# Relationship of Clothing Comfort to Motion Ergonomy

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**Supervisor**

**Prof. Dr. Ali KİREÇCİ**

**Co-Supervisor**

**Assoc. Prof. Dr. Nazım PAŞAYEV**

**By**

**Cemile Emel KIRLANGIÇ**

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T.C.

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Name of student: Cemile Emel KIRLANGIÇ

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Approval of the Graduate School of Natural and Applied Sciences

Assoc. Prof. Dr. Metin BEDİR

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Ali KIREÇCİ

Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Nazım PAŞAYEV

Co-Supervisor

Prof. Dr. Ali KİREÇCİ

Supervisor

Examining Committee Members:

Assoc. Prof. Dr. Nihat ÇELİK

Prof. Dr. Ali KİREÇCİ

Assoc. Prof. Dr. Mehmet TOPALBEKİROĞLU

**I declare that the related thesis was written and all the relevant literature was used in accordance with the academic and ethical rules.**

**Cemile Emel KIRLANGIÇ**

**ABSTRACT**

**RELATIONSHIP OF CLOTHING COMFORT TO MOTION ERGONOMY**

KIRLANGIÇ, Cemile Emel

M. Sc. in Textile Engineering

Supervisor: Prof. Dr. Ali KİREÇCİ

Co-Supervisor: Assoc. Prof. Dr. Nazım PAŞAYEV

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Nowadays, special demands/properties which are required from garments by each consumer, differ greatly between themself. However, many consumers meet in a common point and this is comfort. Comfort is a subjective concept which depends on personal and enviromental factors, and can be evaluated personally. Generally if a garment is comfortable for a consumer; its meant this is functional and ergonomical for user. In this experimental study; with fixed fabric and sewing features, effects of different patterns for clothing comfort and motion ergonomy have been searched/analysed. Anthropometry, ergonomy and comfort have been scrutinised as the main sciences which effect clothing comfort. Commercially available 4 different pants patterns have been analysed in sitting, walking and running positions, degrees of provided comfort have been determined by scoring system and then the results are analyzed and interpreted. Concordance of point tables were calculated by statistical formulas. And finally regarding to demands of the users, a new pants pattern was designed by considering of the analysed model which provides the highest comfort level.

**Key Words:** Comfort, Clothing Comfort, Ergonomy, Anthropometry

# ÖZ

## GİYSİ KONFORU VE HAREKET ERGONOMİSİ İLİŞKİSİ

KIRLANGIÇ, Cemile Emel

Yüksek Lisans Tezi, Tekstil Mühendisliği Bölümü

Tez Danışmanı: Prof. Dr. Ali KİREÇCİ

İkinci Tez Danışmanı: Doç. Dr. Nazım PAŞAYEV

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71 Sayfa

Günümüzde, her tüketicinin giysiden talep ettiği özellikler birbirinden farklılık göstermektedir. Ancak konfor hemen hemen bütün tüketicilerin ortak noktasıdır. Konfor, sübjektif bir kavram olup, kişisel ve çevresel etmenlere bağlıdır, kişiden kişiye farklı yorumlanabilir. Genel olarak, bir giysinin konforlu olması, fonksiyonel ve ergonomik olması anlamına gelmektedir. Bu çalışmada, kumaş ve dikiş özellikleri standart tutularak, kalıp farklılıklarının giysi konforuna ve hareket ergonomisine olan etkileri araştırılmıştır. Giysi konforuna etki eden başlıca bilimler olarak; Antropometri, Ergonomi ve Konfor konuları detaylıca incelenmiştir. Ticari olarak kullanılan 4 farklı pantolon kalıbının oturma, yürüme ve koşma pozisyonlarında kullanıcılara sağladıkları konfor dereceleri puanlama sistemiyle saptanmış ve bu sonuçlar analiz edilerek yorumlanmıştır. Puan tablolarının uyumlulukları istatistiksel formüllerle hesaplanmıştır. Son olarak, kullanıcıların talepleri doğrultusunda, en yüksek konfor algısını sağlayan model üzerinden gidilerek, yeni bir pantolon kalıbı tasarlanmıştır.



**Anahtar kelimeler:** Konfor, Giysi konforu, Ergonomi, Antropometri

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# CHAPTER 1

# INTRODUCTION

## 1.1. Introduction

Clothes have been an object which is used only to cover the body for many years. However, in recent years, the primarily clothing demand of consumers is feeling the concept of comfort literally. The expected functional properties of clothing vary from consumer to consumer.

Nowadays, with the effect of the rising standard of living and fashion trends, comfort features as well as apparels functional characteristics (purpose), has become an important factor in the selection of clothing.

Comfort is a complex concept that consists of multi-component. A garment to be comfortable, a person who is wearing it, need to be fully achieved the comfort in terms of physical, psychological and physiological. The comfort of clothing can be mentioned when the user is able to ease movement and finds himself adequate aesthetically. Comfort is not only means fully relaxed, but also it is feeling comfortable in the garment whatever the conditions.

Person cannot change the properties of the body and the environment, but he can chance the clothing factor alone. Selecting the properties of clothing depends on person and person chooses the clothing that is most appropriate to the environment is he in. Comfort is an important characteristic to enhance the value of textile products [1].

Comfort is a concept that varies from person to person. Apparel products are prepared in basic measurements. However, on earth there are billions of people and billions of different size of body. In this case, all of the individual evaluation of comfort are different from each other, is possible.

Anthropometry that examines the measurements of human and its environment, is an important science for apparel industry, and also related to ergonomic requirements. Anthropometry, as a discipline, is interested in the measurements of human body, has an important role in the production of clothing. In the process of clothing design, one of the priority operations is the preparation of patterns of garments produced. An individual to feel comfortable and ease movement, are possible with clothes fitted to the body. However, there are differences between anthropometric (dimensional) measurements of people. Because of this difference, clothing to fit to the body, be functional and allow easy movement, patterns should be prepared using the anthropometric measurements [2].

It has great importance of uniforms used by private security officers who provide security designs of varies businesses and do checking activities regularly while their checking performances. The purpose of uniform is to make officers feel the privilege of being a member of a group and also take the responsibilities of it. The uniforms of private security officers, who is in these clothes at least eight hours of a day, must have specifications that provide comfortable moving, have appropriate raw materials and surface structure, being easy to use and care and accordance with body concepts [3].

In this study, the suitability of pants that are similar models with different patterns, were investigated. Generally, security guards pants are similar to the soldier (camouflage) pants. However, in some companies, the security guards are expected to work with fabric pants to look more serious and formal. For this reason, the classical cut pants models were investigated in this study. A new pattern was designed according to the demands of security guards at the end of the assessments of comfort.

### 1.2. Literature Survey

Kirk and Ibrahim (1966), had been reported that the human body size changed depending on the movement. In their study, extension / expansion rates found by identifying 6 different measuring points in the squatting position [4].

Süer (1992), aimed in her study to determine the importance of the human body mechanics for the design work clothes. It was stated in the study that; work clothes is an important factor to improve the productivity of worker and besides it's essential to design the patterns considering the measurements of body in static and dynamic positions to ensure easy movement [5].

Bozkurt (1995), in her study, aimed to determine the relationship between body movements and clothing properties. In the research, fabric, stitch, flexibility of body movements, garment patterns were stated as the factors that are effective on the relationship. Totally, 23478 measurements were taken on 301 participants, stretching rates of fabrics (both warp and weft) were calculated and finally, minimum allowances for movement that does not prevent the motion of body, were determined [6].

Mete (2001) presented a new method of two-dimensional pattern drafting for personally fitted garments during her study. 16 different measurements were taken from female body and they were converted into two-dimensional bodice patterns within scope of her study [7].

Schofield, Ashdown, Hethorn, Labat and Salusso (2006), produced trial trousers for 5 different sizes in balance with two different body shapes for women aged 55 and older; and these pants have been tried on 176 experimentals. It was determined that these samples, even though they were same size, were produced according to different body shapes, and made significant difference regarding the fit to body; as a conclusion of this study [8].

Chen (2007) within the framework of study, clothing's fit to body for people who have different body shapes have been analyzed. For this purpose, Chen prepared individual patterns for 10 women representing different body shapes; and these were tested. As a resultant of this study; it was mentioned that non-standard body shapes causes fit to body problem [9].

Özcan (2007) , in her study, analyzed the suitability on the sweatsuits and sportsgears to the expectations of the footballers. 20 football team; 10 professional and 10 amateur, participated in the survey to evaluate the comfort grades of sweatsuits and

sportsgears. As a conclusion, it was determined that footballers are generally satisfied with the sweatsuits and sportsgears that do not cause to prevent the movement [10].

Utkun (2007) researched in her study that the patient garments (for after surgical operations) which has suitable model, material and sewing properties and the best functional in terms of clothing comfort. Two different types of women and men nightdresses, one unisex overalls were analyzed in detail and it's determined that the expectations of patients about clothing comfort after surgical operations [1].

Yeşilpınar and Bulgun (2007), during their study; have conducted a survey to a group who is between the ages of 25-55, in order to analyze Turkish women' problems regarding clothing's fit. At the end of the study; it was noticed that only 9.2 % of female consumers, who is a member of this tester group, do not have fitting problem in clothings that were purchased by them [11].

Çivitci and Bulat (2008) observed in their study that, the low-waist pants fashion which has an important place in the garment industry, caused the increasing of waist circumferences in male and female users and also mentioned that the vast majority of consumers made the choice of clothing to provide psychological satisfaction, not to any other comfort aspect [12].

Dursun, Abanoz and Çalışan (2010) carried out a survey that; the private security officers in all faculties, high schools and vocational high schools in Düzce University were applied for questionnaire and the data were analyzed. The expectations, satisfactions and also comfort/discomfort levels of security officers were evaluated in accordance with the questionnaires that were made by 70 participants. In consequence of the survey it was determined that; security officers were unsatisfied with the waist and hip circumferences and croch lengths of pants, waist girth of shirt, arm width of coat. As a conclusion, a number of recommendations were stated to improve the grade of comfort [3].

### 1.3. Structure of the Thesis

Chapter 1 defines the general purpose of thesis and previous studies about clothing comfort and clothing ergonomy.

Chapter 2, includes the concept of comfort in detail and also incorporates disciplines such as anthropometry, ergonomy and some other topics which are related to clothing comfort.

Chapter 3 is composed of subtopics which are belong to experimental study. Test methods, point tables and analyses are presented in this section. The inferences of these analyses are evaluated and also designing of new pants pattern is explained in detailed form in the chapter.

Chapter 4 covers the discussion and conclusion. General assessment of experiment and interpretation of the perception of comfort are included in this section. Recommendations are given to enhance the comfort grade of pants and other garments of uniforms which are worn by security guards.

# CHAPTER 2

# COMFORT

## 2.1. What is Comfort?

The term of comfort is defined as “the absence of unpleasantness or discomfort” or “a neutral state compared to the more active state of pleasure”, besides comfort can be characterized as “being away from the pain” or “being conscious about feel good” and therefore the comfort is being without aware of feeling a neutral sense of clothing worn by the person [1 and 13]. In other words comfort can be defined as a pleasant state of physiological, psychological and physical convenience between a human being and the environment where physiological comfort is related to the human body’s ability to maintain life, psychological to the mind’s ability to keep itself functioning satisfactorily with external help and physical comfort to the effect of the external environment on the body. Further, the psychological and physiological states have the aspects of thermophysiological comfort which expresses a comfortable thermal and wetness state, sensorial comfort that corresponds neural sensations when a textile comes into contact with skin, body movement comfort which incorporates ability of a textile to allow freedom of movement and body shaping and aesthetic appeal that contributes to overall wellbeing of the wearer [14].

Various consumers consider comfort as one of the most important attributes in their purchase of apparel products, therefore companies tend to focus on the comfort of apparel products. Slater defined comfort as “a pleasant state of physiological, psychological and physical harmony between a human being and the environment” [15].

The researchers stated that comfort can be studied with subjective and physical approach. The importance of body, harmony and aesthetic features are emphasized as subjective concepts in addition to the temperature, humidity and air circulation factors that are resulting of motion. Even if the temperature, humidity and air

circulation values of fabric are well, required clothing comfort can not be provided. Bad-compliant garment can cause damage the skin, effect the blood circulation, make the wearer frustrated and annoyed, interfere with body movements. On the other hand good or bad accordance criteria may vary by depending on the purpose of garment and region of body. On that account a clear result will never be given because of the difference in the population [1].

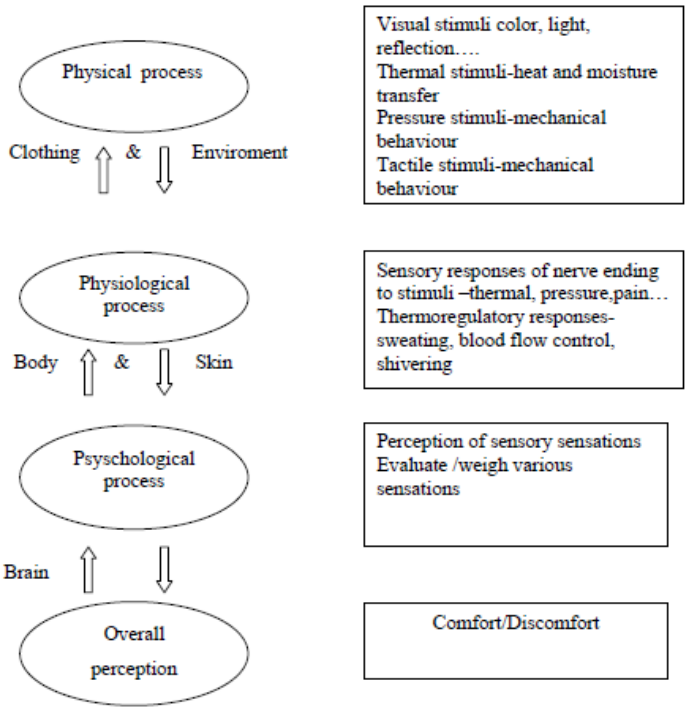


Figure 2.1. The flow chart for the subjective perception of comfort [16]

Many researchers define comfort as a neutral feeling. In order to be regarded as a person comfortable, an alert related to environmental factors such as temperature of ambient, humidity, wind speed, light, shouldn't be delivered to the brain. Depending on our clothes or psychological state, the discomfort feeling to any of these factors will eliminate the comfort sense [17]. As regards Alexanders; fitting of clothing to the body and its comfort is an important factor for the user. The clothes which exactly fit on the body positively affects the psychological and social behaviors of the individual, and the unfitting clothes are one of the most frequently encountered problems when buying clothes [18].

Generally speaking clothing comfort is governed by the interplay of three components:

- Body
- Climate
- Clothing

The human body, its microclimate and its clothing form a mutually interactive system. The body and its microclimate are invariable, the clothing system is the only variable [19].

It is obvious that comfort involves a complex combination of properties, both subjective and physical. There is general agreement that the movements of heat, moisture and air through a fabric are the major factors governing comfort, but some of the subjective factors such as size, fit and aesthetic behaviour like softness, handle and drape are obviously very important in the textile field [20].

