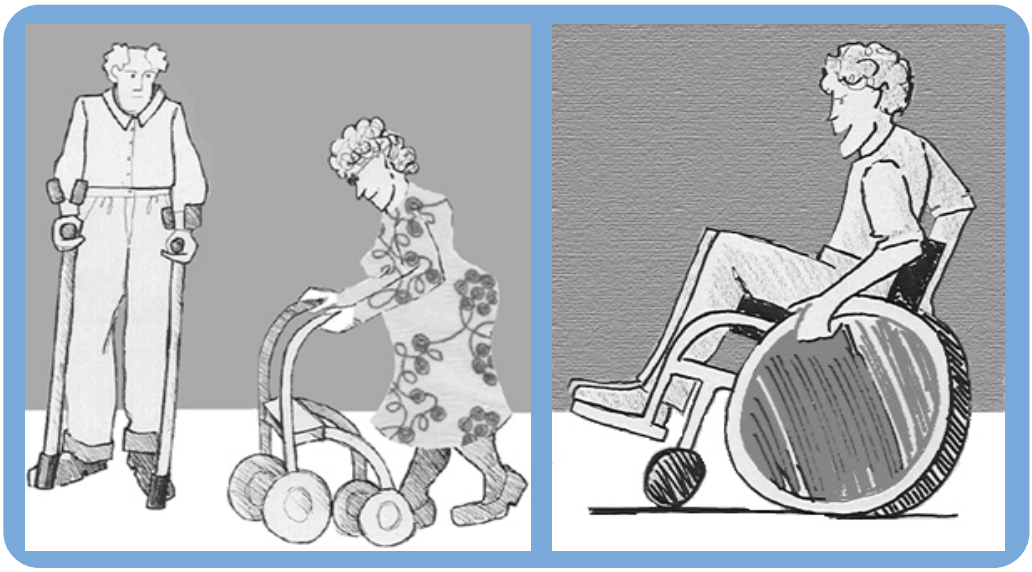
ESPOO 2002 VTT RESEARCH NOTES 2143



Harriet Meinander & Minna Varheenmaa

Clothing and textiles for disabled and elderly people

VTT TIEDOTTEITA – RESEARCH NOTES 2143

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VTT Processes

ISBN 951–38–5897–9 (soft back ed.)
ISSN 1235–0605 (soft back ed.)

ISBN 951–38–5898–7 (URL:http://www.inf.vtt.fi/pdf/)
ISSN 1455–0865 (URL:http://www.inf.vtt.fi/pdf/)

JULKAISIJA – UTGIVARE – PUBLISHER

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Otamedia Oy, Espoo 2002

Meinander, Harriet & Varheenmaa, Minna. Clothing and textiles for disabled and elderly people. Espoo 2002. VTT Tiedotteita – Research Notes 2143. 57 p. + app. 4 p.

Keywords textiles, clothing, handicapped persons, elderly persons, EASYTEX, recommendations, thermal insulation, durability, comfortability, safety

Abstract

The quality of life for disabled and elderly people can in many cases be substantially improved by a better choice of good looking and functional clothing and other textile products.

Disabilities often lead to special functional requirements of clothing and other textile products in living environment. Persons with highly sensitive skin have to consider the skin contact or tactile properties and avoid clothing with hard seams. For wheelchair users and for persons lying prolonged time in bed, who have a relatively low heat production, the thermal comfort properties are important. The transmission of moisture (sweat) from the skin is also a frequent problem. Also the mechanical durability of the materials in certain parts of the products can be a problem in many cases.

This leaflet was written as a part of the European EASYTEX project. The objective is to identify the problems that can occur concerning clothing and textiles for disabled and elderly people and to suggest solutions to these problems where possible.

Preface

We would like to thank the European Commission for funding this very challenging and rewarding EASYTEX project.

The international EASYTEX (aesthetical, adjustable, serviceable and mainstay textiles for disabled and elderly) project focused on how the functionality and aesthetics of clothing and textiles for disabled and elderly people could be improved. The results of the project (1997–2000) were: the build up of a database in order to improve the availability of the information of the clothing and textiles for the disabled and elderly; the development of a system that enables the industrial production of individually modified clothing by using the automated body scanning technique and the alteration of the standard patterns according to individual dimensions. The project partners were from France, Greece, Sweden, UK and Finland.

We thank warmly all the project partners for supporting our work by providing us feedback along the project. A special thank to Petros Mamalis for his contribution and Jane Wyatt for the enormous work for checking the English language and grammar of this brochure and Niina Hernández and Marianne Thorén for their valuable comments and Helene Berglin for the illustrations.

