**Assessing Functional Needs of Rock Climbing Pants**

by

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## Abstract

The objective of this exploratory study was to assess the functional needs of outdoor rock climber pants by looking at fit, mobility, comfort, protection, and donning/doffing, based on the functional category of the Functional, Expressive, Aesthetic (FEA) Consumer Needs Model. Data from 185 active rock climbers was collected by questionnaire at two rock climbing events. The study utilized a mixed methods approach with open-ended questions being analyzed with grounded theory, and quantitative data analyzed by descriptive statistics and repeated measure ANOVA. Participants reported mild satisfaction with pant fit. Pant mobility was only slightly satisfying and was affected by the type of climbing technique performed. Climbers rated pants as uncomfortable after climbing and only somewhat protective and durable in knees, seat, and crotch. Based on these results improvements in climbing pant fit, design, and fabric performance would improve the functional pant needs for rock climbers.

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# CHAPTER I. INTRODUCTION

## Problem Statement

Rock climbing, an extreme outdoor sport, experienced an overall 9.5% increase in participation from 1999–2009 (U.S. Department of Agriculture Forest Service, Southern Research Station [SRS], 2012), a 6% increase in participation over the past year (Outdoor Foundation, 2014b), and has a projected growth of 50.2-86.1% by 2060 (SRS, 2012). The Outdoor Industry Association (2012) reported that the outdoor recreational economy growth between 2005 and 2011 was approximate 5% annually. In 2013, there were 11,218,000 people participating in some form of outdoor climbing activity with 40% planning to spend the same on outdoor apparel as the prior year and 12% planning to spend more (Outdoor Foundation, 2014a). Based on these statistics, rock climbers represent a growing market segment that could see a significant increase in outdoor apparel spending.

Currently, there are no published studies on the apparel needs of rock climbers, especially rock climbing pants. Rock climbing pants, a functional garment, are one of the most important apparel items worn by a rock climber (Gerrard, 1990; Gupta, 2011a). They provide protection from outdoor and environmental elements, along with limiting bodily injury such as lacerations and abrasions, when the climber approaches and ascends rock formations (Cox & Fulsaas, 2007; Gupta, 2011b). Studies conducted on other functional sport garments, such as golf, sailing, bicycling, in-line skating, tennis, and outdoor performance garments found that participants did have concerns in one or more of the following four functional aspects: fit, mobility, comfort, and protection (Bye & Hakala, 2005; Casselman-Dickson & Damhorst, 1993; Chae & Evenson, 2014; Dickson & Pollack, 2000; Faber, 2013; Jin & Black, 2012). To assist in the understanding of how various functional aspects affect consumer concerns, a framework is used to gain insight

into the all functional aspects of a garment before assessing the functional apparel needs of rock climber pants. This study used Lamb and Kallal's (1992) Functional, Expressive and Aesthetic Consumer Needs Model (FEA Model) that combines the consumer, their culture, along with addressing the functional, expressive, and aesthetic needs of the group. As rock climbing pants are designed with functional needs as the primary concern, this study only used the functional aspect of the FEA Model (Boorady, 2011; Gupta, 2011a; Gupta, 2011b). The sport of rock climbing is the culture surrounding the target consumer, and the functional apparel needs - fit, mobility, comfort, protection, and donning/doffing – were assessed for the rock climbing pants (Lamb & Kallal, 1992). Fit relates to how the garment hangs on the body and whether the garment is not too tight or loose in any given area of the body it covers (Talbot, 1943). Mobility surveys the ease in which the wearer does various motions that are related to the functional garment (Gupta, 2011a). Comfort is the psychological, physiological, and physical factors that the garment has with the wearer's body, especially in varying temperature or weather conditions (Das & Alagirusamy, 2010; Cox & Fulsaas, 2007). Protection focuses on keeping the body safe from potential harm (Gupta, 2011a). Donning and doffing assesses any problems with getting in and out of the garment due to wearer safety or physical limitations (Watkins, 1984). The integration of all the functional aspects – fit, mobility, comfort, protection, and donning/doffing – helped determine the pant needs of outdoor rock climbers. The purpose of this exploratory study was to assess the functional pant needs of outdoor rock climbers.

## Objective

The objective of this study was to assess the functional needs of outdoor rock climber pants by looking at: a) fit, b) mobility, c) comfort, d) protection, and e) donning/doffing. The following research questions were addressed:

1. **How does fit satisfaction differ across the different dimensions of pant fit (i.e., pant length, waist, crotch, etc.)?**
2. **What is the overall pant mobility and wearability while rock climbing?**
3. **How does pant mobility and wearability differ based on the rock climbing technique?**
4. **Do rock climbers prefer certain brands, types, or styles of rock climbing pants for specific rock climbing techniques?**
5. **What is the overall comfort of rock climbing pants after rock climbing?**
6. **How do different comfort dimensions (stickiness, itchy, stiffness, etc.) in rock climbing pants differ after rock climbing?**
7. **What is the overall protection and durability in rock climbing pants currently in the market?**
8. **Which areas of rock climbing pants have the most durability problems?**
9. **How do rock climbers rate the ease with which they can don and doff rock climbing pants?**

## Significance of Study

As the number of rock climberers continues to increase, outdoor recreational clothing manufacturers and retailers should anticipate that consumers will demand rock climbing pants that fit properly, provide adequate range of motion, are comfortable, protection the wearer, as well as being easy donning/doffing (Outdoor Industry Association, 2012). Due to a lack of research concerning outdoor recreational apparel, specifically rock climbing pants, there was no way to assess the needs of this consumer. Therefore, this research will contribute to the limited scholarly studies pertaining to outdoor sport apparel, mainly rock climbing pants, and will

expand the understanding of the outdoor sport apparel functional needs related to fit, mobility, comfort, protection, and donning/doffing while participating in a outdoor sport.

## Assumptions

The assumptions for this study include:

1. Rock climbing pants are currently not fulfilling the needs of the consumer.
2. Rock climbers are able to articulate the functional problems with their rock climbing pants.

## Definition of Terms

- Comfort: Garment ability to provide thermal balance of the body by (1) creating an insulating layer of air between the skin and garment to help keep the wearer warm, (2) keeping rain from reaching the skin so the wearer stays dry, (3) protecting against wind chill, and (4) keeping the wearer from becoming excessively hot when climbing in high temperatures, thereby creating an overall sense of comfort, which is psychological and physiological, for the wearer (Cox & Fulsaas, 2007; Das & Alagirusamy, 2010; Fan & Tsang, 2008; Ho, Fan, Newton & Au, 2011; Kamalha, Zeng, Mwasiagi, & Kyatuheire; 2013).
- Donning: The act of putting on an article of clothing ("Don", n.d.).
- Doffing: The act of taking off an article of clothing ("Doff", n.d.).
- Functional, Expressive, Aesthetic (FEA) Model: A user-centered model that identifies the target consumer, culture, and aids in developing design criteria for a variety of end consumers by assessing functional, expressive, and aesthetic needs (Lamb & Kallal, 1992).
- Fit: The way a garment properly hangs on the body without bulkiness or wrinkles (Talbot, 1943).
- Functional Apparel: Apparel that is designed and engineered to perform a specific function for the end consumer (Gupta, 2011a).

- Mobility: Movement of the body with minimal obstruction from the clothing (Gupta, 2011a).
- Outdoor Rock Climbing: The ascent of a natural rock formation by using handholds and footholds found on the rock formation (Cox & Fulsaas, 2007).
- Protection Apparel: A barrier between the human body and environmental elements that is crucial to the health and safety of the wearer (Bye & Hakala, 2005).
- Protective Apparel: A barrier between the human body and other elements that could injure, harm, or kill the wearer (Gupta, 2011a).
- Rock Climbing: The ascent of a rock formation (natural or man-made structure) by using handholds and footholds found on the rock formation (Cox & Fulsaas, 2007).
- Rock Climbing Apparel: Garments made for the sport of rock climbing; due to inclement weather conditions, this includes a variety of garments to cover the upper and lower portions of the body; such as, pant, short, t-shirt, short sleeve top, long sleeve shirt, sweater, sweatshirt, jacket, along with a type of head covering (Cox & Fulsaas, 2007).

# CHAPTER II. LITERATURE REVIEW

A review of literature was conducted to fully understand the functional pant needs of rock climbers. First, functional apparel classifications were reviewed as rock climbing pants are a functional garment. Then a review of rock climbing, types of rock climbing, rock climbing techniques, rock climbing clothing and gear, along with the functional needs of rock climbers with regards to fit, mobility, comfort, protection, and donning/doffing. Finally, the Functional, Expressive, and Aesthetic conceptual framework (FEA Model) was examined to cohesively assess the rock climbing pant.

## Functional Apparel Classifications

All apparel provides protection from the environment, but functional apparel provides a specific, and often crucial, function for the wearer (Gupta, 2011a). The wearer's expectations for a functional garment are the primary concerns and any aesthetic or expressive feature on the garment is secondary (Gupta, 2011a; Gupta, 2011b). Functional apparel is a new, diverse, and growing industry encompassing multiple markets and end consumers (Gupta, 2011a). As technology and textiles continue to develop, the functional apparel industry should develop new functional garments and classes for this growing market (Gupta, 2011a). Gupta (2011a) provides a six category classification system for functional apparel – protective, medical, sports, vanity, cross-functional, and special needs. Each of these classes features unique attributes for the end consumer, and many of the classes have sub-categories.

Protection apparel addresses occupational hazards; potential injuries and/or the possibility of fatalities in the workplace or sport (Gupta, 2011a). For example, firefighters work in extreme temperatures and are exposed to fires, so their firefighting garments must protect them from the fire and heat while helping them to maintain a normal body temperature. Lawson

(1996) found that heat and flames were the highest concern for firefighters regarding firefighting functional garments. Improving the firefighter garment to provide better protection in these conditions allows firefighters to safely perform their job.

Medical apparel has grown beyond protection in recent years and now encompasses bio-sensing, healing, and rehabilitative properties (Gupta, 2011a). Burn units in hospitals are using compression garments to limit blood flow and reduce scar tissue on burn victims (Anand, Govarthanam, & Gazioglu, 2013). Bio-sensing clothing incorporates sensors into the garment to access a patient's heart rate, blood oxygen level, pulse, and various other vital signs (Cho et al., 2009). Currently, health monitoring clothing is being developed and tested to better assess electric heart signals in active, mobile patients to allow for accurate readings while the patients do normal activities (Cho et al., 2009). These medical garments give patients an improved level of care and comfort while being treated as a patient.

Sports class apparel enhances the performance of the player (Gupta, 2011a). Compression textiles incorporated into cycling shorts reduced muscle fatigue and decreased the wind resistance (Casselman-Dickson & Damhorst, 1993; Gupta, 2011a). Male tennis players studied by Jin and Black (2012) stated that comfort, fit, and movement of their apparel potentially affected their performance. Dickson and Pollack (2000) found female in-line skaters to have high comfort needs in skating clothing, whereas Casselman-Dickson and Damhorst (1993) found female bicyclists were concerned more about comfort, fit, and protective features, especially in cycling shorts. Based on the aforementioned studies, having a pair of high wicking shorts would remove perspiration from the body more quickly thereby potentially increasing comfort while enhancing athletic performance (Casselman-Dickson & Damhorst, 1993; Dickson & Pollack, 2000; Jin & Black, 2012).

Vanity apparel, an undergarment also known as shapewear and foundation garments, is designed to provide a "slimming and flattening effect on stomach, waist, hips, thighs, buttocks, and back" (p. 325) as it compresses and shapes a particular body area(s) to provide smooth lines under the garments (Gupta, 2011a). The Nakahaski, Morooka, Nakamura, Yamamoto, and Morooka (2005) study found participants that wore a higher compression waist garment tended to view their silhouette more satisfactory even though they reported higher garment discomfort levels. While studies in consumer satisfaction of vanity apparel are limited, studies on the skin pressure of compression garments report these garments impact blood circulation and effect the core body temperature of wearers (Lee, Hyun, & Tokura, 2000; Lee, Hyun, & Tokura, 2001; Nakahaski, et al., 2005)

Special needs apparel strives to enhance the well-being and self-sufficiency of a group that is perceived as *different* by the general population (Gupta, 2011a). Stokes and Black (2012) in their assessment of adolescent girls with disabilities, found issues with fit, comfort, mobility, and safety to be paramount. While the girls wanted to have clothing similar to that of their peers, it was difficult for them to find garments that accommodated their handicap.

Cross-functional apparel is a more complex class, which incorporates multiple functions into one garment. Military applications are the most common garment in this class as multiple protective elements along with gear and military accessories are incorporated into the garment (Gupta, 2011a). Body armor is constantly being improved in order to be lightweight, more mobile, and provide better body coverage, yet the amount of gear a soldier wears over the uniform should be addressed, too (Park et al., 2011; Starr, Cao, Peksoz, & Branson, 2015). Each layer of protection, along with necessary survival gear, changes the way the uniform fits the body creating problems with protection, mobility, and comfort (Shanley, Slaten, & Shanley,

1993). Understanding all of these multiple functions and assessing them as a whole unit helps improve the cross-functional garment, and ultimately the safety of the wearer.

Of these six functional categories discussed above, cross-functional apparel is the category that most closely applies to rock climbing pants. The main purpose of a pant is to protect the wearer from outdoor elements which puts it into the protection category. However, since rock climbing is also a sport, the rock climbing pant fits most appropriately into the cross-functional category.

## Rock Climbing

Rock climbing, as a sport, began with the first ascent of Mont Blanc in 1786 and has its roots in mountaineering (Perkins, 2005). Over the next 200 years, rock climbing continued to evolve as a separate sport from mountaineering, developing its own set of ethics, rules, and language that define it as a culture (Cox & Fulsaas, 2007; Perkins, 2005). Participating in rock climbing requires a partner, but usually groups of people climb together (Bates, 2012; Lyman & Riviere, 1975). Having a common interest in climbing, group members dress accordingly by wearing specialty gear, rock climbing shoes, and apparel that are specifically designed for the sport (Cox & Fulsaas, 2007). It is this entire assemble of dress that defines them as a rock climber (Cox & Fulsaas, 2007). Ethics in rock climbing revolve around environmental impacts and the overall safety of all climbers (Lyman & Riviere, 1975; Perkins, 2005). Rock climbers respect the environment, follow "leave no trace" rules, obey posted signage, and respect private property (Bates, 2012; Cox & Fulsaas, 2007). Climbers have a concise language when climbing together that communicates their movements, thereby maintaining a standard level of safety for all climbers (Cox & Fulsaas, 2007). Commands like; *on belay, climbing, rock, falling, up rope, slack*, all have meaning to a rock climber that communicates not only to their partner but also to

anyone climbing in that area (Cox & Fulsaas, 2007). The culture of rock climbing defines itself by its unique characteristics of ethics, rules, language, gear, and apparel.

**Rock Climbing Techniques**

Of all the various techniques used in rock climbing, this section will focus only on the commonly used techniques involving movement of the lower body; (1) belay, (2) chimney, (3) face climbing/friction, (4) ledges, overhang, or roof, (5) lieback, (6) mantle, (7) rappel, (8) stem, and (9) traverse (Cox & Fulsaas, 2007).

Belaying is where one climber anchors him or herself and feeds out or takes in rope to safeguard the climber should the climber loses their hold and fall (Lyman & Riviere, 1975). The person that is safeguarding the climber is called the belayer. Belaying is critical in rock climbing. A good belayer is always watching the climber to take up rope, communicate to the climber, anticipate a fall, or hold fast to the rope if the climber falls (Long, 1989). If the climber falls, and has a good belayer, then the climber may only fall a few inches or a few feet depending on the type of climbing they are performing (Long, 1989; Lyman & Riviere, 1975). The belayer wears a harness over their pant. A belay device is attached to the front of the harness with a carabiner, a looped metal device with a hinged gate used to connect two pieces of equipment, and then the climbing rope is run through the belay (Gerrard, 1990; Lyman & Riviere, 1975). Depending of the type of climbing, location of the belay site, and the style of the belayer, the belaying technique can involve sitting, squatting, or standing. If a severe enough fall occurs, the belayer could be lifted off the ground by the force of the fall (Cox & Fulsaas, 2007). The combination of the harness, rope tension, belay position, and possibility of a fall may cause the pant to become uncomfortable, pinch, or rub in various areas around the harness.

Any crack in the rock formation large enough for the climber to place their body into can be ascended using the chimney technique (Cox & Fulsaas, 2007; Long, 1989). These types of rock formations are called chimneys, hence the climbing technique name associated with the formation. The climber uses the counterforce of their body against the chimney wall to move up the chimney (Cox & Fulsaas, 2007). Depending on the size of the chimney, the climber may use their lower back, knees, or feet in combination with their arms and hands to ascend the chimney (Cox & Fulsaas, 2007; Long, 1989). The climber's body being used as counterforce can cause bruising, lacerations, or abrasions on the body while performing this technique. So proper garment protection is essential to minimize this (Long, 1989).

Face climbing, also known as friction climbing, is the technique used to ascend a nearly featureless rock slab (Cox & Fulsaas, 2007). Face climbing involves the use of foot friction and balance in order to ascend safely. Most of the climbing is done by applying foot friction on top of the feature then pushing the body up while maintaining good balance (Cox & Fulsaas, 2007). The climber uses a variety of leg and foot movements to ascend a slab face. Depending on the location of the feature, they may have to use the side of the foot, heel, or toe, and though rarely done, the placement of a knee for friction may be needed (Cox & Fulsaas, 2007).

Ledges, overhangs, or roofs are all rock outcroppings that require different techniques in order to ascend the route. Techniques vary based on the angle, width, or length of the outcropping, along with available hand and footholds. The climber may have to use a high step, heel hook, or even a knee in order to gain a foothold that will allow them to ascend (Cox & Fulsaas, 2007). These types of positions require dynamic balance and flexibility in the climber, along with the pant flexibility so to not impede the climbing, which could result in a fall (Hague & Hunter, 2006). Additionally, these types of movements place pressure on the heel, ankle, or

knee which can cause bruising. Pants with a good range of motion are important when climbing routes that involve a ledge, overhang, or roof.

Liebacking is a technique used when climbing small vertical cracks that require the hands to pull and the feet to push in opposite direction while ascending the crack (Cox & Fulsaas, 2007; Long, 1989). Some part of the climber's body, torso to hip, is pressed again the rock while the climber uses the lieback technique to move up the crack, which can result in bruising, lacerations, or abrasions. This technique is also strenuous for the climber; if the hands slip, or the body becomes off balance, the climber falls (Long, 1989). Pants that provide protection from the rock and flexibility are important when performing this technique.

A climber uses the mantle technique when they arrive at an area with no useful handholds within arms distance so the climber must bring the body up so the existing handhold can become a foothold (Cox & Fulsaas, 2007). The climber must use their feet to walk up the rock until the hands can be used with downward pressure. The climber must then place one foot onto the handhold while still maintaining downward pressure along with balance and then push up on the foot to bring the body firmly onto the foothold (Cox & Fulsaas, 2007). This technique requires knee flexion in the lower body, sometimes raising it as high as the hip level. So pants with considerable movement ability would be key for the mantel technique.

Rappelling is used by the climber to bring themselves off a rock formation. The body is fully weighted in the harness with the climber in a sitting position, legs straight out, while they safely descend down the rock (Long, 1989). Since the body is fully weighted in the harness, pant problems with the waistband lowering or crotch bunching may cause discomfort for the climber in rappelling situations.

A rock formation with right-angled walls and no handholds require a stemming technique to ascend the route (Cox & Fulsaas, 2007; Long, 1989). The feet and hands are placed on opposite walls with counter pressure while the body springs up to the next foothold (Long, 1989). This technique is another that requires flexibility and balance in order to ascend the route and a pant accommodating this flexibility is needed (Long, 1989).

Traversing is used to go sideways across a section of the rock in order to complete the route (Cox & Fulsaas, 2007). This technique is done in various ways based on the rock and location of the hand or footholds but the hands and feet move sideways in lieu of upwards (Cox & Fulsaas, 2007). Given the rock formation, a traverse could have the climber in a standing, crouching, or squat position while they work their way across the rock. The climbers pants would need to allow for ease of movement while in these positions. Based on all nine of these rock climbing techniques, the following research question was developed.

RQ 4. Do rock climbers prefer certain brands, types, or styles of rock climbing pants for specific rock climbing techniques?

**Types of Rock Climbing**

There are different types of rock climbing available to climbers based on the geology of an area, the formation of the rock, and the skill level of the climber. Rock climbers must have geological knowledge of the area they are climbing, and what the formations are in order to make a decision of the type of rock climbing available. Rock climbers call this “beta” as they research what type of rock is at the climbing site, what type of anchors (natural or placed) are available, the height of the route, protection available on the route, and the overall rating of the route. Once this information is collected, they can ascertain if (1) top rope climbing, (2) face

climbing, (3) traditional climbing, (4) sport climbing, or (5) crack climbing is the best option of the area and route.

Top roping involves the rope being attached to an anchor at the top of the route, and one end of the rope is attached to the belayer at the bottom of the route while the other end is attached to the climber (Cox & Fulsaas, 2007). As the climber ascends the route, the belayer takes in the rope and once the climber is at the top of the route they can signal to the belayer that they are ready to be lowered back to the ground (Cox & Fulsaas, 2007). If a climber falls while on top rope, the total distance of the fall is the length of the rope not taken up by the belayer plus any rope stretch. So ideally a climber will fall only a few inches or a foot or two (Cox & Fulsaas, 2007). As top rope can be done in many places, the movements involved are varied based on the geology and formation of the rock. A climber could easily perform a mantel, traverse, or lieback while on top rope.

Traditional climbing, also known as “trad” or “lead” climbing, involves placing protective gear into the rock cracks or crevices so the climber can anchor themselves to the rock as they are ascending the route (Cox & Fulsaas, 2007). When traditional climbing, one end of the top is attached to the climber. The climber then must place protective gear into the rock as they climb. Once protection is placed, they clip the rope into the protective gear and continue to ascend. The other end of the rope is attached to the belayer that may be on the ground, rock ledge, or other location on the rock (Cox & Fulsaas, 2007). Traditional or lead climbing requires the climber to carry an extensive amount of gear based on the climb. This gear adds weight to the climber, can get in the way as they climb, or become stuck on the rock in rare circumstances (Cox & Fulsaas, 2007). If the climber falls, the fall is dependent on the distance of the last placed protection plus the rope stretch so the climber may fall inches or multiple feet depending on the

route (Cox & Fulsaas, 2007). Movements in traditional climbing are also varied and could involve cracks, stemming, mantels, traverses, etc.

Sport climbing are special routes that have permanently placed anchors or bolts along with route that the climber clips the rope into as they ascend (Cox & Fulsaas, 2007). Like traditional climbing, one end of the top is attached to the climber. The climber then clips the rope into the anchors or bolts as they ascend, and the other end of the rope is attached to the belayer (Cox & Fulsaas, 2007). The difference is that the climber does not have to carry as much protective gear and typically has a set of quickdraws, a length of webbing with a carabiner at each end, which is used to attach to the permanent anchors on one end and then place the climbing rope through the other end. Movements in sport climbing are also varied based on the rock formation and route but could include a roof, mantel, traverse, or a ledge.

Face climbing, sometimes called slab climbing, is merely climbing the face of the rock which is devoid of obvious cracks, rock jugs, or other rock outcroppings to place your hands and feet on; to the untrained eye it appears featureless (Cox & Fulsaas, 2007; Long, 1989). Climbers who face climb must keep their body weight correctly balanced, use foot friction to climb, hand holds for balance, and rely on counter pressure (Cox & Fulsaas, 2007; Long, 1989). Movements like foot crossing, manteling, stemming, and liebacking are typically used in face climbing (Cox & Fulsaas, 2007).

Crack climbing is exactly what the name implies, climbing in a rock crack. The climber follows the natural line of the crack requiring sophisticated and strenuous movements where jamming of a limb or contouring the body inside the crack is needed to ascend (Long, 1989). Crack climbing can be done either by top rope, traditional, or sport climbing. Movements

involved in crack climbing consist of jamming hands or fingers, placing a portion of the body into an off-width crack, chimney, stemming, and liebacking (Cox & Fulsaas, 2007; Long, 1989).

**Rock Climbing Clothing and Gear**

**Pants**. Many outdoor apparel manufacturers make pants for climbing. These pants are designed to improve mobility by using various fabrics, functional design features and/or functional ease (Boorady, 2011; Watkins, 1984). The pants are made of fabric blends (natural and synthetic fibers) along with Lycra® or spandex (Broudy, n.d.; Ellison, 2013). The Lycra® or spandex blend adds functional ease to the pants by way of stretch, giving fabric flexibility, thereby allowing more movement to take place, and providing a better fit (Watkins, 2011; Watkins, 1984). A gusseted crotch is a common feature in many mens rock climbing pants (Ellison, 2013). It allows for more movement in the hip and leg area allowing the climber to have a larger range of motion when compared to a non-gusseted pant (Ellison, 2013; Gerrard, 1990; Watkins, 1984). Articulated knees, darts sewn on the front pant around the knee, are featured in several pants to provide the climber with more movement by placing a dart(s) on each side of the knee, thereby adding functional ease (Broudy, n.d.; Ellison, 2013; Watkins, 1984). The design of the pants range from a jean appearance with front fly zipper, snap waistband closure, but with zippered pockets to a more athletic pull on style with a drawstring or elastic wasitband with zippered pockets (Broudy, n.d.; Ellison, 2013). The wide range of styles and features found in the current rock climbing pants allows for some mobility and protection in the pant for rock climbers. It is these functional design features and/or ease that can increase the wearers' range of motion and provide protection when exposed to abrasive or sharp rock (Cox & Fulsaas, 2007). As rock climbing relies on the legs to push the body upward, many of the climbing techniques

involve various areas of the lower body to be in contact with the rock formation thereby making it the most important garment in rock climbing (Cox & Fulsaas, 2007; Gerrard, 1990).

**Shirts/Tops.** A review of climbing magazines, outdoor apparel websites, and outdoor apparel retail shops found that there were no specifically made shirts or tops for rock climbing. Shirts and tops manufactured and displayed with climbing pants ranged from t-shirts to highly technical athletic tops featuring wicking, odor control, and body mapping designs. All were made for a wide range of motions, most body fitting in styles, and varied sleeve lengths from long sleeve to short sleeve, along with sleeveless styles. Fabric stretch, wicking ability, and warmth without overheating were common traits found in these shirts and tops.

**Shoes.** Rock climbing shoes are specifically made for rock climbing with leather or synthetic uppers, unlined or lined, with a highly technical rubberized sole including a rubberized area that is above the sole, around the sides, back and in front of the toe known as a complete rand (Gerrard, 1990; Rockandice.com, 2014). These shoes are made only for climbing and are not worn for normal walking or even during the approach walk due to the rubberized soles and overall unqiue fit (Gerrard, 1990). This highly technical rubber used in rock climbing shoes varied in thickness from the sole to the rand, and allows for increased friction without tearing, even in high heat conditions, and stretch while climbing (Gerrard, 1990; Rockandice.com, 2014). The rubber rand that covers the outside of the foot, including the heel and toes, enable the climber the use these areas of the foot for friction or jambing into cracks without the foot slipping off the rock (Gerrard, 1990). Standard rock climbing shoes have Velcro® or lacing closures, and those with wide elastic closures are called slippers (Gerrard, 1990).

**Gear.** Basic rock climbing gear includes a climbing harness, helmet, belay device with carabiner, and a climbing rope (Gerrard, 1990). Additionally, a climber may want a chalk bag,

gloves, and a variety of climbing hardware and protection; such as, carabiners, nuts, cams, quickdraws, chocks, slings, etc. that may be needed depending on the type of climbing (Gerrard, 1990). Rock climbing hardware and protection are typically worn on the body, either attached to the harness or worn on a gear sling across the torso, and has the potential to cause problems with the climber due to weight, hindrances on the route, or conflicts with garments (Cox & Fulsaas, 2007). It is important for the climber to recognize and understand these problems when selecting the hardware and protection needed for each route (Cox & Fulsaas, 2007).

**Functional Needs for Outdoor Rock Climbing**

Functional apparel needs are assessed by looking at the fit, mobility, comfort, protection, and donning/doffing aspects of the garment (Lamb & Kallal, 1992). Each aspect is an important and unique component to assess the overall pants performance in rock climbing.

**Fit.** The fit of apparel is a balance between the human body and clothing, which is dependent of the perception of the clothing on the wearer's body (Chen, LaBat, & Bye, 2010). Fit is very individualistic, and differs based on wearer's gender, age, apparel size, cultural influences, ethnicity, body shape, lifestyle, apparel trends, function of garment, and can also change in one's lifetime (Boorady, 2011; Brown & Gallagher, 1992; LaBat & DeLong, 1990; Pisut & Connell, 2007; Yu, 2004). The wearer's perceptions of fit comes from how a garment conforms to the body (LaBat & DeLong, 1990). It should hang smoothly on the body, and not pull, sag, bind, or twist while standing still and should not impede the wearer's body while in motion (Boorady, 2011). Additionally, an individual's perceived satisfaction of fit can also depend on factors such as, comfort (psychological and physiological), range of motion, and aesthetics, and should be considered as contributors to overall garment fit satisfaction (Boorady,

2011; Das & Alagirusamy, 2010; LaBat & DeLong, 1990; Huck, Maganga, & Kim, 1997; Pisut & Connell, 2007; Yu, 2004; Watkins, 1984).

Several studies analyze fit satisfaction with participant satisfaction ratings, and then assess key body measurement areas (LaBat & DeLong, 1990; Mitchka, Black, Heimeyer, & Cloud, 2008; Park et al., 2011; Schofield, Ashdown, Hethorn, LaBat, & Salusso, 2006; Stokes & Black, 2012; Yoo, Khan, Rutherford-Black & Khan, 1995). Based on the responses from the research participants, each area was analyzed, and fit satisfaction could be seen by area, along with an overall satisfaction of garment fit. In this study, areas of pant fit analyzed were waist, crotch, hip, thigh, knee, calf, ankle, and pant length (see Figure 1) (Joseph-Armstrong, 2010). Thus, the following research question was developed.

**RQ 1. How does fit satisfaction differ across the different dimensions of pant fit (i.e., pant length, waist, crotch, etc.)?**

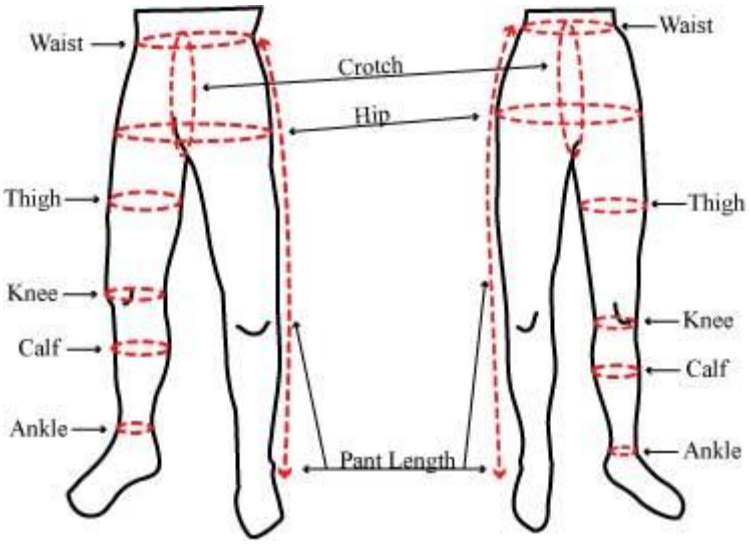



Figure 1. Key measurement areas in pant fit. © 2015 Dawn Michaelson.

