP	0.25”
R	SLEEVE LENGTH	15.25”
S	WAIST PLACEMENT FROM UNDERARM SEAM	8”
T	BACK HEM DROP	1.5”

2021.06.10

KNIT SCHEMATIC





Jaquard knit waistband

Engineered mesh panels

Engineered compression knit

Adaptive NEUROKNIT

1	INSEAM	24"
2	OUTSEAM	29.5"
3	BACK CROTCH (NO WAISTBAND)	9"
4	FRONT SEAM (NO WAISTBAND)	10.5
5	CENTER FRONT CROTCH LENGTH (NO WAISTBAND)	9.5"
6	LEG OPENING	10"
7	WAIST	12"
8	CROTCH GUSSET TOP	5"
9	CROTCH GUSSET BOTTOM	2"
10	CROTCH GUSSET SIDE LENGTH (NO WAISTBAND)	10.25"
11	THIGH OPENING CIRCUMFERENCE @ CROTCH SEAM	21.5"
12	WAISTBAND LENGTH	28"
13	WAISTBAND WIDTH	2"

PACKAGING

STASIS

Men Women Youth Prime Recover Sports

Men / Prime / Tops

Men's STASIS Basketball CompressionTank

$120.00

Black / Fire

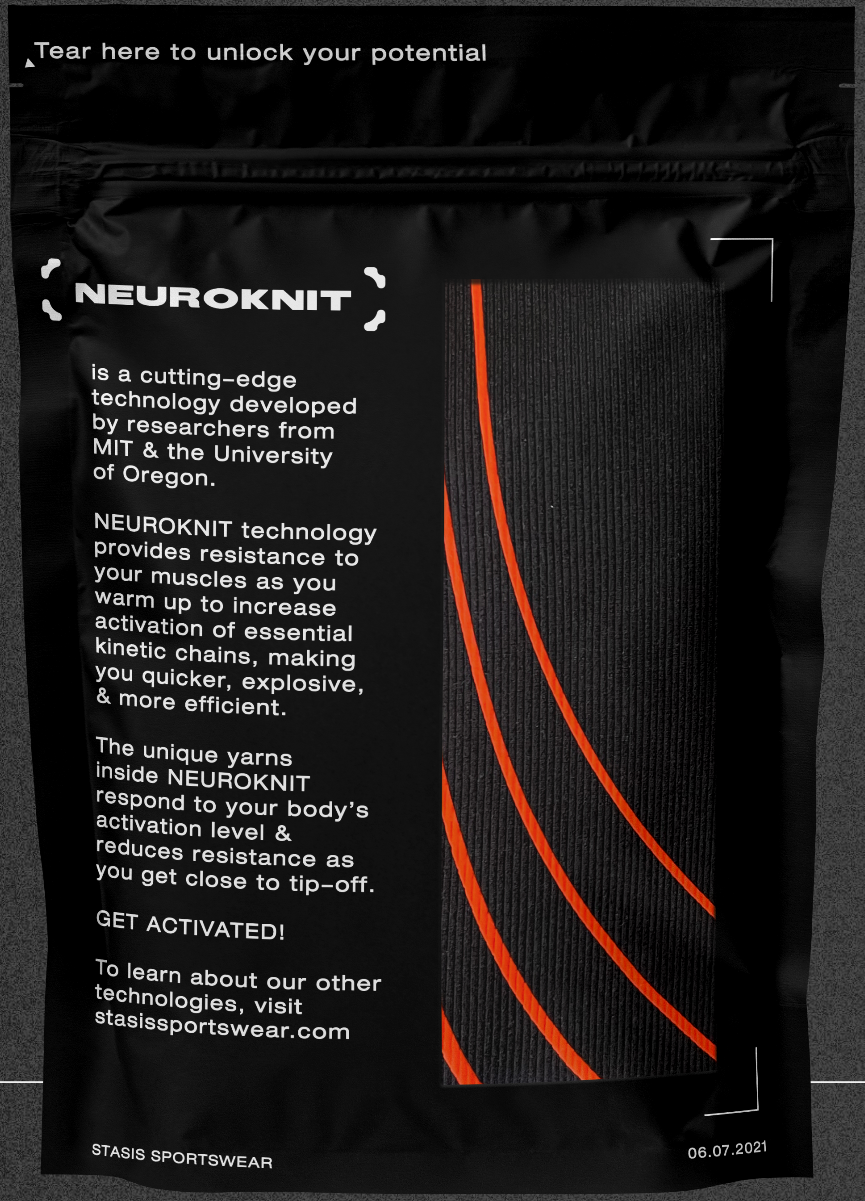
Small Medium Large XL XXL

1 Add to Cart Add to Wishlist

Description

The future of performance is here

Prime your body for gameday with the Men's Basketball Compression Tank by STASIS, featuring cutting edge NEUROKNIT technology. Developed by researchers from M.I.T. and the University of Oregon, NEUROKNIT provides resistance to your muscles as your warm up to increase activation of essential kinetic chains, making you quick, explosive, and more efficient.