Today comfort is considered as a fundamental part when a textile product is valued. In some cases it is analyzed following an analysis technique called HPA (Human Perception Analysis). This analysis is based on some main elements [21]:

- Warmth,
- Absorbing capacity and humidity,
- General comfort,
- Cloth convenience,
- Skin perception,
- Weight,
- Softness.

Comfort is mainly determined by the heat and moisture transport of fabric, which is related to fibre characteristics as well as yarn and fabric construction and fabric finish, recognising that the extent of their relationship to comfort perception in clothing is also influenced by garment design, cut and fit [22].

## 2.2. Classification of Comfort

### 2.2.1. Physical Comfort

Physical comfort is a result of feelings that are felt at the time of direct contact of textile surfaces with the body. Physical comfort includes the softness and easy movement ability of fabric and also itching and stickiness feeling which are consist of wet fabric, effect the clothing comfort negatively. Mechanical and surface properties of fabric are effective to determine the feelings can be listed as smoothness of the surface, weight, density, stiffness, type and shape of clothing, fabric geometry, softness, smoothness, wetness, stickiness [15 and 17]. In the event of garment eases body movement, takes the form of body and prevent to overload, comfort can be mentioned [14].

Fabric structure and design of clothing is very important for physical comfort. Because, both structure and design effect skin friction, tight fit, irritation and stinging. The impact (physical discomfort) may be impressed by the feeling that is formed at the moment of contact with the skin or the nonconformity such as garment is not fit to body [23 and 24].

It is obvious that comfort involves a complex combination of properties, both subjective and physical. There is general agreement that the movements of heat, moisture and air through a fabric are the major factors governing comfort, but some of the subjective factors such as size, fit and aesthetic behaviour like softness, handle and drape are obviously very important in the textile field [20].

### 2.2.2. Psychological Comfort

Psychological comfort is directly related with factors which affect clothing. These factors can be ranked as sex, age, season, social status, social life, environment, fashion, place and date. Model, form and colour of the garment are the main factors of psychological comfort [1 and 15]. Aesthetic factors may also include properties such as colour, lustre, style, fashion compatibility and other similar characteristics. The aesthetic properties are normally judged by the way in which it feels or looks, but some of them are in pressed in quantitative terms in the textile technology. The aesthetic behaviour may be modified in fabrics by either chemical or mechanical

treatment. Imparting softness, crease resistant finishes, modifications causing a change in its appearance, wrinkling, pilling and lustre of fabrics are some of the properties investigated in the recent literature [20].

Psychological comfort is an expression of how much expectations and feelings of the users have been provided by fabric or garment. It is interested in questions such as: what we feel when dressed up or how does it seem. Psychological comfort is affected by garment characteristics such as fashion, beautiful appearance (aesthetics, body alignment and color), keeping clean, protection of shape after washing. Fashionable and esthetically attractive clothes will satisfy the user's incentive to be noticed in the community, provides psychological relief. Person feels psychologically uncomfortable when thinks that garment is not suitable for himself and environment. Psychological comfort may be more dominant in case of the purchase of daily clothings [23 and 25].

### 2.2.3. Physiological (Thermophysiological) Comfort

Physiological comfort concerns the heat and moisture transport properties of clothing and skin sensorial wear comfort concerns the mechanical contact of the fabric with the skin and its lack of prickle, irritation and cling when damp, in other words how a fabric or garment feels when it is worn next to skin [26]. In other words physiological comfort is related with garments' effects on the heat balance between human body and external environment. If clothing helps to keep body temprature in required levels, people feels comfortable. Moisture, liquid and temprature transfer, air permeability and drying characteristics are the factors of physiological comfort [15].

The covered body feels the current climate conditions on the skin and under the clothing. Wearing the garment, the heat produced in body determines the character of microclimate on body and the feelings of comfort as a result, by waiting on the air layer that is between the layer of fabric and body, before spreading to the atmosphere [27].

Physiological comfort depends on heat conduction of skin and spreading of sweat from skin to environment. Heat production and heat loss of body should be equal to

maintain the thermal balance. In warm atmosphere the resistance of clothes is low for thermal insulation, high for water vapor transmission. On the other hand, in cold atmosphere and low physical activity (low heat generation), the thermal insulation of fabric is higher. The concept of physiological comfort has a role in the heat and moisture permeability properties of fabric that constitutes garment and equilibrium of thermal balance of fabric during different activities. It depends on environmental conditions, activity level and fabric that constitutes clothing [17 and 28].

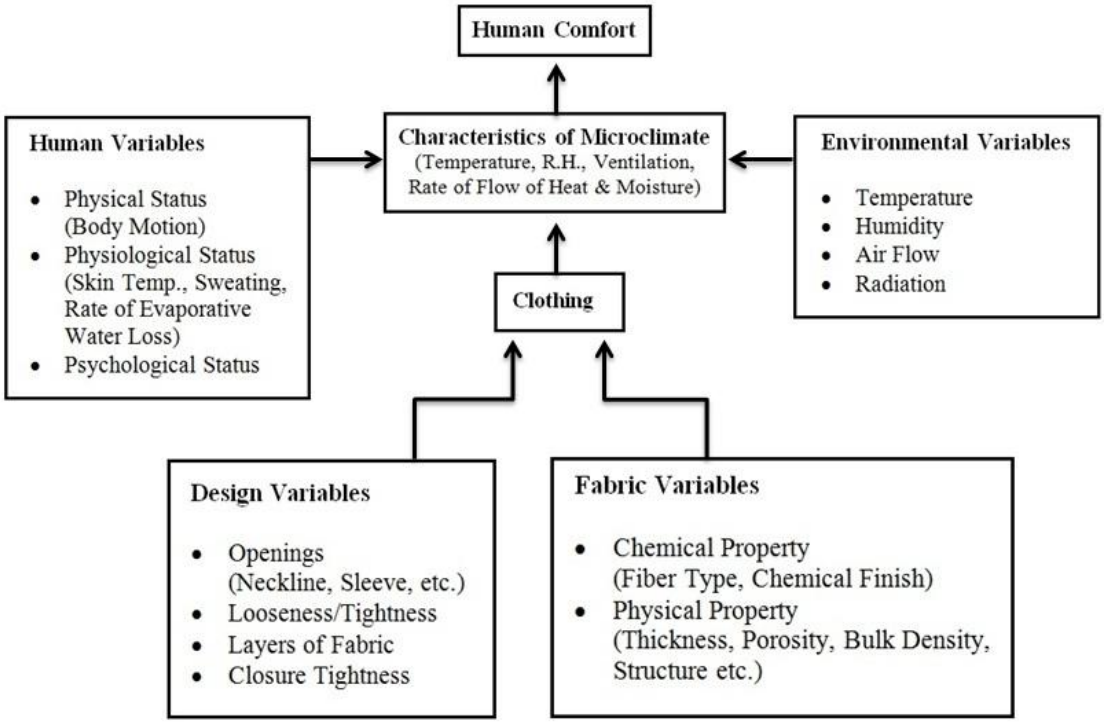


Figure 2.2. Factors affecting the microclimate between the skin and clothes [27].

The fact that the body temperature is the most critical factor in deciding comfort means that we must examine more closely the mechanisms by which textile fabrics assist or hinder the maintenance of a uniform temperature in the body that they enclose. Heat is gained by the body from the sun (directly or indirectly), by internal metabolism, by physical exercise, or by involuntary contractions of skeletal muscles in shivering [20].

The ambient air temperature is the another dominant influence in determining the skin temperature and that at low temperature, clothing is essential for the regulatory

process because the body does not have the ability to continue compensating for heat loss under these conditions. In addition to prevent excessive heat loss, the winter clothing must also allow the escape of surplus heat or moisture when this is necessary [20]. For a better comfort grade, the garment system should have some certain parameters. These parameters are as follows:

#### 2.2.3.1. Heat Transfer

The resistance that a fabric offers to the movement of beat through it is of critical importance to its thermal comfort. In studying the thermal insulating properties of garments during wear, it is reported that the total thermal resistance to transfer of heat from the body to the surrounding air is the sum of three parameters:

- The thermal resistance to transfer of heat from the surface of the material,
- The thermal resistance of the clothing material,
- The thermal resistance of the air interlayer.

It is obvious that heat transfer through a fabric is a complex phenomenon affected by many factors. The three major factors in normal fabrics appear to be thickness, enclosed still air and external air movement [20].

#### 2.2.3.2. Air Permeability

Permeability is a property composed of performance and thickness of a material in [m3/s.m2] in SI system. Air permeability can be defined as the volume of air permitted to pass a certain area of the textile material in a period of time under a specific pressure. Air permeability of a fabric is an auxiliary factor affecting the comfort properties of textile materials [29].

The air permeability of a fabric can influence its comfort behaviour in several ways. In the first case, a material that is permeable to air is also, in general, likely to be permeable to water, in either the vapour or the liquid phase. Thus, the moisture-vapour permeability and the liquid-moisture transmission are normally closely related to air permeability. In the second case, the thermal resistance of a fabric is strongly dependent on the enclosed still air, and this factor is in turn influenced by the fabric structure, as also is the air permeability. A very open cloth can inflict

serious wind chill problems on the wearer in cold climates with a breeze blowing and may thus affect survival chances in extreme cases. Finally, a highly air-permeable fabric may be sheer or have as very open structure, so that aesthetic factors such as modesty, dimensional stability, drape, handle etc may result in discomfort of a psychological or physical nature in the wearer. Although air permeability in itself is merely another effect, rather than a cause, associated with such manifestations of discomfort, it can nevertheless provide a convenient and readily measured way of quantifying the likely behaviour of a fabric in these other areas [20].

#### 2.2.3.3. Moisture Permeability

Moisture permeability is an important property of a fabric, from the comfort standpoint, is the way in which it allows water to pass through it. This process can take place in both the liquid and vapour phases of water and the difference is an important one. This property is known as 'permeability of a fabric to moisture vapour'. Water vapour transmission rate is defined as the steady water vapour flow in unit time through unit area of a body, normal to specific parallel surfaces, under specific conditions of temperature and humidity at each surface. The movement of water vapour through a fabric depends considerably on the micro porous nature of the material, and this movement can therefore be modified by any operation that brings about a change in this structure. The factors affecting moisture vapour permeability are enumerated by different authors, some of which are the effect of fabric structure and properties, finishing treatments, texturising, different yarn twists, blending and mechanical treatments [20 and 30].

## 2.3. Clothing Comfort

People have always been in need of getting dressed because of the fundamental and physiological needs such as covering, protection, showing the difference in sex, reflecting the social environment they are in, carrying the culture they are from, and getting in contact with others. Therefore, dressing has come out as a requirement for being a human and existing in a society [31]. Today, many consumers regard dressing something far more beyond a basic need and they use it for defining themselves in a social class, presenting a positive image and improving it by adding more sense to their general appearance. So, there are many reasons for dressing

which are complicated and connected to each other. Dressing not only protects the physical health of individuals, but also meets their many psychological and social needs [32 and 33].

It is difficult to characterize many factors that effect the concept of comfort. Additionally, it can be characterized easier to perceive the discomfort and restlessness that give a sense of discontent feeling or to be aware of what you wear. Accordingly clothing comfort is a scale which minimizes deterioration of body functions or how well a garment help body functions [1].

People when they are relaxed and comfortable, physical and mental performances are at the highest standards. Working people under disturbing thermal conditions are adversely affected operating performance and business efficiency. In consequence, by taking into account activities and clothing styles of people work in an environment, determination of the required environmental conditions are extremely important due to it will effect quality of work besides personal comfort [34].

The basic requirement of garment is that; it should not cause discomfort in terms of wearing. Expectations of users in a wide variety of clothing, but the appearance and touch feel of the performance criteria cannot be ignored in no time. In many cases, suitability to the terms of use and not to giving a sense of discomfort, come to the forefront than outer appearance. In contrast with, the aesthetically appealing and trendy clothing will provide psychological relief by satisfying the user's desire to be noticed in the community [35]. On the consumer's choice of clothing, the color, the model, the fabric appears to be effective in the first place, but providing compatibility and mobility of clothing on body have priority. Each garment is intended for different purposes. For this reason, patterns are different from each other. However, the common aim of all garments is not to prevent the body movements by clothing. To achieve this purpose, it must be known the changes in dimensions caused by the movement at the end of body movements. Size changes caused by body movements, take effect as the forces that create the various changes on people [6].

Kirk and Ibrahim, have achieved the equality; "Body Stretching = Clothing Harmony + Clothing Freeness + Fabric Stretch", by searching the relation between fabric and

body stretch. The relation between body and clothing, friction coefficient of fabric, designing naturality of clothing, garment contact to the body and fabric parametres are effective on clothing harmony and freeness. According to the results which are obtained from hip and knee circumferences, by taken into consideration clothing harmony and freedom issues, the fabric stretching is about %25, and also it is appointed that; the stretching extent is not enough some other movements. It's understood that the movements in the knee fray clothing and to obstruct that, high-flexibility-rate fabrics are preferred [4 and 36].

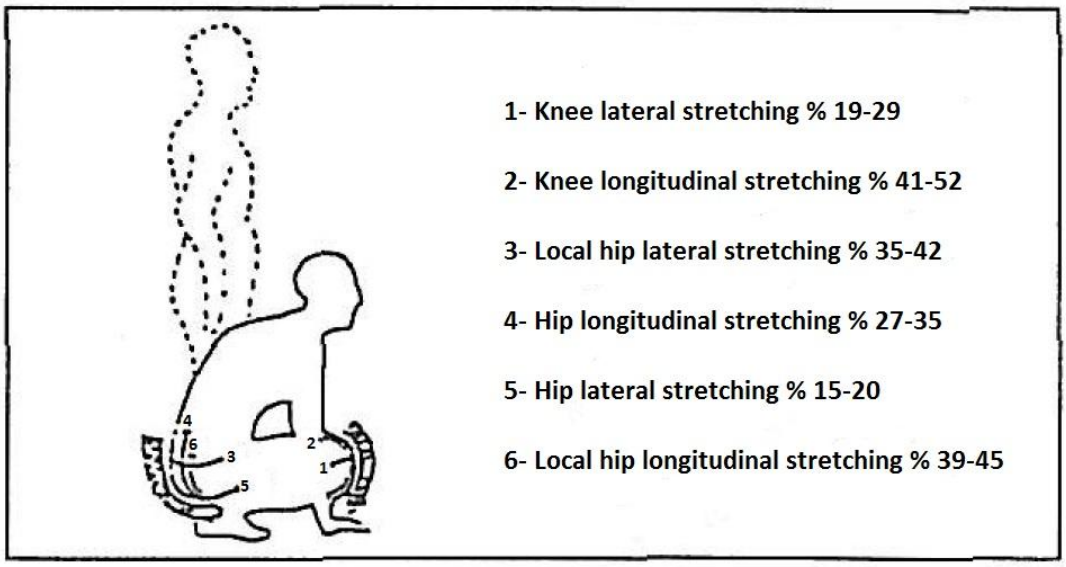


Figure 2.3. The dimensional changes of the body in squatting position [4]

## 2.4. Anthropometry

Physical variations between humans have always been a subject of wonder. Each human shows various growing properties during his life. Stages of this period depend on person's genetic structure and environmental factors. Every person and every society have its own structure and they have specific anthropometrical qualifications. Each size in human body has a meant. For using equipments and machines, anthropometrical standarts should be known [5].