Also we want to thank all the partners in co-operation: Ullamaija Jaala, the mother of the project; the active members of Finnish user group for guiding our work; all the end-users and their carers for giving us vital feedback via the questionnaire, national seminars or contacting us otherwise; special thanks to Toivo Enqvist, Esko Ronkainen and Kristiina Nieminen for sharing their experiences as end-users; members of the workshop panels in Finland and in Greece; all Peer Reviewers for reviewing our reports; the old people`s home of Koukkuniemi in Tampere and the care centre of Ylinen in Ylöjärvi for providing us the possibility for visits; all the companies giving us fabrics for the tests and all the companies in database.

Without your help this would not have been possible. This is not the end – this is the start, we hope.

The authors

Contents

1. Introduction

The quality of life for disabled and elderly people can in many cases be substantially improved by a better choice of good looking and functional clothing and other textile products. There are however several reasons why the possibilities for this choice are restricted. Compared to the majority of the population, the special requirements of disabled people are diverse, and the local demand for special products is often limited. Retail stores and fitting rooms are designed for people who are walking without restrictions, and clothing is constructed for people with standard body dimensions and figuration.

The European policy concerning disabled people is that wherever possible the principles of equal opportunities and design for all should be realised, in order to make an independent, high quality life possible. This policy should also be applied when it concerns clothing, to make the daily life as comfortable as possible for persons who have many other obstacles to deal with.

Some clothing producers make special designs for disabled people, e.g. for wheelchair users, and the distribution is often by mail order. However, many disabled people feel that these special garments still emphasise their disability, and they prefer to take the trouble to buy the clothing in normal shops with a much larger choice and adapt to their needs. But wheelchair users, or other categories of disabled people, often are not standard sized, and alterations of "normal" and specially designed and relatively expensive clothing still might be necessary. To have the garments tailor-made is very expensive, and requires special tailoring skills.

Disabilities also often lead to special functional requirements of clothing and textile products. Persons with highly sensitive skin have to consider the skin contact or tactile properties and avoid clothing with hard seams. For wheelchair users and for persons lying prolonged time in bed, who have a relatively low heat production, the thermal comfort properties are important. The transmission of moisture (sweat) from the skin is also a frequent problem. Also the mechanical durability of the materials in certain parts of the products can be a problem in many cases.

These problems are not unique for disabled people but might occur for all consumers. Such problems are dependent upon an individual`s needs, and should basically be identified by the user or carer in each case.

This leaflet was written as a part of the European EASYTEX project. The objective is to identify the problems that can occur concerning clothing and textiles for disabled and elderly people and to suggest solutions to these problems where possible. It is based on the work done within the project and more information is given in the project reports (*D5.1 Definition of critical fabric properties and relevant test methods, D6.1 Definition of special furnishing textiles, D6.2 Textiles for medical uses, D6.3 Textiles for personal and intimate care, D5.3 Results of laboratory tests, suggestions for limiting values, D5.4&6.4 Information on available fabrics and products* [11, 12, 13, 14, 15, 16]). This leaflet will be available in EASYTEX database which in addition contains information on special products, manufacturers, suppliers, care organisations and research. The database is available on the internet: http://www.s2.chalmers.se/~neuez/EASYTEX.

One field that is not covered in this leaflet is the aiding devices used e.g. to facilitate dressing and undressing for persons with restricted mobility and dexterity. Another field that is not covered here nor in this project is the footwear.

Within the project we have heard about many problems in this field. We are quite aware that many other problems exist. Feedback to the authors is therefore very welcome.

2. General considerations

For all consumers, the choice of textile and clothing products is governed by a number of different needs and restrictions. These can be classified as “aesthetic”, “functional” and “availability” requirements. Clothing should enhance an individual’s self esteem and be attractive to both the wearer and others. It should also be comfortable and appropriate for any physical requirements. In addition it should be easily available for reasonable price.

Aesthetics

- Clothing is an essential part of our appearance, and with the choice of clothing we show a part of our personality. We generally prefer different types of clothing for different types of activities (leisure, work, parties, etc.). Properly designed clothing can act as camouflage hiding possible disabilities. Indoor decoration textiles are used with the main purpose to improve the aesthetic appearance of the living environment.

Functionality

- **comfort:** Clothing and other textiles which are in close contact with the body must not cause any kind of discomfort. Different aspects of comfort which need to be considered are thermal (insulation and breathability), tactile factors (hand properties), freedom of movement, pressure, non-allergenic, etc.