APPAREL INNOVATION

GRADUATE THESIS

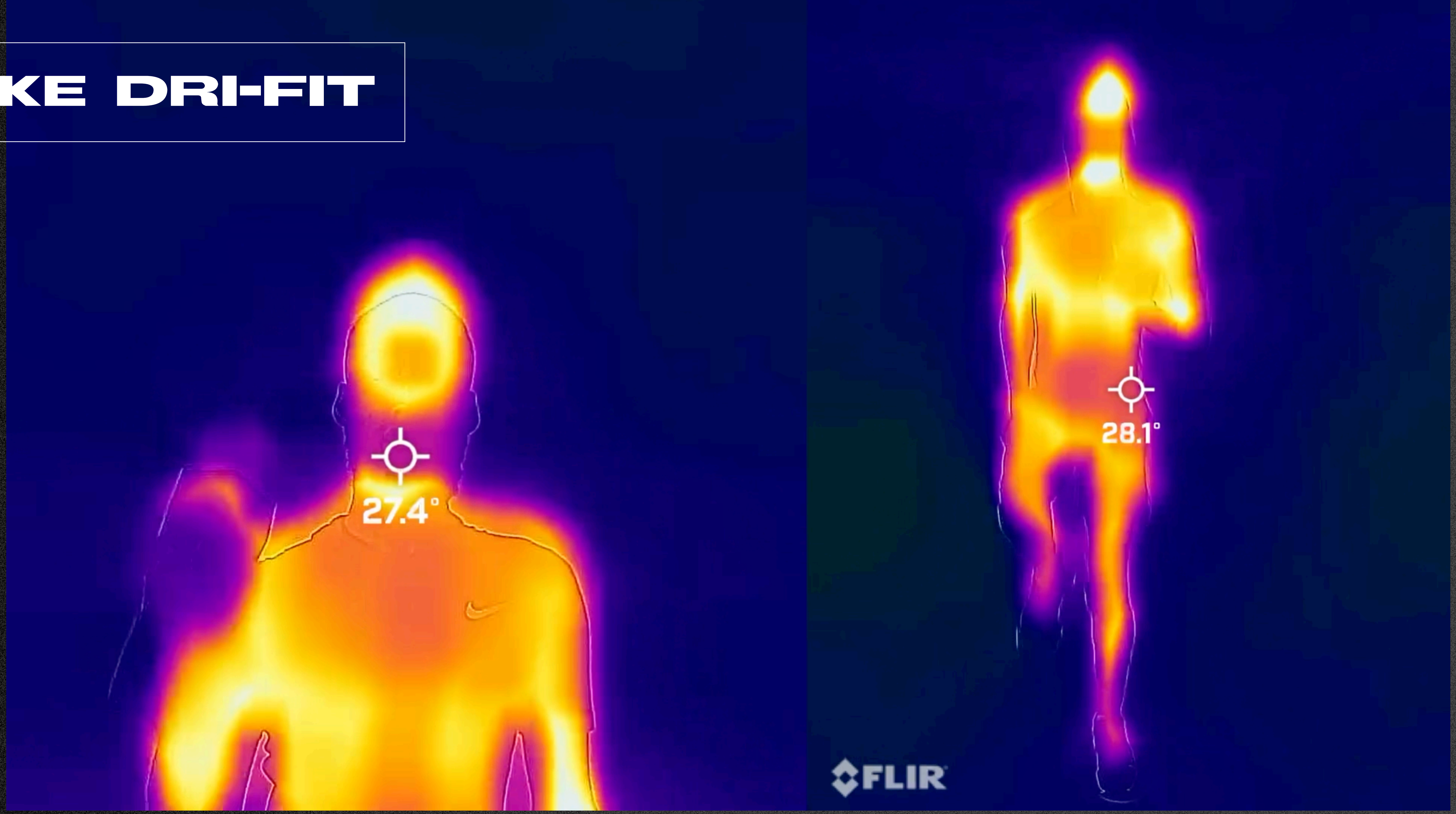
2021.06.10


APPAREL INNOVATION
GRADUATE THESIS
2021.06.10

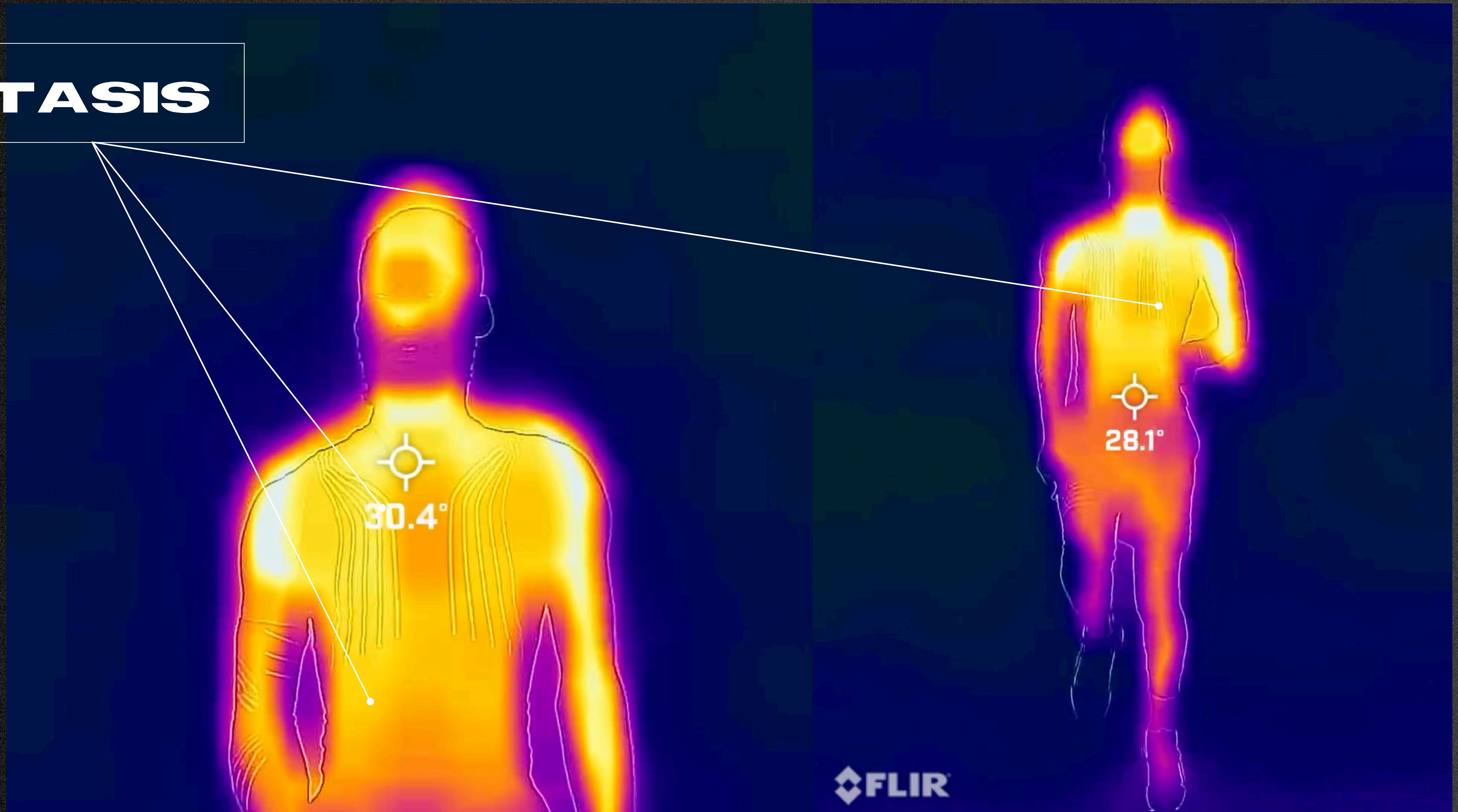
VALIDATION

VALIDATION
VALIDATION

NIKE DRI-FIT



STASIS



RESULTS

Thermal imaging using FLIR technology shows greater activation of stabilizing muscles when using STASIS compression garments compared to traditional base layers


STASIS
DYNAMIC. ACTIVATING. SECOND SKIN
APPAREL INNOVATION
GRADUATE THESIS
2021.06.10

THANK YOU

THANK YOU
THANK YOU

LOOKING AHEAD

A special thanks to my friends, peers, and family for their support & encouragement over the past two years. Its been a joy sharing this journey with you all.

Looking ahead, I hope to design the future of sport through a career in apparel & footwear innovation.