Anthropometry is a special science which is interested with the human body's measurements. These sizes include different techniques as width, height, weight etc. Till today, anthropometrical sizes of human are always analysed because of various reasons. Conventional anthropology measuring techniques are used in variety areas

from space flights required the most advanced technology to designing studies of companies which produce industrial equipments and clothing [37].

Usage area of anthropometry [38]:

- Identifying the type of human race,
- Identifiying of variations between human groups from the point of biotypology,
- Analysing of somatic structure of human,
- In clothing industry which produces military and daily garments,
- Developing of design criters which are related with whole or part of society,
- Design of indoor,
- Design of the human-machine systems,
- The furniture industry.

Anthropometric measurements are interested in the human body as a field, has an important role in the production of clothing. In clothing designing, preparation of patterns of garments will be produced is one of the priority operations. Feeling comfortable and being able to easy movement is possible with garments suitable to the body and provides freedom of movement. Due to the differences between the anthropometric dimensions of people, garment patterns should be prepared by using anthropometric measurements so that garments to be functionel, fit to person and ensure easy movement [39].

Some of the rules must be followed in terms of the consistency of the measurements obtained from anthropometric studies. Measurement should be taken naked or on thin clothing. During the measurement, sitting or standing floor must have a structure not to be deformed due to gravity. In addition, the measurement should be carry out on both side of body in other words symmetrically [5]. Anthropometry is analysed 2 different methods in ergonomical sense.

### 2.4.1. Static Anthropometry

In fact, anthropometry evaluates metric values of human measured while sitting and standing. Up to 140 separate measurements can be measured on human body

regarding to this basic rule. These measurements can be used for different purposes, e.g.: to measure face sizes for a gasmask, to measure hand sizes for protective gloves of extreme sports [37].

### 2.4.2. Dynamic Anthropometry

In working life, in the passage used by people, in standing volumes and in seating designs static datas are being used however human is in motion in business life. While a human is driving car; his arms, legs and body have to be moved with several dimensions to perform the function of a driver and therefore it is a must to measure dynamic measurements. Measuring of motions such as bending or reaching is also very important for the optimization of the design of human-machine systems [37]. Anthropometrical measurements are taken as a basis on designing of working areas and garments, on detecting of physical properties such as body's volume and center of gravity. However only the body measurements are not enough for garment design. Joints and dynamic properties of body are important factors on specifying of garment structure [40].

## 2.5. Ergonomy

Ergonomy is the science of human working. This science searches specifical qualifications and abilities of human to find needed conditions for human-work harmony. In other words, as an interdisciplinary science ergonomy, researches human and working environment as scientifically and transfers this to application area. It has been known as human engineering or working science. Ergonomy searches physical, biological, anatomical and other properties of human to provide proper designing of machine and job to harmonize human, machine and job for the interaction [41 and 42].

Ergonomy brings to the fore of human and it has important functions like increasing of performance meanwhile reducing fatigue, protecting against working accidents and occupational illnesses. The science is processed in different way in a wide range and it can be applied for industrial system design, architecture relations, education, environment and also age. Therefore important point is understanding general

principles of ergonomy and apply them all areas to get optimal performance and to increase life quality level [43].

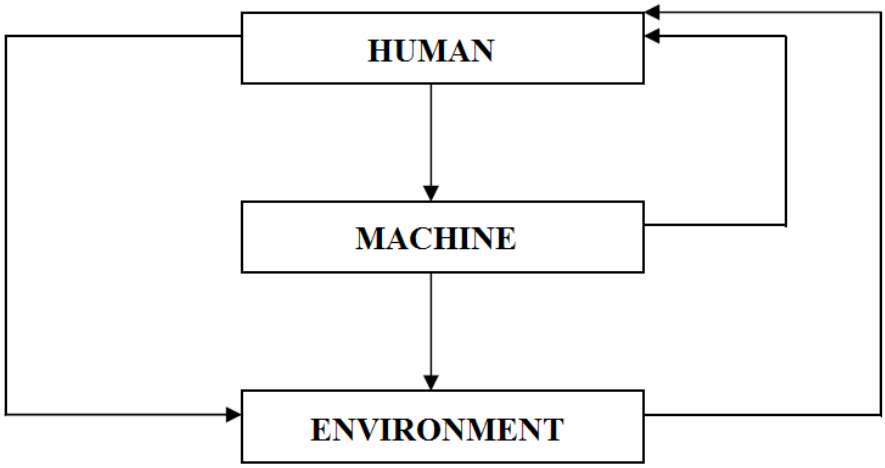


Figure 2.4. The relationship between human, machine and environment [44]

System-human harmony should be thought with all details, which include physical, perceptive, cognitive, sensational, social, organizational and enviromental factors, regarding to reference point of ergonomy. This is the objectification of inputs and outputs which defines the interaction of set of the system-human. It is possible to describe ergonomy's goals as below [45]:

- Providing workers' health and working security,
- Avoiding workforces' losts,
- Reducing fatigue and work stress,
- Reducing work accidents and occupational risks,
- Maximising efficiency and quality.

Ergonomy tries to extend limits of natural abilities of human on the one hand, and on the other hand tries to improve human-machine systems' performances [46]. In fact, the focus point of the ergonomical studies is human-machine systems' designing. It is provided with the contributions of different disciplines like physiology, psychology, work physician, engineering and statistics. Basic approach in ergonomy is to benefit from data of anatomic, physiologic and psychologic qualifications for designing of equipments and physical environment to upgrade persons' comfort, health and performances.

## 2.6. Clothing Ergonomy

Garment is obtained with sewing operations of patterns which have been cut from a particular fabric according to a model by considering of human shape and size. So, garments should be analysed in this respect and consider of ergonomical factors while designing and producing. Shape of human body, obtaining of pattern which is proper to body shape, fabric, sewing properties, fashionableness and comfort can be counted as firstly [47]. Each clothes are for different purposes therefore patterns are different. However common purpose of all clothes is: "should not to block the movement of the body" and to supply this purpose, dimension changings which is caused by body movement, should be known well [6].

Working clothes, which help worker to adapt on working environment, register a good effect of performance by protecting workers' mental and physical health. Therefore to ensure human-work harmony, working clothes should be designed according to working conditions, movement and the most important human's body. While forming pattern, dynamic and static conditions of body and movement areas should be known well [48]. While working, if worker feels uncomfortable with his working clothes, he will pay attention to this problem and he will lose attention of job. Therefore we should evaluate clothing comfort, which is described as "satisfaction of clothing and environment in psychological and physical balance" in the light of ergonomy science to increase workers' performance and motivation [49].

## 2.7. Measurements of Body and Clothing

Apparels must be suitable to desired dimensions as well as to be fashionable, high quality of fabric and stitching. Suitability to the consumer's body of the garment is very important [50]. There are billions of people living on the earth, in other words; billions of type (body size) are available. Separate body size cannot be made to the all people, so they must be collected in standard body groups [51]. Since the human body comes in an almost infinite variety of sizes and shapes, apparel fit problems effect both the aesthetic and functional characteristics of a garment [7]. The fact that human body differs from person to person causes to problems based on harmony between garment and body shapes. This situation reveals the importance of production according to individual body measurements and body shapes in garment

production [52]. Garment products are made according to average measurements; consumers having different body shapes use these products, and problems occur due to harmony between clothing and body shape related customer dissatisfactions [53].

From the first day of clothes began to be produced mass production, numbering the sizes and measurements of garments have always been problem. For this reason, in apparel industry for garment production, standard body measurements, relationship between body and pattern dimensions and also sizing of clothing should be known well. Structure and measurements of body constitute a basis to production of garment. And the specifications that constitute the basis can be summarized as follows [54]:

- The human body is three-dimensional (width, length, depth),
- The human body is subdivided as trunk, head, arms and legs,
- There are specific proportions between parts of the body,
- There are differences between the measurements of moving body and static body,
- The bodies can be divided into three groups as women, men and children,
- Individual differences can be seen in normal body structures,
- Different forms of posture and body deformations can vary compared to the normal structures.

The stage of drafting pattern in garment industry is an important factor directly affecting clothing's fit to body and aesthetical features. In individual production process, comfort of use at expected level is as important as aesthetical look while providing the harmony between clothing and body shape. Because of genetic structure; social status, cultural structure, sport activities, and economic elements; body shapes, body posture and proportions of body parts differ from person to person [55].

The standard measures that reflects body measurements, are not used directly as a measure of cutting. One of the main problems in the design of clothes is determining the relationship between body measurements to cutting measures. Garment to be appropriate to the body, to ensure not to restrict movement and provide ease of use, cutting dimensions are created by adding looseness allowance to the body measures

in specific proportions. The allowances vary depending on anatomical and mechanical structure of the human body, the usage area of garment, the thickness of fabric and fashion [56].

### 2.8. Work Clothes

Nowadays, working conditions are considerably severe, so the clothes which workers wear, have a great importance. As they carry the clothes at least 8 hours each day. Hence, usage of these clothings and appropriate for the body characteristics are required as well as keeping worker's health and providing work safety. Especially; it's essential work clothes should not restrict the body movements. If the work cloth shows preventive or restrictive attitude, this both makes the worker uncomfortable and effect the efficiency of the work and complete time. Work clothes are worn to protect worker from dangerous/ hazardous materials, prevent and/or increase the risk of being exposed to bad ambient conditions. As today the efficiency is very important, the effect of working clothes on efficiency is inevitable. Working clothes that the workers wear during their working tasks should fit both the tasks done and the worker. Thus the problems caused work wears occured while working are elected and quick and efficient working can be possible [57].

Due to the fact that there is a relation between body movements and clothing, there are numerous factors which effect both subjects. When body movements are discussed seperately, primarily the anatomical structural properties of human then the capabilities of body movements and in the meanwhile the physical and chemical interactions occured in body should be presented. In view of garment; at first the intended purpose, afterwards the other factors (such as fashion, model, pattern, fabric, stitch, comfort) should be determined [57].

### 2.9. Definition of Security Guard

A security guard is a person who is paid to protect property, assets, or people. They are usually privately and formally employed civilian personnel. Security officers are generally uniformed and act to protect property by maintaining a high visibility presence to deter illegal and inappropriate actions, observing (either directly, through patrols, or by watching alarm systems or video cameras) for signs of crime, fire or

disorder; then taking action and reporting any incidents to their client and emergency services as appropriate [58].

Security guards are on their feet much of the time. Small companies may need guards only for an eight-hour shift at night, while large institutions and companies may need security around the clock. They carry guns. Security work may be very dangerous, so guards often wear uniforms and bulletproof vests. The clothes should be comfortable as high workload guards have. All the time they are in motion. Movement should not be certainly restricted [59 and 60].

# CHAPTER 3

# EXPERIMENTAL STUDY

## 3.1. Material

In this study, the most suitable pants pattern for security guards was investigated in terms of clothing comfort. Four different commercial pants samples were produced from polyviscose (67% polyester, 33% viscose) gabardine fabric.

Gabardine is woven as a warp-faced steep or regular twill, with a prominent diagonal rib on the face and smooth surface on the back. Gabardine always has more warp than weft yarns [61]. Gabardine fabric is the most used material due to the its durable structure for security guards clothing.

The reason of using polyester viscose blending is to improve chemical and physical properties of fabric such as washing, drying, ironing etc. Polyester fiber can be mainly characterized by hydrophobicity, high strength, and wrinkle recovery. With these features, polyester is an important type of fiber that roles improving the properties of cotton, viscose and wool blend [62].

Fastness' to perspiration and sunlight were applied to fabrics and the reactive dyes are used for dyeing.

### 3.1.1. Sample 1

Sample 1 is the widest model of all samples in terms of crotch, thigh and knee circumferences dimensions. There are 2 pleats in front of the pants; one is right and the other one is on the left. The placket is entegrated to the model. There are side seam pockets, besides there is no back pocket.

The measured front and back patterns of the sample are shown in Figure 3.1., the image of participant A is shown in Figure 3.2., the image of participant B is shown in Figure 3.3., the image of participant C is shown in Figure 3.4.

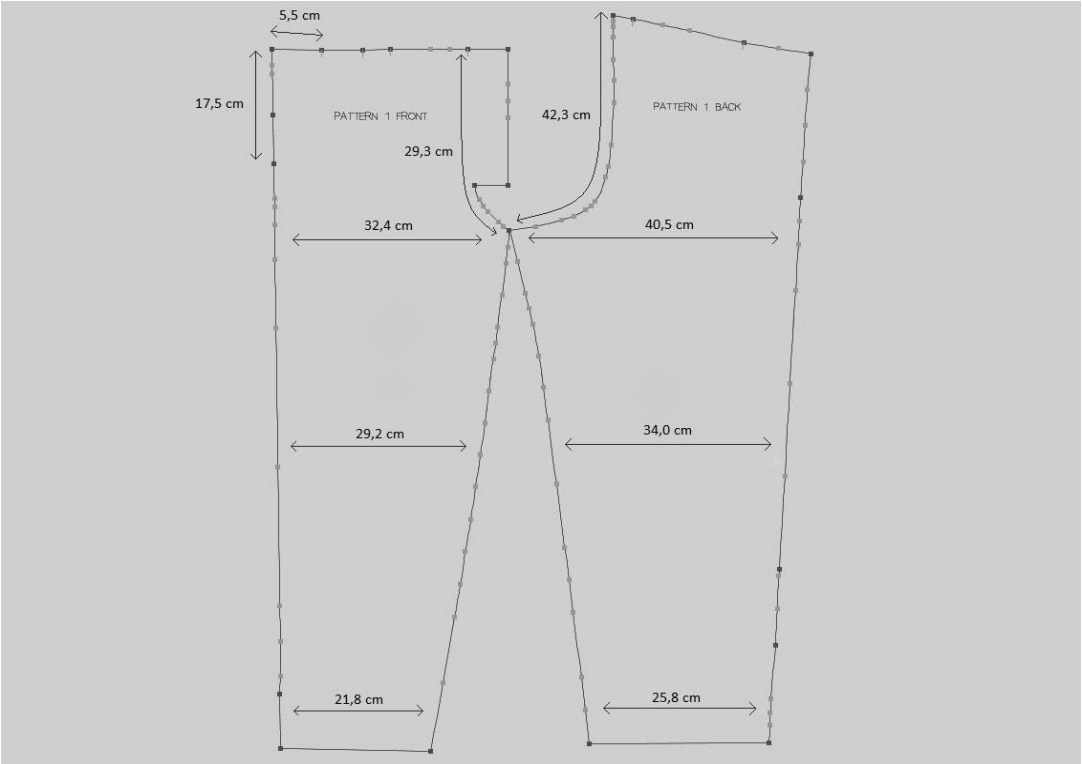


Figure 3.1. Dimensioned image of sample 1

Figure 3.2. The image of participant A in sample 1

Figure 3.3. The image of participant B in sample 1

Figure 3.4. The image of participant C in sample 1

### 3.1.2. Sample 2

There are 2 pleats in front of pants; one is right and the other one is on the left side. There are side seam pockets and a back pocket on right back. It's similar to the classic cutting pants model.