- **protection:** In certain cases, the textile products are expected to protect us from risks in the environment. For example, outdoor clothing gives protection against rain, wind and cold. In the home, curtains and sunshades give protection against solar radiation, and screens can be used to provide some level of privacy.

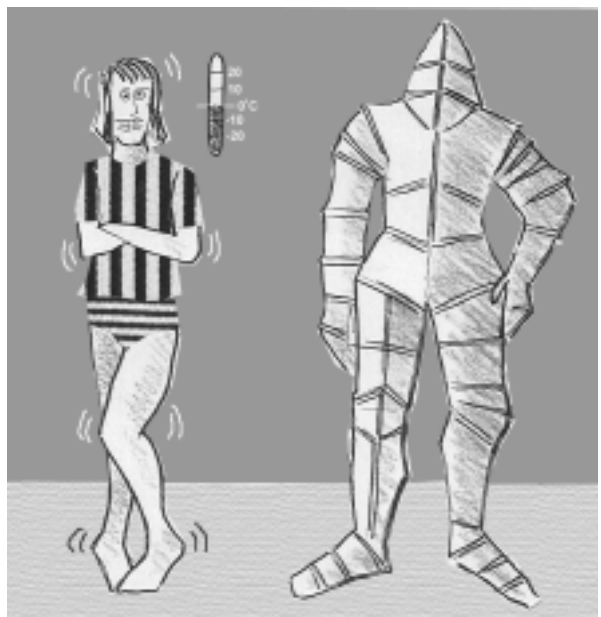
Availability

- **available resources:** In most cases the price must be considered when buying new textile or clothing products. It is however not always remembered that there are other factors that will influence the total costs of the product, for example service costs and durability.

- **shopping facilities:** The supply of products may be dependent on location. Choice and availability will be greater in large cities than in rural areas. For persons with restricted mobility, normal shopping in stores might be impossible, and disabled people are often restricted to mail order shopping, special clothing demonstrations, or assistance from a carer or relative.

The choice of products for disabled and elderly people can vary considerably, depending on who makes the decision and the nature of the caring situation. An independently living person with good support and care will have almost the same possibilities as the majority of the population to choose products. For persons in institutional care and without personal help, the choice may be governed by practical aspects as washing conditions and durability.

2.1 Function – comfort



A basic requirement of clothing is that it must not cause discomfort for the wearer. Severe and prolonged discomfort caused by clothing, might lead to unbearable suffering or health risks. Clothing comfort or discomfort is affected by several factors, defined as follows:

- the **thermal comfort** depends on how well the clothing transmits heat and evaporated sweat from the skin into the environment. The heat production of the body has to be equal to the heat loss, in order to maintain a thermal balance. In a hot environment this means that the clothing resistance to dry heat loss (= the thermal insulation) should be low and the breathability (transmission of water vapour) should be high. On the other hand, in a cold environment and with low physical activity (= low heat production by the body) the thermal insulation of clothing fabric should be high.

- the **tactile comfort** or mechanical contact between the textile product and the skin is particularly critical for people who are sitting or lying for prolonged periods. The tactile properties are dependent on the mechanical properties of the fabric (surface smoothness, protruding coarse fibres, friction, elasticity, etc.) as well as possible hard seams and sharp wrinkles in the clothing or seat. A continuous high moisture level on the skin makes it more sensitive to mechanical irritation. Persons with supersensitive skin have to be very careful when choosing particularly underwear and bed textiles in order to get products that do not irritate the skin.

- true **allergies** caused by textile fibres are not very common, and the allergy problems are very much individual. Problems might however be caused by impurities in the textiles (dye stuffs, finishing agents, accessories like metal buttons, resins of detergents, dirt, etc.). Fibres that are known to give allergic reactions are wool, raw silk, rubber and monomers containing polyamid.

- **static charges** in fabrics cause the clothing to cling to the body, to attract dust particles, and to spark when undressing or getting out of a car. The energy released in the sparks is small, and in normal use the static charges are not a direct safety risk. Indirectly the shock from a spark can sometime cause sudden, uncontrolled movements in a person which might prove to be a risk. Static charges in textiles occur particularly in dry environments (in the wintertime), and the synthetic fibre products are particularly problematic.

Another aspect of comfort is the psychological satisfaction with the product. It has to be aesthetically attractive, fashionable, in harmony with the personality and appropriate for the wear situation in order not to cause psychological feelings of discomfort.