**Mobility**. Mobility and body movement are closely connected to fit when analyzing functional apparel (Ashdown, 2011; Boorady, 2011; Huck, 1988). Functional apparel is designed

for specific tasks or activities; each having its own requirements for body movement so the garment does not impact mobility (Ashdown, 2011; Boorady, 2011; Huck, 1988). Prior research involving mobility of functional garments has been done with firefighters' turnout gear, protective overalls, ballistic vests, sport bras, cricket leg guards, sailing apparel, tennis players, and disabled adolescent girls (Bye & Hakala, 2005; Huck, Maganga, & Kim, 1997; Jin & Black, 2012; Park & Hahn, 2014; Park et al., 2011; Stokes & Black, 2012; Webster & Roberts, 2011; Zhou, Yu, & Ng; 2011). Improper fit and/or design of a functional garment may restrict movement, limit mobility, impact performance, adversely affect the level of protection, and even contribute to bodily pain and/or injury (see Figure 2) (Bye & Hakala, 2005; Huck, 1988; Huck, et. al., 1997; Jin & Black, 2012; Park et al., 2011; Stokes & Black, 2012; Watkins, 2011;

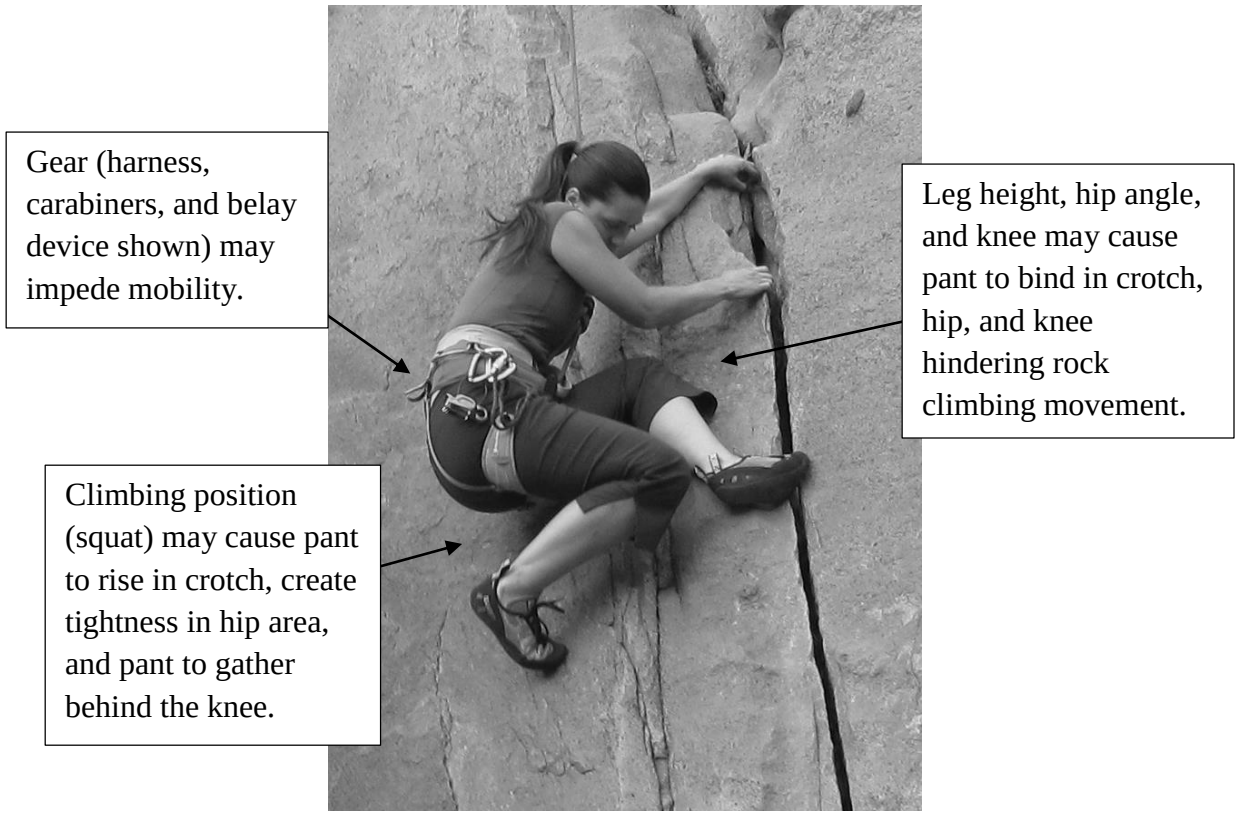



*Figure 2*. Conceptual problematic areas of rock climbing pant related to mobility while performing a lie back maneuver. © 2015 Dawn Michaelson.

Watkins, 1984; Webster & Roberts, 2011; Zhou, et. al., 2011). Movement analysis is paramount, as it investigates the necessary range of movements or tasks needed to be accomplished by the wearer to gain maximum mobility (Boorady, 2011; Huck, et. al., 1997; Watkins, 1984). Analysis can be achieved in various ways – observation, photographic, video, motion capture, questionnaires, surveys, interviews, and measurement of range-of-motion (Boorady, 2011; Huck, et. al., 1997; Park et al., 2011; Watkins, 1984). Ashdown (2011) reported that physics-driven body avatars and fabrics are currently being developed so fully clothed avatars can be analyzed while in dynamic motion. These methods should include all typical garments, accessories, or gear worn during the activites so realistic movements can be observed, whether performed in field or a labatory (Boorady, 2011; Huck, 1988; Park et al., 2011; Watkins, 1984). Once analysis is completed, then problematic areas can be evaluated for redesign to improve mobility (Boorady, 2011; Huck, et. al., 1997; Watkins, 2011; Watkins 1984). Thus, the following research questions were developed.

**RQ 2. What is the overall pant mobility and wearability while rock climbing?**

**RQ 3. How does pant mobility and wearability differ based on the rock climbing technique?**

**Comfort.** Clothing comfort can be broadly defined by looking at psychological, physiological, and physical aspects and how they affect the wearer in the near environment (Branson & Sweeney, 1991; Das & Alagirusamy, 2010; Kamalha, et. al., 2013; Markee & Pedersen, 1991; Roy Choudhury, Majumdar, & Datta, 2011; Slater, 1985). Due to these multiple aspects, comfort can be problematic to measure as the term is both relative and subjective to each wearer (Markee & Pedersen, 1991; Slater, 1985). Rock climbing clothing is worn to protect the body from climate changes, environmental elements, and unconventional situations while

maintaining thermal balance of the body temperature (Branson & Sweeney, 1991; Das & Alagirusamy, 2010; Ho, et. al, 2011). A micro-climate is created between the body and the garment to help achieve overall comfort for the wearer (Branson & Sweeney, 1991; Das & Alagirusamy, 2010). Prior studies with military apparel, sailing apparel, dancewear, in-line skating, bicycling shorts, male tennis apparel, and girls' disability apparel all found psychological and physiological comfort levels to affect wearer satisfaction with clothing (Black & Cloud, 2008; Bye & Hakala, 2005; Dickson & Pollack, 2000; Jin & Black, 2012; Mitchka, Black, Heitmeyer & Cloud, 2008; Shanley, et. al., 1993; Stokes & Black, 2012). As rock climbing is a sport requiring dynamic movements, the climber's body, mental status, and near environment all play a role in comfort (Kamalha, et. al., 2013; Watkins, 1984). When overall comfort is optimized, the wearer is not distracted by clothing, and is able to perform competently with no hindrances (Ho, et. al, 2011; Kamalha, et. al., 2013; Roy Choudhury, et. al, 2011).

The psychological aspects of clothing comfort are sensory and tactile perception, and thermoregulation (Branson & Sweeney, 1991; Das & Alagirusamy, 2010; Kamalha, et. al., 2013). Sensory and tactile sensations are when the clothing makes direct contact with the skin (Das & Alagirusamy, 2010; Kamalha, et. al., 2013; Roy Choudhury, et. al, 2011). The wearer may state clothing feels smooth, stiff, prickly, itchy, rough, or scratchy when describing tactile sensations as this is how the fabric feels against the wearer's body (Kamalha, et. al., 2013; Roy Choudhury, et. al, 2011). Thermoregulatory responses, such as sweating or shivering, will result if the wearer is stating they feel chilly, hot, damp, sticky, clingy, or wet (Das & Alagirusamy, 2010; Kamalha, et. al., 2013; Roy Choudhury, et. al, 2011). This type of thermoregulatory response is observed regularly with sports or other intensive physical activities that cause the skin moisture to become trapped between the skin and clothing creating discomfort for the

wearer (Das & Alagirusamy, 2010; Ho, et. al, 2011). Bye and Hakala (2005) found women's sailing apparel needed to have a layering system to maintain thermal balance and avoid hypothermia. Shanley, Slaten, and Shanley (1993) stated military apparel must be comfortable in various climate zones and during intensive exercise otherwise there is a serious threat of dehydration or heat exhaustion.

Physiological comfort describes the body thermal regulatory process to produce or reduce body heat (Kamalha, et. al., 2013; Slater, 1985). Physiological comfort aspects involve thermo-physiological, age, gender, health, and activity levels (Das & Alagirusamy, 2010; Kamalha, et. al., 2013). Outdoor clothing has significant thermo-physiological comfort aspects as garments are worn during physical activities in a broad range of climate conditions (Slater, 1985). Thereby, thermo-physiological comfort factors vary for each wearer and comprises of environmental factors (wind, temperature, and humidity), clothing performance (insulation, wicking, and air permeability), and the level of activity being performed (Das & Alagirusamy, 2010; Kamalha, et. al., 2013; Watkins, 1984).

The physical activity level can greatly affect physiological comfort as sweat and higher body temperature are the direct result of intense activity (Ho, 2011). Age, gender, and health all contribute to physiological comforts whether it is from heat, humidity, or wind (Das & Alagirusamy, 2010; Kamalha, et. al., 2013). These three aspects (age, gender, and health) are difficult for a wearer to differentiate from other physiological aspects so this study focused on thermo-physiological and physical activity aspects only. Each of these factors contribute to how the body will handle blood flow to maintain internal body temperatures, and in extreme environments and/or intensive physical activity can cause hypothermia or hyperthermia, which

affects the body heat equilibrium, wearer's mental state, performance, and comfort (Ho, 2011; Kamalha, et. al., 2013; Watkins, 1984).

Physical comfort aspects related to the textile, garment fit, and pressure comfort in a garment could be described by the wearer as snug, loose, light, heavy, soft, or stiff (Das & Alagirusamy, 2010; Kamalha, et. al., 2013; Roy Choudhury, et. al, 2011). Textiles are a physical aspect of a garment that is described by the senses (smell, touch, hearing, etc.) (Das & Alagirusamy, 2010; Slater, 1985). The textile thickness, fiber, yarn, and other properties affect how the wearer describes comfort. The garments fit and pressure comfort are often described based on how the garment comes in contact with the body. Stokes & Black's (2012) study with adolescent girls with disabilities stated excess fabric created discomfort while confined to a wheelchair. It should be noted that physical comfort aspects are interlinked with both psychological and physiological comfort when measured as the wearer's senses (smell, touch, hear, etc.) effect their perceptions of comfort (Das & Alagirusamy, 2010; Slater, 1985). The wearer may state the garment feels rough thereby being a subjective comment that could be both physical and psychological in meaning.

While it is not always easy for a wearer to subjectively describe clothing comfort, it has been found that people are able to describe various discomforts more readily than some comforts (Markee & Pedersen, 1991; Roy Choudhury, et. al, 2011). Various methods have been developed over the years to quantify clothing factors based on both comfort and discomfort levels (Markee & Pedersen, 1991; Kamalha, et. al., 2013). For this study, subjective thermal comforts (psychological and physiological) were studied as it directly relates to sport activity, environmental factors, and clothing (see Figure 3). Thus, the following research questions were developed.

**RQ 5. What is the overall comfort of rock climbing pants after rock climbing?**

**RQ 6. How do different comfort dimensions (stickiness, itchy, stiffness, etc.) in rock climbing pants differ after rock climbing?**

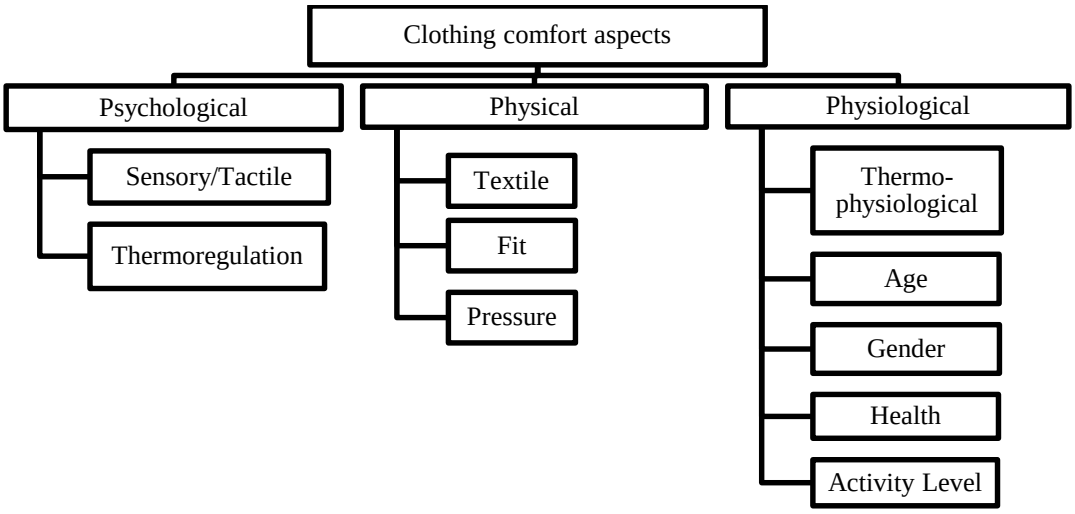



*Figure 3.* Clothing comfort aspect model. © 2015 Dawn Michaelson.

**Protection.** Protection clothing has multiple classifications, materials, and technologies depending the type of protection it is used for; occupational, recreational, or everyday (Dammacco, Turco, & Glogar, 2012; Zhou, Reddy & Yang, 2005). Occupational protection clothing systems include military and a wide range of professional occupations such as; areospace workers, pilots, fire fighters, police officers, medical workers, welders, agricultural workers, and hazardous material workers (Black & Cloud, 2008; Chen & Chaudhry, 2005; Crown & Capjack, 2005; Fenne, 2005; Leonas, 2005; Makinen, 2005; Park et. al., 2011; Shanley, et. al., 1993; Stull, 2005; Tan, Crown, & Capjack, 1998; Truong & Wilusz, 2005; Watkins, 1984). Recreational protection clothing covers a wide range of sports such as scuba diving, surfing, skiing, snowboarding, sailing, mountaineering, rock climbing, cricket, cycling, in-line skating, motorcycling, and swimming (Bitterman, Ofir, & Ratner, 2009; Bye & Hakala,

2005; Casselman-Dickson & Damhorst, 1993; Dickson & Pollack, 2000; Dammacco, et. al., 2012; Emerich, 2011; Varnsverry, 2005; Webster & Roberts, 2011). Everyday protection clothing features ultraviolet light, heat, cold, and/or rain protection (Sarkar, 2005; Watkins, 1984). Classifications of thermal (hot/cold), fire/burn, chemical/biological, ultraviolet light, respiration, and impact/ballistic can be found within each of the types of clothing protection (Chen & Chaudhry, 2005; Krucinska, 2005; Leonas, 2005; Stull, 2005; Truong & Wilusz, 2005).

Rocking climbing pants fall into both recreational and everyday protection categories. The pant must provide protection for the wearer while participating in the sport yet also from everyday environmental conditions. The general nature of rock is abrasive and sharp. So rock climbing pants need to be durable and abrasion resistant enough to hold up to these conditions (Cox & Fulsaas, 2007). Additionally, the rock climbing route typically involves walking or hiking to the rock formation. During this approach, the climber may encounter poisonous or spiny plants, biting insects, along with varying degrees on heat and cold (Cox & Fulsaas, 2007). Incorporating protection aspects into the design of the rock climbing pants through fabrics, fabric finishes, and construction techniques can increase the protection of the climber.

The materials used to produce protection clothing are both natural and synthetic fibers, technical textiles, and various surface treatments (Buckley, 2005; Hearle, 2005; Potluri & Needham, 2005). Additionally smart/intelligent technologies such as electronic devices, cooling or heating systems, light-emitting fibers, and wearable power sources may be incorporated into the final clothing product (Dammacco, et. al., 2012; Quinn, 2010; Van Langenhove, Puers, & Matthys, 2005). The overall durability of the clothing must be evaluated for lasting protection and consumer satisfaction (Hunter, 2009; U.S. Navy, 1998). Durability factors should include abrasion resistance, fabric and garment strength, dyeing and finishing effects on fabric fibers,

along with the effects of modelling on fabric strength (Hunter, 2009). It is the incorporation of these that make the garments capable of providing a higher level of protection for the wearer.

Most rock climbing pants are made from fabrics that prevent punctures, rips, or have abrasion resistant properties (Broudy, n.d.; Ellison, 2013). Moisture wicking capabilities combined with fibers that provide warmth are also seen in many rock climbing pants (Ellison, 2013). Even unique finishes like ultra-violet or insect-repellent finishes are incorporated into some current outdoor apparel garments (Outdoor Research, 2013). Rock climbing pants must be durable due to the movement and the environmental conditions they are used in. Reinforced seams and knees along with higher quality construction standards make rock climbing pants more durable and longer lasting for the rock climber (Ellison, 2013). Rock climbing pants that are able to provide these protection features are more highly rated than those the climber finds lacking in one of these areas (Broudy, n.d.; Ellison, 2013). Thus, the following research questions were developed.

**RQ 7. What is the overall protection and durability in rock climbing pants currently in the market?**

**RQ 8. Which areas of rock climbing pants have the most durability problems?**

**Donning and Doffing.** The ease in which a person can get in and out of clothing is rarely thought of until they experience a problem (Watkins, 1984). In rock climbing pants, the donning and doffing areas that can cause a problem are the waistband and pant leg opening. The waistband area can conflict with other rock climbing gear, usually the harness, and interfers with the sport (Ellison, 2013). The pant leg opening needs to accommodate the foot when both donning and doffing the pant including a foot with a shoe. The use of fasteners (zippers, buttons, snaps, hook and loop tape, elastic, etc.) aid in the donning and doffing of clothing to make it

easier and even safer for the wearer (Watkins, 1984). Disabled individuals experience a range of problems with donning and doffing clothing depending on their type of disability and seek out a variety of fastener types to aid them with their dressing (Carroll & Kincaid, 2007; Stokes & Black, 2012; Watkins, 1984). Studies on military clothing, spacesuits, thermal flightsuits, and chemical-biological suits all report donning and doffing to be critical to their protection and safety (Shanley, et. al., 1993; Tan, et. al., 1998; Watkins, 1984). Bye and Hakala (2005) found female sailors had donning and doffing problems when reducing clothing layers and using the bathroom. The U.S. Army Test and Evaluation Command (2011) tested soldier donning and doffing of clothing for speed, reliability, durability, and performance in cold regions along with the ability to use a bathroom. The Bitterman, Ofir, & Ratner (2009) study on recreational divers reported that donning and doffing of the wetsuit to be highly problematic for divers. Currently, there are no studies on the donning and doffing of rock climbing pants. An online customer review of rock climbing pants have shown that there is conflicting preferences among consumers with regard to donning and doffing the pant with waistband styles (Broudy, n.d.; Ellison, 2013). Some prefer a jean style with a front fly and snap closure, others like a flat waistband with side elastic, while others like a drawstring waistband (Broudy, n.d.; Ellison, 2013). Evaluating the donning and doffing abilities of rock climbing pants is necessary to assess ease, comfort, and safety of the wearer (Watkins, 1984). Thus, the following research question were developed.

**RQ 9. How do rock climbers rate the ease which they can don and doff rock climbing pants?**

## Conceptual Framework

Lamb and Kallal's (1992) FEA Model was the conceptual framework used for this research to assess the needs of rock climbers' pants. This framework (see Figure 4) was originally developed as a teaching method that has the target consumer in the center of a framework surrounded by their culture and then assesses their functional, expressive, and aesthetic needs (Lamb & Kallal, 1992). The framework starts with the problem identification, then proceeds to preliminary ideas, design refinement, prototype development, evaluation, and then implementation (Lamb & Kallal, 1992). The initial problem identification and evaluation is ideal for use in apparel design research on an existing product. These two areas were then developed into the FEA Model (see Figure 5). The FEA Model has been applied to research for functional apparel needs in mature women's golf wear (Chae & Evenson, 2014), women's sailing apparel (Bye & Hakala, 2005), male tennis apparel (Jin & Black, 2012), women's snowboard apparel (Emerich, 2011), and apparel for adolescent girls with disabilities (Stokes & Black, 2012).

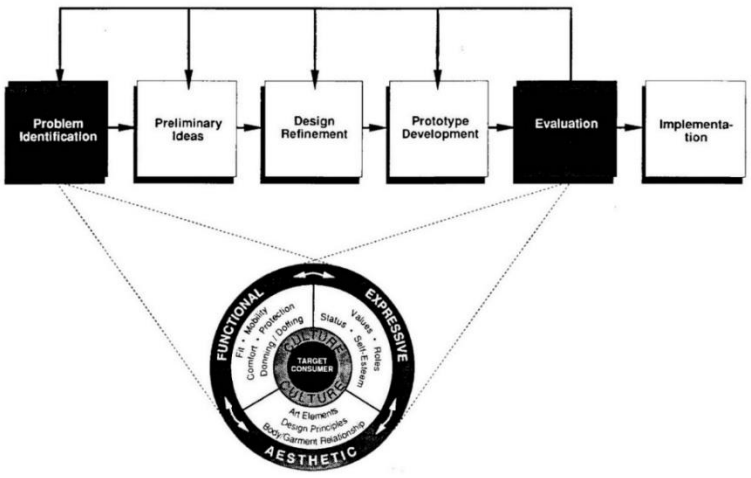



*Figure 4*. Apparel design framework (Lamb & Kallal, 1992).

Functional considerations are paramount for this study's consumer since the garment is made to protect the climber while providing proper fit, comfort, and mobility (see Figure 5) (Gupta, 2011a; Lamb & Kallal, 1992). As rock climbing is an outdoor sport where weather, terrain, and diverse physical activity are required, all aspects of the functional category of the FEA Model are relevant to this study. The assessment of rock climbing pants using the FEA Model addressed fit, mobility of the pant in a dynamic state, comfort, protection from the environment, and the donning and doffing of the pant while wearing additional rock climbing gear.

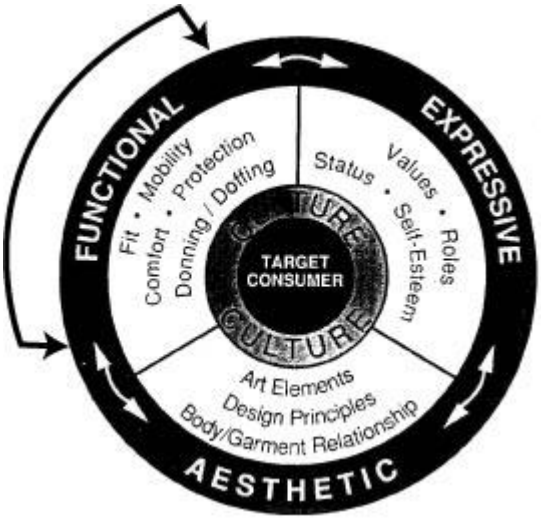



*Figure 5.* FEA Consumer Needs Model (Lamb & Kallal, 1992).

# CHAPTER III. METHODOLOGY

## Research Design

This exploratory study investigated the needs assessment for rock climbing pants as a functional garment by looking at fit, mobility, comfort, protection, and donning/doffing expectations of the rock climbing pant. A survey was conducted to gain an in-depth understanding of the needs of the rock climber and their pant as a functional garment.

## Sampling Procedures and Sample Characteristics

A convenience sample of male and female adult rock climbers attending rock climbing events in the United States was asked to participate in this study. The United States has more rock climbing routes than any other country making it a destination for rock climbing events and festivals (Kresner, 2012; Rockclimbing.com, 2014). This sample included international climbers attending these rock climbing events, as well as American climbers. The study looked at all active rock climbers that were at least 19 years old and up. Outdoor Foundation (2013) stated first time rock climbers median age ranged from 26 (sport) to 31 (traditional) years of age but there is a significant drop in participation after the age of 60. An active rock climber was defined as any rock climber participating in the sport for at least 6 months and had been rock climbing in the past two years. Auburn University Institutional Review Board (IRB) approval was obtained prior to data collection (Appendix C). A booth was setup at multiple rock climbing events to distribute the self-administered, paper-and-pencil questionnaire. An IRB approved Information Letter that discussed the purpose of the study, potential risks and discomforts, benefits, compensation, confidentiality, voluntary participation and withdrawal, consent, and contact information for the study was given with the questionnaire (Appendix C). The booth consisted of

a pop-up tent structure, a 6-foot folding table, an advertising sign, along a minimum of 5 folding chairs. The booth was manned during open event hours with a 15 minute break every 4 hours.

Potential respondents coming to the booth were told the research was looking at the fit, mobility, comfort, protection, and donning/doffing abilities of rock climbing pants, their satisfaction levels with their rock climbing pants while performing specific climbing techniques, and the incentives. The first 180 respondents to return a completed questionnaire received an incentive. They were asked if they would be willing to participate in the research study. If interested, they are given an information letter and questionnaire to complete.

No preference of gender was required for the survey but respondents had to be at least 19 years of age and participated in the sport of rock climbing within the past two years. Rock climbing events are held typically between March and October in the United States and vary in number of participants so more than one location was needed for this study. Climbing events were chosen by event longevity, overall event participation, and event date. The climbing events, dates, and approximate participant numbers for this study are below.

- The International Climbers' Festival, in its 21st year is considered the longest running climbing festival in the world draws approximately 400 attendees each year (Pohja, 2014). The 2014 event was held July 9-13 had 478 attendees. Permission was obtained to collect data during the trade fair area on July 11, 2014 from 2 pm -11 pm at City Park, 405 Fremont St., Lander, WY 82520 .
- Twenty-four Hours of Horseshoe Hell had its first competition in 2006. Today, the event can accommodate 450 competitors and has approximately 1,000 attendees each year (Chasteen, 2014). The 2014 event was held September 24-28th and permission to collect data at the

trading post area on Thursday, September 25th from 2 pm-7 pm from the competitors at Horseshoe Canyon Ranch, Jasper, AK 72641 was obtained.

A 10% response rate was expected for this survey thereby providing an approximate sample size of 140 potential respondents. Once the survey was completed, the respondent was thanked for their time and given the incentive, if one was available. At the completion of all events, a total of 191 completed questionnaires were received thereby exceeding our original response rate by 36.5% and providing an approximate response rate of 20.6%.

## Instrumentation

The questionnaire (Appendix A) was developed based on published needs assessment studies and the functional category of the FEA Model (Black & Cloud, 2008; Bye & Hakala, 2005; Casselman-Dickson & Damhorst, 1993; Dickson & Pollack, 2000; Huck, et. al., 1997; Jin & Black, 2012; Lamb & Kallal, 1992; Mitchka, et. al., 2008; Shanley et al., 1993; Stokes & Black, 2012). It was a self-administered paper-and-pencil questionnaire with a colored cover page displaying the Auburn University logo and title of the research study.

### Fit

The first question based on LaBat and DeLong (1990) Fit Satisfaction Scale (see Figure 6) asked for the respondents' satisfaction of rock climbing pant fit at different areas of the body while climbing. Using a 9-point Likert type scale (1 = *Stongly Dissatisfied*; 9 = *Strongly Satisfied*), participants were asked to rate eight lower body areas that relate to pant fit: pant length, waist, crotch, hip, thigh, knee, calf, and ankle (see Figure 7). Two body areas, the knee and ankle, were added to the LaBat and DeLong (1990) Fit Satisfaction Scale as these body areas have a lot of movement that can cause fit problems. This question was modified from LaBat and

| Site |
|---|
| Pant length |
| Crotch |
| Thigh |
| Buttocks |
| Hip |
| Sleeve length |
| Waist length |
| Waist |
| Abdomen |
| Shoulder blade |
| Bust |
| Shoulder |
| Skirt length |
| Armscye |
| Upper arm |
| Midriff |
| Calf |
| Lower arm |
| Elbow |
| Neckline |

*Figure 6.* Fit Satisfaction Scale (LaBat & DeLong, 1990).

DeLong's (1990) 5-point scale (1 = *lowest satisfaction* to 5 = *highest satisfaction*) to a 9-point scale (1 = *Stongly Dissatisfied*; 9 = *Strongly Satisfied*) along with the addition of a "not applicable" area. LaBat and DeLong's (1990) study did not report scale reliability.

1. **Circle** a number on a 9-point scale (1= Strongly disagree, 9 = Strongly agree) that best matches your level of satisfaction with the **various fit areas of rock climbing pants you typically or most frequently wear while climbing** for each of the following areas.

| Site | Strongly Dissatisfied | Dissatisfied | Moderately Dissatisfied | Mildly Dissatisfied | Neither | Mildly Satisfied | Moderately Satisfied | Satisfied | Strongly Satisfied | Not applicable |
|---|---|---|---|---|---|---|---|---|---|---|
| Pant length | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Waist | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Crotch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Hip | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Thigh | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Knee | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Calf | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Ankle | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |

*Figure 7.* Question 1 relating to fit satisfaction of rock climbing pants typically or most frequently worn while climbing.

**Mobility**

The second question dealt with mobility and was modified from Huck, Maganga, & Kim's (1997) Wearer Acceptability 9-point semantic differential scale (see Figure 8).