The measured front and back patterns of the sample are shown in Figure 3.5., the image of participant A is shown in Figure 3.6., the image of participant B is shown in Figure 3.7., the image of participant C is shown in Figure 3.8.

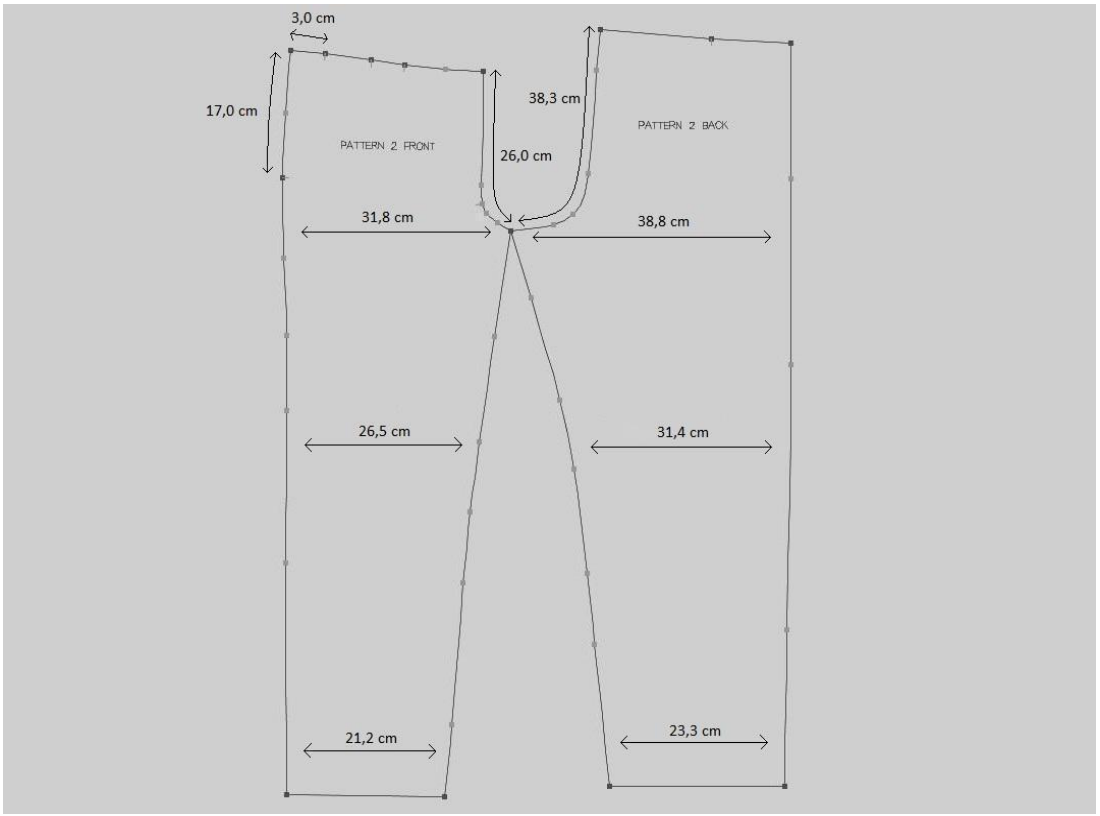


Figure 3.5. Dimensioned image of sample 2

Figure 3.6. The image of participant A in sample 2

Figure 3.7. The image of participant B in sample 2

Figure 3.8. The image of participant C in sample 2

### 3.1.3. Sample 3

Sample 3 is a wide cut pants model in terms of crotch, thigh and knee circumferences dimensions. In the front, there are 2 pleats, one is on the right side and the other one is on the left. There are side seam pockets and a back pocket on right back.

The measured front and back patterns of the sample are shown in Figure 3.9., the image of participant A is shown in Figure 3.10., the image of participant B is shown in Figure 3.11., the image of participant C is shown in Figure 3.12.

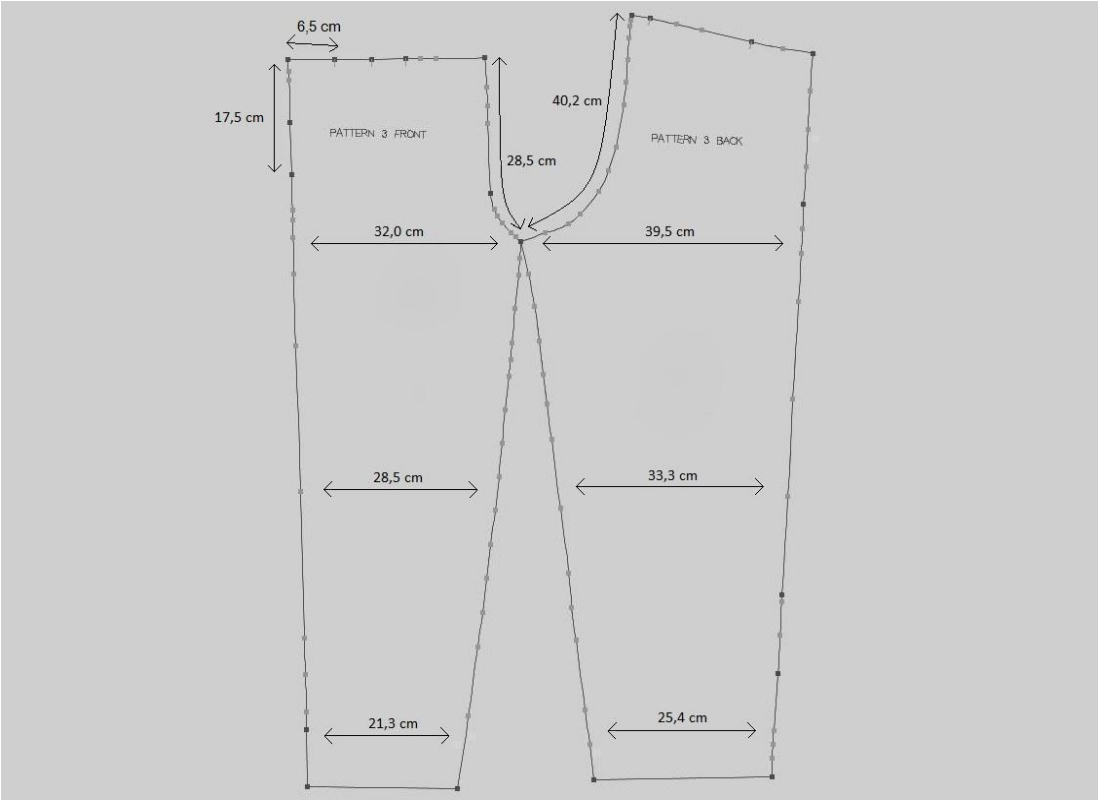


Figure 3.9. Dimensioned image of sample 3

Figure 3.10. The image of participant A in sample 3

Figure 3.11. The image of participant B in sample 3

Figure 3.12. The image of participant C in sample 3

### 3.1.4. Sample 4

In this sample there isn't pleat on front part. There are side seam pockets and a back pocket on right back. Sample 4 is also similar to the classic cutting pants model like sample 2.

The detailed pants model is shown in Figure 3.13., the image of participant A is shown in Figure 3.14., the image of participant B is shown in Figure 3.15., the image of participant C is shown in Figure 3.16.

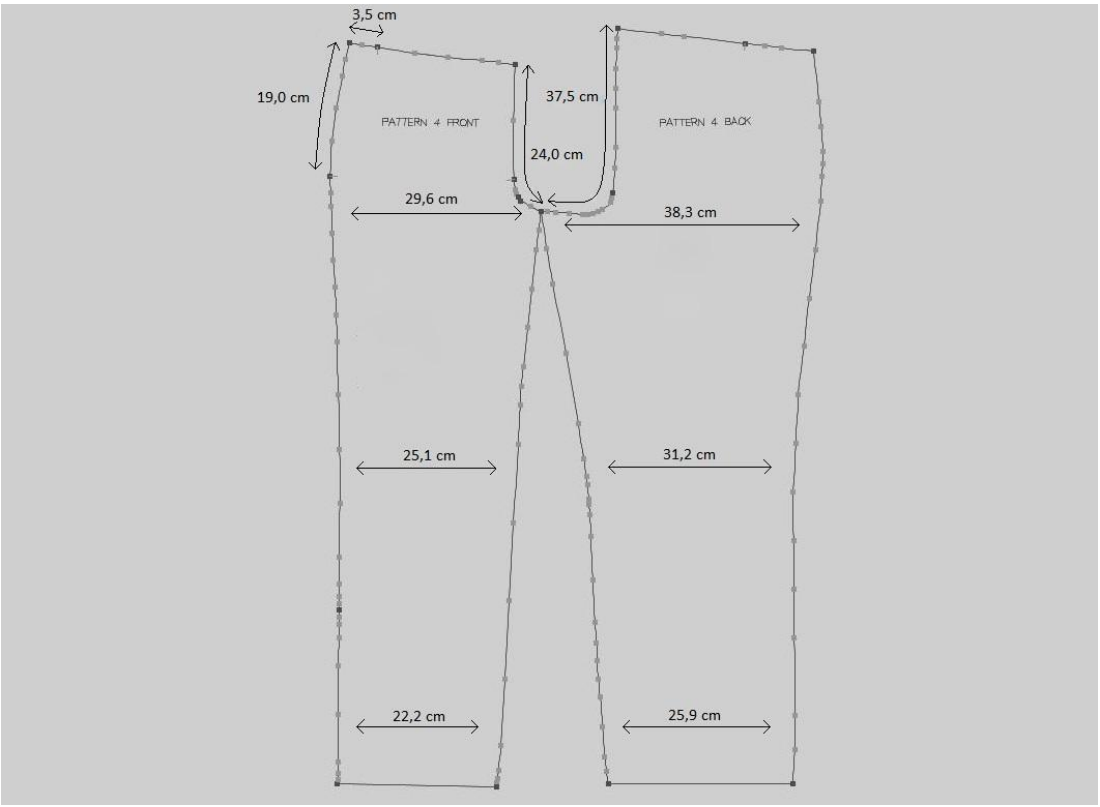


Figure 3.13. Dimensioned image of sample 4

Figure 3.14. The image of participant A in sample 4

Figure 3.15. The image of participant B in sample 4

Figure 3.16. The image of participant C in sample 4

### 3.2. Method

The study evaluates the comfort of models for security guards and workflow is as below:

1. Totally 4 patterns were selected from different firms which produce workwear and the cardboard patterns were prepared via Intelli-Di Digitizer to WearCadfe pattern design software.

2. Three samples of each different pant models were sewed and totally 12 pants were produced.

3. Comfort scoring charts (from 1 to 10 points) were prepared.

4. The pants and scoring forms were given to the security guards for experimental study.

5. Security guards tested each sample during 2 days and evaluated the comfort of pants.

6. Body measurements of security guards and measurements of pants were taken.

7. In the direction of feedbacks that were taken from security guards, comfort analysis was done by considering the measurements.

### 3.2.1. Measuring of Samples

The measurements of parts were taken from 44 size pants samples. Measurement points are shown in Figure 3.17.

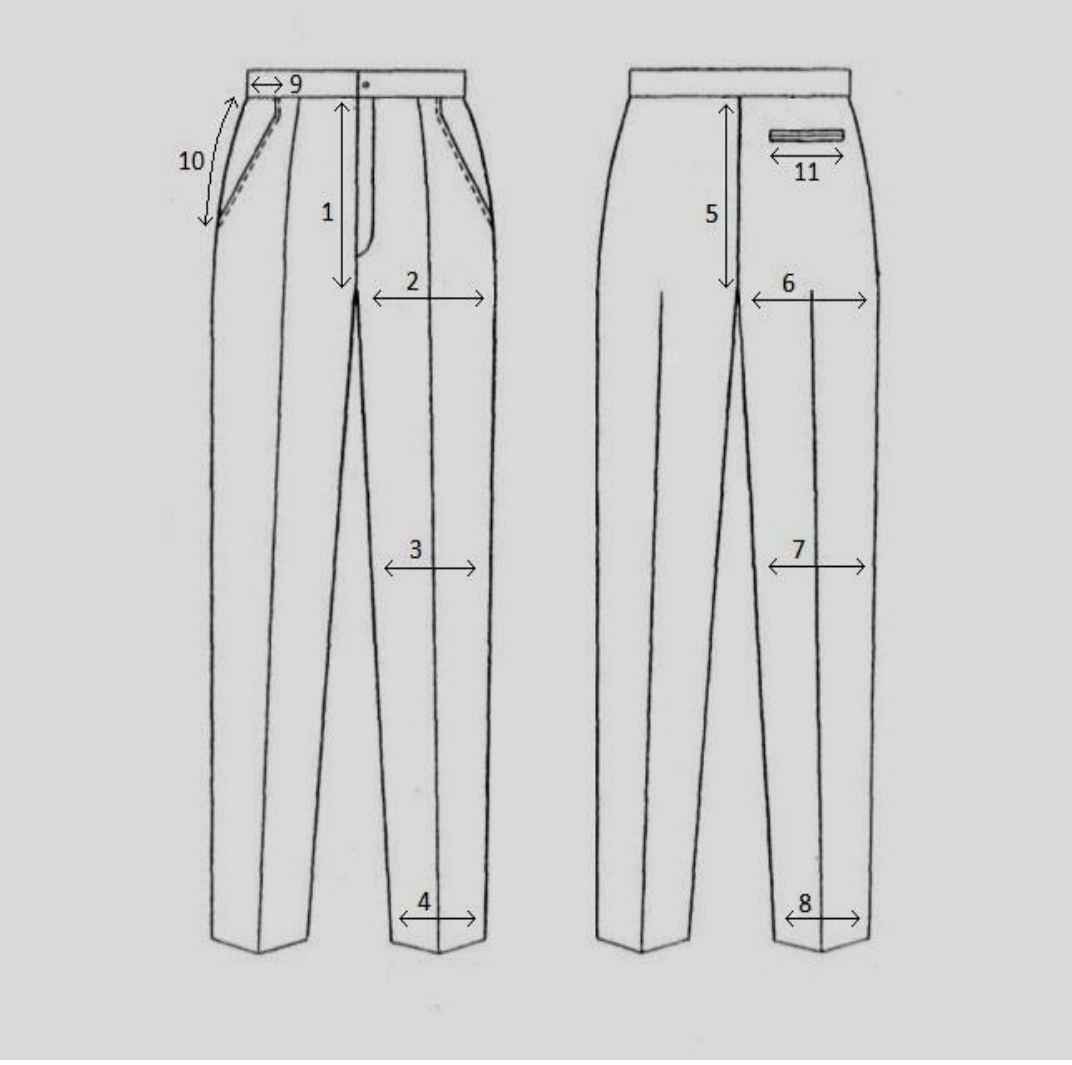


Figure 3.17. Measurement points of samples

Descriptions of the measure points are as below:

1. Front Crotch Length: Distance from just below the belt at the front center to the intersection crotch seamline and the inseam line.

