ERGONOMIC PRINCIPLES TO DESIGN CLOTHING FOR ROCK CLIMBERS

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Abstract. *Rock climbers often find themselves in the situation of needing textile equipment that offers protection without limiting body mobility. This paper seeks to organize a framework of knowledge of the concept of ergonomics in the fashion engineering and design process, focused on functional clothing for boulder athletes. The point of this research is to highlight the necessity for ergonomic principles in clothing design. The study presents a description of the broad range of issues related to the climber's needs, demands and problems in regards to wearing trousers.*

Keywords: *design, ergonomics, functional clothing, equipment, bouldering, rock climbing.*

Introduction

Ergonomics is concerned with understanding the science of work: of the people who do it and how the activity is done by the workers; the tools and equipment they use, the places they work in, and the psychosocial aspects of the working process. Ergonomics explores the interaction between man, working systems and environment. As a science-based discipline, ergonomics, brings together knowledge from other scientific branches such as anatomy and physiology, anthropology, psychology, engineering and statistics.

In the study of a work activity, the clothes or the textile equipment used constitutes an important and central component. However, ergonomics has expanded into many different areas.

In science, ergonomic systems are constantly researched. We can consider rock climbing and the practitioners of this kind of sport as a socio-technical system. Rock climbing is a fast growing sport that offers challenging mental dexterity and physical workout emphasizing dynamics, strength and endurance. Persons engaged in this sport activities should be protected according to environment safety by means of appropriate clothing, footwear and equipment specifically designed to meet ergonomic requirements.

Study methods

In sport, ergonomics studies human capabilities in a socio-technical system with adaptive possibilities, in the following relations: sport-material, sport-effort, athlete-opponent-effort, environment.

Yang pointed out that the clothing ergonomics is the system engineering discipline with "human centered" clothing as the media, and environment as condition [1].

It is fundamental to know the anatomy and anthropometry of individuals for functional clothing. Gupta proposed an efficient method to design functional clothing, stating that at the "garment design" stage of this method, the usage of a 3D human body shape, 3D technology, and 3D program is highly recommended (Figure 1) [2].

Kanika & Krzywinski have investigated that static 2D anthropometry fails to accurately capture the dimensions of complex 3D human form, and conventional patterns produced by 2D flat pattern methods fail to factor in the change in body shape and size during extreme bodypostures [3].

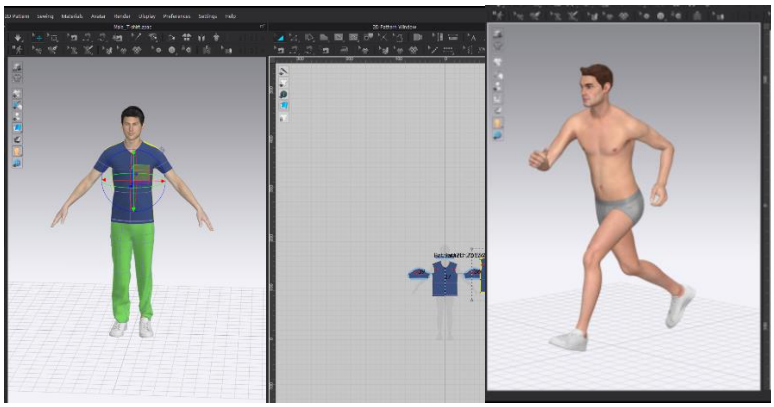

Figure 1. Patterns in 3D

Kim & Na paper theorizes and investigates the characteristics of ergonomic fashion design. Ergonomics through pattern design, it is related to the 3D structure division pattern, the reduction pattern design, the closing and opening part design for easy detachment, the receipt and the changeable design. In sewing, ergonomics is related to the proper use of sewing techniques, heat sealing and the finish using silicon or rubber band. In material, it is related to the use of high-performance fabrics. In detail, it is related to the convenient detail, the storage detail, the adjustable detail, and the body protection detail [4].

In this study, user experience is important in defining design product characteristics. For this reason, the study aims to collect information from the user experience of climbers, in order to establish its usability as criteria for design recommendations. Focused on ergonomic approach, the first step is to study the adaptation of an athlete's body during the activity, establishing the optimal capacity, the changes that occur in the body as a result of the determination effort:

- effort capacity,
- the efficiency of the submitted activity
- efficiency of training methods
- the ability of maintaining optimal health, preventing injuries
- the possibility of increasing performance
- the possibility to train and maintain the mental dexterity.

The functioning of the ergonomic system in sports involves the following mechanism:

- • the athlete's perception, decision and action,
- • decision management (which is the result of the environment composed of equipment,
- materials, opponent, obstacles, etc.)
- • the effect-the final result will be a cumulation of these interactions.

Rock climbing is unique from a physiological point of view because it requires sustained and intermittent isometric forearm muscle contractions for upward propulsion [4]. In order to achieve this, it is necessary to measure the climber’s body in static and dynamic (Figure 2).