Place a check between each pair of adjectives at the location that best describes how you feel:

| | | | |
|---|---|---|---|
| 1. | Comfortable | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1* | Uncomfortable |
| 2. | Acceptable | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Unacceptable |
| 3. | Tired | 1 \| 2 \| 3 \| 4 \| 5 \| 6 \| 7 \| 8 \| 9 | Rested |

Place a check between each pair of adjectives at the location that best describes the clothing you are wearing:

| | | | |
|---|---|---|---|
| 4. | Flexible | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Stiff |
| 5. | Easy to put on | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Hard to put on |
| 6. | Freedom of movement of arms | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Restricted movement of arms |
| 7. | Easy to move in | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Hard to move in |
| 8. | Satisfactory fit | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Unsatisfactory fit |
| 9. | Freedom of movement of legs | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Restricted movement of legs |
| 10. | Freedom of movement of torso | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Restricted movement of torso |
| 11. | Dislike | 1 \| 2 \| 3 \| 4 \| 5 \| 6 \| 7 \| 8 \| 9 | Like |
| 12. | Loose | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Tight |
| 13. | Crotch of overall right distance from body | 9 \| 8 \| 7 \| 6 \| 5 \| 4 \| 3 \| 2 \| 1 | Crotch of overall too close or too far from body |

* Number added for reader reference only

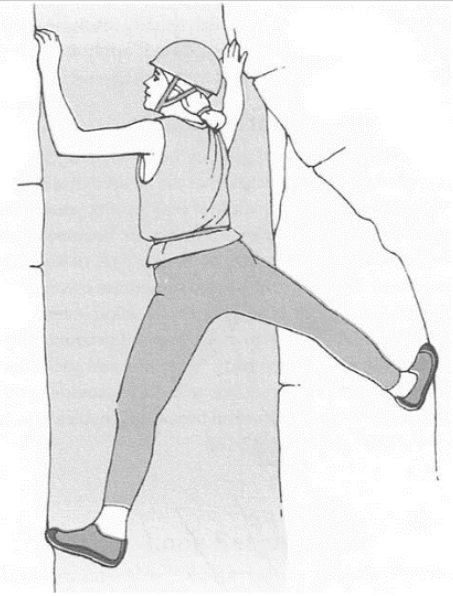
*Figure 8.* Wearer Acceptability Scale (Huck, Maganga, & Kim, 1997).

Huck, Maganga, & Kim's (1997) study did not report scale reliability. Respondents used this scale to describe the rock climbing pant wearability that they typically or most frequently wear while moving to perform nine different rock climbing techniques. These nine different rock climbing techniques all use the lower body and were chosen by the researcher to get an overall assessment of the rock climbing pant based on the most common techniques using the lower body. Each of the rock climbing techniques had nine bipolar adjective pairs taken from the scale; 1) comfortable to uncomfortable, 2) acceptable to unacceptable, 3) flexible to stiff, 4) easy to move in to hard to move in, 5) satisfactory fit to unsatisfactory fit, 6) freedom of movement of

legs to restricted movement of legs, 7) dislike to like, 8) loose to tight, and 9) crotch overall right distance from body to crotch overall too close or too far from body, with a 9-point scale (ranging from 9 to 1). Each technique was shown individually with the semantic 9-point scale along with an image of the technique for reference (see Figure 9). The respondent also had the ability to skip the question if they have not performed that particular rock climbing technique. The question also asked the participant to choose the type of climbing that they typically participated in for this technique (i.e., top rope, face climbing, sport climbing, traditional climbing, etc.). This establishes the types of rock climbing this technique was performed under to help the respondent remember climbing difficulties experienced with the pant. An open-ended question was also included for the repondent to list what brand, type, or style of rock climbing pant they prefer to wear while performing this technique to see if a pant preference could be established.

## H. STEMMING

| Have you performed stemming before? | Yes | No |
|---|---|---|



What style of climbing do you typically do when performing this technique? (Choose all that apply.)

| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

10

*Figure 9.* Question 2h scale relating to the fit of the rock climbing pant while performing a stemming movement. Image adapted from *Mountaineering: The freedom of the hills* (p. 166 & 231), by S.M. Cox & K. Fulsaas (Eds.), 2007, Seattle, WA: The Mountaineer Books. Copyright 2007 by The Mountaineers.

## Comfort

The third question was based on Fan & Tsang (2008) Subjective Thermal Comfort Evaluation for comfort sensations *after* playing the sport, and was modified to include two additional comfort sensations; itchy, and cool (see Figure 10). Fan & Tsang (2008) study did not

**Table 3** Rating scales of comfort sensations.

(a) Rating scale of comfort sensations before playing badminton.

| Comfort sensation | Rating scale | | | | |
|---|---|---|---|---|---|
| | No | Slightly | Neutral | Very | Extre-mely |
| Warmth | 1 | 2 | 3 | 4 | 5 |
| Prickliness | 1 | 2 | 3 | 4 | 5 |
| Stiffness | 1 | 2 | 3 | 4 | 5 |
| Roughness | 1 | 2 | 3 | 4 | 5 |
| Overall comfort | 1 | 2 | 3 | 4 | 5 |

(b) Rating scale of comfort sensation after playing badminton.

| Comfort sensation | Rating scale | | | | |
|---|---|---|---|---|---|
| | No | Slightly | Neutral | Very | Extre-mely |
| Warmth | 1 | 2 | 3 | 4 | 5 |
| Permeability | 1 | 2 | 3 | 4 | 5 |
| Skin dryness | 1 | 2 | 3 | 4 | 5 |
| Stickiness | 1 | 2 | 3 | 4 | 5 |
| Clinginess | 1 | 2 | 3 | 4 | 5 |
| Prickliness | 1 | 2 | 3 | 4 | 5 |
| Stiffness | 1 | 2 | 3 | 4 | 5 |
| Roughness | 1 | 2 | 3 | 4 | 5 |
| Overall comfort | 1 | 2 | 3 | 4 | 5 |

*Figure 10*. Subjective Thermal Comfort Evaluation (Fan & Tsand, 2008).

report scale reliability although the correlation coefficients for overall comfort before and after playing a sport was 0.920. This third question covered psychological and physiological comfort and incorporates thermal comfort factors that crosses into the protection features of the rock climbing pant (see Figure 11).

3. **Circle** a number on a 5-point scale that best matches your comfort sensations after rock climbing in the **rock climbing pants you typically or most frequently wear**.

| Comfort sensation after rock climbing | No | Slightly | Neutral | Very | Extremely |
|---|---|---|---|---|---|
| Warmth | 1 | 2 | 3 | 4 | 5 |
| Cool | 1 | 2 | 3 | 4 | 5 |
| Permeability | 1 | 2 | 3 | 4 | 5 |
| Skin dryness | 1 | 2 | 3 | 4 | 5 |
| Stickiness | 1 | 2 | 3 | 4 | 5 |
| Itchy | 1 | 2 | 3 | 4 | 5 |
| Clinginess | 1 | 2 | 3 | 4 | 5 |
| Prickliness | 1 | 2 | 3 | 4 | 5 |
| Stiffness | 1 | 2 | 3 | 4 | 5 |
| Roughness | 1 | 2 | 3 | 4 | 5 |
| Overall comfort | 1 | 2 | 3 | 4 | 5 |

*Figure 11*. Survey question 3 on the comfort sensation after rock climbing in a pant typically or most frequently worn while climbing.

## Protection

The fourth question was based on the U.S. Navy Wear Test and User Evaluation of Enlisted Utility Uniforms: Durability (1998) (see Figure 12). It covered the durability aspects of

**q12.** How durable are the following garments to rips, tears, abrasions, or failures in seams, fasteners, buttons etc.?

| Shirt | Not Durable | | Fair | | Very Durable | Please explain. |
|---|---|---|---|---|---|---|
| 53a. A (Poplin) | ○1 | ○2 | ○3 | ○4 | ○5 | 54a. _____ |
| 53b. B (Chambray) | ○1 | ○2 | ○3 | ○4 | ○5 | 54b. _____ |
| Pant | | | | | | |
| 55a. A (Twill) | ○1 | ○2 | ○3 | ○4 | ○5 | 56a. _____ |
| 55b. B (Denim) | ○1 | ○2 | ○3 | ○4 | ○5 | 56b. _____ |

**q13.** For the following garments please indicate all areas that have any durability problems.

| Shirt | Arms | Back | Chest | Collar | Front | Cuff | Pockets | Seams | Buttons |
|---|---|---|---|---|---|---|---|---|---|
| 57a. A (Poplin) | ○1 | ○2 | ○3 | ○4 | ○5 | ○6 | ○7 | ○8 | ○9 |
| 57b. B (Chambray) | ○1 | ○2 | ○3 | ○4 | ○5 | ○6 | ○7 | ○8 | ○9 |

| Pant | Legs | Knee | Front | Seat | Waist | Pockets | Seams | Zippers | Buttons/ Snaps | Crotch |
|---|---|---|---|---|---|---|---|---|---|---|
| 58a. A (Twill) | ○1 | ○2 | ○3 | ○4 | ○5 | ○6 | ○7 | ○8 | ○9 | ○10 |
| 58b. B (Denim) | ○1 | ○2 | ○3 | ○4 | ○5 | ○6 | ○7 | ○8 | ○9 | ○10 |

*Figure 12*. U.S. Navy wear test and user evaluation of enlisted utility uniforms: Durability (Navy Clothing and Textile Research Facility, 1998).

the pant only. Question q12. of U.S. Navy Wear Test and User Evaluation of Enlisted Utility Uniforms: Durability (1998) scale was modified to ask each item individually (rips and tears, abrasion, failure in seams, failure with zippers, and failures in fasteners) with a 5-point Likert scale (1= *Not durable,* 5 = *Very Durable*) along with a place for explanations (see Figure 13). Question q13 of the U.S. Navy Wear Test and User Evaluation of Enlisted Utility Uniforms: Durability (1998) scale was modified to only incorporate the pant section (see Figure 13). U.S. Navy's (1998) study did not report scale reliability.

**e. How durable to failures in fasteners (snaps, buttons, hook & eye tape, drawstrings, etc.) are the rock climbing pants you typically or most frequently wear**?

| Not Dura-ble | Some-what Not Du- | Fair | Some-what Durable | Very Dura-ble | Please explain |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

**f. Circle all the areas that have durability problems in the rock climbing pants you typically or most frequently wear**?

| Legs | Knee | Front | Seat | Waist | Pockets | Seams | Zippers | Snaps/ Buttons | Crotch |
|---|---|---|---|---|---|---|---|---|---|

*Figure 13*. Survey question 4e and 4f on the durability of rock climbing pant typically or most frequently worn while climbing.

**Don/Doff**

The fifth question was based on the U.S. Army Test and Evaluation Command - Cold Regions – Environmental Testing of Individual Soldier Clothing: Test Participant Interview Form (2011) questions 8 and 9 (see Figure 14) for ease of donning and doffing by rating 1 = *excellent* to 6 = *extremely poor* (see Figure 15). U.S. Army's (2011) study did not report scale reliability.

8. a. How do you rate the ease with which you were able to don the test item?

1. ____ Excellent
2. ____ Very Good
3. ____ Adequate
4. ____ Not Quite Adequate
5. ____ Poor
6. ____ Extremely Poor

b. Comments: _____

9. a. How do you rate the ease with which you were able to doff the test item?

1. ____ Excellent
2. ____ Very Good
3. ____ Adequate
4. ____ Not Quite Adequate
5. ____ Poor
6. ____ Extremely Poor

b. Comments: _____

*Figure 14*. Cold Regions – Environmental Testing of Individual Soldier Clothing: Test Participant Interview Form, question 8 and 9 (U.S. Army Test and Evaluation Command, Range Infrastructure Division, Cold Regions Test Center, 2011).

**5a. Rate** the ease with which you are able to don **the rock climbing pants you typically or most frequently wear.**

| Excellent | Very Good | Adequate | Not Quite Adequate | Poor | Extremely Poor |
|---|---|---|---|---|---|

**Comments:**

**5b. Rate** the ease with which you are able to doff **the rock climbing pants you typically or most frequently wear.**

| Excellent | Very Good | Adequate | Not Quite Adequate | Poor | Extremely Poor |
|---|---|---|---|---|---|

**Comments:**

*Figure 15*. Survey question 5 on the ease of donning and doffing a rock climbing pant typically or most frequently worn while climbing.

The last 8 questions (Questions 6 – 13) were open-ended to investigate the ideal pair of rock climbing pants for each respondent. These open-ended questions provided for unanticipated findings, allowed for richness of detail, and revealed the respondent's thinking process when it comes to functional attributes in rock climbing pants. Question 6 asked if the respondent could change the fit of your rock climbing pants, what would they change. Question 7 asked what area of the rock climbing pant causes the most mobility problems for them when climbing (i.e., waistband, crotch, thighs, etc.). Question 8 asked if the respondent could change the comfort of your rock climbing pants, what aspects would offer them more comfort. Question 9 asked if the respondents pants could provide more protection, and if so what type of protection would that be (i.e., abrasion, padding, UV, etc.). Question 10 asked if the respondent could change the ease of getting in and out (don/doff) of your rock climbing pants, what they would change. Question 11 asked what design details were their favorite or if certain design details should be incorporated into the rock climbing pants to make them more functional (i.e., pocket, gear loops, convertible, etc.). Question 12 asked if they had ever worn a pair of climbing pants that they didn't like and if so, what were the problem(s). Question 13 asked respondent when they purchased new climbing pants what were the most important features they look for, be specific, and to list all features (i.e., fabric, functions, design details, price, brand cause, etc.?).

In the demographic section, questions 4 through 6 established if the participant is an active rock climber by asking (1) how many years the respondent had been climbing, (2) when was the last time they went rock climbing, and (3) what is their experience level (beginner to professional) in rock climbing.

### Face Validity

Face validity of the instrument was conducted to ensure the questions and language of the questionnaire were not vague or unclear for the respondents. The questionnaire was reviewed by a rock climbing instructor/research project manager along with the researcher's committee. The questionnaire was modified based on the suggestions made by the rock climbing instructor and research committee members. Suggestions were (1) adding a section on mobility so the participants could indicate what type of climbing style was typically performed for this rock climbing technique (i.e., top rope, face climbing, traditional climbing, etc.), (2) have participant indicate if they perferred a particular brand and/or style of climbing pant while performing the above technique, and (3) an additional open-ended question asking the participant if they had a pair of pants that they did not like and if so what were the problems. The additional information could provide more in-depth knowledge about the functional expectations of the rock climbing and problems. This resulted in a modified questionnaire establishing face validity for the measure and confirmed that the questions were not vague or unclear for the respondents, avoiding random errors, and increased the reliablity of the questionnaire prior to using it in this study.

## Data Collection Procedures

The questionnaire was placed on a clipboard and handed to the potential participant with a pen. As those were an outdoor events, a minimum of five chairs were provided and allowed the respondents a comfortable and shaded environment to complete the questionnaire. Once the questionnaire was completed, the respondent was thanked for their time and given an incentive if they were one of the first 180 respondents. A total of 191 questionnaires were collected in total;

112 at International Rock Climbing Festival and 79 at Twenty-four Hours of Horseshoe Hell providing an approximate 20.6% response rate.

If for some reason the respondent did not wish to complete the questionnaire in the booth, the respondent was given the questionnaire without a clipboard and asked to return the questionnaire before the end of the event, if possible. They are informed that there was a return address on the back of the questionnaire but was encouraged to return the questionnaire at the event in order to receive the incentive. The questionnaire had to be received within 30 days of the event in order to be included in the study. No questionnaires were received after the events.

## Data Analysis

Data were coded and entered into an Excel spreadsheet that were then imported into SPSS version 22.0 statistical software. Prior to analysis, the data were cleaned, and all errors or anomalies identified, corrected, or removed. A total of 191 questionnaires were received with 185 being usable. Questionnaires were deemed unusable if they were under the age of 19, were not an active rock climber, had an incomplete demographic section, selected more than one response for an item, answered a selection of items in a diagonal manner, or by responding to open ended questions improperly. Question 4d and 4e of the protection measure dealt with zipper and fasteners failure and upon input of data it was noted that multiple respondents provided a response yet stated a contradicting remark such as “does not have a zipper”, “no fasteners”, “not applicable”, etc. Consequently, all responses that stated there was no zipper or fasteners in the pant were coded as 0-not applicable and not included in analysis. Future use of this measure should include a not applicable option for respondents. Reverse coding of the mobility semantic scale item “dislike/like” was done prior to analysis. Demographic data for age, residence, years climbing, and last time climbing were re-coded into groups for improved data assessment. Age

of the respondents was grouped into 19-24, 24-34, 35-44, 45-54, and 55 and up. Residence was grouped into Northeast, South, Midwest, West, and Outside of USA. The number of years spent climbing was grouped into 6 mo. – 2 years, 3 – 5 years, 6 – 10 years, 11 – 15 years, 16 – 20 years, and over 20 years. The last time rock climbing was grouped into within past week, 8 days – 2 weeks, 15 days – 1 month, and over a month. It should be noted that not all respondents had experience with every rock climbing technique so the mobility measure (for each of the nine climbing techniques) will report a different sample size. Additionally, respondents reported pant brand, style, or type for each climbing technique differently so some had no response. Others may have reported multiple pant brands, styles, or types (including fabric references) so sample size for these open-ended questions vary greatly.

Descriptive statistics were used to analyze the sample characteristics and rock climbing experience of the study sample. A table for each item was used to report the frequency and percentages for the sample characteristics along with the rock climbing experience of the study sample.

## Reliability Analysis

Scale reliability was analyzed using Cronbach's *alpha* coefficient for each of the measures. Fit, mobility (for each of the 9 techniques), protection, and don/doff scales revealed good reliability with Cronbach's alpha coefficient over 0.70 (see Table 3). Comfort scale revealed poor reliability (Cronbach's *alpha* .599*)* so an analysis of "scale if item deleted" was performed. Analysis revealed five measures (warmth, cool, permeability, skin dryness, and overall comfort) with corrected item-total correlation below 0.12 that needed to be deleted from the scale. After these corrections were performed, comfort scale reliability revealed good reliability with a Cronbach's alpha coefficient of 0.786 (see Table 1).

Table 1

*Reliability Analysis of Measures*

| Measure | Cronbach's *alpha* | N of Items | *n* |
|---|---|---|---|
| Fit | .779 | 8 | 178 |
| Mobility: Belay | .782 | 9 | 174 |
| Mobility: Chimney | .852 | 9 | 132 |
| Mobility: Ledge, Overhang, or Roof | .802 | 9 | 171 |
| Mobility: Face Climb | .830 | 9 | 164 |
| Mobility: Lieback | .831 | 9 | 167 |
| Mobility: Mantel | .869 | 9 | 169 |
| Mobility: Rappel | .854 | 9 | 169 |
| Mobility: Stem | .852 | 9 | 150 |
| Mobility: Traverse | .789 | 9 | 154 |
| Comfort | .786 | 6 | 178 |
| Protection | .737 | 5 | 180 |
| Don/Doff | .838 | 2 | 178 |

## Research Question Analysis

The research questions were analyzed as follows after reliability analysis was established.

**Research Question 1. How does fit satisfaction differ across the different dimensions of pant fit (i.e., pant length, waist, crotch, etc.)?** Repeated-measures ANOVA with all 8 levels for each site were used to assess if there were overall differences in fit satisfaction by comparing the means of the various dimensions of pant fit (pant length, waist, crotch, hip, thigh, knee, calf, and ankle). If the ANOVA revealed a significant difference, a Tukey's HSD post hoc analysis was performed to determine which pairwise comparisons were significantly different.

**Research Question 2. What is the overall pant mobility and wearability while rock climbing?** Descriptive statistics were used to access the overall pant mobility and wearability in rock climbing pants. First, a mean composite measure was created for each of the nine rock climbing techniques then an average of all techniques were reported. A table showing the central

tendency, and dispersion of the measures were used to report the overall pant mobility and wearability for each rock climbing technique. Additionally, a mean composite measure was created for each of the nine bipolar adjective pairs based on all the rock climbing techniques and an average for each pair was reported. A figure showing the mean for each pair based on all the rock climbing techniques is shown.

**Research Question 3. How does pant mobility and wearability differ based on the rock climbing technique?** Repeated-measures ANOVA with 9 levels were used to assess pant mobility and wearability by creating a composite variable for each of the nine rock climbing techniques (belay, chimney, ledge, lieback, etc.), then comparing the means of each variables (belay, chimney, ledge, liebak, etc.) to determine if there was differences based on the rock climbing technique. If the ANOVA revealed a significant difference, a Tukey's HSD post hoc analysis was performed to determine which pairwise comparison was significantly different.

**Research Question 4. Do rock climbers prefer certain brands, types, or styles of rock climbing pants for specific rock climbing techniques?** Content analysis was used to break down the participant responses based on brand, style, and type. All participants responded differently to the questions. Some participants listed multiple pant brand and/or styles, other listed only the brand, and some listed a pant type or fabric preference. Responses were categorized into brand, style, type, or fabric for each response. Descriptive statistics were then used to assess if there was a particular brand, type, or style of pant used based on the rock climbing technique. Appropriate tables were used to showcase pant brand, type, or style preferences based on climbing technique.

**Research Question 5. What is the overall comfort of rock climbing pants after rock climbing?** Descriptive statistics were used to assess the overall comfort of all eleven dimensions

(warmth, cool, itchy, stiffness, etc.). A table showing the central tendency and dispersion of the category was used to report the overall comfort of rock climbing pants after participating in the sport.

**Research Question 6. How do different comfort dimensions (stickiness, itchy, stiffness, etc.) in rock climbing pants differ after rock climbing?** Repeated-measures ANOVA with 11 levels were used to assess comfort dimensions by comparing the means of the eleven dimensions of comfort. If the ANOVA revealed a significant difference, a Tukey's HSD post hoc analysis was performed to determine which pairwise comparison was significantly different.

**Research Question 7. What is the overall protection and durability in rock climbing pants currently in the market?** Descriptive statistics were used to assess the overall protection and durability of five measures (rips and tears, abrasion, seam failures, zipper failures, and fastener failures). A table showing the central tendency and dispersion of the category was used to report the overall protection and durability of rock climbing pants.

**Research Question 8. Which areas of rock climbing pants have the most durability problems?** Descriptive statistics were used to assess most reported durability problem areas (legs, knee, front, seat, waist, pockets, seams, zippers, snaps/buttons, or crotch) in rock climbing pants. Participants were allowed to choose multiple durability problem areas if they chose to. A table showing the central tendency and dispersion of the category was used to report the durability problems.

**Research Question 9. How do rock climbers rate the ease with which they can don and doff rock climbing pants?** Descriptive statistics were used to report ease of don and doff in rock climbing pants with a table showing the central tendency and dispersion of the category.

**Open-ended Questions.** Open-ended questions were analyzed using Strauss and Corbin's (1990) grounded theory approach. Grounded theory analyzes qualitative data in a three stage process – open, axial, and selective coding – by searching for concepts, relationships, and finally categories or themes. Open coding is the first stage. Strauss and Corbin (1990) stated it to be "the process of breaking down, examining, comparing, conceptualizing, and categorizing data" (p. 61) thereby generating concepts that eventually yield categories or themes. The second stage, axial coding, makes connections between the themes developed in open coding allowing the researcher to visualize developing relationships that will eventually become a theme (Strauss, 1987). In the final stage, selective coding, relationships found in axial coding allow the researcher to develop themes (Strauss & Corbin, 1990). An example of how grounded theory was used to analyze open-ended questions in this study is shown in Figure 16 based on some responses from Q6. If you could change the fit of your rock climbing pants, what would you change?

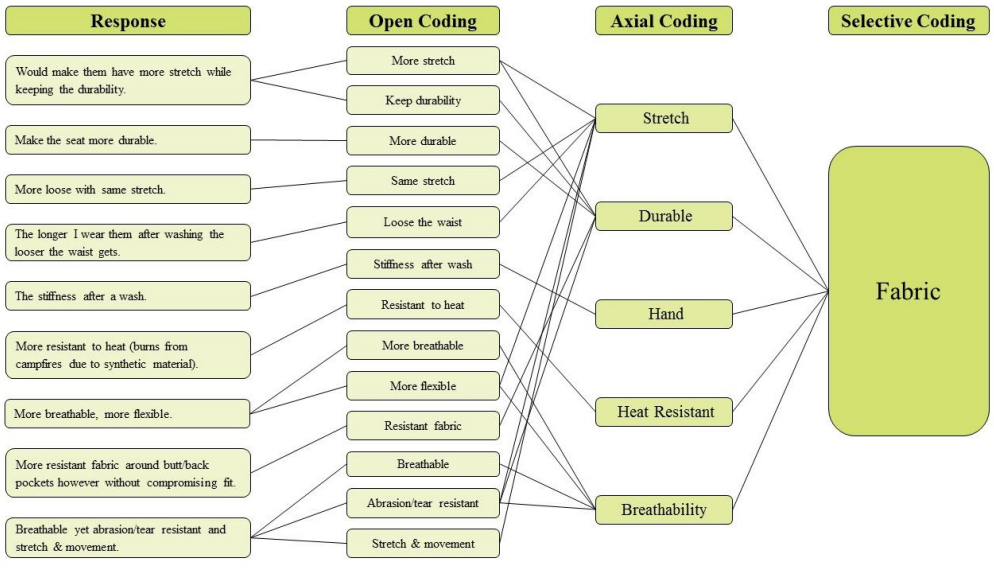



*Figure 16*. Theme development using grounded theory.

Each open-ended question resulted in no more than seven themes. A compilation of all the themes for the open-ended questions are shown in Table 2. A coding guide showing the number, theme, theme label, definition, and comment examples for each open-ended question was then developed, see Appendix B.

Table 2

*Open-ended Question Themes*

| Q6. | Q7. | Q8. | Q9. | Q10. | Q11. | Q12. | Q13. | Additional Comments |
|---|---|---|---|---|---|---|---|---|
| Fabric | Fabric/Construction | Fabric | Fabric/Construction | Fabric | Fabric/Design | Fabric | Fabric/Construction | Fabric/Construction |
| Style/Design | Fasteners/Design Details | Style/Design | Reinforce/Padded | Fit/Style | Gusset Crotch | Style/Design | Fit/Range of Motion | Fit/Range of Motion |
| Length/Inseam | Waist/Waistband | Waist/Waistband | Waist/Crotch/Hip | Closures | Gear Loops | Length/Inseam | Comfort | Comfort |
| Waist/Crotch/Hip | Crotch/Hip | Crotch/Hip | Thighs | Waist | Pocket Details | Waist/Crotch/Hip | Price | Price |
| Thighs/Knees | Thighs | Thighs | Knees | | Knee Details | Thighs/Knees | Brand | Sustainability |
| Calf/Ankle | Knees/Calf/Ankle | Knees/Calf/Ankle | Ankle | | Waist Details | Calf/Ankle | Design Details | Design Details |
| | Pant Length | Pant Length | | | Leg Details | | Aesthetics | Aesthetics |

To establish intercoder reliability, two graduate students were used as the coders and an additional graduate student was used as the mediator. Graduate students were recruited from Auburn University, Department of Consumer and Design Sciences, to code the data using a computer-assisted qualitative data analysis software (CAQDAS) called Coding Analysis Toolkit (CAT). CAQDAS has been publically available since the late 1990s for qualitative research (Rademaker, Grace, & Curda, 2012). CAQDAS provides opportunities over and above the classic code-and-retrieve approach by integrating multiple functions to analyze patterns in the data while allowing data to be imported and exported into other software programs (Lu & Shulman, 2008; Seror, 2013). The CAT platform is user friendly allowing multiple coders access to the data through any device that has the ability to access the internet (Lu & Shulman, 2008). This allowed the coders access to the data at their leisure without having to have their personal

computer or the coding guiding. CAQDAS has been increasingly used by researchers in mixed methods studies as it uses a qualitative approach with quantitative tools (Seror, 2013). Open-ended responses were imported into the CAT system along with the coding guides. The CAT software shows each response with coding options to the user along with being able to expand the coding to see the coding descriptions. An example from this study is shown in Figure 17 below.

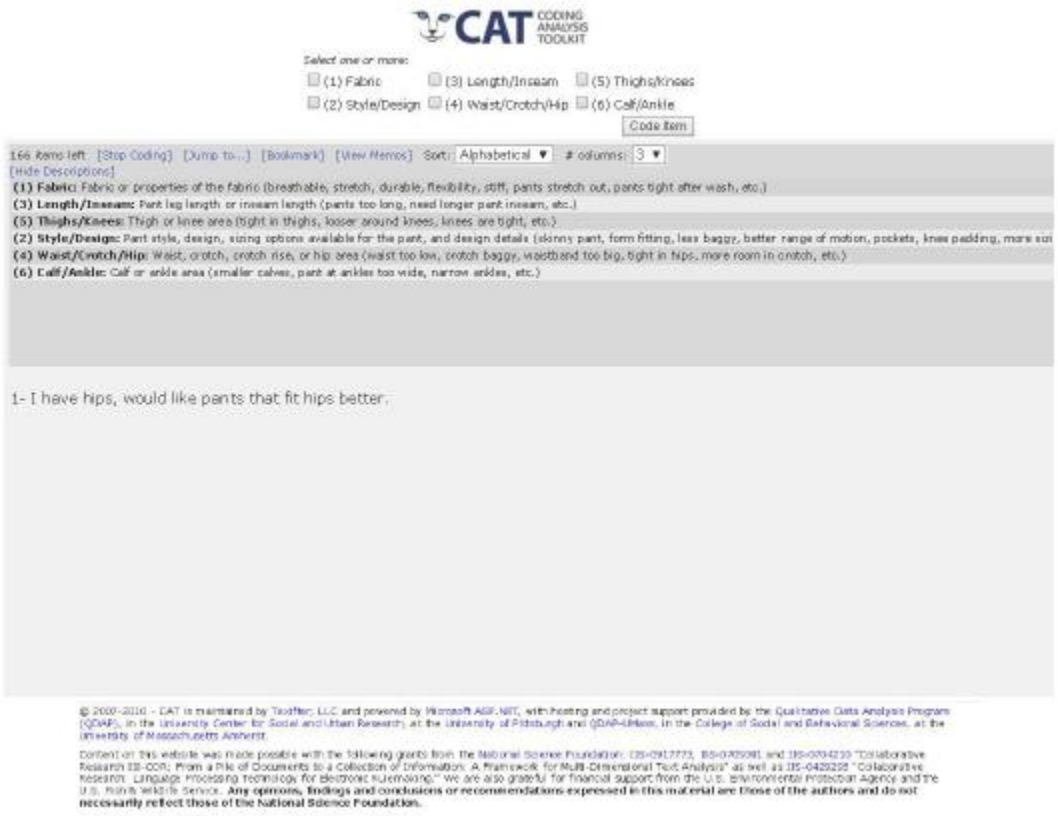



*Figure 17.* Coding screen from Coding Analysis Toolkit (CAT).

CAT training was provided to all coders before coding commenced. Once training was completed and all questions were answered, the coders were allowed to start coding study data. Any data with missing codes or memos were addressed by the researcher and a mediator was used if a discrepancy still existed after further explanation. Once all data was coded, the data was

exported from CAT and imported into SPSS for analysis. The inter-coder reliability Kappa statistics are reported below in Table 3. The coded results were cross tabulated by coder to reveal the most reported theme(s). The results were then reported with each applicable research question and included a sample of the respondents' comments. Additionally, the frequency of the coder cross tabulated findings for each open-ended question were reported in both a table and chart.