2. Front Thigh Width: On front part the distance from the inseam to the side seam on the crotch seamline.

3. Front Knee Width: On front part the distance from the inseam to the side seam on the knee line.

4. Front Leg Bottom Width: On front part the distance from the inseam to the side seam on the bottom line.

5. Back Crotch Length: Distance from just below the belt at the back center to the intersection crotch seamline and the inseam line.

6. Back Thigh Width: On back part the distance from the inseam to the side seam on the crotch seamline.

7. Back Knee Width: On back part the distance from the inseam to the side seam on the knee line.

8. Back Leg Bottom Width: On front part the distance from the inseam to the side seam on the bottom line.

9. Pocket Width: Distance from side seam to initial point of pocket mouth.

10. Pocket Height: Distance from just below the belt to the endpoint of pocket on the side seamline.

11. Pocket Length: Distance from end to end of back pocket.

### 3.2.2. Detecting Body Measurements

The measured parts are shown as schematically in Figure 3.18. and Figure 3.19.

1. Hip Vertical Length: The vertical distance from initial point of sacral region to the bottom of the hip line.

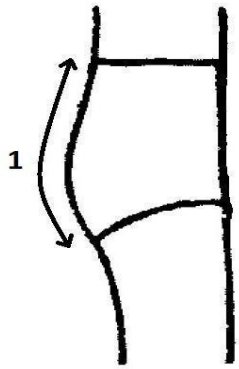


Figure 3.18. Measuring points of hip vertical length [63]

2. Thigh Circumference: The length of thigh circumference in parallel to the crotch line**.**

3. Knee Circumference: The measurement of the knee line.

4. Ankle Circumference: The measurement of the ankle line.

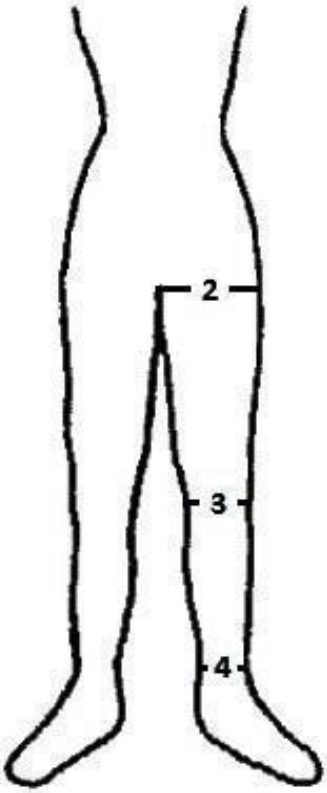


Figure 3.19. Measuring points of circumferences of thigh, knee, ankle [63]

### 3.3. Analyses and New Pants Design

Tablo 3.1. Comfort evalution table of sample 1

| SAMPLE 1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Survey Questions | Participants' Points | | | Average $(\bar{R}_i)$ | Standard Deviation $(\sigma_i)$ | Variance $(\sigma_i)^2$ | % Coefficient of Variation $(v_i)$ | Concordance |
| | A | B | C | | | | | |
| Crotch Length (Sitting Position) | 6 | 6 | 5 | 5,667 | 0,577 | 0,333 | 10,189 | High |
| Crotch Length (Walking Position) | 4 | 5 | 3 | 4,000 | 1,000 | 1,000 | 25,000 | Low |
| Crotch Length (Running Position) | 3 | 5 | 2 | 3,333 | 1,528 | 2,333 | 45,826 | Very Low |
| Thigh Circumference (Sitting Position) | 8 | 8 | 7 | 7,667 | 0,577 | 0,333 | 7,531 | Very High |
| Thigh Circumference (Walking Position) | 4 | 4 | 3 | 3,667 | 0,577 | 0,333 | 15,746 | Medium |
| Thigh Circumference (Running Position) | 4 | 4 | 3 | 3,667 | 0,577 | 0,333 | 15,746 | Medium |
| Knee Circumference (Sitting Position) | 6 | 7 | 5 | 6,000 | 1,000 | 1,000 | 16,667 | Medium |
| Knee Circumference (Walking Position) | 2 | 3 | 3 | 2,667 | 0,577 | 0,333 | 21,651 | Medium |
| Knee Circumference (Running Position) | 2 | 2 | 3 | 2,333 | 0,577 | 0,333 | 24,744 | Medium |
| Leg Bottom Circumference (Sitting Position) | 7 | 6 | 7 | 6,667 | 0,577 | 0,333 | 8,660 | Very High |
| Leg Bottom Circumference (Walking Position) | 5 | 5 | 4 | 4,667 | 0,577 | 0,333 | 12,372 | High |
| Leg Bottom Circumference (Running Position) | 5 | 3 | 3 | 3,667 | 1,155 | 1,333 | 31,492 | Low |
| Belt Loop Length | 6 | 5 | 5 | 5,333 | 0,577 | 0,333 | 10,825 | High |
| Side Pocket | 5 | 6 | 6 | 5,667 | 0,577 | 0,333 | 10,189 | High |
| Back Pocket | 1 | 1 | 1 | 1,000 | 0,000 | 0,000 | 0,000 | Very High |
| $R_i$ | 68 | 70 | 60 | | | | | |
| $\sum \bar{R}_i$ | 66 | | | | | | | |
| $(R_i - \sum \bar{R}_i)^2$ | 4 | 16 | 36 | | | | | |
| $m$-1 | 2 | | | | | | | |
| $\sigma_T$ | 5,291502622 | | | | | | | |
| % $v_T$ | 8,0174282 | | | | | | | |

Tablo 3.2. Comfort evalution table of sample 2

| SAMPLE 2 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Survey Questions | Participants' Points | | | Average ($\bar{R}_i$) | Standard Deviation ($\sigma_i$) | Variance $(\sigma_i)^2$ | % Coefficient of Variation ($v_i$) | Concordance |
| | A | B | C | | | | | |
| Crotch Length (Sitting Position) | 9 | 8 | 8 | 8,333 | 0,577 | 0,333 | 6,928 | Very High |
| Crotch Length (Walking Position) | 8 | 9 | 8 | 8,333 | 0,577 | 0,333 | 6,928 | Very High |
| Crotch Length (Running Position) | 8 | 9 | 8 | 8,333 | 0,577 | 0,333 | 6,928 | Very High |
| Thigh Circumference (Sitting Position) | 8 | 7 | 9 | 8,000 | 1,000 | 1,000 | 12,500 | High |
| Thigh Circumference (Walking Position) | 8 | 8 | 8 | 8,000 | 0,000 | 0,000 | 0,000 | Very High |
| Thigh Circumference (Running Position) | 8 | 7 | 8 | 7,667 | 0,577 | 0,333 | 7,531 | Very High |
| Knee Circumference (Sitting Position) | 10 | 9 | 9 | 9,333 | 0,577 | 0,333 | 6,186 | Very High |
| Knee Circumference (Walking Position) | 8 | 7 | 8 | 7,667 | 0,577 | 0,333 | 7,531 | Very High |
| Knee Circumference (Running Position) | 8 | 7 | 7 | 7,333 | 0,577 | 0,333 | 7,873 | Very High |
| Leg Bottom Circumference (Sitting Position) | 9 | 9 | 8 | 8,667 | 0,577 | 0,333 | 6,662 | Very High |
| Leg Bottom Circumference (Walking Position) | 9 | 7 | 8 | 8,000 | 1,000 | 1,000 | 12,500 | High |
| Leg Bottom Circumference (Running Position) | 8 | 7 | 8 | 7,667 | 0,577 | 0,333 | 7,531 | Very High |
| Belt Loop Length | 7 | 8 | 8 | 7,667 | 0,577 | 0,333 | 7,531 | Very High |
| Side Pocket | 10 | 9 | 10 | 9,667 | 0,577 | 0,333 | 5,973 | Very High |
| Back Pocket | 10 | 10 | 10 | 10,000 | 0,000 | 0,000 | 0,000 | Very High |
| $R_i$ | 128 | 121 | 125 | | | | | |
| $\sum \bar{R}_i$ | 124,6666667 | | | | | | | |
| $(R_i - \sum \bar{R}_i)^2$ | 11,11 | 13,44 | 0,111 | | | | | |
| $m$-1 | 2 | | | | | | | |
| $\sigma_T$ | 3,511884584 | | | | | | | |
| % $v_T$ | 2,8170179 | | | | | | | |

Tablo 3.3. Comfort evalution table of sample 3

| SAMPLE 3 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Survey Questions | Participants' Points | | | Average $(\bar{R}_i)$ | Standard Deviation $(\sigma_i)$ | Variance $(\sigma_i)^2$ | % Coefficient of Variation $(v_i)$ | Concordance |
| | A | B | C | | | | | |
| Crotch Length (Sitting Position) | 7 | 7 | 6 | 6,667 | 0,577 | 0,333 | 8,660 | Very High |
| Crotch Length (Walking Position) | 4 | 6 | 5 | 5,000 | 1,000 | 1,000 | 20,000 | Medium |
| Crotch Length (Running Position) | 4 | 5 | 4 | 4,333 | 0,577 | 0,333 | 13,323 | High |
| Thigh Circumference (Sitting Position) | 9 | 8 | 8 | 8,333 | 0,577 | 0,333 | 6,928 | Very High |
| Thigh Circumference (Walking Position) | 5 | 4 | 5 | 4,667 | 0,577 | 0,333 | 12,372 | High |
| Thigh Circumference (Running Position) | 5 | 4 | 5 | 4,667 | 0,577 | 0,333 | 12,372 | High |
| Knee Circumference (Sitting Position) | 7 | 7 | 6 | 6,667 | 0,577 | 0,333 | 8,660 | Very High |
| Knee Circumference (Walking Position) | 4 | 5 | 4 | 4,333 | 0,577 | 0,333 | 13,323 | High |
| Knee Circumference (Running Position) | 3 | 4 | 4 | 3,667 | 0,577 | 0,333 | 15,746 | Medium |
| Leg Bottom Circumference (Sitting Position) | 8 | 7 | 7 | 7,333 | 0,577 | 0,333 | 7,873 | Very High |
| Leg Bottom Circumference (Walking Position) | 7 | 6 | 5 | 6,000 | 1,000 | 1,000 | 16,667 | Medium |
| Leg Bottom Circumference (Running Position) | 6 | 5 | 5 | 5,333 | 0,577 | 0,333 | 10,825 | High |
| Belt Loop Length | 6 | 5 | 5 | 5,333 | 0,577 | 0,333 | 10,825 | High |
| Side Pocket | 5 | 4 | 5 | 4,667 | 0,577 | 0,333 | 12,372 | High |
| Back Pocket | 10 | 8 | 10 | 9,333 | 1,155 | 1,333 | 12,372 | High |
| $R_i$ | 90 | 85 | 84 | | | | | |
| $\sum \bar{R}_i$ | 86,33333333 | | | | | | | |
| $(R_i - \sum \bar{R}_i)^2$ | 13,44 | 1,778 | 5,444 | | | | | |
| $m$-1 | 2 | | | | | | | |
| $\sigma_T$ | 3,214550254 | | | | | | | |
| % $v_T$ | 3,7234173 | | | | | | | |

Tablo 3.4. Comfort evalution table of sample 4

| SAMPLE 4 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Survey Questions | Participants' Points | | | Average $(\bar{R}_i)$ | Standard Deviation $(\sigma_i)$ | Variance $(\sigma_i)^2$ | % Coefficient of Variation $(v_i)$ | Concordance |
| | A | B | C | | | | | |
| Crotch Length (Sitting Position) | 7 | 5 | 7 | 6,333 | 1,155 | 1,333 | 18,232 | Medium |
| Crotch Length (Walking Position) | 8 | 7 | 7 | 7,333 | 0,577 | 0,333 | 7,873 | Very High |
| Crotch Length (Running Position) | 8 | 6 | 7 | 7,000 | 1,000 | 1,000 | 14,286 | High |
| Thigh Circumference (Sitting Position) | 6 | 4 | 5 | 5,000 | 1,000 | 1,000 | 20,000 | Medium |
| Thigh Circumference (Walking Position) | 6 | 6 | 7 | 6,333 | 0,577 | 0,333 | 9,116 | Very High |
| Thigh Circumference (Running Position) | 7 | 5 | 6 | 6,000 | 1,000 | 1,000 | 16,667 | Medium |
| Knee Circumference (Sitting Position) | 10 | 9 | 9 | 9,333 | 0,577 | 0,333 | 6,186 | Very High |
| Knee Circumference (Walking Position) | 9 | 8 | 8 | 8,333 | 0,577 | 0,333 | 6,928 | Very High |
| Knee Circumference (Running Position) | 9 | 8 | 8 | 8,333 | 0,577 | 0,333 | 6,928 | Very High |
| Leg Bottom Circumference (Sitting Position) | 6 | 6 | 7 | 6,333 | 0,577 | 0,333 | 9,116 | Very High |
| Leg Bottom Circumference (Walking Position) | 4 | 5 | 4 | 4,333 | 0,577 | 0,333 | 13,323 | High |
| Leg Bottom Circumference (Running Position) | 4 | 4 | 3 | 3,667 | 0,577 | 0,333 | 15,746 | Medium |
| Belt Loop Length | 6 | 5 | 5 | 5,333 | 0,577 | 0,333 | 10,825 | High |
| Side Pocket | 10 | 10 | 10 | 10,000 | 0,000 | 0,000 | 0,000 | Very High |
| Back Pocket | 10 | 8 | 10 | 9,333 | 1,155 | 1,333 | 12,372 | High |
| $R_i$ | 110 | 96 | 103 | | | | | |
| $\sum \bar{R}_i$ | 103 | | | | | | | |
| $(R_i - \sum \bar{R}_i)^2$ | 49 | 49 | 0 | | | | | |
| $m$-1 | 2 | | | | | | | |
| $\sigma_T$ | 7 | | | | | | | |
| % $v_T$ | 6,7961165 | | | | | | | |

**Method of Expert Assessments**

The method of expert assessments includes the following steps:

- Grouping of the experts,
- Preparing the assessments of experts,
- Enforcing of the evaluations by experts,
- Analysing of experts' evaluations.

This method can be applied in any cases where there is not an objective criteria to make a decision, for instance; to investigate the consumers demands about quality parameters, to determine which series of fabric samples and clothing models will be produced, to determine a category that the products belong it due to the processing errors, to evaluate the immeasurable parameters. The method is referred to in some references as a method of for experts voting [64].

- $(v_i)$ - coefficient of variation of the assessments of experts for parameter *i*,
- $(\sigma_i)$ - standard deviation of the assessments of experts for parameter *i*,
- $\bar{R}_i$ - the average value of assessments of experts for parameter *i*,
- $R_{ij}$ - the value of expert number *j* for parameter *i*,
- $m$ - number of experts.

$$\sigma_i = \sqrt{\frac{\sum_{j=1}^{m}\left(R_{ij}-\bar{R}_i\right)^2}{m-1}} \quad \text{(Eq.1)}$$

$$v_i = \frac{100\sigma_i}{\bar{R}_i} \quad \text{(Eq.2)}$$

If the coefficient of variation $(v_i)$ increases, the concordance value of experts decreases. The following table is used to evaluate the concordance of expert assessments.