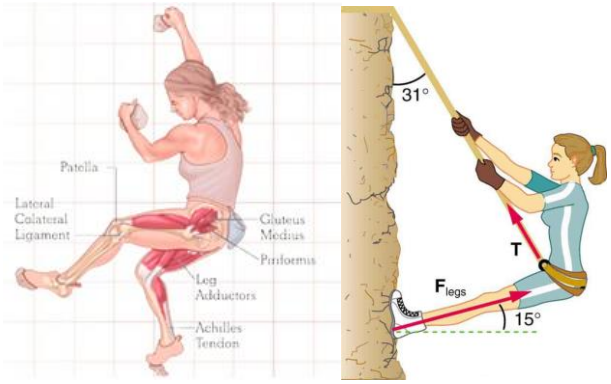

Figure 2. Climber’s body

Many researches are carried out on the ergonomics of clothing that include the activity analysis by following concepts such as: comfort, functionality and usability. Comfort is defined as the moment when the body doesn't make any effort to feel good. Personal clothing comfort requirement is a complicated characteristic, consisting of a number of conditions such as thermal, non-thermal, physiological, and wear conditions. Functionality reveals the performance of the product. Usability concept means the ability of the product to be used.

Depending on whether limbs and/or pelvis were moving, Dovgalecs et. al. detected four states of behavior: immobility (absence of limb and pelvis motion), hold exploration (absence of pelvis motion but at least one limb in motion), pelvis movement (pelvis in motion but absence of limb motion) and global motion (pelvis in motion and at least one limb in motion). These aspects influence clothing items in a way that their size and shape follow the dimensions and form of the climber's body without limiting mobility [6].

Biomechanical engineering in clothing studies the interaction between garment pressure imposed on the human body and the extensibility of clothing in dynamic conditions [7].

When developing ergonomic principles, one must take into account disruptive factors such as: excessive heat or cold, moisture, altitude, time zone offset, noise, dust, insufficient or too strong lighting, inappropriate sports materials or equipment [8].

Bouldering is typically practiced either indoors on artificial boulders or outdoors on natural rock formations. Traditional climbing involves removable equipment, such as cams that are wedged into rocks, in order to protect the climber; bouldering is done lower to the ground without roped protection, but using crash pads. The primary purpose of a crash pad is to add a foam layer between the climber and the ground, to lessen the impact of a bouldering fall.

This study aimed to identify climbers' need and demand for movement functionality in pants worn for bouldering. Data was collected through in-depth interviews with 10 semi-professional climbers using a qualitative research technique. Pilot study entailed a focus group discussion with climbers and analysis of climbing brands for trousers to gather information for proceeding stages. Design analysis stage involved same focus group for a written questionnaire and discussion to gather data regarding ergonomic design specification. Design specification stage involved a focus group meeting for garment design presentation and fabric discussions.

The research findings were as follows. The respondents were intermediate and semi-professional climbers having more than 5 years of experience. Their climbing ability outdoor (80% of answers) ranged from 5.9 to 5.10 on the Yosemite Decimal System (YDS) of grading routes.

Most interviewees own 4-5 pairs of pants for climbing outdoor or indoor. For example, for indoor climbing they mostly wore high-stretch, pants. At the question of what type of trousers they prefer, the answers were as following: straight, functional cutting, leggings, joggers with tapered legs and trousers with elastic ankles and waist. The preferred brands were: Arc'teryx, The North Face, Patagonia, prAna, Simond, Mammut, Mountain Hardwear, Montura.

Survey application evaluated the fit satisfaction and comfort perceived by the climbers participating in the test. The survey was developed using a graphic medium in which they identify the following criteria: comfortable, acceptable, tight, dissatisfied.

We identified gender differences regarding the parts of the body in which climbers frequently reported the most discomfort when wearing climbing pants; male most commonly responded 'knees', 'crotch', 'inner thighs', 'inner shin' while female climbers most commonly responded 'inner thighs', 'exposed back', 'waist', 'hips' and 'inner lower hem' in that order.

Differences were also found between rock climbing and gym climbing in terms of wear and tear on pants, preferred fabric properties, and length of pants. Wear and tear was found mainly on the knees and crotch of rock-climbing pants.

Listed in the order of preference, the most preferred fabric properties were elasticity, light weight material, not showing sweat and durability for rubbing against the wall for indoor climbing pants and elasticity, insulation, resistance and protection against wind for rock climbing pants.

They also mentioned variable fabrics: mesh fabric for ventilation, reinforced protection or abrasion resistance.

Interviewees listed important features in choosing climbing trousers like: fit, breathability, comfort, mobility.

Design characteristics mentioned were:

- roll up ankles, correct length,
- not a drawstring waist,
- reenforced part on knee and crotch areas,
- high waisted (for the harness),
- pockets,
- adjusting in inseam/length.

Men showed a high level of preference for ergonomically cut climbing pants. Respondents said the waistband on climbing pants should be simplified so as not to adversely affect climbing techniques. They also suggest that pants should fit well by length.

Conclusions

Understanding rock climber's body limitations, equilibrium techniques and moves, environmental conditions, and using good ergonomic design principle can help to minimize discomfort and improve performance.

There is a need to develop ergonomic clothing garments for rock climbers, that fit well, are comfortable and do not restricts the climbers body movements.

Design analysis revealed that climbers need pants with reinforced but stretchy knees, waist high enough at back for those who wear harness, adjusting systems and pockets.

In this paper we present our research in the creative process of following ergonomic principles in designing clothes for rock climbers. In order to validate the pilot study about climber user-centred approach, a prototype must be developed and evaluated. Our research seeks to enroll the end-user (rock climber) of the product (trousers) as an active participant in the design process.

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