Table 3

*Inter-coder Reliability of Open-ended Questions*

| Question | Kappa | N of Themes | N of Valid Cases |
|---|---|---|---|
| If you could change the fit of your rock climbing pants, what would you change? | .958 | 6 | 218 |
| What area of your rock climbing pant causes the most mobility problems for you when climbing? | .905 | 7 | 201 |
| If you could change the comfort of your rock climbing pants, what would offer more comfort to you? | .886 | 7 | 187 |
| If your pants could provide more protection, what type of protection would that be? | .975 | 6 | 233 |
| If you could change the ease of getting in and out (don/doff) of your rock climbing pants, what would you change? | 1.000 | 4 | 54 |
| What design details are your favorite or would you like to have incorporated into your rock climbing pants to make them more functional? | .822 | 7 | 233 |
| Have you ever worn a pair of climbing pants that you didn't like? If so, what were the problem(s)? | .740 | 6 | 161 |
| When purchasing new climbing pants what are the most important features you look for? Be specific and list all features | .901 | 7 | 383 |
| Additional Comments | 1.000 | 7 | 19 |

# CHAPTER IV. RESULTS

This study had six main objectives to explore the functional needs of outdoor rock climber pants by assessing: a) fit, b) mobility, c) comfort, d) protection, and e) donning/doffing. Data was collected at the International Rock Climbing Festival in Wyoming and Twenty-Four Hours of Horseshoe Hell in Arkansas with a total of 191 questionnaires collected. All questionnaires were input in Excel with 185 being useable. It should be noted that variable sample size will differ for each variable as not all participants have the same skill level and may not have performed all of rock climbing techniques. Additionally, there were a few occasions where one page of the questionnaire was not completed. No questionnaires contained more than one incomplete page. The useable data were then imported into SPSS software and scale reliability for all the measures were established. Research questions were analyzed using either decriptive statitics or repeated-measures ANOVA. Open-ended responses were coded by two coders using Coding Toolbox Analysis (CAT) software. The coded data was then exported from CAT and imported into SPSS software where inter-coder reliability was established. Each open-ended question was analyzed in SPSS for frequency distributions. Results section consists of (1) study sample demographics, (2) research question analyses, (3) open-ended question analyses, and (4) additional comments.

## Study Sample Demographics

The sample consisted of 185 participants, 126 males (68.1%) and 59 females (31.9%), with an age range from 19 to 67 years with a male mean age of 30 years and female mean age of 27 years. The majority of the participants were single (63.8%), White/Caucasian (89.2%), residing in the West (52.4%), had some college or a college degree (74%), and earned under

$25,000 annually (49.2%). Table 4 reports the frequencies and percentages associated with gender, age, residence, ethnicity, education, marital status, and annual income.

Table 4

*Characteristics of the Study Sample*

| Demographic Characteristic | Frequency *(n=185)* | Percentage |
|---|---|---|
| Gender | | |
| Male | 126 | 68.1% |
| Female | 59 | 31.9% |
| Age | | |
| 19-24 | 68 | 36.8% |
| 25-34 | 83 | 44.9% |
| 35-44 | 22 | 11.9% |
| 45-54 | 7 | 3.8% |
| 55 and up | 5 | 2.7% |
| Residence | | |
| West | 97 | 52.4% |
| South | 47 | 25.4% |
| Midwest | 20 | 10.8% |
| Northeast | 11 | 6.0% |
| Outside of USA | 10 | 5.4% |
| Ethnicity | | |
| White/Caucasian | 165 | 89.2% |
| Other | 7 | 3.8% |
| Asian | 6 | 3.2% |
| Hispanic/Latino | 6 | 3.2% |
| American Indian/Alaska Native | 1 | 0.5% |
| Black/African American | 0 | 0% |
| Native Hawaiian/Pacific Islander | 0 | 0% |
| Education | | |
| Some High School | 2 | 1.1% |
| High School Degree | 5 | 2.7% |
| Some College/Technical School | 53 | 28.6% |
| College Degree (4 year) | 84 | 45.4% |
| Some Graduate School | 12 | 6.5% |
| Graduate Degree | 29 | 15.7% |

Table 4 Continued

| Demographic Characteristic | Frequency *(n=185)* | Percentage |
|---|---|---|
| Marital Status | | |
| Single | 118 | 63.8% |
| Married | 43 | 23.2% |
| Divorced/Separated | 12 | 6.5% |
| Living with Partner | 12 | 6.5% |
| Widowed | 0 | 0% |
| Gender | | |
| Under $25,000 | 91 | 49.2% |
| $25,000 - $49,999 | 36 | 19.5% |
| $50,000 - $74,999 | 26 | 14.1% |
| $75,000 – 99,999 | 19 | 10.3% |
| $100,000 - $149,999 | 11 | 5.9% |
| $150,000 or more | 2 | 1.1% |

The rock climbing experience of the sample shows the majority had 3-5 years of experience (45.4%) with an experience level of Intermediate to Advanced (74.1%) and had rock climbed in the past week (91.4%). Table 5 reports the frequencies and percentages associated with the number of years climbing, the last time climbing, and experience level of the sample.

Table 5

*Rock Climbing Experience of the Study Sample*

| Rock Climbing Experience | | Frequency *(n=185)* | Percentage |
|---|---|---|---|
| Gender | | | |
| Male | (*M* – 30 years) | 126 | 68.1% |
| Female | (*M* – 27 years) | 59 | 31.9% |
| Years Climbing | | | |
| 6 mo. – 2 years | | 25 | 13.5% |
| 3 – 5 years | | 84 | 45.4% |
| 6 – 10 years | | 38 | 20.5% |
| 11 – 15 years | | 15 | 8.1% |
| 16 – 20 years | | 9 | 4.9% |
| Over 20 years | | 14 | 7.6% |

Table 5 Continued

| Rock Climbing Experience | Frequency *(n=185)* | Percentage |
|---|---|---|
| Last Time Climbing | | |
| Within past week | 169 | 91.4% |
| 8 days – 2 weeks | 9 | 4.9% |
| 15 days – 1 month | 6 | 3.2% |
| Over a month | 1 | 0.5% |
| Experience Level | | |
| Novice | 1 | 0.5% |
| Beginner | 15 | 8.1% |
| Intermediate | 66 | 35.7% |
| Advanced | 71 | 38.4% |
| Expert | 30 | 16.2% |
| Professional | 2 | 1.1% |

**Research Question Analysis**

Each research question was looked at individually by discussing the statistical data results and then the related open-ended question to provide a deeper breadth of knowledge and understanding for each of the study's five variables.

**Research question 1. How does fit satisfaction differ across the different dimensions of pant fit (i.e., pant length, waist, crotch, etc.)?**

A repeated measures ANOVA was conducted to compare the effect of pant length, waist, crotch, hip, thigh, knee, calf, and ankle dimensions on fit satisfaction. The means and standard deviations for pant fit dimensions are presented in Table 6. The results for the ANOVA indicated a significant fit satisfaction effect with a small effect size, Wilks's $\Lambda = 0.796$, $F(7, 171) = 6.279$, $p < .000$, multivariate $\eta^2 = .204$. Post hoc analyses were conducted given the statistically significant ANOVA *F* test. Tukey HSD post hoc tests were conducted on all possible pairwise comparisions using the Bonferroni correction. Six pairs were found to be significantly different ($p < .05$): calf was found to significantly different from pant length, waist, crotch, thigh, and

ankle while the waist was significantly different from the hip.These results suggest that fit satisfaction differs with pant length and calf, waist and hip, waist and calf, crotch and calf, thigh and calf, along with calf and ankle.

Table 6

*Descriptive Statistics for Fit Satisfaction Across Pant Fit Dimensions*

| Fit Dimensions | *n* | *M* | *SD* |
|---|---|---|---|
| Calf | 178 | 6.90 | 1.72 |
| Hip | 178 | 6.61 | 1.81 |
| Knee | 178 | 6.52 | 1.94 |
| Ankle | 178 | 6.43 | 2.23 |
| Thigh | 178 | 6.33 | 1.99 |
| Crotch | 178 | 6.24 | 2.08 |
| Length | 178 | 6.20 | 2.40 |
| Waist | 178 | 5.93 | 2.27 |

Note: Based on 9 point Likert scale.

The first open-ended question, "Q6-If you could change the fit of your rock climbing pants, what would you change?", revealed six themes that were relevant to the study – fabric, style/design, length/inseam, waist/crotch/hip, thighs/knees, and calf/ankle – with a total of 210 responses (see Table 7). Descriptive statistics revealed that the waist/crotch/hip to be the most prevalent area of the pant that required change, with a total of 74 referencing this particular area of the lower body. Comments associated with the waist/crotch/hip accounted for 35% of the total responses for this question (see Figure 18). Response totals for each theme are shown in Table 7 while Figure 18 features the theme percentages in a colored pie chart.

Table 7

*Coded Responses for Q6 - Changes to Pant Fit (n=210)*

| Theme | Number of Responses |
|---|---|
| **Waist/Crotch/Hip** | **74** |
| Fabric | 36 |
| Length/Inseam | 30 |
| Style/Design | 29 |
| Thighs/Knees | 27 |
| Calf/Ankle | 14 |

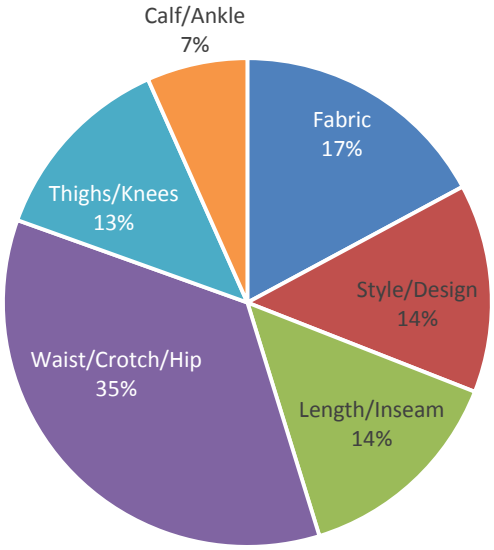



*Figure 18.* Pie chart showcasing themes and percentages found in open-ended question (Q6) on changes to pant fit.

A sample of comments from respondents based on each theme are featured in Table 8.

Table 8

*Sample of Respondent Comments for Pant Fit*

| Theme | Pant Fit Comments |
|---|---|
| Waist/Crotch/Hip | "high waist so they come above my harness", "no fixed waist size. I do not want to wear a belt under my harness", "waistband that can be tightened", "waist sizing adjustment", "waist fits higher so it doesn't fall under harness", "waist is loose often when I'm hanging or holding a belay or rapping (rappelling)", "crotch closer to body so not affected by harness", "more crotch room for high leg lifts", "I would prefer high crotch without sacrificing flexibility", "I would make the crotch short in front", "more room/flexibility in hips and crotch", "how high the rise is – too often you worry about them falling and your bum showing", I have hips, would like pants that fit hips better", and "the waist and hip size" |
| Fabric | "more spandex mix in flex areas", "would make them even stretchier (sic) while keeping the durability", "lightweight and airy but durable", "breathable yet abrasion/tear resistant along with better stretch and movement", and "more resistant fabric around butt/back pockets" |
| Length/Inseam | "correct length", "I would prefer … shorter legs or availability for smaller sizes. A man's XS doesn't exist.", "shorter, I always roll my pants up", "longer leg with option for rolling up", and "I'd make them longer so they cover my ankles" |
| Style/Design | "able to button bottom (of pant) when climbing", "less baggy legs", "more gussets", "crotch and pockets", "slimmer legs so they won't catch on rock", "angled waistband – back slightly higher or more pre-cut to bend position", and "more reliable buttons and snaps" |
| Thighs/Knees | "it seems that most climbing pants get tight in the thighs when the leg is lifted 90 degree to the torso", "more thigh room, some of us got legs to put in pants, not twigs", "knees are a bit tight … high stepping is difficult", and "more flexibility in knee area" |
| Calf/Ankle | "calves too tight sometimes", "smaller calves and ankles", "taper the ankle", and "less baggy … around ankle but keep ability to push up above calf" |

**Research question 2. What is the overall pant mobility and wearability while rock climbing?**

Descriptive statistics revealed overall pant mobility and wearability in rock climbing pants to have a mean of 6.85 on a 9 point semantic scale based on all nine rock climbing techniques indicating participants found pant mobility and wearability to be mildly satisfying. A breakdown of mean by climbing technique is reported in Table 9.

Table 9

*Overall Pant Mobility and Wearability Based on Climbing Technique (n=185)*

| Climbing Technique | *n* | *M* | SD |
|---|---|---|---|
| Traverse | 157 | 7.05 | 1.02 |
| Ledge, Overhang, or Roof | 174 | 6.93 | 1.08 |
| Lieback | 170 | 6.93 | 1.13 |
| Face Climb | 171 | 6.91 | 1.16 |
| Rappel | 170 | 6.91 | 1.23 |
| Belay | 183 | 6.80 | 1.00 |
| Mantel | 170 | 6.77 | 1.36 |
| Stem | 154 | 6.75 | 1.25 |
| Chimney | 135 | 6.63 | 1.26 |
| **Overall** | | **6.85** | **.975** |

*Note.* Based on 9 point semantic scale.

Additionally, the mean score for comfortable to uncomfortable was 7.59, acceptable - unacceptable was 7.44, flexible - stiff was 7.30, easy to move in - hard to move in was 7.34, satisfactory fit - unsatisfactory fit was 6.95, freedom of movement - restricted movement of legs was 7.09, dislike - like was 3.39, loose - tight was 5.36, and crotch overall right distance from body - crotch overall too close or too far from body was 6.15 (see Figure 19).

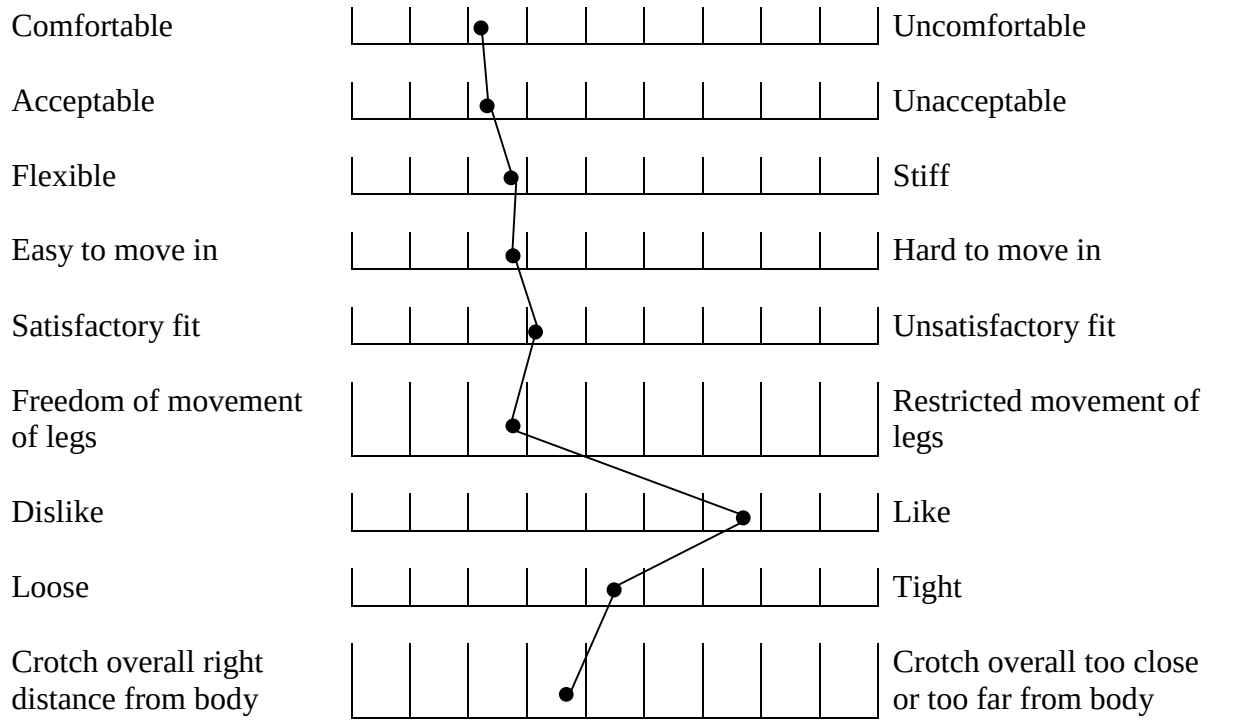



*Figure 19.* Pant mobility and wearability mean scores based on all rock climbing techniques.

**Research question 3. How does pant mobility and wearability differ based on the rock climbing technique?**

A repeated measures ANOVA was conducted to compare the effect of the nine different rock climbing techniques on pant mobility and wearability. The means and standard deviations for pant mobility and wearability are presented in Table 10. The results for the ANOVA indicated a significant pant mobility and wearability effect with a small effect size, Wilks's $\Lambda = 0.751$, $F(8, 93) = 3.845$, $p = .001$, multivariate $\eta^2 = .249$. Post hoc analyses were conducted given the statistically significant ANOVA *F* test. Tukey HSD post hoc tests were conducted on all possible pairwise comparisions using the Bonferroni correction.

Table 10

*Descriptive Statistics for Pant Mobility and Wearability By Rock Climbing Technique*

| Rock Climbing Techniques | *n* | *M* | *SD* |
|---|---|---|---|
| Belay | 101 | 6.76 | 0.94 |
| Chimney | 101 | 6.50 | 1.28 |
| Ledge, Overhang, or Roof | 101 | 6.97 | 1.05 |
| Face Climb | 101 | 6.94 | 1.16 |
| Lieback | 101 | 6.88 | 1.19 |
| Mantel | 101 | 6.77 | 1.40 |
| Rappel | 101 | 6.92 | 1.25 |
| Stem | 101 | 6.80 | 1.22 |
| Traverse | 101 | 7.02 | 1.06 |

*Note.* Based on 9 point semantic scale.

Fourteen pairs were found to be significantly different ($p < .05$): belay was found to significantly different from chimney, ledge/overhang/roof, and traverse, chimney was found to significantly different from ledge/overhang/roof, face climb, lieback, mantel, rappel, stem, and traverse, ledge/overhang/roof was found to significantly different from mantel, traverse was found to significantly different from lieback, mantel, and stem. These results suggest that some climbing techniques when compared to each other have different pant mobility and wearability. This may be because the movements required for each of the techniques has a different lower body position which could affect the pant mobility and wearability.

The second open-ended question, "Q7-What area of your rock climbing pant causes the most mobility problems for you when climbing?", revealed seven themes that were relevant to the study – fabric/construction, fasteners/design details, waist/waistband, crotch/hip, thighs, knees/calf/ankle, and pant length – with a total of 186 responses (see Table 11). Descriptive statistics revealed that the crotch/hip to be the most prevalent area of the pant for mobility problems. Comments associated with the crotch/hip accounted for 33% of the total responses

(see Figure 20). Response totals for each theme are shown in Table 11 while Figure 20 features the theme percentages in a colored pie chart.

Table 11

*Coded Responses for Q7 – Pant Mobility Problems (n=186)*

| Theme | Number of Responses |
|---|---|
| **Crotch/Hip** | **61** |
| Thighs | 40 |
| Knees/Calf/Ankle | 40 |
| Waist/Waistband | 27 |
| Fabric/Construction | 7 |
| Fasteners/Design Details | 6 |
| Pant Length | 5 |

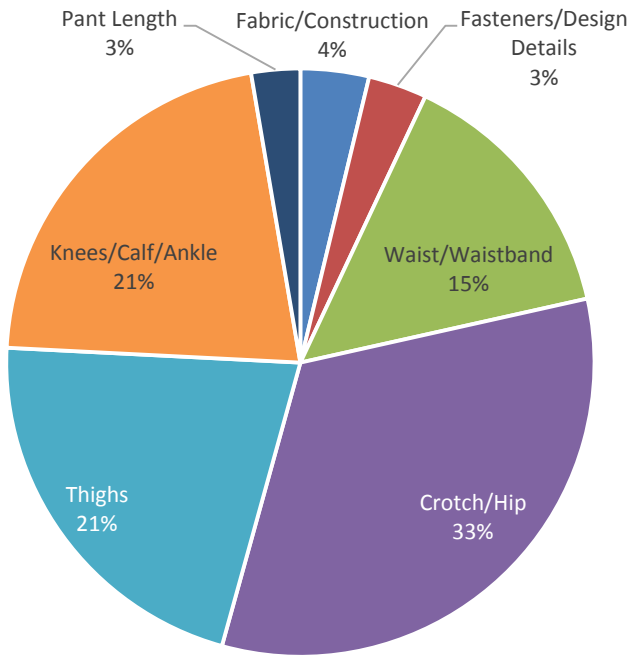



*Figure 20.* Pie chart showcasing themes and percentages found in open-ended question (Q7) on changes to pant mobility.

A sample of comments from respondents based on each theme are featured in Table 12.

Table 12

*Sample of Respondent Comments for Change to Pant Mobility*

| Theme | Changes to Pant Mobility Comments |
|---|---|
| Crotch/Hip | "crotch and hips when stemming or high step", "crotch area", "crotch", "must have a gusseted crotch", "crotch, sometimes they sag down in the butt too", "crotch during stems", "crotch – no high steps with intense crotches", "crotch with comparison to harness on or off", and "crotch too low (and) have to pull up thigh material too high" |
| Thighs | "tightness around thighs", "front thighs inside seams", "thigh, high stepping my foot above my waist", "my thighs are larger than my waist … when they flex sometimes the pant needs to be scooted", and "thighs are snug" |
| Knees/Calf/Ankle | "knees not stretchy enough", "sliding around knee with high feet placement", "tightness around knees", "knee mobility", "always too loose in the calves", and "excess fabric at calves and ankles" |
| Waist/Waistband | "Waistbands! Too tight or too loose", "Waistband if it becomes too loose it feels like they (pant) might slip down", and "waist not high enough" |
| Fabric/Construction | "stitching and chaffing", "tearing or loose threads", and "(fabric) shrinking causing tightness" |
| Fasteners/Design Details | "exposed hardware gets torn up", "waist button failure", "zippers", "buckles", and "drawstrings" |
| Pant Length | "legs – have to roll them up", "long pants for short legs", and "pant legs are too long" |

**Research question 4. Do rock climbers prefer certain brands, styles, or types of rock climbing pants for specific rock climbing techniques?**

Descriptive statistics revealed participants reported 55 brands, 58 styles, 6 types, and additional references to 10 fabrics. Prana pants was the preferred brand with a 22.4% - 37% response depending on the climbing technique. Patagonia pants was the second preferred brand with a 5.8% - 9.5% response. Table 13 reports the brand preference in rock climbing pants along with frequency and percentage based on each climbing technique. Preferred styles reported by participants were Stretch Zion by Prana, a men's only style, with 13.7% - 22.2% response

depending on the climbing technique. It should be noted that yoga pants were reported with equal preference on ledge, roof, or overhang (14.1%) and face (17.9%) climbing techniques. Table 14 reports the style preference in rock climbing pants along with frequency and percentage based on each climbing technique. Additionally, reference was made on styles that were produced for men or women only. Full length pants was the preferred type with 56.3% - 69.7% response depending on the climbing technique. Additionally, shorts was the second largest preference for all but chimney and rappel climbing techniques reporting 12.6% - 24.5%. The second largest preference type for chimney was jeans (19.4%) and rappel was capri (8.1%). Table 15 reports the pant type preference in rock climbing pants along with frequency and percentage based on each climbing technique. Fabric preference was overwhelmingly stretch/spandex with 62.5% - 83.3% response depending on climbing technique. Table 16 reports the fabric preference in rock climbing pants along with frequency and percentage based on each climbing technique.

Table 13

*Pant Brand Preferences Based On Rock Climbing Technique*

| Preference | Belay | | Chimney | | Ledge, Roof or | | Face | | Lieback | | Mantel | | Rappel | | Stem | | Traverse | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Adidas | 1 | 0.4 | | | 2 | 1.1 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | | | 1 | 0.6 | | |
| Alpine | 1 | 0.4 | | | | | | | | | | | | | | | | |
| Arc'teryx | 5 | 2.1 | 2 | 1.1 | 2 | 1.1 | 1 | 0.5 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.2 | 2 | 1.1 |
| Black Diamond | 3 | 1.2 | | | 1 | 0.5 | 2 | 1.1 | 1 | 0.5 | 1 | 0.5 | 3 | 1.6 | 2 | 1.2 | 3 | 1.6 |
| Blurr | 1 | 0.4 | | | | | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.6 | 1 | 0.5 |
| Carhartt | 7 | 2.9 | 8 | 4.4 | 4 | 2.2 | 3 | 1.6 | 3 | 1.6 | 4 | 2.2 | 5 | 2.7 | 6 | 3.5 | 4 | 2.2 |
| Champion | 1 | 0.4 | 1 | 0.5 | 2 | 1.1 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.6 | | |
| Cloud Veil | | | 1 | 0.5 | | | | | | | | | | | | | | |
| Columbia | 5 | 2.1 | 2 | 1.1 | 5 | 2.7 | 5 | 2.6 | 4 | 2.2 | 6 | 3.4 | 4 | 2.2 | 2 | 1.2 | 2 | 1.1 |
| Craghoppers | 2 | 0.8 | 2 | 1.1 | 1 | 0.5 | | | 2 | 1.1 | 1 | 0.5 | 2 | 1.1 | 1 | 0.6 | 1 | 0.5 |
| DC | 1 | 0.4 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.6 | 1 | 0.5 |
| Dickies | 1 | 0.4 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | | | 1 | 0.5 | 2 | 1.1 | 1 | 0.6 | 1 | 0.5 |
| Duluth Trading Co. | 1 | 0.4 | 1 | 0.5 | | | | | 1 | 0.5 | | | | | | | | |
| Eddie Bauer | 5 | 2.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 3 | 1.6 | 1 | 0.6 | 1 | 0.5 |
| FMTech | 1 | 0.4 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.6 | 1 | 0.5 |
| Gap | 1 | 0.4 | | | 1 | 0.5 | 1 | 0.5 | 2 | 1.1 | 1 | 0.5 | 1 | 0.5 | 1 | 0.6 | 1 | 0.5 |
| General Lee | | | 1 | 0.5 | | | | | | | | | | | | | | |
| Gramicci | 2 | 0.8 | 4 | 2.2 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.2 | 2 | 1.1 |
| H & M | | | | | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.6 | 1 | 0.5 |
| Hind | | | | | | | | | 1 | 0.5 | | | 1 | 0.5 | | | | |
| Holly Hansen | 1 | 0.4 | | | | | | | | | | | | | | | | |
| Horny Toad | 1 | 0.4 | | | | | 1 | 0.5 | | | | | | | | | | |
| Jag Jeans | 1 | 0.4 | | | | | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.6 | 1 | 0.5 |
| Kuhl | 5 | 2.1 | 4 | 2.2 | 5 | 2.7 | 5 | 2.6 | 5 | 2.7 | 6 | 3.5 | 4 | 2.2 | 4 | 2.3 | 3 | 1.6 |
| Las Portiva | 1 | 0.4 | | | | | | | | | | | | | | | | |
| Levi | 2 | 0.8 | 2 | 1.1 | 2 | 1.1 | 1 | 0.5 | 2 | 1.1 | 1 | 0.5 | 2 | 1.1 | 1 | 0.6 | 1 | 0.5 |

Table 13 Continued

| Preference | Belay | | Chimney | | Ledge, Roof or | | Face | | Lieback | | Mantel | | Rappel | | Stem | | Traverse | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Lululemon | 3 | 1.2 | | | 3 | 1.6 | 3 | 1.5 | 1 | 0.5 | 3 | 1.7 | 3 | 1.6 | 1 | 0.6 | 3 | 1.6 |
| Mammut | 5 | 2.1 | 4 | 2.2 | 3 | 1.6 | 3 | 1.6 | 3 | 1.6 | 2 | 1.1 | 3 | 1.6 | 2 | 1.2 | 3 | 1.6 |
| Marshalls | | | | | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.6 | | |
| MEC | 1 | 0.4 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | | | | |
| Merrell | 1 | 0.4 | | | 1 | 0.5 | 1 | 0.5 | | | | | 1 | 0.5 | 1 | 0.6 | 1 | 0.5 |
| Millet | 1 | 0.4 | | | | | 1 | 0.5 | | | | | | | | | | |
| Moon Climbing | 1 | 0.4 | | | 1 | 0.5 | 1 | 0.5 | | | | | | | | | | |
| Mountain Hardwear | 15 | 6.2 | 9 | 4.9 | 12 | 6.5 | 16 | 8.4 | 17 | 9.2 | 11 | 6.1 | 11 | 6 | 14 | 8.1 | 14 | 7.7 |
| Mountain Khakis | 6 | 2.5 | 6 | 3.3 | 5 | 2.7 | 2 | 1.1 | 4 | 2.2 | 2 | 1.1 | 4 | 2.2 | 1 | 0.6 | 2 | 1.1 |
| New Balance | | | | | | | | | | | | | 1 | 0.5 | | | 1 | 0.5 |
| Nike | 1 | 0.4 | | | | | | | | | | | | | | | | |
| Nols | | | | | | | | | | | | | | | | | 1 | 0.5 |
| North Face | 9 | 3.7 | 5 | 2.7 | 5 | 2.7 | 7 | 3.7 | 9 | 4.9 | 9 | 5 | 6 | 3.3 | 6 | 3.5 | 6 | 3.3 |
| Old Navy | 1 | 0.4 | | | | | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | | | 1 | 0.6 | 1 | 0.5 |
| Outdoor Research | 5 | 2.1 | 3 | 1.6 | 3 | 1.6 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 3 | 1.6 | 3 | 1.7 | 2 | 1.1 |
| Patagonia | 23 | 9.5 | 11 | 6 | 12 | 6.5 | 17 | 8.9 | 13 | 7 | 16 | 8.9 | 14 | 7.7 | 10 | 5.8 | 11 | 6 |
| **Prana** | **90** | **37** | **41** | **22.4** | **58** | **31.2** | **63** | **33.2** | **52** | **28.1** | **56** | **31.3** | **55** | **30.1** | **46** | **26.7** | **53** | **29.1** |
| Reebok | 1 | 0.4 | | | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | | | | | | | 1 | 0.5 |
| REI | 6 | 2.5 | 4 | 2.2 | 4 | 2.2 | 4 | 2.1 | 7 | 3.8 | 5 | 2.8 | 5 | 2.7 | 4 | 2.3 | 4 | 2.2 |
| Roscoe | | | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.5 | | | | | | | | |
| StoneMaster | 2 | 0.8 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.1 | 2 | 1.2 | 1 | 0.5 |
| Tools of the Adventure | 1 | 0.4 | | | | | | | | | | | | | | | | |
| Tradesman | 1 | 0.4 | 1 | 0.5 | | | | | | | | | 1 | 0.5 | | | | |
| Under Armour | 1 | 0.4 | | | | | | | | | | | | | 1 | 0.6 | 1 | 0.5 |
| Vans | 1 | 0.4 | | | 1 | 0.5 | 1 | 0.5 | | | | | | | | | | |
| Verve | 6 | 2.5 | 3 | 1.6 | 4 | 2.2 | 5 | 2.6 | 5 | 2.7 | 5 | 2.8 | 4 | 2.2 | 5 | 2.9 | 5 | 2.7 |
| Volcom | 1 | 0.4 | | | 1 | 0.5 | | | | | | | | | | | 1 | 0.5 |
| Walmart | | | 1 | 0.5 | | | | | | | | | | | | | | |