Table 3.5. The classification of quality parameters of product

| Coefficient of variation, $v_i$ | Concordance |
|---|---|
| $v_i < 10$ | Very High |
| $10 \leq v_i < 15$ | High |
| $15 \leq v_i < 25$ | Medium |
| $25 \leq v_i < 35$ | Low |
| $v_i \geq 35$ | Very Low |

On the tables, besides comfort levels, concordance of experts evaluations throughout the tables are also calculated. Formulas of the calculations are given below [64]:

- $(\sigma_T)$ - standard deviation of the table,
- $(v_T)$ - coefficient of variation of the table.

$$\sigma_T = \sqrt{\frac{\sum_{j=1}^{m}(R_i - \sum \bar{R}_i\ )^2}{m-1}} \quad \text{(Eq.3)}$$

$$v_T = \frac{100\sigma_T}{\sum \bar{R}_i} \quad \text{(Eq.4)}$$

Sample 2 has the lowest CV compared to other samples and it means that, the table of sample 2 as a whole is the best consistent assessment. Besides, the highest average score belongs still sample 2. Thereby, the best comfort perception is ensured with sample 2.

### 3.3.1. Crotch Length Analysis

The length of crotch is an effective parameter of active movement, such as walking, running, sitting, squatting positions. When the crotch length is out of minimum and maximum length limits, it firstly effects the comfort of movement. If the length is

longer than the maximum limit, it causes wrinkle, baggy appearance on the fabric and then user feels uncomfortable. If the length is less than required limit, it causes also discomfort.

Previous studies determined that; in squatting position, extension ratio of buttocks vertical length is about % 27-35, horizontal length is about % 15-20. In this study, crotch length examined in terms of sitting position [4]. Measurements of buttocks vertical length and percentage of change are shown in table 3.6.

Table 3.6. Buttocks vertical length and percentage of change

| | Participant A | Participant B | Participant C |
|---|---|---|---|
| Upright Position | 30,8 cm | 31,6 cm | 30,5 cm |
| Sitting Position | 35,6 cm | 36,3 cm | 35,7 cm |
| % Change | %15,58 | %14,87 | %17,04 |

$$\% \text{ Change} = \frac{(\text{Sitting Position} - \text{Upright Position}) \times 100}{\text{Upright Position}} \quad \text{(Eq.5)}$$

As it is shown on the above table, the percentage change in vertical length of the buttocks varies for each user. The percentage changes of body measurements have different values in squatting and sitting positions, because the degrees of movements are different. In squatting position, minimum percentage change of the vertical length of buttocks is approximately % 12 higher when compared to the sitting position.

Table 3.7. Crotch length measurements and total points for each sample

| | Crotch Length | Total Points |
|---|---|---|
| Sample 1 | 71,6 cm | 39 pts |
| Sample 2 | 64,3 cm | 75 pts |
| Sample 3 | 68,7 cm | 48 pts |
| Sample 4 | 61,5 cm | 62 pts |

In sitting position the average value of users' buttocks vertical length is 36,5 cm. As it can be seen on the table above, crotch lengths of samples have different dimensions. The total scores are analyzed and it is observed that; users are uncomfortable with the higher and lower lengths than optimum value. Users explained the reason of discomfort as the looseness in crotch, especially in walking and running positions.

Sample 2 provides the best comfort with its 64,3 cm crotch. When sample 2 compared with the sample 4 which has 61,5 cm length of crotch, it is understood that sample 4 causes much discomfort feeling for users.

In sample 1, higher crotch length caused feeling discomfort in each of the 3 positions and mostly in the running position. Participants explained this case as looseness and bagginess in both of front and back parts. According to the point table, comfort sense of participant B is better than A and C. This situation can be explained by higher vertical length of buttocks of participant B than others'. Sample 1 caused users felt uncomfortable in terms of crotch curve. When the sample was analyzed, it is seen that the crotch has much curved structure. This curve creates looseness in the back therefore it causes a negative impact on the users.

Sample 2 provides high comfort level to all participants in each position. Participants A and C felt the low level of comfort compared with participant B, because their

vertical length of buttocks are shorter than participant B's. The back crotch curve of sample 2 is inside compared with sample 1 and sample 3, and this situation ensures pants to be fit on users.

Participants perceived a relatively high level of comfort in sample 3 compared to sample 1. Crotch length difference is 2,9 cm and this causes diversity on comfort level. The reason of discomfort can be explained with the longer crotch length of sample 1. It causes pants to hang loosely between legs, especially in positions of walking and running.

When compared the points which are given by participants, it is seen that; total score of participant B's is higher than participants A's and C's. This is associated with the higher vertical length of the buttocks of participant B compared with others'. The back crotch curve of sample 2 is less than the crotch curve of sample 1, so it reduces the degree of bagginess on crotch.

In sample 4, the values of comfort appear slightly lower than sample 2. It depends on the 2,8 cm difference of crotch lengths between two samples, particularly low front crotch length. Comfort sense of participant B is lower than other participants, because of his longer vertical length of buttocks. Crotch curve of sample 4 is similar sample 2's. In the buttocks, sample 2 and sample 4 fit on body better than sample 1 and sample 3.

When the point table is analyzed to determine the optimal crotch length, it is understood that; the vertical length of buttocks is highly important. Body measurements which varied from person to person, proves that the ready-to-wear has not an exactly standard.

### 3.3.2. Thigh Circumference Analysis

Thigh circumference is an effective parameter on users to feel comfort in walking and running positions. If the width is more than necessary, it causes users' feeling discomfort in walking and running positions. Optimum width values of the samples should be evaluated by considering thigh circuit of users in sitting position. In this study, pants were examined in sitting, walking and running positions. Measurements of thigh circumferences and percentage of change are shown in Table 3.8.

Table 3.8. Thigh circumference measurements and percentage of change

| | Participant A | Participant B | Participant C |
|---|---|---|---|
| Upright Position | 60,5 cm | 61,2 cm | 58,4 cm |
| Sitting Position | 65,1 cm | 66,4 cm | 63,1 cm |
| % Change | % 7,60 | % 8,49 | % 8,04 |

As it can be seen on the above table, thigh circumferences and the percentage change values vary for each user. On the following table, thigh circumferences of the different samples and the total comfort scores are shown (see Table 3.9).

Table 3.9. Thigh circumference measurements and total points for each sample

| | Thigh Circumference | Total Points |
|---|---|---|
| Sample 1 | 72,9 cm | 45 pts |
| Sample 2 | 70,6 cm | 71 pts |
| Sample 3 | 71,5 cm | 53 pts |
| Sample 4 | 67,9 cm | 52 pts |

In sitting position, the average value of thigh circumferences of users is 64,8 cm. As seen on the table, there are differences on thigh circumferences of samples. When the total scores of the samples are examined, it is detected that; sample 2 provides the best comfort level with its 70,6 cm circumference to participants. It is observed that comfort grades of other samples are considerably lower than sample 2.

Participants got a good comfort with sample 1 which has 72,9 cm thigh circumference, in sitting position. In addition, the values of comfort significantly reduce in walking and running positions. When scoring is analyzed, the participant C's comfort sense appears to be relatively lower compared to other users. This is related with the shorter thigh circumference of participant C. Participants explained the reason of discomfort which depends on loose thigh, as hanging folds at the buttocks and formation bagginess in crotch area in walking and running positions. The looseness that consists in crotch part is also related with longer croth length.

There is 2,3 cm difference between sample 1 and sample 2, and this difference effects value of comfort. In sample 2, the users have quite high perception of comfort in all positions. The comfort grade of participant B is lower than the others' in the sitting and running positions. This case depends on the thigh circumference of participant participant B is longer and regarding to this, the looseness allowance in pants is less than other testers.

The circumference length of sample 3 is 1,4 cm shorter than sample 1 and it effects the comfort level. In sample 3, the participants have quite high perception of comfort in sitting position. In addition, the grades of comfort dramatically decrease in walking and running positions. As in the sample 1, participants explained same reason for discomfort feeling and this depends on loose thigh and as the formation of bagginess in crotch area, particularly in walking and running positions.

Sample 4 is the tightest sample in terms of thigh width with its 67,9 cm circumference. When the assessment of sample 4 is analyzed, the situation appears different than other samples. Sample 4 presented users a moderate perception of comfort in particular sitting position. It is the only non-pleated model between all samples and thigh circumference is shorter due to the model is non-pleated. The other three models are pleated pants and it's obvious that their thigh widths are wider than model 4. As it is understood in the results, pleat is a property which ensures user relaxing effect on motion especially in thighs and hip parts of pants. By considering the all users' scorings, it's seen that participant B has lower comfort level than other participants. Particularly in sitting position, comfort is on medium level. This case results from thigh circumference in sitting position and thigh width of pants that are very close to each other.

By taking into consideration the all samples, it’s obvious that extremely wide or tight thigh circumference cause users to feel discomfort.

### 3.3.3. Knee Circumference Analysis

Knee width of pants should be enough in order not to restrict the freedom of knee movements. If the width is more than necessary, it causes the user to feel discomfort as a limiting factor on walking and running. If the width is less than necessary, it also causes the user to feel discomfort, especially in sitting and squatting positions.

Previous studies determined that, in squatting position, the vertical extension ratio of knee circumference is around % 41-52 and the horizontal is about % 19-29 [4]. In this study, knee circumference is examined in terms of sitting, walking and running positions. Measurements of knee circumference and percentage of change are shown on table 3.10.

Table 3.10. Knee circumference measurements and percentage of change

| | Participant A | Participant B | Participant C |
|---|---|---|---|
| Upright Position | 38,4 cm | 41,1 cm | 40,2 cm |
| Sitting Position | 42,2 cm | 44,6 cm | 44,0 cm |
| % Change | % 9,89 | % 8,52 | % 9,45 |

Each participant has a different percentage change of knee circumference as it is seen on the above table. Different individuals may have the same size but regional measurements' differences can be observed.

In squatting position, the minimum percentage change of knee circumference is approximately % 10 more than the sitting position when we compared. In this study, pants were tried and evaluated in terms of the knee circumference like as crotch length, tight circumference analyses. On the following table, knee circumferences of the different samples and the total points can be seen (see Table 3.11).

Table 3.11. Knee circumference measurements and total points for each sample

| | Knee Circumference | Total Points |
|---|---|---|
| Sample 1 | 63,2 cm | 33 pts |
| Sample 2 | 57,9 cm | 73 pts |
| Sample 3 | 61,8 cm | 44 pts |
| Sample 4 | 56,3 cm | 78 pts |

In sitting position, the average value of users' knee circumferences is 43,6 cm. As seen on the table, knee circumferences of samples have differences. When the total scores are analyzed, it is observed that; participants are uncomfortable with wider widths.

Sample 4, which has 56,3 cm knee circumference, provides the best comfort level in all samples. As the reason of discomfort sense of other samples, participants explained that extra looseness restricts movement especially in walking and running positions.

Sample 1 is the widest sample in terms of knee width between all the samples with its 63.2 cm circumference. This width causes a decrease on level of comfort. It is obvious that the comfort senses of participants are lower in all positions. When the point table is analyzed, it is understood that participants felt the most discomfort sense in walking and running movements. Participants explained this case with the touching of the knee areas of two legs while stepping. In addition, this is indicated with the feeling psychological (aesthetical) discomfort which depends on looseness. For these reasons, sample 1 causes the lowest comfort perception in all samples.
Knee circumference of sample 2 is 5,3 cm shorter than sample 1's. Comfort level of sample 2 is at a quite good level in sitting position. However values are relatively reduced in walking and running positions.

As sample 1, participants explained the same reason for discomfort sense and this is caused by loose knee width with touching the knee areas of two legs particularly in walking and running movements.

Sample 3 has 1,4 cm tighter width when compared with sample 1 in terms of knee circumference. However, regarding to this difference, it is seen that the comfort perception of sample 3 is relatively higher than sample 1. Sample 3 presented a comfort grade, which is under medium level, to users in particular walking and running positions. Participants explained the reason of uncomfortableness with the usage difficulties which depends on looseness, as in sample 1 and sample 2. Comfort evaluation of participant B is comparatively higher than the other users'. This case is associated with the higher length of knee circumference of participant B.

When the point tables are analyzed for the sample 4, it is seen that the users reached almost the perfect comfort level. If sample 4 compared with the sample 1, there is 6,9 cm differences between knee circumferences. It has been determined that; the difference provides a significant increase in comfort particularly in walking and running movements. Reduction of knee width means shortening the length of circumference and relatively the looseness of pants also decrease. However, the reduction should protect the necessary looseness which ensures user smooth movement.

### 3.3.4. Leg Bottom Circumference Analysis

Leg bottom circumference is an important parameter for pants models to ensure a comfortable stepping movement. If the width is more than necessaried level, this causes user to feel discomfort as a limiting factor in walking and running positions. If the width is less than necessary, this also causes user to feel discomfort especially in sitting and squatting positions.

Leg bottom width provides a sense of comfort depending upon the user's ankle circumference. Ankle is one of the most important parts to feel comfort during active movement such as walking and running. To reduce the sense of discomfort in this part means to increase freedom of movement. Measurements of ankles circumferences of participants are shown in table 3.12.

Table 3.12. Ankle circumference measurements

| | Participant A | Participant B | Participant C |
|---|---|---|---|
| Upright Position | 23,8 cm | 25,1 cm | 24,9 cm |

On the following table, leg bottom circumferences of the different samples and the total points given by users are shown.

Table 3.13. Leg bottom circumference measurements and total points for each sample

| | Leg Bottom Circumference | Total Points |
|---|---|---|
| Sample 1 | 47,6 cm | 45 pts |
| Sample 2 | 44,5 cm | 73 pts |
| Sample 3 | 46,7 cm | 56 pts |
| Sample 4 | 48,1 cm | 43 pts |

When the total points are analyzed, it is observed that; users are uncomfortable with the wider leg bottom widths. Sample 2 with its 44,5 cm leg bottom circumference has the best comfort level between all samples. For other samples, participants explained that the reason of discomfort sense depends on eexcessive looseness that restricts movements, particularly in walking and running positions.

In sample 1, participants felt a mid-level comfort in all positions, including sitting position. Particularly in walking and running positions, excessive looseness causes the touching of each leg bottom areas and restricts movement while stepping. For this reason, users evaluated 47,6 cm leg bottom circumference is a parameter that causes a sense of uncomfortable. Circumferences of thigh and knee regions of sample 1 are also higher than other samples'. Participants made the assessment of

comfort by taking consideration of the psychological (aesthetic) comfort. As conclusion, it has been found that excessive looseness causes discomfort.