Table 13 Continued

| Preference | Belay | | Chimney | | Ledge, Roof or | | Face | | Lieback | | Mantel | | Rappel | | Stem | | Traverse | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Wrangler | 2 | 0.8 | 1 | 0.5 | | | | | | | | | | | | | | |
| No Response | 10 | 4.1 | 57 | 31.1 | 34 | 18.3 | 26 | 13.7 | 31 | 16.8 | 29 | 16.2 | 31 | 16.9 | 44 | 25.6 | 45 | 24.7 |
| Total Responses | 243 | | 183 | | 186 | | 190 | | 185 | | 179 | | 183 | | 172 | | 182 | |

Table 14

*Pant Style Preferences Based On Rock Climbing Technique*

| Preference | Belay | | Chimney | | Ledge, Roof or Overhang | | Face | | Lieback | | Mantel | | Rappel | | Stem | | Traverse | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| 514 (Levis) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | | | 1 | 1.8 | | | 1 | 1.5 | | | | |
| Alpine Guide Soft Shell (Patagonia) | 5 | 5.1 | 4 | 7.8 | 2 | 3.1 | 7 | 10.4 | 5 | 8.9 | 5 | 7.7 | **10** | **15.2** | 5 | 9.3 | 7 | 11.9 |
| Axiom* (Prana) | 4 | 4.1 | 1 | 2.0 | 1 | 1.6 | 1 | 1.5 | | | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Belay (Merrell) | 1 | 1.0 | | | 1 | 1.6 | 1 | 1.5 | | | | | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Belikos (Verve) | 1 | 1.0 | | | | | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Bliss** (Prana) | 1 | 1.0 | 1 | 2.0 | | | | | | | | | | | | | | |
| Brion* (Prana) | 5 | 5.1 | 2 | 3.9 | 2 | 3.1 | 2 | 3.0 | 2 | 3.6 | 2 | 3.1 | 2 | 3.0 | 2 | 3.7 | 2 | 3.4 |
| Bronson* (Prana) | 4 | 4.1 | 2 | 3.9 | 3 | 4.7 | 3 | 4.5 | 3 | 5.4 | 2 | 3.1 | 2 | 3.0 | 3 | 5.6 | 2 | 3.4 |
| Cargo (Various) | 2 | 2.0 | | | 1 | 1.6 | 2 | 3.0 | 2 | 3.6 | 2 | 3.1 | 1 | 1.5 | 2 | 3.7 | 2 | 3.4 |
| Chef (Various) | 1 | 1.0 | | | | | | | | | | | | | | | | |
| Cirque (Outdoor Research) | | | | | | | | | | | | | 1 | 1.5 | 1 | 1.9 | | |
| Commuter (Arc'teryx ) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Convertible (Various) | 2 | 2.0 | 3 | 5.9 | 3 | 4.7 | 4 | 6.0 | 4 | 7.1 | 3 | 4.6 | 4 | 6.1 | 2 | 3.7 | 2 | 3.4 |
| Cords (Various) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | | | | | | | | | | | | |
| Cordura (Various) | | | | | 1 | 1.6 | | | | | | | | | | | | |
| Double Layer Firehose* (Duluth) | | | | | | | | | 1 | 1.8 | | | | | | | | |
| Essex** (Prana) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | 1 | 1.5 | | | 1 | 1.5 | 1 | 1.5 | | | 1 | 1.7 |
| Ferrosi* (Outdoor Research) | | | 1 | 2.0 | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Fire Hose (Duluth) | 1 | 1.0 | 1 | 2.0 | | | | | | | | | | | | | | |
| First Ascent (Eddie Bauer) | 2 | 2.0 | 1 | 2.0 | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Full (Various) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | | | | | | | | | | | | |
| Groove** (Lululemon) | 1 | 1.0 | | | 1 | 1.6 | 1 | 1.5 | | | 1 | 1.5 | 1 | 1.5 | | | 1 | 1.7 |
| Halle** (Prana) | 2 | 2.0 | 1 | 2.0 | | | | | | | | | | | | | | |
| Hiking (Various) | | | | | | | | | | | | | | | | | 1 | 1.7 |
| Loose (Various) | | | | | 1 | 1.6 | | | | | | | | | | | | |
| Marlow (Various) | | | | | 1 | 1.6 | | | | | 1 | 1.5 | 1 | 1.5 | | | 1 | 1.7 |
| Mojo* (Prana) | 3 | 3.1 | 1 | 2.0 | 3 | 4.7 | 2 | 3.0 | 1 | 1.8 | 2 | 3.1 | 2 | 3.0 | 2 | 3.7 | 1 | 1.7 |
| Monarch** (Prana) | 1 | 1.0 | | | 1 | 1.6 | 1 | 1.5 | | | 1 | 1.5 | 1 | 1.5 | | | 1 | 1.7 |
| Mountaineering (Various) | 2 | 2.0 | 1 | 2.0 | | | | | | | | | | | | | | |
| Nemesis* (Prana) | 2 | 2.0 | | | 1 | 1.6 | | | | | | | | | | | | |
| Paladin* (Outdoor Research) | | | | | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | | | 1 | 1.9 | 1 | 1.7 |

Table 14 Continued

| Preference | Belay | | Chimney | | Ledge, Roof or Overhang | | Face | | Lieback | | Mantel | | Rappel | | Stem | | Traverse | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Parachute (Various) | 1 | 1.0 | | | | | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Paramount (North Face) | 2 | 2.0 | | | | | | | | | 1 | 1.5 | | | | | | |
| PFG Blood and Guts II* (Columbia) | | | | | | | 1 | 1.5 | | | | | | | | | | |
| Pulaski* (REI) | 1 | 1.0 | 2 | 3.9 | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | | | 1 | 1.5 | | | | |
| Rock Craft (Patagonia) | 3 | 3.1 | 1 | 2.0 | 2 | 3.1 | 1 | 1.5 | | | 3 | 4.6 | 1 | 1.5 | | | | |
| Rock Guides (Pantagonia) | 1 | 1.0 | | | | | 1 | 1.5 | 1 | 1.8 | | | 1 | 1.5 | 1 | 1.9 | | |
| Sahara Convertible (REI) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Scrubs (Various) | 1 | 1.0 | | | | | | | | | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | | |
| Simple Guide (Patagonia) | 7 | 7.1 | 3 | 5.9 | 3 | 4.7 | 2 | 3.0 | 3 | 5.4 | 3 | 4.6 | 4 | 6.1 | 1 | 1.9 | 2 | 3.4 |
| Ski (Various) | 1 | 1.0 | | | | | | | | | | | | | | | | |
| Soft Shell (Various) | 1 | 1.0 | 3 | 5.9 | | | | | | | 1 | 1.5 | 2 | 3.0 | 1 | 1.9 | 2 | 3.4 |
| Stretch Zion* (Prana) | **16** | **16.3** | **7** | **13.7** | **9** | **14.1** | **12** | **17.9** | **10** | **17.9** | **11** | **16.9** | 9 | 13.6 | **12** | **22.2** | 13 | 22.0 |
| Sutra* (Prana) | 1 | 1.0 | | | | | 1 | 1.5 | | | | | | | | | | |
| Sweat (Various) | 1 | 1.0 | | | 2 | 3.1 | 2 | 3.0 | 1 | 1.8 | 2 | 3.1 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Teton Twill* (Mountain Khakis) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | | | | | | | | | | | | |
| Theorem* (Prana) | 1 | 1.0 | | | | | | | | | | | | | | | | |
| Tights (Various) | | | | | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | | | | | | |
| Titanium* (Columbia) | 1 | 1.0 | | | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | | | | | 1 | 1.7 |
| Trousers (Various) | | | 1 | 2.0 | | | | | | | | | | | | | | |
| Vintage G (Gramicci) | 1 | 1.0 | 2 | 3.9 | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Warlow* (Mountain Hardwear) | 1 | 1.0 | | | | | | | | | | | | | | | | |
| Wind (Various) | | | | | | | | | | | 1 | 1.5 | 1 | 1.5 | | | 1 | 1.7 |
| Work (Various) | 1 | 1.0 | 1 | 2.0 | | | | | | | | | | | | | | |
| Work Dungarees* (Carhartt) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | | | | | 1 | 1.5 | | | 1 | 1.9 | | |
| Wunder under** (Lululemon) | 1 | 1.0 | | | 1 | 1.6 | 1 | 1.5 | | | 1 | 1.5 | 1 | 1.5 | | | 1 | 1.7 |
| Yoga (Various) | **7** | **7.1** | 3 | 5.9 | **9** | **14.1** | **9** | **13.4** | **10** | **17.9** | **8** | **12.3** | **7** | **10.6** | **8** | **14.8** | 6 | 10.2 |
| Yuma** (Mountain Hardwear) | 1 | 1.0 | 1 | 2.0 | 1 | 1.6 | 1 | 1.5 | 1 | 1.8 | 1 | 1.5 | 1 | 1.5 | 1 | 1.9 | 1 | 1.7 |
| Total Responses | 98 | | 51 | | 64 | | 67 | | 56 | | 65 | | 66 | | 54 | | 59 | |

*Men only style

**Women only style

Table 15

*Pant Type Preference Based On Rock Climbing Technique*

| Preference | Belay | | Chimney | | Ledge, Roof or Overhang | | Face | | Lieback | | Mantel | | Rappel | | Stem | | Traverse | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Capri | 10 | 8.4 | 3 | 4.8 | 6 | 6.4 | 8 | 9.1 | 6 | 8.1 | 10 | 11.5 | 6 | 8.1 | 6 | 8.2 | 7 | 10 |
| Jean | 6 | 5 | 12 | 19.4 | 7 | 7.4 | 5 | 5.7 | 4 | 5.4 | 4 | 4.6 | 3 | 4.1 | 2 | 2.7 | 2 | 2.9 |
| Knicker | 2 | 1.7 | 1 | 1.6 | 3 | 3.2 | 2 | 2.3 | 1 | 1.4 | 2 | 2.3 | 2 | 2.7 | 2 | 2.7 | 1 | 1.4 |
| Legging | 3 | 2.5 | 3 | 4.8 | 2 | 2.4 | 1 | 1.1 | 3 | 4.1 | 2 | 2.3 | 2 | 2.7 | 3 | 4.1 | 1 | 1.4 |
| **Pant** | **83** | **69.7** | **41** | **66.1** | **53** | **56.3** | **58** | **65.9** | **50** | **67.6** | **55** | **63.2** | **56** | **75.7** | **48** | **65.8** | **46** | **65.7** |
| Short | 15 | 12.6 | 2 | 3.2 | 23 | 24.5 | 14 | 15.9 | 10 | 13.5 | 14 | 16.1 | 5 | 6.8 | 12 | 16.4 | 13 | 18.6 |
| Total Responses | 119 | | 62 | | 94 | | 88 | | 74 | | 87 | | 74 | | 73 | | 70 | |

Table 16

*Pant Fabric Preference Based On Rock Climbing Technique*

| Preference | Belay | | Chimney | | Ledge, Roof or Overhang | | Face | | Lieback | | Mantel | | Rappel | | Stem | | Traverse | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % | N | % |
| Canvas/Duck | 2 | 5.3 | 1 | 6.3 | | | | | | | | | | | | | | |
| Cotton | 2 | 5.3 | 2 | 12.5 | 2 | 8.7 | 1 | 4.2 | 2 | 9.1 | 2 | 8.3 | 3 | 14.3 | 2 | 9.5 | 3 | 15 |
| Hi-Tech | 1 | 2.6 | 1 | 6.3 | 1 | 4.3 | 1 | 4.2 | | | 1 | 4.2 | 1 | 4.8 | | | 1 | 5 |
| Non-cotton | 3 | 7.9 | 1 | 6.3 | | | | | 1 | 4.5 | 1 | 4.2 | 1 | 4.8 | 1 | 4.8 | 1 | 5 |
| Nylon | 1 | 2.6 | | | | | | | | | | | | | 1 | 4.8 | 1 | 5 |
| **Stretch/Spandex** | **27** | **71.1** | **10** | **62.5** | **17** | **73.9** | **20** | **83.3** | **17** | **77.3** | **19** | **79.2** | **15** | **71.4** | **17** | **81** | **14** | **70** |
| Synthetic | 1 | 2.6 | 1 | 6.3 | 1 | 4.3 | 1 | 4.2 | 2 | 9.1 | 1 | 4.2 | 1 | 4.8 | | | | |
| Woven | 1 | 2.6 | | | 2 | 8.7 | 1 | 4.2 | | | | | | | | | | |
| Total Responses | 38 | | 16 | | 23 | | 24 | | 22 | | 24 | | 21 | | 21 | | 20 | |

**Research question 5. What is the overall comfort of rock climbing pants after rock climbing?**

Descriptive statistics revealed that the overall comfort based on all six dimensions had a mean of 1.80 (1=No, 2=Slightly, 3=Neutral, 4=Very, 5=Extremely) and standard deviation of .70 indicating that participants almost had a slightly satisfied level of comfort after rock climbing. The comfort sensation means for each dimension is reported in Table 17.

Table 17

*Overall Pant Comfort After Rock Climbing*

| Sensation | *N* | *M* | SD |
|---|---|---|---|
| Stickiness | 183 | 2.22 | 1.11 |
| Clinginess | 182 | 2.08 | 1.12 |
| Roughness | 182 | 1.79 | 1.09 |
| Stiffness | 182 | 1.76 | 1.01 |
| Itchy | 180 | 1.56 | .94 |
| Prickliness | 180 | 1.39 | .84 |
| **Overall** | | **1.80** | **.70** |

*Note.* 1=No, 2=Slightly, 3=Neutral, 4=Very, 5=Extremely

**Research question 6. How do different comfort dimensions (stickiness, itchy, stiffness, etc.) in rock climbing pants differ after rock climbing?**

A repeated measures ANOVA was conducted to compare the effect of stickiness, clinginess, roughness, stiffness, itchy, and prickliness dimensions after rock climbing had pant comfort. The means and standard deviations for pant comfort dimensions are presented in Table 18. The results for the ANOVA indicated a significant pant comfort effect with a medium effect size, Wilks's $\Lambda = 0.557$, $F(5, 173) = 27.478$, $p < .0001$, multivariate $\eta^2 = .443$. Post hoc analyses were conducted given the statistically significant ANOVA *F* test. Tukey HSD post hoc tests were conducted on all possible pairwise comparisions using the Bonferroni correction. With the

exception of 1) stickiness and clinginess and 2) roughness and prickliness all other pairs were found to be statisically significant. These results suggest that all the comfort dimensions in rock climbing pants differ significantly after rock climbing with exception of stickiness and clinginess, and roughness and prickliness.

Table 18

*Descriptive Statistics for Pant Comfort Dimensions*

| *Comfort Dimension* | *n* | *M* | *SD* |
|---|---|---|---|
| Stickiness | 178 | 2.21 | 1.11 |
| Clinginess | 178 | 2.08 | 1.12 |
| Roughness | 178 | 1.79 | 1.09 |
| Stiffness | 178 | 1.54 | 0.94 |
| Itchy | 178 | 1.40 | 0.85 |
| Prickliness | 178 | 1.76 | 1.00 |

*Note.* 1=No, 2=Slightly, 3=Neutral, 4=Very, 5=Extremely

The third open-ended question, "Q8-If you could change the comfort of your rock climbing pants, what would offer more comfort to you?", revealed six themes that were relevant to the study – fabric, style/design, waist/waistband, crotch/hip, thighs, and pant length – with a total of 171 responses (see Table 19). Descriptive statistics revealed that the fabric to be the most prevalent item for pant comfort. Comments associated with the fabric accounted for 43% of the total responses (see Figure 21). Response totals for each theme are shown in Table 18 while Figure 21 features the theme percentages in a colored pie chart.

Table 19

*Coded Responses for Q8 – Pant Comfort (n=171)*

| Theme | Number of Responses |
|---|---|
| **Fabric** | **74** |
| Waist/Waistband | 30 |
| Crotch/Hip | 27 |
| Pant Length | 22 |
| Style/Design | 9 |
| Thighs | 9 |

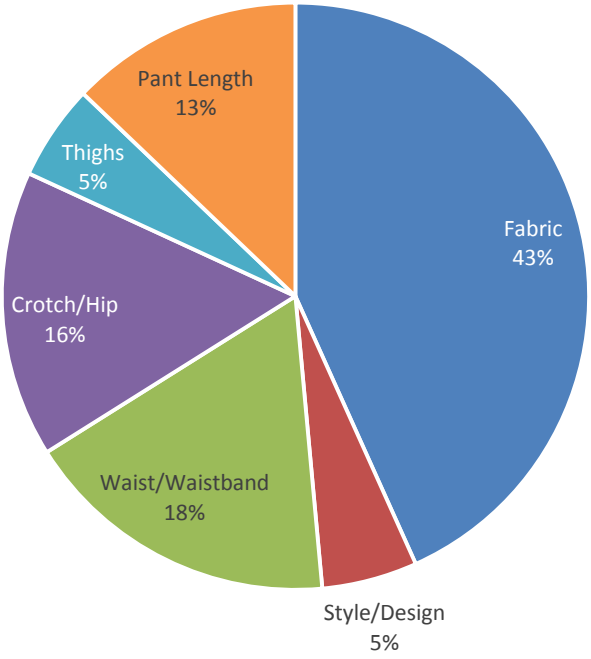



*Figure 21.* Pie chart showcasing themes and percentages found in open-ended question (Q8) on pant comfort.

A sample of comments from respondents based on each theme are featured in Table 20.

Table 20

*Sample of Respondent Comments for Pant Comfort*

| Theme | Pant Comfort Comments |
|---|---|
| Fabric | "more stretch", "better all-around pants (some warmth, good breathability, stretch)", "wick more moisture", "flexibility", "more flexible materials or maybe in high mobility areas", "bit more elasticity", "cooler while maintaining durability", "wick moisture", "heat/cool factor", "breathable, flexible, durable", "softer fabric", and "material that is softer" |
| Waist/Waistband | "drawstring to keep waistband from sagging", "fitted waist", "waist high enough to rest above harness", "lined waistband to prevent rubbing under a harness", and "more adjustable waist" |
| Crotch/Hip | "not enough room in crotch", "loose crotch", "crotch space", "better crotch fit with harness", and "I'd like more elastic crotch area" |
| Pant Length | "leg a little longer", "slightly shorter leg length", and "correct length" |
| Style/Design | "looser fit", "sizes", "loose fitting leg", and "high snaps (on pant) for leg roll-ups" |
| Thighs | "thigh flexibility", "looser thigh", and "slightly larger thighs" |

**Research question 7. What is the overall protection and durability in rock climbing pants currently in the market?**

Descriptive statistics revealed that the overall protection and durability in rock climbing pants was "somewhat durable" to "very durable" to rips and tears, abrasion, seam failures, zipper failures, and fastener failures. Table 21 reports the pant protection and durability by issue with the number of respondents for each level of protection and durability.

Table 21

*Pant Protection and Durability*

| Issue | *n* | Not Durable | Somewhat Not Durable | Fair | Somewhat Durable | Very Durable | Not Applicable |
|---|---|---|---|---|---|---|---|
| Rips and Tears | 183 | 8 | 34 | 28 | 55 | **58** | - |
| Abrasion | 184 | 9 | 30 | 38 | **58** | 49 | - |
| Seam Failures | 183 | 3 | 18 | 27 | 56 | **79** | - |
| Zipper Failure | 183 | 6 | 5 | 16 | 25 | **105** | 26 |
| Fastener Failure | 182 | 6 | 19 | 27 | 38 | **76** | 16 |

**Research question 8. Which areas of rock climbing pants have the most durability problems?**

Descriptive statistics revealed that the most reported durability problem areas in rock climbing pants were knees (26.7%), seat (16.7%) and the crotch (13.7%). Table 22 reports all areas of the rock climbing pant along with the percentage of responses from participants.

Table 22

*Durability Problem Area in Rock Climbing Pants (n = 424)*

| | Responses | |
|---|---|---|
| Area | *n* | % |
| Knees | 113 | 26.7% |
| Seat | 71 | 16.7% |
| Crotch | 58 | 13.7% |
| Snaps/Buttons | 37 | 8.7% |
| Pockets | 36 | 8.5% |
| Seams | 36 | 8.5% |
| Legs | 21 | 5.0% |
| Zippers | 21 | 5.0% |
| Front | 17 | 4.0% |
| Waist | 14 | 3.3% |

The fourth open-ended question, “Q9-If your pants could provide more protection, what type of protection would that be?”, revealed six themes that were relevant to the study –

fabric/construction, reinforced/padded, waist/crotch/hip, thighs, knees, and ankles – with a total of 229 responses (see Table 23). Descriptive statistics revealed fabric as the most prevalent item that would improve protection in the pant. Comments associated with the fabric accounted for 46% of the total responses (see Figure 22). Response totals for each theme are shown in Table 23 while Figure 22 features the theme percentages in a colored pie chart.

Table 23

*Coded Responses for Q9 – More Protection for Pant (n=229)*

| Theme | Number of Responses |
|---|---|
| **Fabric** | **105** |
| Knees | 55 |
| Reinforce/Padded | 39 |
| Waist/Crotch/Hip | 23 |
| Ankle | 5 |
| Thighs | 2 |

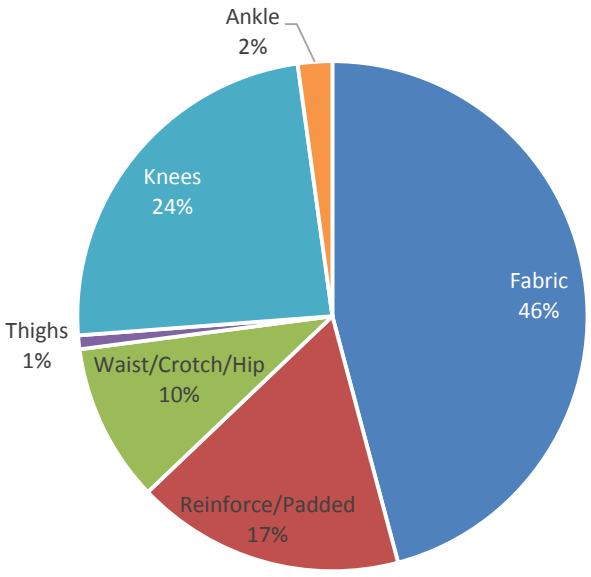



*Figure 22.* Pie chart showcasing themes and percentages found in open-ended question (Q9) on pant protection.

A sample of comments from respondents based on each theme are featured in Table 24.

Table 24

*Sample of Respondent Comments for Pant Protection*

| Theme | Pant Protection Comments |
|---|---|
| Fabric | "abrasion", "UV", "more durability", "abrasion and breathability", "bug repellent", "water resistant", "abrasion in seat", "wind", "knee and heel protection so they don't wear", "abrasion/rip resistant", "abrasion resistant, trad (traditional) climbing = lots of rubbing on rock", and "better protection on knees" |
| Knees | "knee area – more stitching or heavier materials", "abrasion and breathable … on back of knees", "knee padding", "maybe another layer of fabric in knees", "reinforced knees", and "knee protection" |
| Reinforce/Padded | "padding at knee and seat would be awesome", "knee padding", "padding in harness strap area", and "reinforced seat and knees" |
| Waist/Crotch/Hip | "stretchy gusseted crotch", "padding in knees/butt", "reinforced knees and crotch", "abrasion on the knee and seat", and "tighter to the skin around waist" |
| Ankle | "ankle elastic for crack climbing", "abrasion and padding on inside ankle" and "ankle protection" |
| Thighs | "thicker on top of thighs" and "leg loop padding" |

**Research question 9. How do rock climbers rate the ease with which they can don and doff rock climbing pants?**

Descriptive statistics revealed that the ease of donning and doffing a pair rock climbing pants to be very good. Table 25 reports the number of responses for each level of ease along with the mean and standard deviation for donning and doffing a pair of rock climbing pants.

Table 25

*Ease of Pant Donning and Doffing*

| Reporting | *M* | SD | 1 - Excellent | 2 - Very Good | 3 - Adequate | 4 - Not Quite Adequate | 5 - Poor | 6- Extremely Poor |
|---|---|---|---|---|---|---|---|---|
| Don (*n=181)* | 1.96 | .89 | 62 | **74** | 37 | 7 | 0 | 1 |
| Doff (*n=178)* | 2.15 | .96 | 47 | **73** | 47 | 8 | 1 | 2 |

The fifth open-ended question, "Q10- If you could change the ease of getting in and out (don/doff) of your rock climbing pants, what would you change?", revealed four themes that were relevant to the study – fabric, fit/style, closures, and waist – with a total of 54 responses (see Table 26). Descriptive statistics revealed that closures were the most prevalent area of the pant needing change or improvement for donning/doffing. Comments associated with closures accounted for 37% of the total responses (see Figure 23). Response totals for each theme are shown in Table 25 while Figure 23 features the theme percentages in a colored pie chart.

Table 26

*Coded Responses for Q10 – Pant Ease for Don/Doff (n=54)*

| Theme | Number of Responses |
|---|---|
| **Closures** | **20** |
| Fabric | 16 |
| Fit/Style | 11 |
| Waist | 7 |

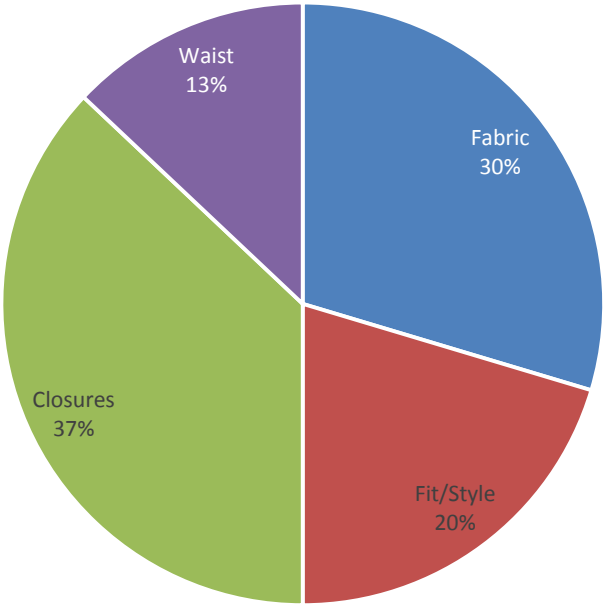



*Figure 23.* Pie chart showcasing themes and percentages found in open-ended question (Q10) on changes to pant donning/doffing.

A sample of comments from respondents based on each theme are featured in Table 27.

Table 27

*Sample of Respondent Comments for Pant Donning/Doffing*

| Theme | Pant Donning/Doffing Comments |
|---|---|
| Closures | "zipper at ankle", "ankle zip so you don't need to take off shoes", "snap that really holds rather than a button", "snap or drawstring – not both", "better snaps and a built in belt", and "snaps but with drawstring" |
| Fabric | "make sure waists have stretch", "higher wicking material to ease doffing", "I like them super stretchy", "(fabric) not stick to my legs", and "easier to remove when sweaty" |
| Fit/Style | "be able to (don/doff) with boots on", "large crotch opening", and "fitted without being skin tight" |
| Waist | "waist needs to be more flexible", "partial elastic waist", and "make sure waists have stretch" |

### Additional Findings

**Pant design details.** The sixth open-ended question, "Q11-What design details are your favorite or would you like to have incorporated into your rock climbing pants to make them more functional?", revealed seven themes that were relevant to the study – fabric/design, gusset crotch, gear loops, pocket details, knee details, waist details, and leg details – with a total of 201 responses (see Table 28). Descriptive statistics revealed that pocket details were the most prevalent (or favorite) area of the pant for function. Comments associated with pocket details accounted for 41% of the total responses (see Figure 24). Response totals for each theme are shown in Table 28 while Figure 24 features the theme percentages in a colored pie chart.

Table 28

*Coded Responses for Q11 – Needed Functional Pant Design Details (n=201)*

| Theme | Number of Responses |
|---|---|
| **Pocket Details** | **82** |
| Fabric/Design | 42 |
| Gear Loops | 33 |
| Leg Details | 14 |
| Knee Details | 13 |
| Gusset Crotch | 9 |
| Waist Details | 8 |

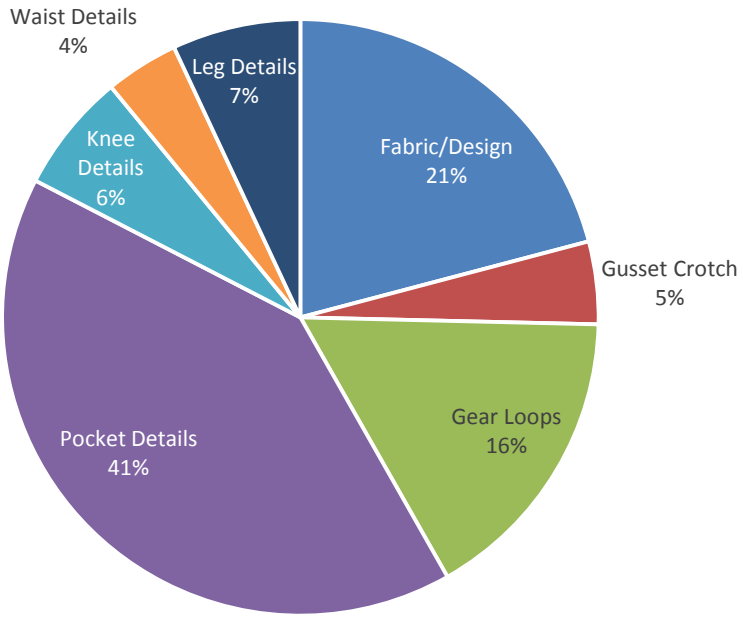



*Figure 24.* Pie chart showcasing themes and percentages found in open-ended question (Q11) on favorite or needed area for pant function.

A sample of comments from respondents based on each theme are featured in Table 29.

Table 29

*Sample of Respondent Comments for Pant Design Details*

| Theme | Pant Design Details Comments |
|---|---|
| Pocket Details | "more pockets", "one zip pocket", "small zipper or Velcro® pocket on lower thigh", "few pockets and those that are there make sure they can be assessed with a harness on", "hip pocket", "lack of pockets on stretch pants stinks", "love zippered pockets", "lay flat pockets", "pocket on leg – easy to get to with harness", "pocket security (zipper or other closure) for watch/phone/keys that clear leg loops of harness", "pocket access around harness", "thigh pockets for maps, guidebook, printouts", "thigh pocket for route topo and bar/snacks", "zippered pockets would be dope", and "durable cell phone pocket out of the way of harness" |

Table 29 Continued

| Theme | Pant Design Details Comments |
|---|---|
| Fabric/Design | "more simple", "tighter", "ability to turn into shorts", "convert into capris, also fleece lined for winter", "simplicity, good fit", style", "knee pads that are also stylish", "simple pants", "stretch", and "better flexibility" |
| Gear Loops | "gear loops", "one gear loop on each side", "gear loops would be bad ass", and "gear loops would be great" |
| Leg Details | "zips off", "convert to capris", "convertible", "roll them or leave hem long without getting in the way", and "loops near calf/knee for rolling up pant legs" |
| Knee Details | "knee pads", "articulated knees", "removable knee pads", "extend knee fabric" and "knee protection" |
| Gusset Crotch | "gusseted crotch" |
| Waist Details | "cinch waist" and "adjustable waist belt" |

**Prior pant dislikes.** The seventh open-ended question, "Q12- Have you ever worn a pair of climbing pants that you didn't like? If so, what were the problem(s)?", revealed six themes that were relevant to the study – fabric, style/design, length/inseam, waist/crotch/hip, thighs/knees and calf/ankle – with a total of 130 responses (see Table 30). Descriptive statistics revealed that fabric was the most prevalent area of pant dislike. Comments associated with fabric accounted for 42% of the total responses (see Figure 25). Response totals for each theme are shown in Table 30 while Figure 25 features the theme percentages in a colored pie chart.

Table 30

*Coded Responses for Q12 – Pant Dislikes (n=130)*

| Theme | Number of Responses |
|---|---|
| **Fabric** | **54** |
| Style/Design | 32 |
| Waist/Crotch/Hip | 22 |
| Length/Inseam | 12 |
| Thighs/Knees | 8 |
| Calf/Ankle | 2 |

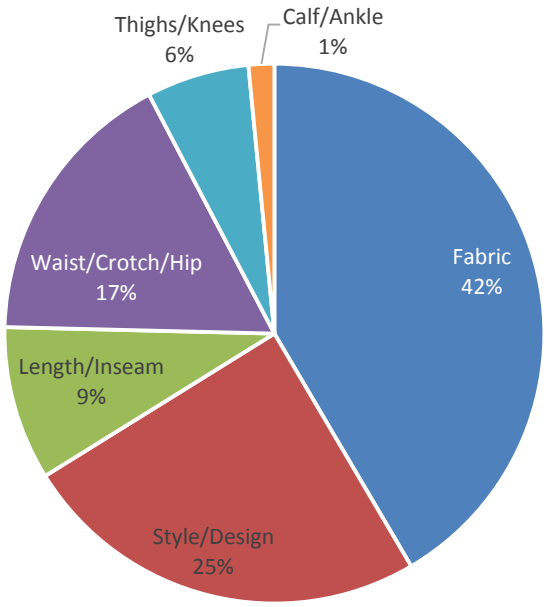



*Figure 25.* Pie chart showcasing themes and percentages found in open-ended question (Q12) regarding pant dislikes.

A sample of comments from respondents based on each theme are featured in Table 31.

Table 31

*Sample of Respondent Comments for Pant Dislike*

| Theme | Pant Dislike Comments |
|---|---|
| Fabric | "too stiff", "not enough stretch", "they wore out too fast", "inflexible material", "hot, sweating, slow to dry", "very lightweight is not durable", "not durable enough", "too thin and they tore everywhere", "too thin", "no stretch – couldn't move well", "no stretch, mobility very impaired in knees and crotch", "scratchy", "too dense – no breathability", and "not abrasion resistant" |
| Style/Design | "poor fit", "pants that were too big or too small, didn't fit around waist", "cheap zippers", "terrible buttons", "too loose", "too tight", "snap closure, easily unsnapped", "awkward fit", and "zipper didn't stay up" |

Table 31 Continued

| Theme | Pant Dislike Comments |
|---|---|
| Waist/Crotch/Hip | "waist doesn't fit with harness", "always the crotch", "very few made for women with hips and small waist", "crotch too tight", "too loose in waist and crotch", and "big waist, tight butt" |
| Length/Inseam | "too short" or "too long" |
| Thighs/Knees | "too small in thighs to go on", "knees bunch", and "too tight in thighs" |
| Calf/Ankle | "flare at bottom" and "large opening near ankle (not tapered)" |

**Important pant features.** The eighth open-ended question, "Q13-When purchasing new climbing pants, what are the most important features you look for? Be specific and list all features.", revealed seven themes that were relevant to the study – fabric/construction, fit/range of motion, comfort, price, brand, design details, and aesthetics – with a total of 353 responses (see Table 32). Descriptive statistics revealed that fabric/construction were the most important when considering pant features. Comments associated with fabric/construction accounted for 32% of the total responses (see Figure 26). Response totals for each theme are shown in Table 32 while Figure 26 features the theme percentages in a colored pie chart.

Table 32

*Coded Responses for Q13 – Important Pant Features (n=353)*

| Theme | Number of Responses |
|---|---|
| **Fabric/Construction** | **112** |
| Fit/Range of Motion | 79 |
| Price | 73 |
| Design Detail | 34 |
| Comfort | 20 |
| Aesthetics | 19 |
| Brand | 16 |

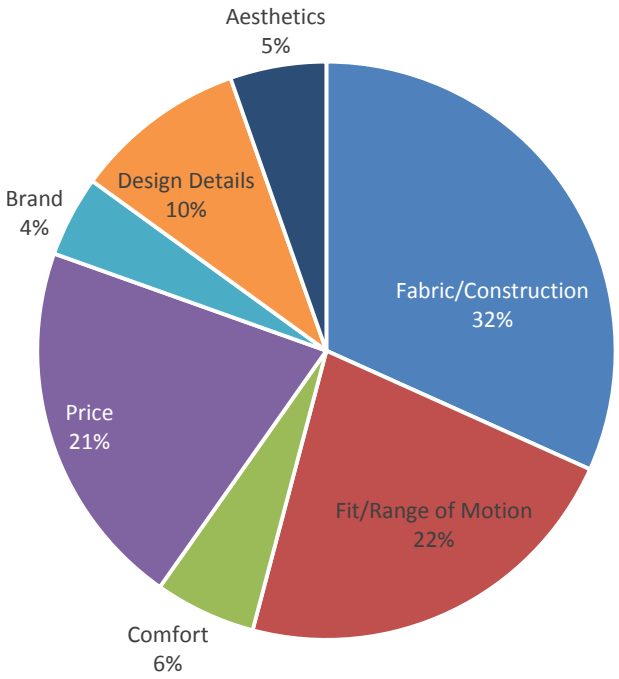



*Figure 26.* Pie chart showcasing themes and percentages found in open-ended question (Q13) on important pant features.

A sample of comments from respondents based on each theme are featured in Table 33.

Table 33

*Sample of Respondent Comments for Important Pant Features*

| Theme | Important Pant Features Comments |
|---|---|
| Fabric/Construction | "fabric (abrasion resistant, stretch)", "durability", "breathability", "stretch, durable", "protection from abrasion", "strong fabric that is still breathable", "strong seams, breathability", "soft fabric, stretchy, tough, wind/water resistant", "fabric that is stretch and durable", and "fabric needs to be durable yet feel good on the skin" |
| Fit/Range of Motion | "good fit", "fit mostly", "great fit, no restriction of movement", "ease of movement", and "fits like a glove and I can do squats in them" |
| Price | "price", "cost", "price (under $75 if I think they'll last)", "must be affordable" and "I buy clearance or on sale" and "typical dirt bag climber so I want something that will last but not cost much" |
| Design Detail | "able to roll up", "zippered pockets", "pockets and belt loops", "gusseted crotch", "pockets that form fit", and "pocket accessibility" |

Table 33 Continued

| Theme | Important Pant Features Comments |
|---|---|
| Comfort | "comfort", "nice to touch", and "feel good on the skin" |
| Aesthetics | "design", "style", "color", and "look good/smart" |
| Brand | "preference toward Prana", "brand", "brand cause, ethically made is important", and "brand practices" |

**Additional Comments**

The additional comments page of the questionnaire revealed seven themes that were relevant to the study – fabric/construction, fit/range of motion, comfort, price, sustainability, design details, and aesthetics – with only 19 responses (see Table 34) which account for less than 10% of all respondents in this study. Descriptive statistics revealed that fabric/construction and design details were the most prevalent areas commented on. This supports the findings from the open ended questions which found fabric, and design details prevalent items of concern or need in a rock climbing pant. Comments associated with fabric/construction and design details each accounted for 26% of the total responses (see Figure 27). Response totals for each theme are shown in Table 34 while Figure 27 features the theme percentages in a colored pie chart. Typical responses included statements such as "stretch", "durability", "gusset crotch", and "knee pads/reinforcement".

Table 34

*Coded Responses for Additional Comments (n=19)*

| Theme | Number of Responses |
|---|---|
| **Fabric/Construction** | **5** |
| **Design Details** | **5** |
| Fit/Range of Motion | 4 |
| Aesthetics | 2 |
| Price | 2 |
| Sustainability | 1 |

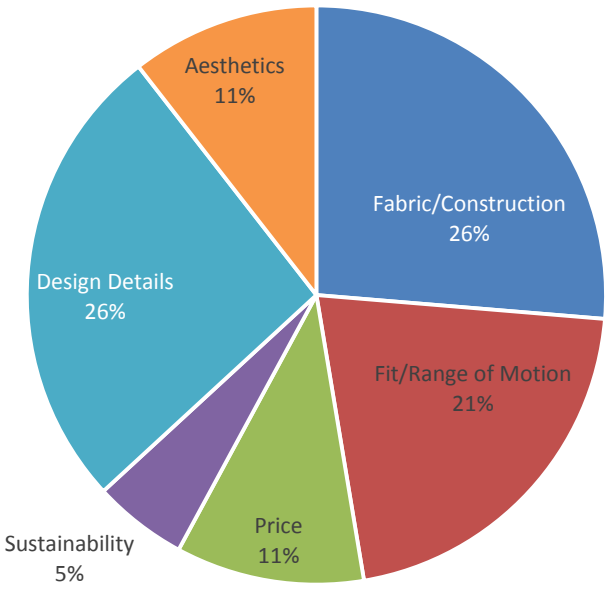



*Figure 27.* Pie chart showcasing themes and percentages found in the additional comments.

## CHAPTER V. DISCUSSION, IMPLICATIONS, AND LIMITATIONS

This chapter will discuss the findings of this study, its implications, limitations, as well as suggestions for future research. As previously stated, this study set out to explore the functional needs of rock climbing pants by looking at fit, mobility, comfort, protection, and donning/doffing. The functional category of Lamb and Kallal's (1992) Functional, Expressive, and Aesthetic Consumer Needs Model (FEA) was utilized as a framework for assessing the functional needs of rock climbing pants. A questionnaire was created by the researcher that measured overall fit satisfaction, pant mobility while performing various climbing techniques involving the lower body, pant comfort after climbing, pant protection and durability, ease of donning and doffing, along with determining if there were pant preferences to brand, style, or pant type based on climbing technique. The questionnaire was distributed at two rock climbing events during the summer of 2014. A total of 185 usable participants, 126 males and 59 females, represented 30 U.S. states along with 10 other countries (see Figure 28). The sample majority are single Caucasians, mean age of 27-30 years, making less than $50,000 annually, have 3-10 years of climbing experience and had been rock climbing in the past week.

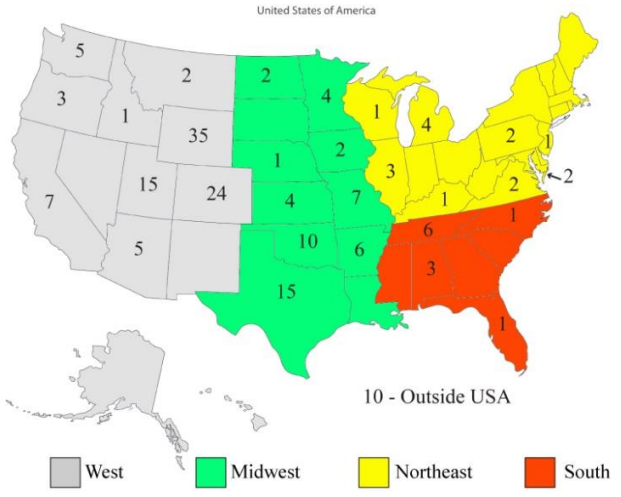



*Figure 28*. Respondents listed by state of resident (or listed as outside USA).

**Fit Satisfaction**

The results for research question 1 "How does fit satisfaction differ across the different dimensions of pant fit?" found that rock climbers were only mildly satisfied with the fit of their pants across the various pant dimensions. Pant fit dimensions evaluated were pant length, waist, crotch, hip, thigh, knee, calf, and ankle. Out of the eight fit dimensions evaluated in this study, the waist had the lowest fit satisfaction with respondents rating it as being neither satisfied nor dissatisfied. Schofield et. al. (2006) study on pant fit for women 55 and older found a good pant fit was not easy to find with waist measurements having the largest variations. The calf had the highest fit satisfaction rating but it was still only moderately satisfying. In this study, every pant dimension had some level of dissatisfaction causing an overall rating of only mildly satisfied. Fowler's (1999) study on sport apparel attributes found that fit was one of the most important attributes for both males and females yet was the second to lowest rated attribute. Other functional garment studies found similar results to this study, participants stated pant satisfaction was important yet various pant dimensions had low satisfaction ratings or overall fit was reported as poor (Bye & Hakala, 2005; Black & Cloud, 2008; Jin & Black, 2012; Mitchka, et. al., 2009; Park & Hahn, 2014; Schoefield, et. al., 2006; Stokes & Black, 2012).

To determine if there were any underlying causes or problems contributing to pant fit satisfaction in rock climbers, the researcher examined responses to open-ended question 6 "If you could change the fit of your rock climbing pants, what would you change?" One complaint from respondents was the waistband needed to sit higher on the body. This is consistent with statistical findings for fit satisfaction that showed the waist has the lowest satisfaction rating of all the pant dimensions. Rock climbing pant are designed similar to jeans so the waistbands sit below the natural waistline. Jeans, both men and women, are drafted so that the back waist is

dropped by 1” to 3” depending on the styling (Armstrong, 2010). Respondents stated that rock climbing waistbands sit too far below the harness, which is secured at the natural waistline, so when climbing the pant moves lower causing their body to be visible (example in Figure 29). As the pant waistline is dropped, due to pant styles, the more easily it is for the body to be visible while climbing.

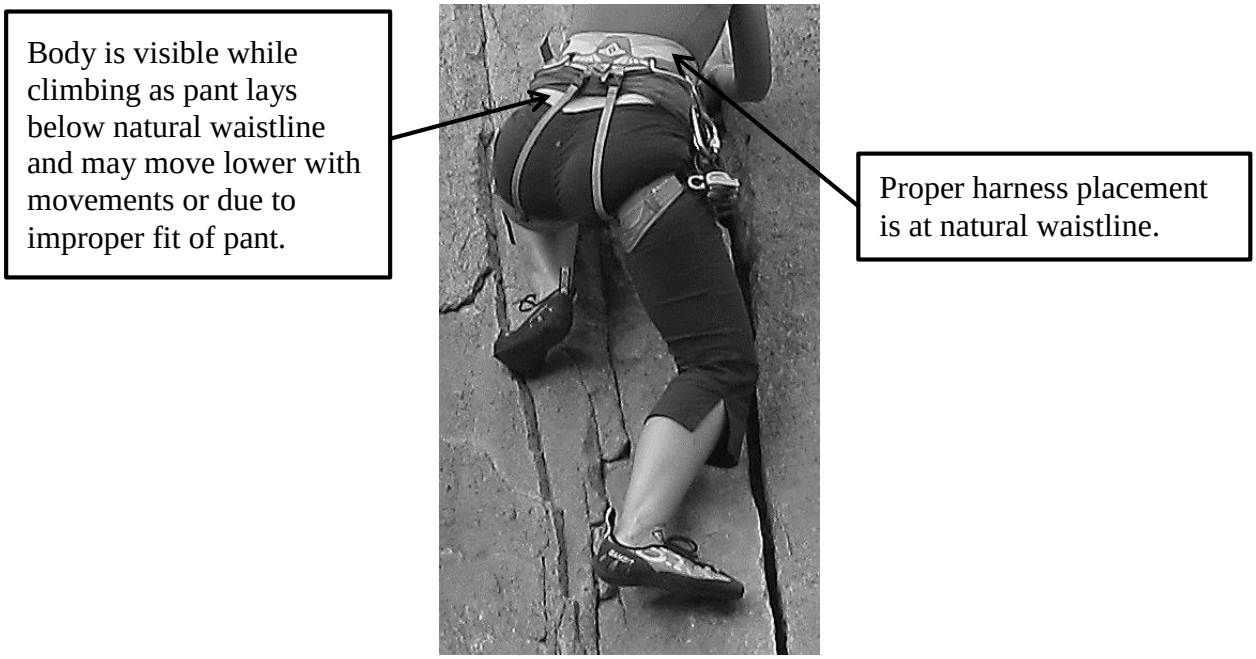



*Figure 29*. Back visible during climbing due to low waistband. © 2015 Dawn Michaelson

One solution would be to redesign the pant so the waistband sits closer to the natural waistband or allow for it to be tightened for a more body forming fit. Climbers expressed that wearing a belt with the climbing pant to hold them in place interfered with the harness and was not desired. This is consistent with Cox & Fulsaas (2007) recommendations on rock climbing apparel and equipment selection, and stated that apparel and equipment should not cause conflicts with climbing.

Crotch rise was another area of pant fit conflict with rock climbers. Climbers wanted the crotch to be closer to the body so it did not infer with the harness yet also provide adequate

flexibility to perform rock climbing techniques. The proper placement of a harness leg strap is under the buttocks (see Figure 29) so a low crotch can result in excess fabric in the crotch area. A higher crotch rise along with a crotch gusset would allow for a better fit while allowing for better flexibility. Crotch gussets should be designed for maximum stretch. This can be achieved by designing the gusset so the grain line is placed on the bias allowing for maximum stretch (Armstrong, 2010) (see Figure 30).

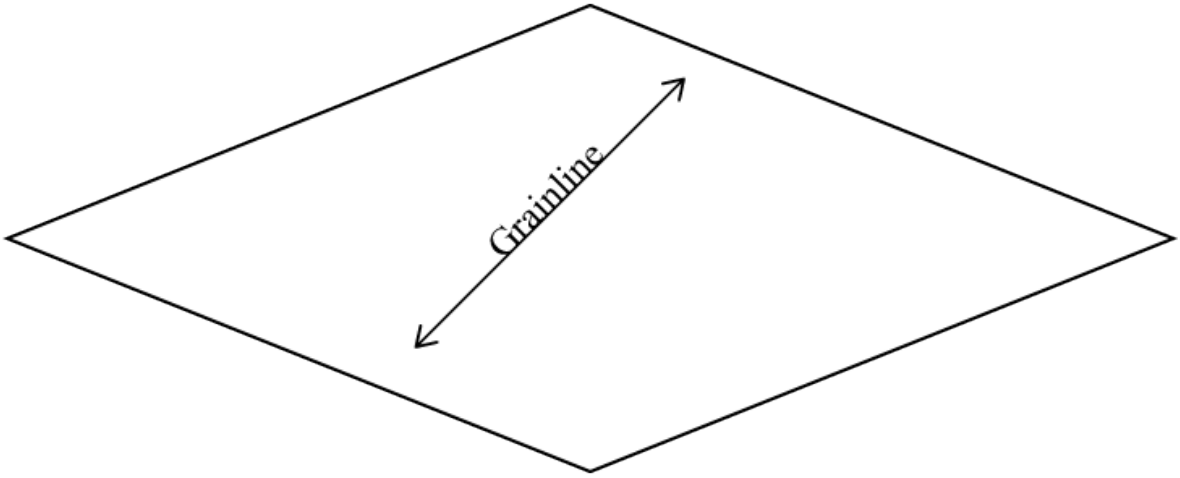



*Figure 30*. Gusset crotch pattern piece with bias grain line.
Note: This is not to scale and is only shown as an example.

Lastly, inseam lengths were either too long or short causing fit dissatisfaction. The hips, thighs, knees, and calf area also needed a fitted body style along with a high level of stretch so movement wasn't impeded. Some climbers stated the ankle area was too wide, needed to be taped, or securely roll up to not impede climbing. Firefighter's reported similar problems and stated a low satisfaction with their turnout gear based on leg fit, pant length, crotch, along with hip and waist fit when bending or performing extreme movements (Park & Hahn, 2014). Dancer's had similar problems with their garments being too short and more than 50% of those that had dance leggings reported leg length to be a problem (Mitchka, et. al., 2009). Gupta (2011b) recommended that functional garments to be drafted in a 3D program allowing the

patternmaker to draft patterns directly onto a 3D body in action (see Figure 31). In this manner, the patterns conform to the body in a dynamic pose more typical to the movements a climber would make.

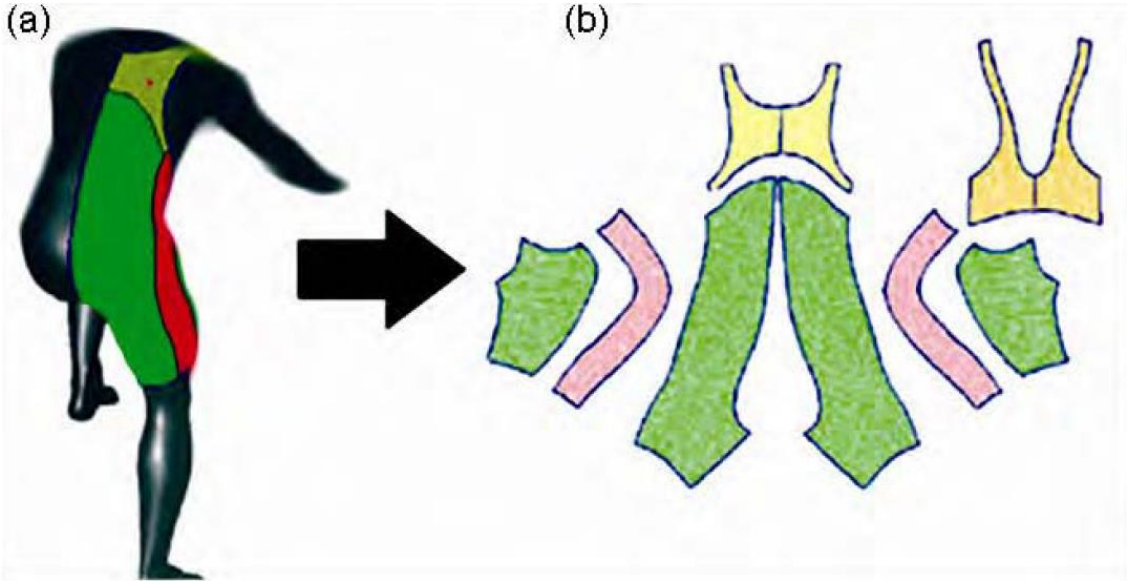



*Figure 31*. 3D Pattern drafting on body in motion (a) patterns drafted on cyclist, and (b) flattened 3D patterns. Adapted from "Human body models from personal scan data for accelerated product development and virtual fit check of sports clothing," by S. Krzywinski, J. Siegmund, and C. Meixner, 2009, *Proceedings of the Avantex-Symposium, Frankfurt*, pp. 16-17. Copyright 2009 by Avantex-Symposium.

**Mobility and Wearability**

Research question 2 "What is the overall pant mobility and wearability while rock climbing?" found that pant mobility and wearability to be only slightly satisfying for rock climbers. For additional clarification, research question 3 asked "How does pant mobility and wearability differ based on the rock climbing technique?" This examined if any of the nine climbing techniques had any different mobility and wearability ratings. The study found that many of the rock climbing techniques differed significantly from each other when it came to mobility and wearability. Belaying was found to be significantly different from chimney,

ledge/overhang/roof, and traverse techniques. The chimney technique was significantly different from ledge/overhang/roof, face climb, lieback, mantel, rappel, stem, and traverse techniques. While ledge/overhang/roof technique was significantly different from mantel, and traversing was significantly different from lieback, mantel, and stem techniques. Upon examination of these differing paired techniques, it was evident that these techniques varied in the type of low body movements needed for the technique. Each technique requires an area of the lower body to articulate through various ranges of motion, thereby affecting mobility and wearability of the climbing pant. Climbing routes typically require multiple climbing techniques in order to complete the route. Rock climbing guide books typically provide beta for each route. This beta will have information about a climb's difficulty, climbing style, specific techniques needed, crux (difficult area of route), height of route, equipment/gear for protection, along with specific information about hand or foot holds. Thereby, a rock climber can anticipate the difficulty of the climb and probable techniques needed for the route. Pant mobility and wearability would need to be diverse in order to accommodate the variety of movements any rock climber may need to complete the route. It is the diversity of movements needed that may have led to the slightly satisfying rating for pant mobility and wearability. As an example, belaying and performing a ledge/overhang/roof technique would require two very different body movements (see Figure 32).

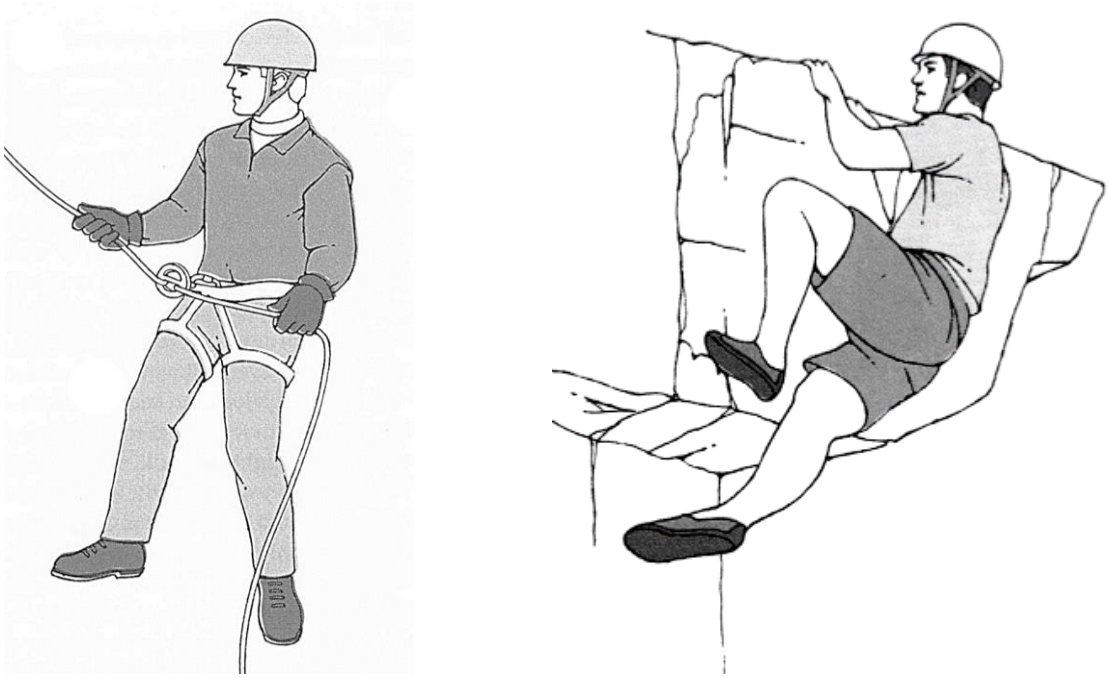


*Figure 32*. Belay (left) and ledge/overhang/roof (right) technique. Adapted from *Mountaineering: The freedom of the hills* (p. 166 & 231), by S.M. Cox & K. Fulsaas (Eds.), 2007, Seattle, WA: The Mountaineer Books. Copyright 2007 by The Mountaineers.

Belaying is typically done in a standing, sitting, or in a squat position. Contrastingly, the ledge/overhang/roof technique requires the leg (or knee) to be lifted to or above the waist so the body can then be pulled up over the ledge/overhang/roof (see Figure 32). Pant mobility for a belay technique would require the hip, waist, and knee area of the pant to stretch and be flexible while a ledge/overhand/ledge technique would requires a high level of stretch in the crotch so that leg mobility would not be hampered in the climb over the ledge/overhang/roof. In discussing pant mobility problems, respondents reported the crotch/hip area as the highest problematic area (33%), following by the knee/calf/ankle (21.5%), and waist/waistband was fourth (14%) which is consistent with the technique mobility differences. Each climbing technique has a different range of motion for the low body resulting in the need for a highly flexible pant. Sport apparel studies also found that snowboarding, sailing, and tennis each had specific movements required in the sport, such as bending at the knee and leg range of motion that affected the mobility and

wearability of the apparel (Bye & Hakala, 2005; Emerich, 2011; Jin & Black, 2012). Occupational apparel studies with bicycle patrol officers, protective overalls, firefighter's turnout gear, and body armor had similar mobility and wearability issues with pants that reported impediment of movements while performing their work (Black & Cloud, 2008; Huck, et. al., 1997; Park & Hahn, 2014; Park, et. al., 2011).

Open-ended question 7 provided some additional insight into pant mobility and wearability by asking "What area of your rock climbing pant causes the most mobility problems for you when climbing?" Rock climbers stated the crotch and hip area caused mobility problems, especially when high stepping or stemming. These techniques, high stepping and stemming, require an extreme range of movement with the legs and hips. High stepping, a mantel technique typically used while face climbing, uses "hand down pressure to permit your feet to get up onto the same hold that your hands are using" (p. 217) and requires a high level of flexibility in the crotch, hip, and knee of the pant in order to perform (Cox & Fulsaas, 2007). It is not uncommon in a high step for the knee to be raised to the waist level. Reports were there was "tightness in the thighs when high stepping" and it interfered with climbing was reported by respondents. This is consistent with pant mobility and wearability ratings that reported stemming, the second to lowest rated climbing technique ($M$ = 6.80), mantel, the fourth to lowest ($M$=6.77), and face climbing, the sixth to lowest ($M$=6.94), to be only slightly satisfying to climbers. Knee constriction was also reported when feet were placed high. Wang, Mok, Li, and Kwok's (2011) study on body measurements found the knee area had the largest measurement change, at 5.4%, when the body went from a standing to squat (knees bent 90 degrees) position and the hip and mid-thigh increased 3%. Additionally, when the knee is bent even further upwards to its maximum range of 120-150 degrees the knee area measurement increased 10.1%, the hip 5.4%,

and the thigh 3.3% (Wang, et. al., 2011). Gill & Hayes's (2012) study on vertical body measurement changes found that when in a squat position the front of the leg (crotch to ankle) increases 7% and back of leg (waist to knee) increased 17.2%. Stemming, a counterforce climbing technique typically used in chimney climbing, allows the climber to place opposing force on each leg as a method of ascending the route (Cox & Fulsaas, 2007). Stemming requires the legs to be extended, sometime in opposite directions, so force is placed on the rock and with opposing force and movement of the body the climber can ascend the route. Climbers expressed the need to have more stretch in crotch and hip for this technique. A gusseted crotch was also mentioned by respondents as a way to increase mobility in their pants. Wang, Mok, Li, and Kwok's (2011) study looked at the sideway lifting of the leg to 45 degrees and found that the crotch depth changed by 3.9% while the front leg changed 1.5% and the back leg 1.4%. Similarly, Gill & Hayes's (2012) study found a 1.1% measurement change (waist to knee) when the hip was either extended or flexed 15 degrees. Figure 31 provides an example of high stepping and stemming techniques being performed by a rock climber to give you a visual representation of the techniques.