Sample 2, with its 44,5 cm width, has the narrowest leg bottom circumference and provides the best comfort grade between all samples. When point table is analyzed, it seems that all participants perceived a high comfort in all positions. The high level of comfort which is provided by sample 2 proves that, in fact, the comfort is not always provided via looseness and wide width. Since the perception of comfort, is a concept that brings together many evaluation. The factor, which effects the perception of participants' comfort in sample 2, is movement comfort as well as psychological comfort (aesthetic) comfort.

Sample 3 is similar sample 1 in terms of the width of leg bottom. Although the difference in length 0.9 cm, these samples have different comfort assessment. On the difference of comfort grades, thigh and knee circumferences of samples are also effective. Although all these are separate parts from each other however looseness, which is felt from thigh to leg bottom, effects the user's perception of comfort. Sample 3 provided participants a good level of comfort in sitting position. However, in walking and running positions, it is affected by foot movements and a decrease is seen on comfort level. This case, as mentioned in sample 1, is explained with that; excessive looseness causes touching of each leg bottom areas to each other and restrict movement while stepping.

Sample 4, which has 48.1 cm leg bottom circumference, provides the lowest comfort perception to participants between all samples. It can be said that; users perceived a better comfort grade in sitting position when we compared to walking and running positions, based on the point table. This leg bottom circumference caused users felt low level of comfort in walking and running movements, because the leg bottom parts are touching to each other while stepping.

### 3.3.5. Belt Loop Length Analysis

The width of belts, which are used for daily pants, varies between 3-3.5 cm and average width of the belts that are used for uniforms is 4,5-5 cm [65]. The length of

belt loop should be set depending on the width of the belt that will be used. Otherwise, difficulties will arise during usage.

Security guards can carry guns on their waists as a matter of their job. The average weight of a gun with its magazine is around 1100-1200 grams. Regarding to their job definition, the security guards can carry other auxiliary equipment such as truncheons, handcuffs together with the gun and therefore the load weight increases on the waist line of pants. These equipments certainly should be supported by a thick belt to carry them in a comfortable way. This is essential especially in active movement positions in which body stretches. For this reason police officers, soldiers and security guards use wider belts on their uniforms. Belt loop length measurements are given in Table 3.14.

Table 3.14. Belt loop length measurements and total points for each sample

| | Belt Loop Length | Total Points |
|---|---|---|
| Sample 1 | 4,5 cm | 16 pts |
| Sample 2 | 5,0 cm | 23 pts |
| Sample 3 | 4,5 cm | 16 pts |
| Sample 4 | 4,5 cm | 16 pts |

Participants were forced to use 4,5 cm length of belt loop in sample 1, sample 3 and sample 4. Participants explained the reason of discomfort as the shortness of belt loops and it is stated that the belt is placed in belt loop difficultly and also caused the low level of comfort on the waist line.

In sample 2, the length of belt loop is 0,5 cm longer than other samples. The difference is enabled to increase the comfort level. Besides, participants stated that the 5,0 cm belt loop length is still not enough to get perfect usage comfort. Even the

width of belt and the length of belt loop are in the same dimension, there is a difficulty due to the friction while placing the belt into the loops.

### 3.3.6. Side Pocket Analysis

Side pockets are an effective parameter in terms of aesthetic comfort of pants. Pocket width and pocket length should be in usable sizes. Putting hands into the pocket comfortably, pocket mouths not to open in sitting position and the absense of risk of falling the objects that are in pocket, makes pants functional. Pocket width and pocket heigth of the samples, which are used in this study, are in different values. Width and heigth measurements of different samples and the total points that were given by users, are shown on the Table 3.15.

Table 3.15. Pocket (width and heigth) measurements and total points for each sample

| | Pocket Width | Pocket Heigth | Total Points |
|---|---|---|---|
| Sample 1 | 5,5 cm | 17,5 cm | 17 pts |
| Sample 2 | 3,0 cm | 17,0 cm | 29 pts |
| Sample 3 | 6,5 cm | 17,5 cm | 14 pts |
| Sample 4 | 3,5 cm | 19,0 cm | 30 pts |

As it can be seen on the table, each sample has a different score, depending on the size of pockets. When total scores are evaluated, we can say that the increases and decreases in values mostly depend on width of pocket. Wider pocket widths caused users felt discomfort.

The sense of discomfort, which is a result of 5,5 cm pocket width in sample 1, is stated as formation looseness on the mouth of pocket by participants. Psychological (aesthetic) comfort has a fundamental importance on the assessment.

3,0 cm pocket width in sample 2, is enabled to increase the comfort grade. Participants stated that the width of pocket is enough to ensure a good aestehetic appearance and also functionality of usage.

Sample 3 has the widest pocket mouth between all samples. As it can be understood from the point table, sample 3 got the minimum score compared to other samples. Participants explained the reason of low level of comfort as formation looseness on the pocket mouth.

Sample 4 provided the best comfort level with its 3,5 cm pocket mouth in all samples. The pocket height of sample 4 is also higher than other samples'. However, the difference in heigth has not an efficient role for comfort evaluation. The standard size of pocket heigth is around 18 cm ± 1 cm.

### 3.3.7. Back Pocket Analysis

Back pocket is a feature that affects the aesthetic comfort and functionality rather than the comfort of movement. The length of back pocket, is important in terms of usability. If the length of pocket is more or less than the required dimensions, the degree of functionality decreases. Pocket length of pants which are used in this study as samples and the total points given by participants are shown in Table 3.16.

Table 3.16. Pocket (length) measurements and total points for each sample

| | Pocket Length | Total Points |
|---|---|---|
| Sample 1 | --- | 3 pts |
| Sample 2 | 13,0 cm | 30 pts |
| Sample 3 | 14,0 cm | 28 pts |
| Sample 4 | 14,0 cm | 28 pts |

In sample 1, there isn't pocket on back. Because of this reason, total score is significantly low compared to other samples. Sample 2, sample 3 and sample 4 provides a good level of comfort in terms of usage of pocket.

### 3.3.8. New Pants Design

After analyzed the pants that were examined in this study, new pants pattern was designed in the direction of feedbacks of participants. New pattern has been achieved by a number of regulations on sample 2 which has the best score in terms of comfort. While designing, the specific regions of pants were taken in, such as; crotch, thigh, knee and especially leg bottom. The functionality of new pattern is expected to be higher than the other samples. Shortenings and lengthenings of measurements are shown in Table 3.17 and Table 3.18.

Table 3.17. Adjustment (shortening) values on pattern 2 to design new pattern

| | Front Pattern | Back Pattern |
|---|---|---|
| Crotch Length | 0,5 cm | 0,5 cm |
| Thigh Circumference | 1,0 cm | 0,5 cm |
| Knee Circumference | 1,5 cm | 1,5 cm |
| Leg Bottom Circumference | 0,5 cm | 1,5 cm |

Table 3.18. Adjustment (lengthening) values on pattern 2 to design new pattern

| | Sample 2 | New Pattern |
|---|---|---|
| Belt Width | 4,5 cm | 5,5 cm |
| Belt Loop Length | 5,0 cm | 5,5 cm |

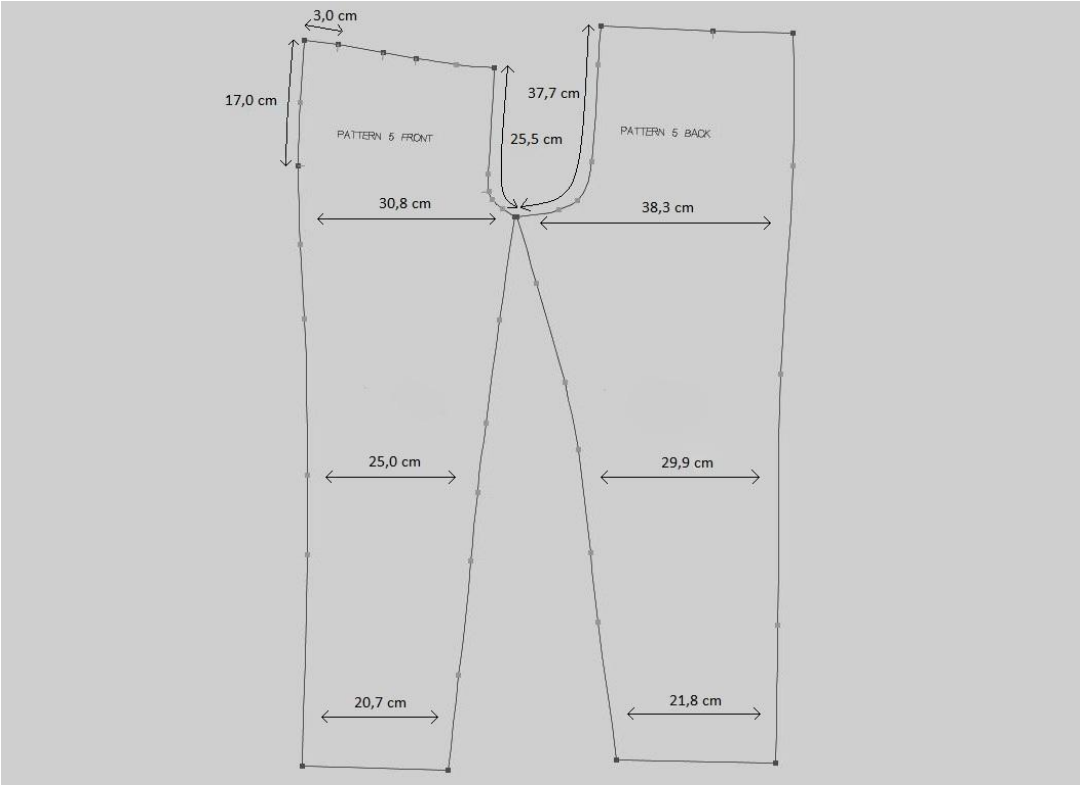


Figure 3.20. Dimensioned image of new pattern

Crotch length was shortened in total 1,0 cm and thigh circumference length was decreased in total 1,5 cm. The most important regulation was made on knee circumference length, as a decrease in total 3,0 cm and also the circumference length of leg bottom was decreased in total 2,0 cm, to ensure easy movement in walking and running positions.


Figure 3.21. Dimensioned image of belt of new pattern

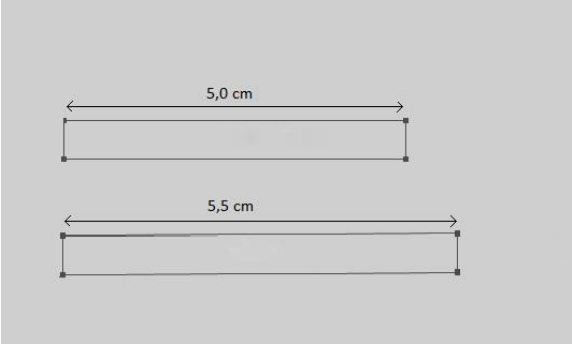


Figure 3.22. Dimensioned image of belt loop of new pattern

In new sample, belt and belt loop were also arranged in accordance with the demands of participants. The width of belt was expanded 1,0 cm to strengthen the waistline while carrying the equipments. The length of belt loop was extended 0,5 cm to easy placing the belt into the belt loop.

# CHAPTER 4

## DISCUSSIONS AND CONCLUSIONS

Ergonomic work clothes that are appropriate to the intended use, don't cause workers discomfort. Because of the functionality of work clothes is directly proportional to the body measurements, work clothes should be prepared taking into account the anthropometric dimensions. The functional properties of work clothes are appropriate to the industry used for. In this study, pants were analyzed in terms of the compliance to the participants' body measurements. Taking into account the security guards, it was observed that; even the smallest differences on patterns were affected the perception of comfort. Pants were evaluated by examining the parts separately. However, pants were considered as a whole to determine the perception of overall comfort. As a result it was determined that; the two of samples are very loose and therefore they cause difficulty in use.

If security guards are uncomfortable with their uniforms during the working period, it affects adversely their work efficiency, because they will lose attention and they will be thinking about their clothes. Workers should primarily have motion comfort and also clothing comfort psychologically. Garment that have motion comfort doesn't block or restrict the movements of user. Psychological comfort is the positive effects that varies from person to person, because each user's expectation from garments is different.

In this study, the types of pants that are produced for the security guards were examined. According to the analyses, loose parts of pants revealed negative results results in terms of movement comfort and psychological comfort. These results prove that; the concepts of comfort and looseness are not directly proportional in all conditions.

Security guards who assess the comfort of pants, had a significantly lower perception of comfort in sample 1 and sample 3. The main reason for the discomfort is that; both samples have large dimensions. Sample 1 and sample 3 proved the opposite of

judgment; "loose-fitting clothes are comfortable". Because, even a person moves comfortably, he can feel discomfort in term of psychological (aesthetic) comfort. A contrary situation can also happen; people feel themselves aesthetically perfect, on the other hand the movement ability may be minimal. For this reason, the comfort is a complex concept and should be evaluated by considering many aspects. In this study, as well as the ability to movement, the aesthetic appearance of pants were also evaluated.

Both sample 2 and sample 4 are similar to fit cut, compared with sample 1 and sample 3, nevertheless the best comfort grades both samples have. The garment which fits well on the body, does not mean the movement comfort will reduce. The essential point is that; user should be satisfied with the psychological comfort.

In general comfort, sample 2 has the best levels in all samples. The reason of the highest grade of comfort is that; the pattern as a whole designed in approximately optimum measurements. When the sample is evaluated in terms of crotch length, thigh-knee and leg bottom circumferences, it's seen that, sample 2 has the appropriate dimensions, so this case ensures higher level of comfort.

Participants felt the most intense discomfort on the parts of knee and leg bottom. The reason of the discomfort is that; circumferences of knee and leg bottom are looser than required dimensions. And the looseness caused a negative impact on user in walking and running movements.

In accordance with the feedbacks that were given by security guards, new pattern was designed alternatively. Pattern 5 was designed by arranging sample 2. New pattern was created suitable to the demands of users by taking in the parts of knee and leg bottom and also belt loop length.

The effects of looseness of pants were searched in this study, by considering comfort of physical and psychological. For the future studies, as well as pants, the following points are recommended to investigate:

- Examining the comfort properties (irritation, perspiration, friction etc.) of fabrics that are used for security guards pants,

- Investigating the comfort grades of security guards shirts, jackets and coats by examining the patterns,
- Searching new models of uniforms that provides easy movement and also fits on body well.
- Investigating the auxiliary materials of uniforms such as reflector, zipper, hook and loop etc.