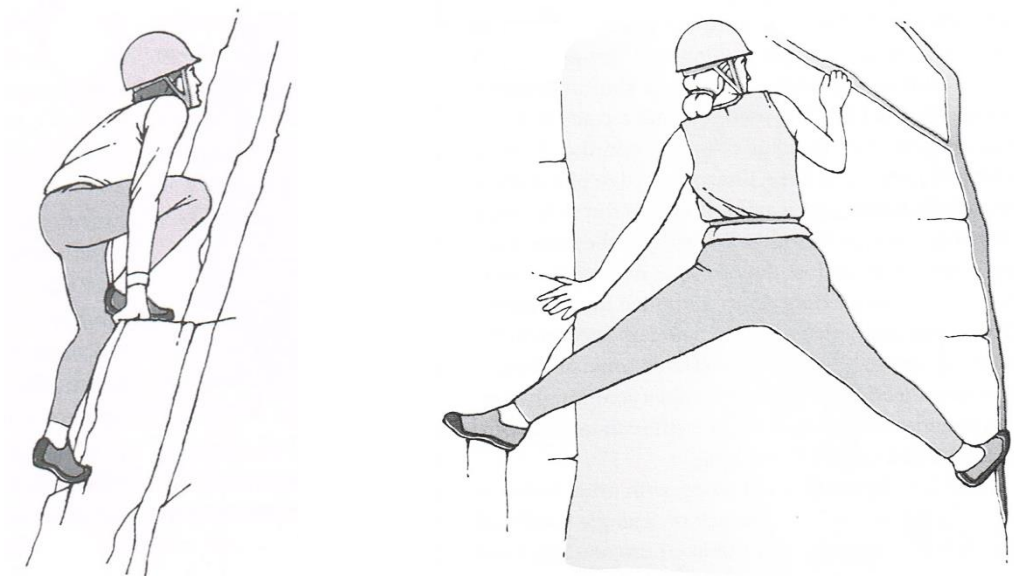


*Figure 33*. High stepping in mantel technique (left) and stemming (right) technique. Adapted from *Mountaineering: The freedom of the hills* (p. 217 & 219), by S.M. Cox & K. Fulsaas (Eds.), 2007, Seattle, WA: The Mountaineer Books. Copyright 2007 by The Mountaineers.

These research questions on pant mobility and wearability, along with the open ended responses, elucidates the dynamic lower body positions needed in rock climbing and how the current pant mobility and wearability satisfaction can decrease if climbers are unable to perform these positions. Body measurement studies on dynamic positions further reinforces this by stating that the hip and knee girth area experienced the most significant increases when in a dynamic position and that the leg length could also increase between 5-7% depending on the position (Gill & Hayes, 2012; Wang, et. al., 2011). These body measurement studies along with this researchers findings show that body changes need to be measured while in various dynamic states so that these changes can be incorporated into the pant design ease (Gill & Hayes, 2012; Wang, et. al., 2011). Additionally, various fabric elasticity should be studied to see if specific percentages can help with functional ease. The combination of body measurement changes in various climbing positions and investigation of fabric elasticity could increase pant mobility and wearability satisfaction in rock climbing pants.

**Comfort**

This study examined thermal pant comfort by asking participants two research questions and one open-ended question. Research question 5 "What is the overall comfort of rock climbing pants after rock climbing?" found that climber's pants were not comfortable after climbing. The pant thermal comfort characteristic that were rated as uncomfortable were roughness, stiffness, itchy, and prickliness, while stickiness and clinginess were rated as only slightly comfortable. Research question 6 "How do different comfort dimensions in rock climbing pants differ after rock climbing?" found that when comparing the comfort dimension ratings – stickiness, clinginess, roughness, stiffness, itchy, and prickliness - all of the pairs with the exception of stickiness and clinginess along with roughness and prickliness were found to have different ratings from each other for thermal comfort. These ratings differed by an entire rating category thus making them differ significantly from one other. This findings are consistent with Fan and Tsang's (2008) study on badminton comfort that found prickliness, stickiness, roughness, and stiffness dimensions to be interrelated. As an example, after climbing rock, climbers found their pant clinginess to be slightly comfortable while the pant itchiness to be uncomfortable. The pant stickiness was rated the same as being slightly comfortable while prickliness was uncomfortable. Overall, thermal comfort of rock climbing pants after climbing was not comfortable and needs to be improved. Other studies on functional garment comfort varied based on the sport or occupation. Male badminton and women sailing apparel was found to be less than satisfying (Bye & Hakala, 2005; Fan & Tsang, 2008), while patrol officer bicycle shorts, tennis wear, and dancewear apparel were found to comfortable for the user (Black & Cloud, 2008; Jin & Black, 2012; Mitchka, et al., 2009). Overall, a functional garment needs to be tested while being used in

typical environmental temperatures and conditions in order to discover the users thermal comfort satisfaction (Watkins & Dunne, 2015).

Comfort is a highly important attribute in sports apparel. Fowler (1999) found that comfort was the highest rated attribute required in sports apparel for both men and women. Davis and Bishop (2013) found that clothing construction, fit, and fabric impacted comfort when exercising in the heat. A common complaint of users after exercising was the clinginess of the garment which lead to decreased comfort (Davis & Bishop, 2013). This is further reinforced by studies with firefighting gear, flight suits, snowboarding, in-line skating, bicycling, sailing, tennis, dancewear, and golf apparel that found comfort to be a significant attribute in their functional garment (Bye & & Hakala, 2005; Casselman-Dickson & Damhorst, 1993; Chae & Everson, 2014; Dickson & Pollack, 2000; Emerich, 2011; Jin & Black, 2012; Mitchka, et al., 2009; Park, et. al., 2014; Tan, et. al., 1998).

Open-ended question 8 “If you could change the comfort of your rock climbing pants, what would offer more comfort to you?” found that other comfort factors, beyond thermal comfort, contributed to the pant comfort. Fabric, a physical comfort aspect, was mentioned most with climbers stating changes in stretch or flexibility (especially in pant areas with high mobility), along with permeability, durability and protection characteristics were needed to improve comfort (see Figure 34). The fabrics ability to wick moisture while not compromising durability was a desired trait with rock climbers along with a soft fabric hand. Women competitive sailors had similar apparel needs when it came to fabric permeability and thermal protection while sailing (Bye & Hakala, 2005).

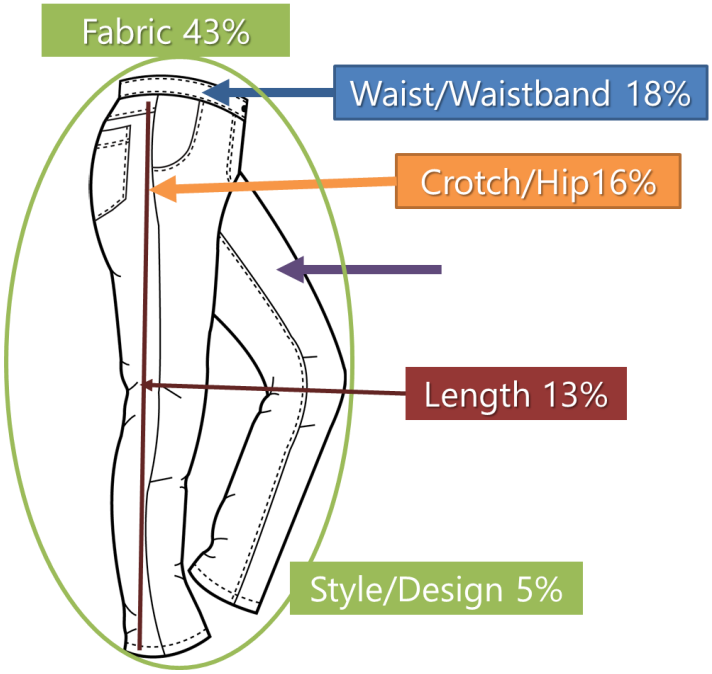



*Figure 34.* Comfort Problem Areas in Climbing Pants.

Rock climber's also stated comfort could be improved with better pant fit. The waistband needed to sit closer to the natural waistline and a waistband lining would prevent discomfort if the harness rubbed on the pant waistband. The crotch and hip needed design ease added for a better fit especially while wearing a harness. Lastly, the pant length was also a comfort issue while climbing due to length being either too long or short. These findings are similar of other functional garment studies where fit, fabric properties, and equipment contributed to decreased comfort (Black & Cloud, 2008; Bye & Hakala, 2005; Emerich, 2011; Park & Hahn, 2014; Stokes & Black, 2012).

**Protection and Durability**

Research question 7 "What is the overall protection and durability in rock climbing pants currently in the market?" investigated five issues for protection and durability. Abrasion was found to be somewhat durable while rips and tears, seams, zippers, and fastener failure were

rated as very durable. The areas of the pant with the most durability issues were asked in research question 8 “Which areas of rock climbing pants have the most durability problems?” and it was found that knees (26.7%), seat (16.7%) and crotch (13.7%) were the areas with the most reported durability issues (see Figure 35). These areas were also reported to have the most wear or mobility problems in prior questions. Similarly, Bye & Hakala’s (2005) study found that all women sailors wanted more durability in the seat and knees as these were the area’s most prone to abrasion and pant wear.

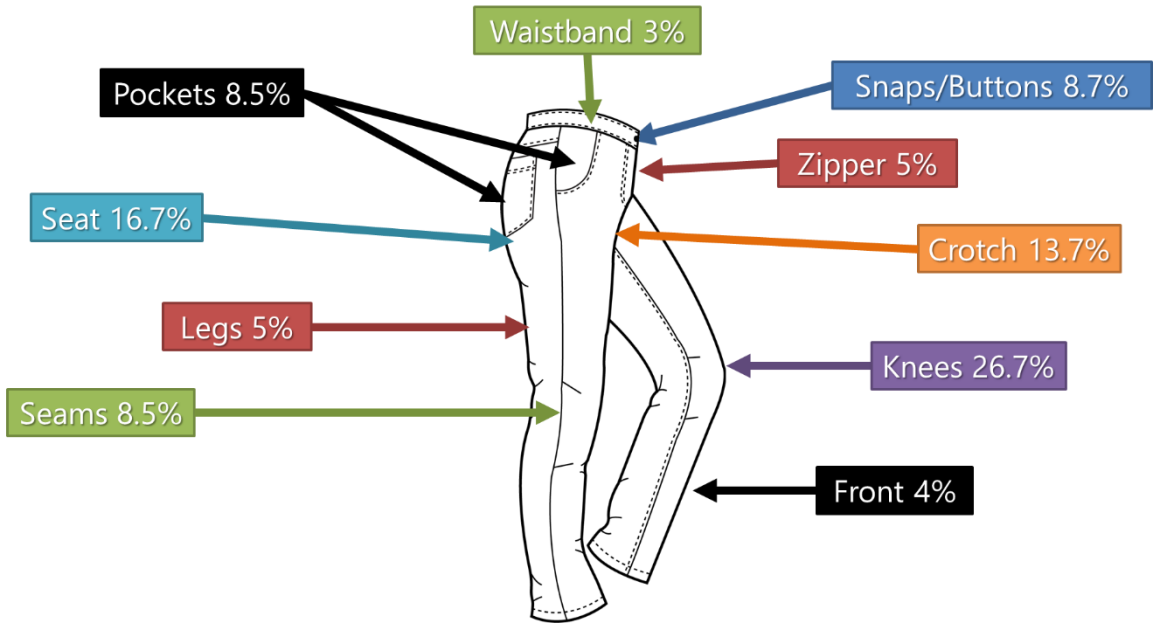



*Figure 35.* Durability Problem Areas in Climbing Pants.

Further investigation, through open-ended question 9 asked “If your pants could provide more protection, what type of protection would that be?” found that climbers wanted fabric with better durability, protection, and permeability characteristics (see Figure 36). Problems with abrasion, breathability, and protection were reported, as in previous open-ended questions, with concerns about knee and heel protection, rips in the pants, and water resistance. Knees needed better overall protection through padding or fabric reinforcement (see Figure 36). Climbers

stated issues with protection and durability due to abrasive rock and rubbing of harness on upper thighs and seat while climbing. Other studies with firefighters turnout gear, bicycle patrol officer garments, and women sailing apparel all reported similar problems with fabric durability, protection, and conflicts with necessary equipment (Black & Cloud, 2008; Bye & Hakala, 2005; Park & Hahn, 2014; Rutherford-Black & Khan, 1995).

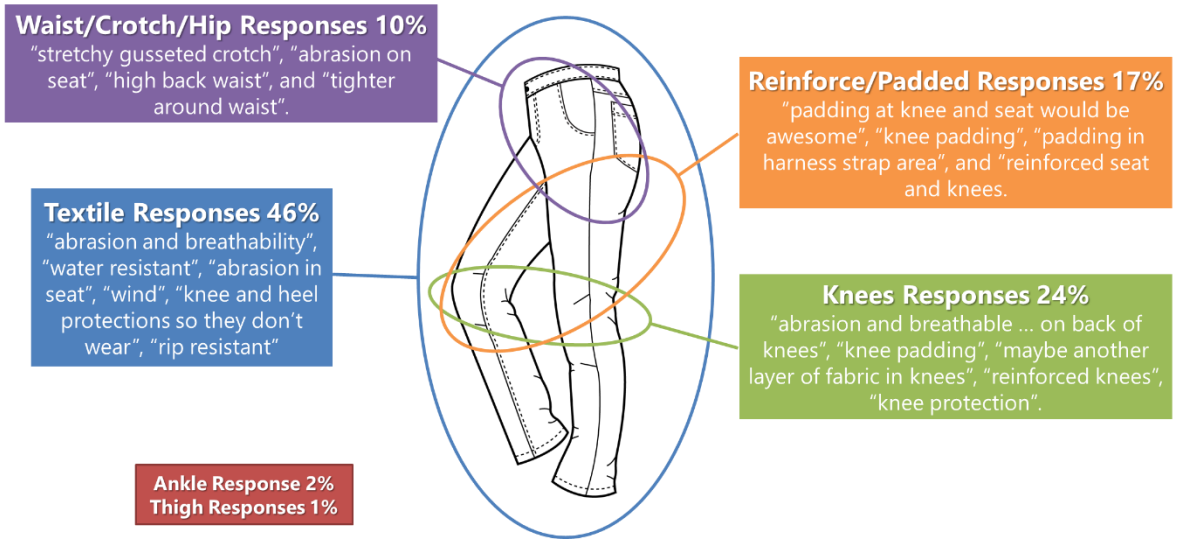



*Figure 36.* Areas for Enhanced Pant Protection.

**Ease of Don/Doffing**

Research question 9 investigated the ease of donning and doffing rock climbing pants and found rock climbers had little difficulties. Closures were the main item mentioned that would improve donning and doffing. Higher quality snaps, ankle zippers, and an adjustable waist closure would be an improvement to the climber's current pant. Every functional garment has different types of closures for donning and doffing garments and quality is always a factor. Protective firefighting garments reported problems with low-quality zippers and other fasteners (Havenith & Heus, 2004), competitive sailors perceived durable elastic closures and wider hook and loop tape as indicators of garment quality (Bye & Hakala, 2005), and girls with disabilities

often had difficulties with the placement of fasteners (Stokes & Black, 2012). Additionally, climber's perceived that fabric stretch and wicking properties would allow the pant to not stick to the body thereby making the doffing of the pant after climbing easier.

**Brand, Style, or Pant Type Preference**

An understanding of brand, style, or pant type preference in climbers was investigated to see if specific pants performed better for rock climbers. To see if this may be the case, research question 4 asked "Do rock climbers prefer certain brands, types, or styles of rock climbing pants for specific rock climbing techniques?" Out of the 55 brands reported in this study, Prana was the favored brand by 22.4-37% for all climbing techniques. Style preferences varied greatly but Prana Stretch Zion, a men's only style, was preferred for all climbing techniques except rappelling. Surprisingly, 7.1% – 17.9% of women, depending on technique, reported wearing yoga pants for its mobility and comfort. Patagonia Simple Guide pants, men's and women's style, was the next favorite style for climbers in some techniques. It should also be noted that some rock climbers responded with generic statements of pant type or fabric preferences. Overall these responses accounted for six different pant types – capri, jean, knicker, legging, pant and short – with a preference for a full length pant. Stretch fabric was also reported as a fabric of preference in these generic statements.

The researcher was unable to locate articles on brand, style, or pant preference for a functional garment. Fowler (1999) found that with sport apparel, brand name was not one of the top attributes in apparel which may contribute to the lack of studies. Additionally, functional garments are a niche market with limited manufacturers. These companies are private with their own research and development departments; so this may also contribute to the lack of research.

**Additional Findings**

Three additional open-ended questions investigated design details, pant dissatisfaction, and important features that were desired in a rock climbing pant. Rock climbers want a simplistic pant design with better fit and stretch. The knees were a key area for protection and mobility with climbers. Other sports and occupational garments also found knees to be important for protection and mobility (Black & Cloud, 2008; Bye & Hakala, 2005; Park & Hahn, 2014). Knee padding or reinforcement was frequently mentioned by respondents as a way to increase bodily protection. It should be noted that knees are a key area of stress in pants so proper design ease and construction should be considered in rock climbing pants (Crow & Dewar, 1986). Additionally, many climbers expressed that a gusseted crotch was either a favorite or needed feature for increased mobility. Lastly, having a contoured waistband and/or adjustable waistband was desired to alleviate waistband movement while climbing was mentioned in this question again. This could be achieved with an internal drawstring or an elasticized panel being used as a waistband lining.

Pockets that were functional, able to be securely closed, and did not impede climbing was desired. Respondents stated that pockets were needed for a multitude of items, such as keys, jewelry, phone, maps, or beta but should be limited to only those that are needed. In other words, climbers did not want pockets that were added for aesthetic purposes. Pockets should be placed in areas that allow for ease of access including when the climber is wearing a harness. Pocket size, location, ease of access, along with pocket conflicts with equipment were a concern in many other functional garments including patrol office uniforms, firefighters, flight suits, snowboarding, sailing apparel, golf wear, and disabled females (Black & Cloud, 2008; Bye & Hakala, 2005; Carrol & Kincade, 2007; Chae & Everson, 2013; Emerich, 2011; Park & Hahn,

2014; Rutherford-Black & Khan, 1995; Stokes & Black, 2012; Tan, et. al., 1998). When designing pockets for rock climbing pants, the harness should be considered along with ease of access, secure closure, and appropriate size.

Some climbers expressed interest in a convertible pant. Two ways to achieve pant convertibility were discussed in the open ended questions. One was being able to roll the pant leg up with a means of securing it in place, such as a pant tab with a snap. Second, was the ability to convert the pant to shorts. Currently, the most convenient way to achieve this modular affect is with a zipper. While this modular design is convenient, as it allows the user to quickly convert the pants to shorts, a zipper placed around the thigh does not stretch when the climber bends or is in a squatted position. Thereby, making the pant even more restrictive in the thigh area. One climber in this study commented on this problem when discussing pant problems. The researcher has also experienced this same thigh constriction problem with a pair of convertible pants that have a thigh zipper. When designing convertible pants, the inability of a zipper to stretch should be seriously considered as the constrictive nature of the zipper may out weight the convenience of having a convertible pant.

Gear loops were also mentioned by a few climbers as a desired pant detail. While this may be a novel idea in rock climbing pants, the placement of gear loops and the weight of the items secured to the loops should be considered before implementing this feature. The most logical places to adhere gear loops would be the waistband or thigh as this would allow for ease of access. Any items or gear of substantial weight placed on these loops would cause the area to be pulled downward leading to dissatisfaction with the pant or the area of placement. Rock climbing gear is engineered to attach to a climbing harness's gear loops so it is very feasible that climbers would use pant gear loops for attaching rock climbing gear to their pants. Designers

should consider the weight of the gear a climber may attached to the loop, then decide if the fabric, construction, and pant design is able to support such equipment before integrating a gear loop into rock climbing pants.

Rock climbers were also asked to tell the researcher about any pants they disliked and what contributed to their dissatisfaction. The most common items causing dissatisfaction was the pant design and fabric choice. Pant design dissatisfaction developed due to poor fit, improper pant sizes, and waistband sizing. Sizing options and proper fit was a common problem found in other studies of functional apparel, such as tennis, golf, sailing, snowboarding, dance, protective overalls, firefighters turnout gear, flight suits, and disabled women (Bye & Hakala, 2005; Carrol & Kincade, 2007; Chae & Everson, 2013; Emerich, 2011; Huck, et. al., 1997; Jin & Black, 2012; Mitchka, et. al., 2009; Park & Hahn, 2014; Rutherford-Black & Khan, 1995; Schoefield, et. al., 2006; Tan, et. al., 1998). Fabric permeability was another fabric characteristic causing dissatisfaction. Climbers felt this issue contributed to them feeling cold, wet, or over heated. The fabrics with low or no wicking properties made the pant stick to their body causing dissatisfaction. Fabric testing of permeability, along with other fabric properties, should be performed or investigated so pant thermal balance and satisfaction can be increased.

Lastly, price should be a consideration. While price was only mentioned by a few climbers, the study's demographics showed that 49.1% of the respondents made under $25,000 per year leading the researcher to feel this should be a listing in the study's findings. One climber commented that it was disappointing to purchase a pair of climbing pants only to have them rip after wearing them a few times and another commented that they would be willing to pay a bit more if they had better fit and were more durable but still wanted them to be priced between $50 to $75 per pair. Currently, the two top brands mentioned in this study have climbing pants in the

range of $69 to $139 per pair. These prices indicate that rock climbing pants can be expensive for climbers. So rock climbing pants may be seen as an investment and should be made to have a longer life expediency than one climbing season.

**Summary of Findings**

This study found that outdoor rock climbers' functional needs in climbing pants were not being fully met. The overall fit of the pant was impacted by all the functional categories (fit, mobility, comfort, protection, and don/doff). The comprehensive view of each pant dimension established in this study provided a detailed understanding of the pants functional needs. Rock climbers expressed that the most prevalent problems in the pant were the waist, crotch, and hip for fit, crotch and hip for mobility, fabric for comfort, knee durability, and improved fabric for protection, along with better closures for donning and doffing (see Table 35).

Table 35

*Summary of Pant Findings*

| Pant Area | Fit | | Mobility | Comfort | Durability Problem Area | Protection | Don/Doff |
|---|---|---|---|---|---|---|---|
| | *M* (n=170) | *Comments (n=210)* | *Comments (n=186)* | *Comments (n=171)* | *Comments (n=424)* | *Comments (n=229)* | *Comments (n=54)* |
| Waist | 5.93 | | 15% | 18% | 3.3% | | 13% |
| Crotch | 6.24 | 35% | 33% | 16% | 13.7% | 10% | |
| Hip | 6.61 | | | | 16.7% | | |
| Thigh | 6.33 | 13% | 21% | 5% | | 1% | |
| Knee | 6.52 | | | | 26.7% | 24% | |
| Calf | 6.90 | 7% | 21% | | | | |
| Ankle | 6.43 | | | | | 2% | |
| Length | 6.20 | 14% | 3% | 13% | 5% | | |
| Fabric | | 17% | 4% | 43% | Seams 8.5% | 46% | 30% |
| Style/Design | | 14% | | 5% | Front 4% | | 20% |
| Design Details | | | 3% | | Snaps/Buttons 8.7% Pockets 8.5% Zippers 5% | Reinforce/ Padding 17% | Closures 37% |

Based on this study, pant improvements would constitute a redesign of the pant to improve overall functional fit (see Figure 37). To mitigate problems with the harness, the waistband should be contoured and closer to the natural waistline along with a more exact crotch rise. A gusseted crotch should be incorporated into the pant to improve flexibility without compromising crotch rise. As the knees sustain the most constriction with certain climbing techniques, improvements in knee design should be explored. Pants should have the option to be rolled and secured at the ankle with a closure while not hindering the climber. Zippered pockets are necessary for functionality in the pant and should be easy to access while wearing the harness. Pant sizing and assortment should be studied to better meet the demands of the consumer. Fabrics need to be tested for abrasion resistance, maximum stretch, permeability, wicking, and softness. Lastly, price should be figured for individuals making $25,000 annually.

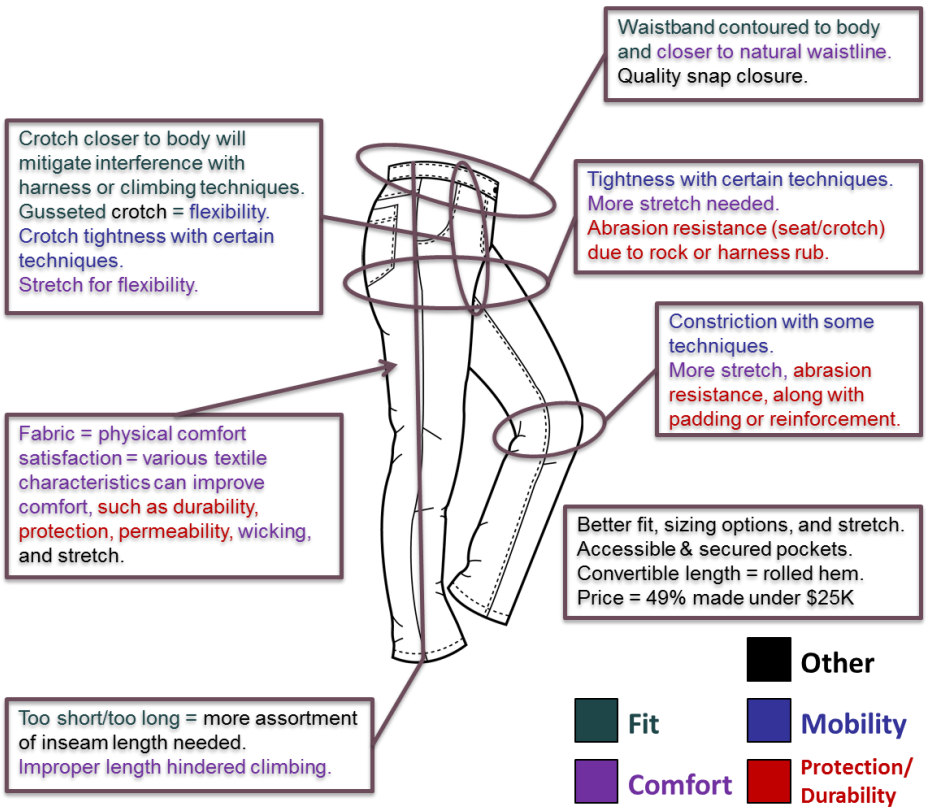



*Figure 37.* Summary of Climbing Pant Improvements.

## Implications

Rock climbing pants have not been previously studied so there is no understanding of the functional needs or pant satisfaction with rock climbers. This study set out to explore rock climber's functional needs with regarding to the rock climbing pants. As this study used Lamb & Kallal's (1992) FEA model, the findings contribute to the overall body of research using this model especially in regards to the functional category and design research issues. Additionally, climbing pants are used as both a sport garment and also occupationally with search and rescue volunteers. Therefore, this study's findings contribute to the current research in sport, occupational, and functional garment research.

Based on the findings of this study, the following Functional Fit Model (see Figure 38) is proposed for future study of functional garments. This model was originally based on Lamb & Kallal's (1992) FEA Model and seeks to provide better overall functional fit. At the center of the model is the target consumer, then the functional classification of the garment needs to be determined, along with the environmental conditions it will be used in, and finally the six functional need categories should be examined. The functional classifications are based on this study's literature review to incorporate protection, medical, vanity, special needs, and cross functional garments. When evaluating functional classifications, any and all equipment used in that particular classification should be researched and included in the garment evaluation. Environmental conditions are based on where and under what conditions the garment will be worn and used. For this study, the environmental conditions would be the varying outdoor temperatures and terrains that the garment is worn in. Other environmental conditions, beyond outdoors, that are applicable for future studies including indoor environments, underwater, or space explorations. This model also included an additional need category, beyond Lamb &

Kallal's (1992) FEA Model, that is design details as many functional garments have specific design needs that should be explored for proper garment function. In this study, the incorporation of a functional pocket was a recommended design detail expressed by the respondents.

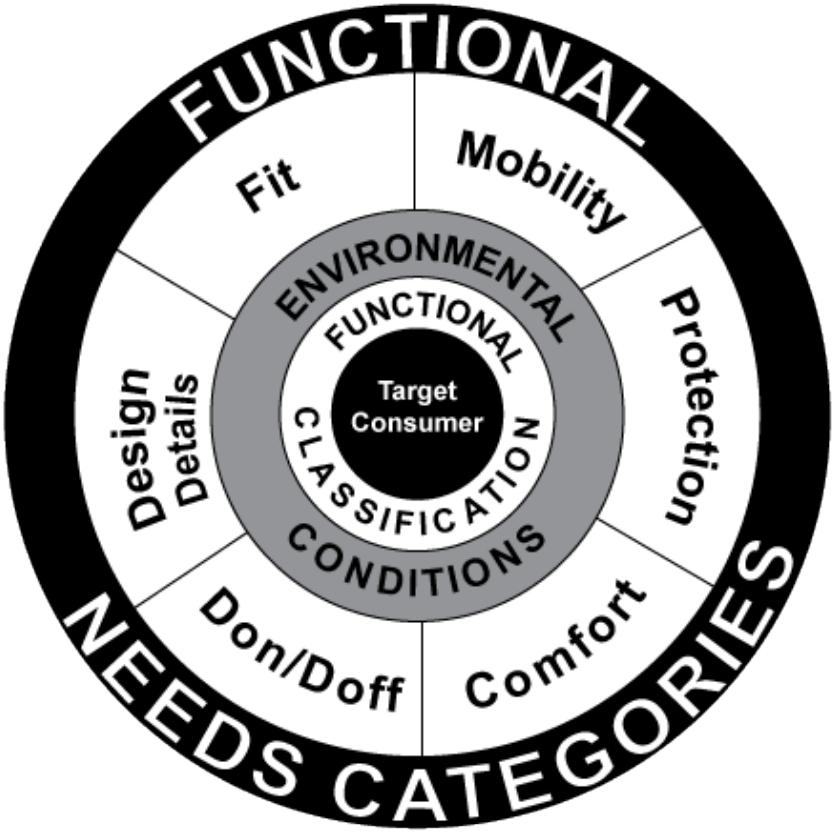



*Figure 38*. Functional Fit Model. © 2015 Dawn Michaelson.

Fulfilling pant functional needs are influenced by multiple categories – fit, mobility, protection, comfort, don/doff, and design details – along with fabric choice. To improve pant fit, each pant dimension needs to be explored for improvement and its possible implication to other pant areas. Waist, crotch, and hip measurements, along with waistband design has implications for improving pant fit and mobility. Knees were a key area for protection and durability in climbers as this area is constricted and scraped while climbing. Donning and doffing, while rated highly, could be improved with better quality closures with a preference toward snaps over

buttons. Lastly, fabric choice impacted pant satisfaction in all categories - fit, mobility, protection, comfort and donning and doffing – with protection and comfort having the highest implication for pant satisfaction. Testing of fabric permeability, abrasion resistance, elasticity, recovery, breaking strength, overall hand, etc. will have future implications in textile research for functional garments and also in overall pant satisfaction.

Findings from this study could be used by outdoor apparel manufacturers to make improvements in their climbing pants. Improvements to climbing pants with changes to pant design, patternmaking, fabric selections, design details, and construction would improve the current pant and potentially improve the overall pant satisfaction. If the findings in the study were addressed, and improvements were made to the rock climber's satisfaction, an outdoor apparel manufacturer could potentially increase their brand name strength in this niche market and hold a larger percentage of the market share.

**Limitations**

This study had a few limitations that should be acknowledged. One, there are no prior published research studies on rock climbing apparel. Hence, no foundation for understanding the research problem and/or prior established needs were in place. The use of the Lamb and Kallal's (1992) FEA model was used as a framework to help establish the required needs for this consumer group. Second, the researcher is a recreational rock climber, which bring both credibility and bias into the study. The researcher controlled bias to the best of her ability by being aware of this limitation. Third, this study relied on participant self-reported data, which was taken at face value and cannot be independently verified. Participant self-reported data may contain bias such as selective memory of certain climbing techniques and exaggerating or embellishment of reported data. Obtaining data at climbing events where the majority of participants had recently climbed helped minimize some of these types of bias.

Fourth, the questionnaire may have contained vague or unclear questions for some participants, which could have resulted in inaccurate data. To limit this, the researcher had the questionnaire reviewed by a rock climbing instructor and the research committee members. Revisions and modifications were made to the questionnaire before administering it in order to limit all vague and unclear questions. The questionnaire was also administered at rock climbing events so experiences, rock climbing terminology, and any rock climbing pant problems could be remembered accurately. Lastly, to avoid confusion on four open-ended questions, the researcher provided examples at the end of the question. The examples provided in four of the questions may have been leadings for some participants answering those questions.

**Future Direction**

Future research should investigate ways to improve mobility, comfort, protection, and its overall effect to fit in the functional design process. Mobility evaluations should be done to further investigate the body positions used in climbing and its overall effect to the measurement changes of the body, especially at the joints. Ideally, mobility evaluations should be videotaped for accuracy and replayed so body movement descriptions can be made and verified by a second party. Advances in sensor technologies may help in recording body motion and body measurement changes while in dynamic positions. Smart sensor technologies are currently advancing so that wearable stretch sensors can to be incorporated into a garment, record data as the body changes, and send it wireless to a device. This new stretch sensor technology needs to be evaluated and tested to confirm that sensors are stretching sufficiently and not hammocking on the body thereby providing inaccurate measurement changes. Wireless transmission is also vital as this would eliminate wires hanging on the body at could potentially impede range of motion while being worn. The incorporation of wireless stretch sensors into a garment will allow

the user to perform a normal range of motions in a real setting while recording data needed for the researcher. Body scanner advances is another possible avenue for evaluating changes in body measurements. The ability to locate and accurately measure body landmarks while in a dynamic position would allow researchers to measure body changes while in different positions and quickly compare it to the static body scan measurements. Lastly, motion capture equipment is still advancing and may be used for body measurement changes while in motion. These advances are allowing the equipment to be wireless and used outside a testing laboratory opening up a wide range of uses that need to be tested in the field. Any future research in body measurement changes should incorporate both genders, various body sizes and heights, along with necessary equipment typically worn while performing the sport or occupation. As fit and sizing were a problem, not only in this study but also in other functional garment studies, the continued gathering of body measurement data is essential so manufacturers can have accurate body measurements for their target markets.

New 3D computer aided drafting software should be tested for accuracy in drafting patterns on a 3D dynamically positioned body. These new methods, once verified, are vital not only for the continued growth of our industry – academically and professionally – but for the end users fit satisfaction. Research should be done not only on the software but also the accuracy of the pattern measurements drafted from the 3D form. The incorporation of these patterns into new garments must include the fabric elasticity, body change percentages, and new grading rules to accommodate the range of motion (Zong & Lee, 2011).

Garment prototyping and wear testing would be the next step needed for evaluating any new advances. The testing of the garment in real settings along with user evaluations after use will help in the evaluation of the body measurement changes, patterns, fabric, and overall fit

satisfaction. Ideally, prototyping would be done with professional or high skilled users so all ranges of movements can be performed in the safest of conditions so an accurate evaluation can be done after wear.

This study used the functional category of Lamb & Kallal's (1992) FEA model. Based on the findings of this study, along with other functional garment studies, it can be proposed that the functional category can be revised or modified to show the overlap that occurs with each of the areas in the functional category. Overall, research into function fit should investigate how mobility, comfort, protection, and don/doff effect the garments functional fit satisfaction. Additionally, wearable equipment should be a consideration in the evaluation of functional garments and should be incorporated into the model as it has an effect on how a garment is worn, hinders movement, and affects garment satisfaction.

Lastly, research into both identity and social theory should be examined to understand the individual and social impact apparel has on rock climber. Outdoor apparel, including rock climbing apparel, has both cognitive and behavioral outcomes that can be investigated. Research using either of these theories can may help investigate how apparel may be viewed by others in the sport, how it can enhance the role of the wearer within the group, and perhaps even the performance of the wearer. Apparel may be worn to protect the body but it can also have an impact on our mental wellbeing and happiness on many different levels.

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**APPENDIX A – QUESTIONNAIRE**

#_____

AUBURN
UNIVERSITY

# QUESTIONNAIRE

RESEARCH STUDY:

## ASSESSING FUNCTIONAL NEEDS OF ROCK CLIMBING PANTS

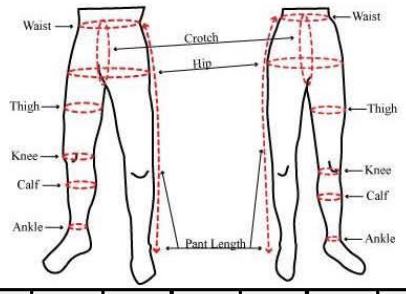
1

## DIRECTIONS FOR QUESTIONNAIRE

The following set of statements relates to the rock climbing pants you typically or most frequently wear rock climbing. Answer all questions based on your impression of the pants while climbing in them.

## FIT OF ROCK CLIMBING PANTS

1. **Circle** a number on a 9-point scale (1= Strongly disagree, 9 = Strongly agree) that best matches your level of satisfaction with the **various fit areas of rock climbing pants you typically or most frequently wear while climbing**.



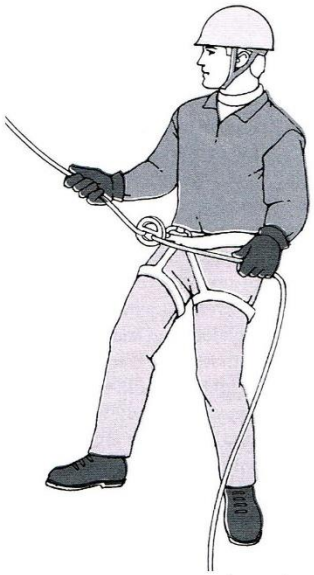

| Site | Strongly Dissatisfied | Dissatisfied | Moderately Dissatisfied | Mildly Dissatisfied | Neither | Mildly Satisfied | Moderately Satisfied | Satisfied | Strongly Satisfied | Not applicable |
|---|---|---|---|---|---|---|---|---|---|---|
| Pant length | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Waist | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Crotch | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Hip | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Thigh | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Knee | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Calf | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| Ankle | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |

## ROCK CLIMBING TECHNIQUES

**2.** Circle the number that best evaluates the following characteristics of the rock climbing pant you typically wear for each of the following 9 techniques. The drawings are just a representation of the technique. If you have not performed one of these techniques, respond "No" and proceed to the next technique.

## A. BELAY

| Have you belayed before? | Yes | No |
|---|---|---|



What style of climbing do you typically do when performing this technique? (Choose all that apply.)

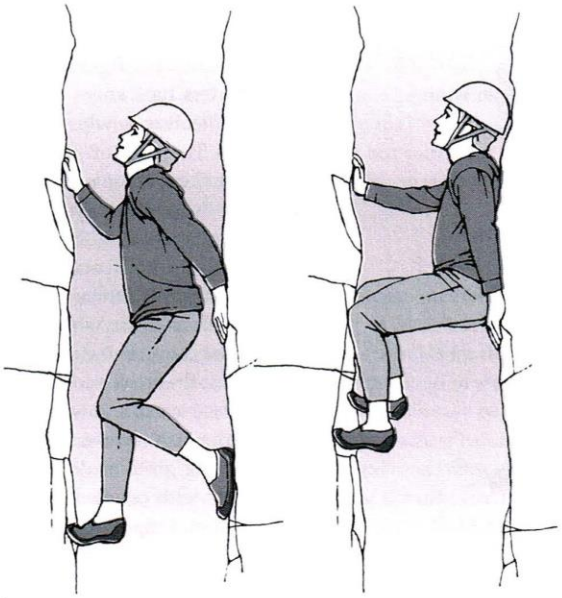
| | | | |
|---|---|---|---|
| | Top rope | | Traditional climbing |
| | Face climbing | | Crack climbing |
| | Sport climbing | | |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of movement of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## B. CHIMNEY

| Have you performed a chimney while climbing? | Yes | No |
|---|---|---|



What style of climbing do you typically do when performing this technique? (Choose all that apply.)

| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## C. LEDGE, OVERHANG, OR ROOF

| Have you ever climbed a ledge , overhang, or roof? | Yes | No |
|---|---|---|

What style of climbing do you typically do when performing this technique? (Choose all that apply.)

| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## D. FACE CLIMB

| Have you face climbed before? | Yes | No |
|---|---|---|

What style of climbing do you typically do when performing this technique? (Choose all that apply.)

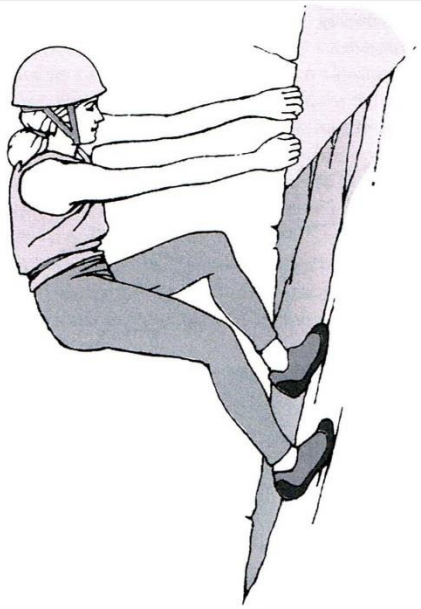
| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## E. LIEBACK

| Have you performed a lieback before? | Yes | No |
|---|---|---|



What style of climbing do you typically do when performing this technique? (Choose all that apply.)

| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## F. MANTEL

| Have you performed a mantel before? | Yes | No |
|---|---|---|

What style of climbing do you typically do when performing this technique? (Choose all that apply.)

| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## G. RAPPEL

| Have you rappelled before? | Yes | No |
|---|---|---|

What style of climbing do you typically do when performing this technique? (Choose all that apply.)

| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## H. STEM

| Have you performed stemming before? | Yes | No |
|---|---|---|

What style of climbing do you typically do when performing this technique? (Choose all that apply.)

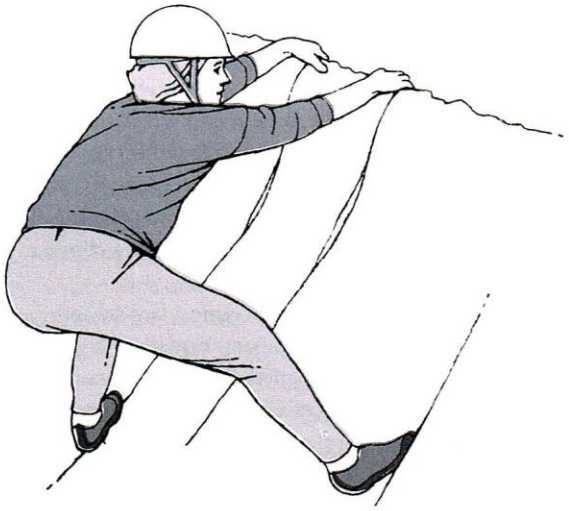
| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## I. TRAVERSE

| Have you ever traversed? | Yes | No |
|---|---|---|



What style of climbing do you typically do when performing this technique? (Choose all that apply.)

| | |
|---|---|
| | Top rope |
| | Face climbing |
| | Sport climbing |
| | Traditional climbing |
| | Crack climbing |
| | Bouldering |

List what brand, type, or style of rock climbing pant you prefer to wear while performing this technique?

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Comfortable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Uncomfortable |
| Acceptable | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unacceptable |
| Flexible | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Stiff |
| Easy to move in | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Hard to move in |
| Satisfactory fit | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Unsatisfactory fit |
| Freedom of move-ment of legs | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Restricted movement of legs |
| Dislike | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Like |
| Loose | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Tight |
| Crotch overall right distance from body | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Crotch overall too close or too far from body |

## COMFORT

3. **Circle** a number on a 5-point scale that best matches your comfort sensations after rock climbing in the **rock climbing pants you typically or most frequently wear**.

| Comfort sensation after rock climbing | No | Slightly | Neutral | Very | Extremely |
|---|---|---|---|---|---|
| Warmth | 1 | 2 | 3 | 4 | 5 |
| Cool | 1 | 2 | 3 | 4 | 5 |
| Permeability | 1 | 2 | 3 | 4 | 5 |
| Skin dryness | 1 | 2 | 3 | 4 | 5 |
| Stickiness | 1 | 2 | 3 | 4 | 5 |
| Itchy | 1 | 2 | 3 | 4 | 5 |
| Clinginess | 1 | 2 | 3 | 4 | 5 |
| Prickliness | 1 | 2 | 3 | 4 | 5 |
| Stiffness | 1 | 2 | 3 | 4 | 5 |
| Roughness | 1 | 2 | 3 | 4 | 5 |
| Overall comfort | 1 | 2 | 3 | 4 | 5 |

## PROTECTION

4. **Circle** a number on a 5-point scale that best matches your level of agreement with the **performance of the rock climbing pants you typically or most frequently wear**.

**a. How durable to rips and tears are the rock climbing pants you typically or most frequently wear**?

| Not Durable | Somewhat Not Durable | Fair | Somewhat Durable | Very Durable | Please explain |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

## PROTECTION (Continued)

**b. How durable to abrasion are the rock climbing pants you typically or most frequently wear?**

| Not Dura-ble | Some-what Not Du- | Fair | Some-what Durable | Very Dura-ble | Please explain |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

**c. How durable to seam failures are the rock climbing pants you typically or most frequently wear?**

| Not Dura-ble | Some-what Not Du-rable | Fair | Some-what Durable | Very Dura-ble | Please explain |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

**d. How durable to zipper failure are the rock climbing pants you typically or most frequently wear?**

| Not Dura-ble | Some-what Not Du- | Fair | Some-what Durable | Very Dura-ble | Please explain |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

**e. How durable to fastener failures (snaps, buttons, hook & eye tape, drawstrings, etc.) are the rock climbing pants you typically or most frequently wear?**

| Not Dura-ble | Some-what Not Du- | Fair | Some-what Durable | Very Dura-ble | Please explain |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

**f. Circle all the areas that have durability problems in the rock climbing pants you typically or most frequently wear?**

| Legs | Knee | Front | Seat | Waist | Pockets | Seams | Zippers | Snaps/ Buttons | Crotch |
|---|---|---|---|---|---|---|---|---|---|

## DONNING / DOFFING

**5a. Rate** the ease with which you are able to don **the rock climbing pants you typically or most frequently wear.**

| Excellent | Very Good | Adequate | Not Quite Adequate | Poor | Extremely Poor |
|---|---|---|---|---|---|

**Comments:**

**5b. Rate** the ease with which you are able to doff **the rock climbing pants you typically or most frequently wear.**

| Excellent | Very Good | Adequate | Not Quite Adequate | Poor | Extremely Poor |
|---|---|---|---|---|---|

**Comments:**

## OPEN ENDED QUESTIONS

6. If you could change the fit of your rock climbing pants, what would you change?

7. What area of your rock climbing pant causes the most mobility problems for you when climbing?(i.e., waistband, crotch, thighs, etc.)?

## OPEN ENDED QUESTIONS Continued

8. If you could change the comfort of your rock climbing pants, what would offer more comfort to you?

9. If your pants could provide more protection, what type of protection would that be (i.e., abrasion, padding, UV, etc.)?

10. If you could change the ease of getting in and out (don/doff) of your rock climbing pants, what would you change?

## OPEN ENDED QUESTIONS Continued

11. What design details are your favorite or would you like to have incorporated into your rock climbing pants to make them more functional (i.e., pocket, gear loops, convertible, etc.)?

12. Have you ever worn a pair of climbing pants that you **didn't like**? If so, what were the problem(s)?

13. When purchasing new climbing pants what are the most important features you look for? Be specific and list all features (i.e., fabric, functions, design details, price, brand cause, etc.?)

## DEMOGRAPHICS

**DIRECTIONS:** Please answer the following questions by checking the appropriate selection, filling in the blanks, circling, or writing in your answer.

1. What is your **gender?** _____ Male _____ Female

2. What is your **age in years?** _____

3. In what **state** do you reside? _____

   If you reside outside the U.S., in which country do you reside? _____

4. How many **years** have you been climbing? _____

5. When was the **last time** you were rock climbing? _____
   (State in days, or weeks, or months, etc.)

6. Circle your **experience** level in rock climbing?

| | | | | | |
|---|---|---|---|---|---|
| Novice | Beginner | Intermediate | Advanced | Expert | Professional |

7. Which of the following **ethnic groups** do you consider yourself to be a member?

| | | | | | | |
|---|---|---|---|---|---|---|
| White/ Caucasian | Black/African American | American Indian/Alaska Native | Asian | Native Hawaiian/ Pacific Is- | Hispanic/ Latino | Other: (Specify) |

8. What is the highest level of **education** you have completed?

| | | | | | |
|---|---|---|---|---|---|
| Some High School | High School Degree | Some College / Technical School | College Degree (4 year) | Some Graduate School | Graduate Degree (Master's, Doctorate, Professional) |

9. What is your **marital status**?

| | | | | |
|---|---|---|---|---|
| Single | Married | Divorced/ Separated | Living with partner | Widowed |

10. What is your **annual income**?

| | | | | | |
|---|---|---|---|---|---|
| Under $25,000 | $25,000 to $49,999 | $50,000 to $74,999 | $75,000 to $99,999 | $100,000 to $149,999 | $150,000 or more |

## ADDITIONAL COMMENTS

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE.

YOUR PARTICIPATION IS GREATLY APPRECIATED.

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AUBURN
UNIVERSITY

Questions regarding this study can be addressed to:

Dawn Michaelson
Graduate Student

Auburn University
Dept. of Consumer and Design Sciences
308 Spidle Hall
Auburn, Alabama 36849

Phone: (334) 844-4084
Fax: (334) 844-1340
E-mail: dmm0029@auburn.edu

## APPENDIX B – CODING GUIDE

6. If you could change the fit of your rock climbing pants, what would you change?

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric | Comments associated with the fabric or properties of the fabric. | "breathable", "stretch", "durable", "flexibility", "stiff", "pants stretch out", etc. |
| 2 | Style/Design | Comments associated with pant style, design, sizing options available for the pant, and design details. | "skinny pant", "form fitting", "less baggy", "better range of motion", "knee padding", "more sizing options", etc. |
| 3 | Length/Inseam | Comments associated with pant leg length or inseam length. | "pants too long", "need longer pant inseam", etc. |
| 4 | Waist/Crotch/Hip | Comments associated with waist, crotch, crotch rise, or hip area. | "waist too low", "crotch baggy", "waistband too big", "tight in hips", "more room in crotch", etc. |
| 5 | Thighs/Knees | Comments associated with thigh or knee area. | "tight in thighs", "looser around knees", "knees are tight", etc. |
| 6 | Calf/Ankle | Comments associated with calf or ankle area. | "smaller calves", "pant at ankles too wide", "narrow ankles", etc. |

## APPENDIX B

7. What area of your rock climbing pant causes the most mobility problems for you when climbing?

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric/Construction | Comments associated with fabric, fabric properties, or construction of pants. | “seams rip”, “more fabric stretch”, “stretched out”, “mobility”, etc. |
| 2 | Fasteners/Design Details | Comments associated with fasteners or design details | “snaps”, “buttons”, pockets”, “cuffs”, etc. |
| 3 | Waist/Waistband | Comments associated with waist or waistband. | “waist falls”, “waistband too big”, etc. |
| 4 | Crotch/Hip | Comments associated with crotch or hip area. | “crotch tight”, “seat too tight”, “more room in hips”, etc. |
| 5 | Thighs | Comments associated with thigh area. | “thighs too loose”, “tight thighs”, etc. |
| 6 | Knees/Calf/Ankle | Comments associated with knees, calf, or ankle area. | “knees sagging”, “binding at knees”, “too loose in calves”, etc. |
| 7 | Pant Length | Comments associated with pant length. | “pants too long”, “long pant legs”, etc. |

## APPENDIX B

8. If you could change the comfort of your rock climbing pants, what would offer more comfort to you?

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric | Comments associated with the fabric or properties of the fabric. | “breathability”, “wicking”, “rough”, “stiff”, “more stretch”, etc. |
| 2 | Style/Design | Comments associated with pant style, design or design details. | “pant fit”, “pockets”, “roll up/cuff pant”, “sizing options”, “vent area”, “zippers”, etc. |
| 3 | Waist/Waistband | Comments associated with waist or waistband. | “fitted waist”, “tighter waist”, “adjustable waist”, etc. |
| 4 | Crotch/Hip | Comments associated with crotch or hip area. | “crotch tight”, “seat too tight”, “more room in hips”, “low rise”, etc. |
| 5 | Thighs | Comments associated with thigh area. | “thighs too loose”, “tight thighs”, etc. |
| 6 | Knees/Calf/Ankle | Comments associated with knees, calf, or ankle area. | “ankle cinches”, “binding at knees”, “tighter calf”, etc. |
| 7 | Pant Length | Comments associated with pant length. | “longer pant legs”, “shorter leg”, etc. |

## APPENDIX B

9. If your pants could provide more protection, what type of protection would that be?

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric/Construction | Comments associated with fabric, fabric properties, or construction of pants. | “stitching”, water resistant”, “UV”, “abrasion”, etc. |
| 2 | Reinforce/Padded | Comments associated with reinforced or padding in a specific area | “padding”, “double/reinforced knee”, etc. |
| 3 | Waist/Crotch/Hip | Comments associated with waist, crotch, or hip. | “fitted waist”, “harness area”, “seat”, “hip”, etc. |
| 4 | Thighs | Comments associated with thigh area. | “top of thighs”, etc. |
| 5 | Knees | Comments associated with knee area. | “back of knee”, “knee bars”, etc. |
| 6 | Ankle | Comments associated with ankle area. | “inside ankle”, “ankle”, etc. |

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10. If you could change the ease of getting in and out (don/doff) of your rock climbing pants, what would you change?

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric | Comments associated with fabric or fabric properties. | “stretch”, “breathability”, “wicking”, “sticky”, etc. |
| 2 | Fit/Style | Comments associated with overall fit, style, or design of pant. | “looser fit”, “bigger pant”, “pant leg width”, etc. |
| 3 | Closures | Comments associated with closures on pant. | “belt”, “buckle”, “drawstring”, “buttons”, “zipper”, etc. |
| 4 | Waist | Comments associated with waist or waistband. | “flexible waist”, “stretch waist”, etc. |

## APPENDIX B

11. What design details are your favorite or would you like to have incorporated into your rock climbing pants to make them more functional?

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric/Design | Comments associated with the fabric or design of pant. | “stretchy”, “shorter length”, “simple design”, “durable”, “form fitting”, “stitching”, etc. |
| 2 | Gusset crotch | Comments associated with gusseted crotch | “gusseted crotch” |
| 3 | Gear Loops | Comments associated with loops on pants for gear. | “gear loops”, “loop for caulk”, etc. |
| 4 | Pocket Details | Comments associated pockets. | “accessible pocket”, “Thigh pocket”, “side pocket”, etc. |
| 5 | Knee Details | Comments associated with knee details. | “articulated knee”, “reinforced knee”, “extended knee”, etc. |
| 6 | Waist Details | Comments associated with waist details. | “cinch waist”, “adjustable waist”, “built in belt “, “drawstring”, etc. |
| 7 | Leg Details | Comments associated with leg details | “roll up pant leg”, “leg zipper”, “convertible”, etc. |

## APPENDIX B

12. Have you ever worn a pair of climbing pants that you didn't like? If so, what were the problem(s)?

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric | Comments associated with the fabric or properties of the fabric. | "not breathable", "no stretch", "not durable", "inflexibility", "stiff", "itchy", etc. |
| 2 | Style/Design | Comments associated with pant style, design, sizing options available for the pant, and design details. | "too tight", "too baggy", "no range of motion", "no pockets", "look stupid", etc. |
| 3 | Length/Inseam | Comments associated with pant leg length or inseam length. | "pants too long", "inseam too short", etc. |
| 4 | Waist/Crotch/Hip | Comments associated with waist, crotch, crotch rise, or hip area. | "waist too low", "crotch baggy", "waistband too big", "tight in hips", etc. |
| 5 | Thighs/Knees | Comments associated with thigh or knee area. | "tight in thighs", "loose around knees", "knees too tight", etc. |
| 6 | Calf/Ankle | Comments associated with calf or ankle area. | "tight calves", "wide ankles", "tapered ankles", etc. |

## APPENDIX B

13. When purchasing new climbing pants what are the most important features you look for? Be specific and list all features.

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric/Construction | Comments associated with fabric, fabric properties, or construction of pants. | “stitching”, “water resistant”, “UV”, “abrasion”, “seams”, etc. |
| 2 | Fit / Range of Motion | Comments associated with overall fit and range of motion. | “mobility”, “ease of movement”, “fit on me”, “form fit”, “fits well”, etc. |
| 3 | Comfort | Comments associated with comfort. | “comfortable”, “soft & comfy”, “overall comfort”, etc. |
| 4 | Price | Comments associated with price. | “inexpensive”, “price”, “cost”, “lifetime value”, etc. |
| 5 | Brand | Comments associated with the brand. | “brand name”, “brand cause”, “where pant was made”, “ethics”, etc. |
| 6 | Design Details | Comments associated with design details on pant. | “pockets”, “ankle zippers”, “gusset crotch”, “double knees”, “adjustable waist”, etc. |
| 7 | Aesthetics | Comments associated with the aesthetics of the pant. | “look good”, “cute style”, “colors”, “fashionable”, etc. |

## APPENDIX B

Additional Comments

| No. | Theme Label | Definition of Theme | Example Comments for Theme |
|---|---|---|---|
| 1 | Fabric/Construction | Comments associated with fabric, fabric properties, or construction of pants. | “flexibility”, “durability”, “stitching”, “seams”, etc. |
| 2 | Fit / Range of Motion | Comments associated with overall fit and range of motion. | “fit ratio”, “slim fit”, “knee room”, “tighter ankle”, etc. |
| 3 | Comfort | Comments associated with comfort. | “warm in winter”, “stay cool”, “not get sweaty”, etc. |
| 4 | Price | Comments associated with price. | “cost”, “inexpensive”, “affordable”, etc. |
| 5 | Sustainability | Comments associated with sustainable materials or practices of the brand. | “sustainability”, “where made”, “ethics”, etc. |
| 6 | Design Details | Comments associated with design details on pant. | “reinforced knees”, “pockets”, “buttons”, “removable knee pads”, etc. |
| 7 | Aesthetics | Comments associated with the aesthetics of the pant. | “look cool”, “colors”, “prints/patterns”, etc. |

# APPENDIX C



DEPARTMENT OF CONSUMER AND DESIGN SCIENCES

AUBURN UNIVERSITY
COLLEGE OF HUMAN SCIENCES

*(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)*

**INFORMATION LETTER**
**for a Research Study entitled**
**"Assessing Functional Needs of Rock Climbing Pants"**

**You are invited to participate in a research study** being conducted by Mrs. Dawn Michaelson, graduate student, under the direction of Dr. Karla P. Teel, Ph.D., Faculty Advisor, in the Auburn University Department of Consumer and Design Sciences. You are invited as a possible participant in this study because you are at least 19 years old, have been a rock climber for six months, and have been rock climbing in the past two years.

**Purpose of the Study.** Rock climbing is a growing sport requiring rock climbing pants. Due to a lack of research concerning outdoor recreational apparel, specifically rock climbing pants, there is no way to assess if the needs of this consumer are being met. Therefore, the purpose of this study is to assess the functional needs of outdoor rock climber pants by looking at: a) fit, b) mobility, c) comfort, d) protection, and e) donning/doffing, including while performing certain rock climbing techniques and to assess what consumer functional expectations are in rock climbing pants.

**What will be involved if you participate?** If you decide to participate in this research study, you will be asked to complete a pencil and paper questionnaire as openly and honestly as possible. Your total time commitment will be approximately 10-15 minutes.

**Are there any risks or discomforts?** The risks associated with participating in this study are psychological and/or social discomfort or embarrassment. To minimize these risks, any question that you are uncomfortable with answering can be skipped.

**Are there any benefits to yourself or others?** There are no direct benefits to the subjects for participation. The results of this study will contribute to the limited scholarly studies pertaining to rock climbing apparel, expand the understanding of the functional needs required for rock climbing pants, and could possibly provide better fitting pants for rock climbers. The results of this project may be submitted for publication in scholarly journals and presentations at professional conferences.

**Will you receive compensation for participating?** To thank you for your time you will be offered a rock climbing carabiner, if you are one of the first 120 participants to complete the questionnaire.

**If you change your mind about participating,** you can withdraw at any time during the study. Your participation is voluntary. Stopping the study will not alter the compensation you will receive. You may skip any questions you do not wish to answer and it will not alter the compensation you will receive.

308 Spidle Hall, Auburn, AL 36849-5601; Telephone: 334-844-4084; Fax: 334-844-1340
www.auburn.edu

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Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University, the Department of Consumer and Design Science.

**Any data obtained in connection with this study will remain anonymous**. This questionnaire is anonymous and no individually identifiable information is obtained. Research data will be stored securely and only researcher and faculty advisor will have access to the records. Information collected through your participation may be used to fulfill an educational requirement, published in a professional journal, and/or presented at a professional meeting.

**If you have any questions about this study,** please ask them now or contact Dawn Michaelson, graduate student, by email (dmm0029@auburn.edu), or mail (Auburn University, Dept. of Consumer & Design Sciences, 308 Spidle Hall, Auburn, AL 36849).

**If you have any questions about your rights as a research participant**, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

**HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, THE DATA YOU PROVIDE WILL SERVE AS YOUR AGREEMENT TO DO SO. THIS LETTER IS YOURS TO KEEP.**

Dawn Michaelson 6/23/14
Investigator's signature Date

Dawn Michaelson
Print Name

The Auburn University Institutional Review Board has approved this document for use from 7/2/14 to 7/1/15 Protocol # 14-245EP1407