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**APPENDIX**

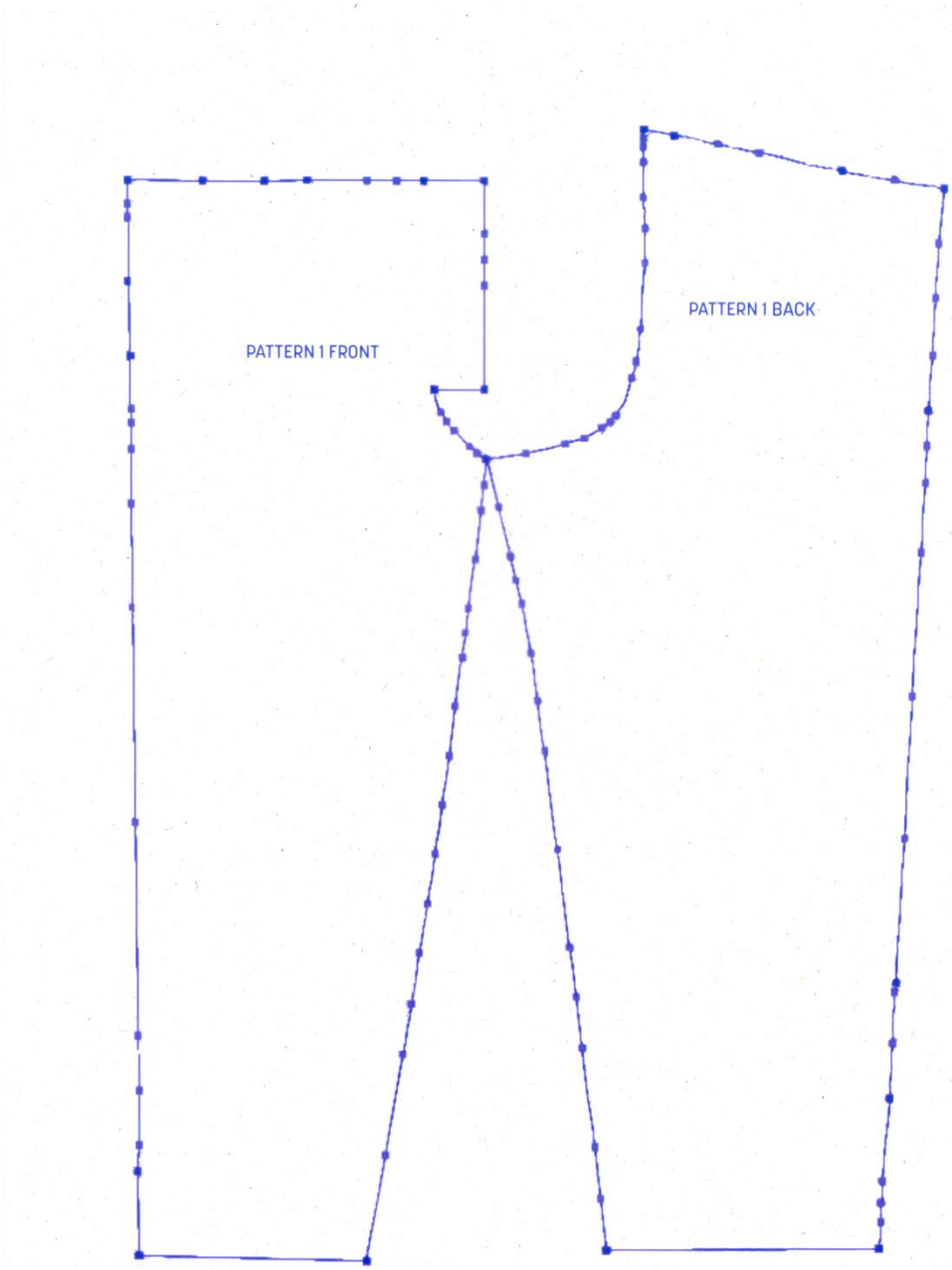


Figure 1. Pattern of sample 1

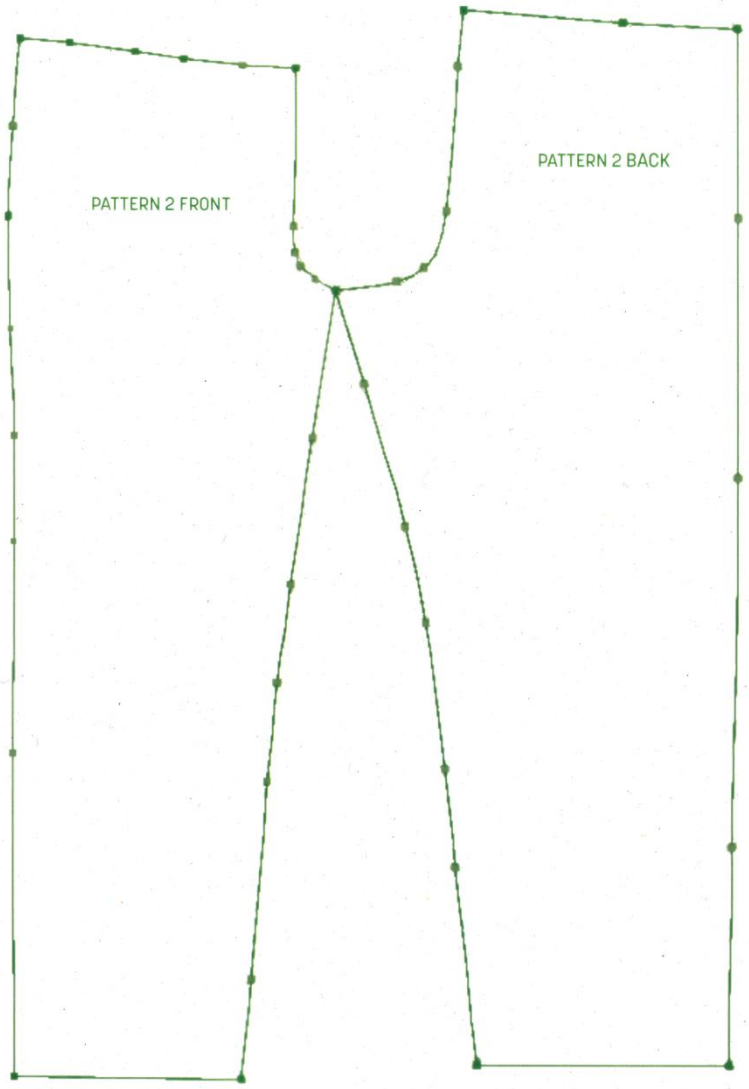


Figure 2. Pattern of sample 2

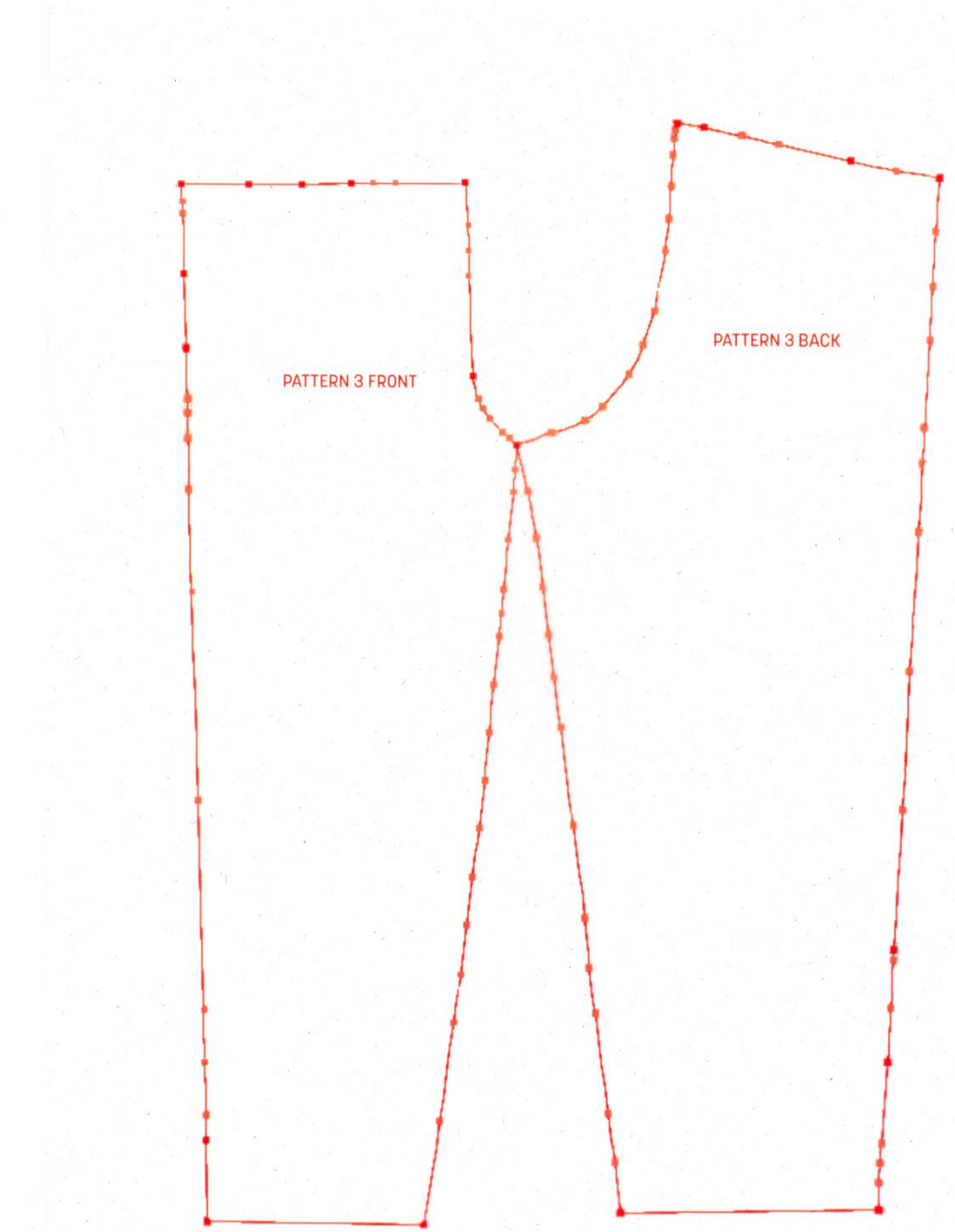


Figure 3. Pattern of sample 3

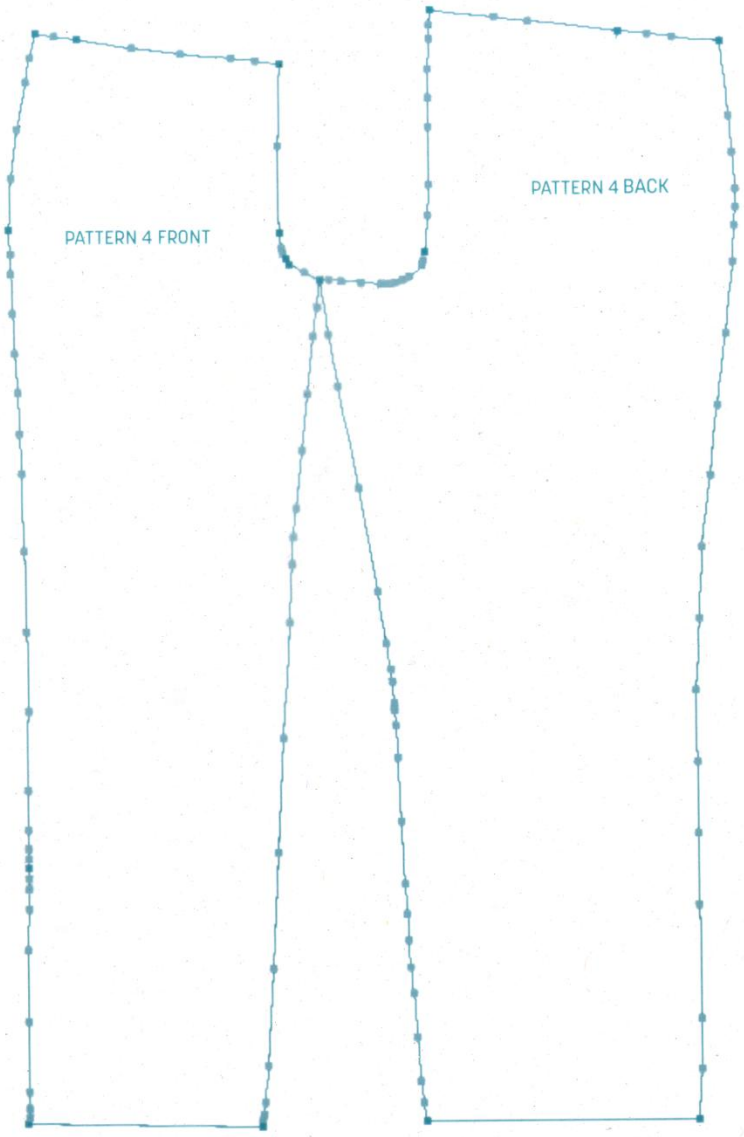


Figure 4. Pattern of sample 4

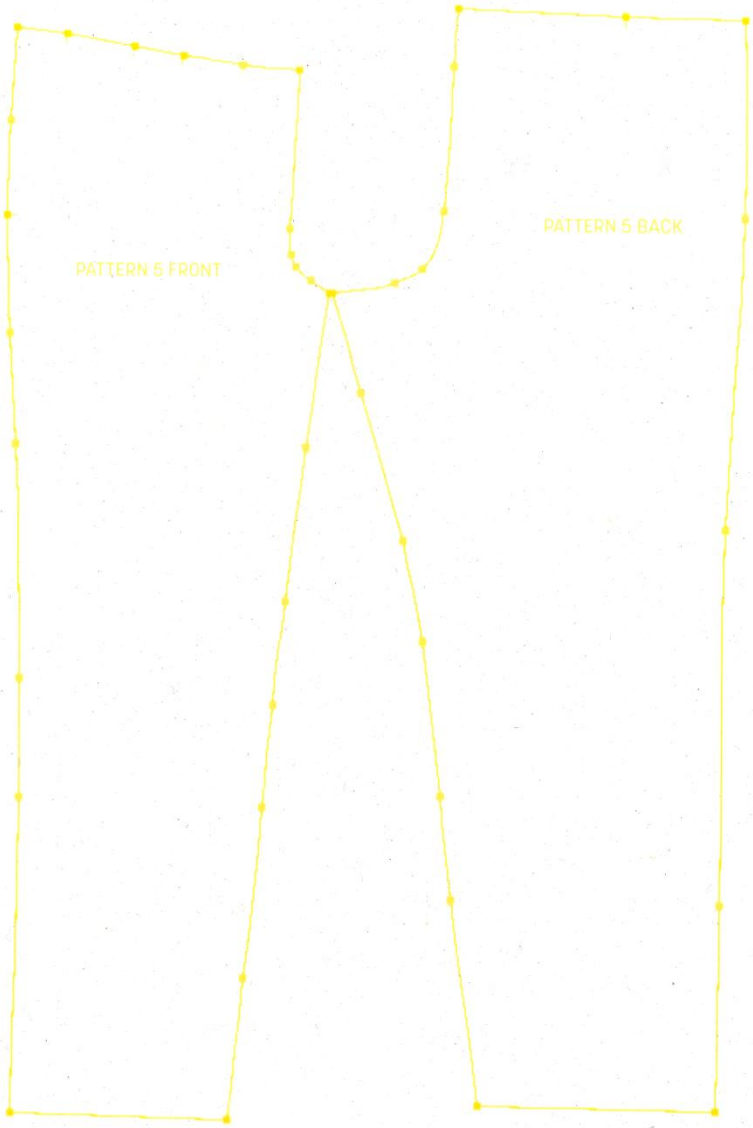


Figure 5. Pattern of new model