The functional requirements of clothing and other textiles may in many cases conflict with comfort requirements. Depending on the type of use, the functional requirements vary, and a compromise may have to be achieved. Textiles and clothing are generally acquired for longer use, and some degree of durability is expected. A high durability fabric (ie possessing high mechanical strength and dimensional stability) may be a thick and high density fabric, which however then generally is stiff and mechanically less comfortable. Clothing also forms a protective boundary layer between the body and the environment. In cold weather we dress in thick clothing to keep the body warm, in rain we wear water resistant clothing to keep the body dry, and in strong sunshine the clothing protects against too much UV-radiation.

2.2 Costs – price, quality, service costs, durability

Most of us have limited resources to spend on clothing and other textiles, and therefore we try to optimise our purchases to get highest possible value for money. The retail prices are easy to compare, and they are often the only criterion whereby the costs of the products can be judged.

However purchasing low quality products can make textiles and clothing more expensive in the long term. For example cheap socks may be worn out after two days of use and have to be replaced by new ones. This becomes more expensive

than an original purchase of better quality, durable socks that will withstand tens of washes. A shirt that shrinks and loses its dimensions in the first wash is not worth its price. Unfortunately it is often very difficult, even for persons with much experience, to judge the quality of the clothing without testing the product. Therefore it is often safer and more economical in the long term to buy products of known brand names, and from retail stores to which the products can be returned if problems with the quality occur, even if the price is a little bit higher.

The care instructions should also be considered when buying textile products. Hand washing or dry cleaning may be difficult in some circumstances, particularly for persons living in care institutions. Dry cleaning becomes very expensive if the clothing has to be frequently cleaned.

There are no general rules for the expected lifetime for textiles and clothing, but if the care instructions are followed most products should retain their appearance and functional properties after at least ten washing cycles. This applies both for the fabrics and for all accessories, like buttons, decoration embroideries, etc.

Many disabilities require special clothing, which is more difficult to find and is more expensive than standard clothing. It is even more important that this clothing is of good quality and durability.

2.3 Products

2.3.1 Clothing

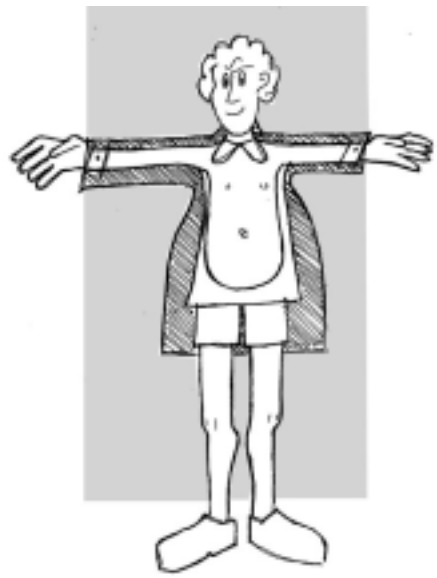
In many situations, several layers of clothing with different functions are worn:

Underwear, socks – skin contact: The most important requirement of underwear, which is in permanent contact with the skin, is that it should feel pleasant (tactile comfort) and does not cause allergic reactions. The way we sense clothing is very individual – some people can only wear silk underwear, while others feel it tacky on the skin. Many people prefer woollen underwear, particularly in the wintertime, while others cannot stand it due to the coarseness of the fibres. The underwear material must therefore be chosen based on personal experience and preferences.

The underwear is a critical component in the moisture transmission from the skin to the environment. The optimal situation is when the sweat can evaporate on the skin and be transmitted in vapour form through the clothing. If this is not possible and the moisture remains in the liquid form, the liquid should not be absorbed in the underwear but instead transmitted from the skin to the outer layers of the clothing, in order to keep the skin dry. Liquid transmission is generally better in synthetic fibre materials than in natural fibres.

The close contact between underwear and skin also affects service properties of the garments. Underwear garments are generally washed more frequently than outerwear, and the hygienic properties must be retained also after washing. This is particularly the case for persons with incontinence, when the washing temperature must be high.

Middle layers – thermal insulation: If additional thermal insulation is needed, layers can be added between the underwear and the outerwear with the main function to make the clothing warmer. People who have low physical activity, and therefore low heat production, e.g. sitting in a wheelchair, need more insulation than highly active ones. A t-shirt under a sweater makes the clothing warmer, as well as long underwear or an extra sweater under the outdoor clothing in the winter.



Outerwear – appearance: The variety of garments that are used as outer layer of the clothing is infinite, ranging from uniforms and heavy protective clothing to fancy party dresses and to everyday indoor clothing. The most important duty of the outerwear is to be a part of the personal image, and therefore the choice of clothing is very individual and will depend on the wear situation.

In addition to the appearance, the outerwear also has a functional duty in many cases. Jeans or other densely woven garments can form a protection of the skin against small mechanical risks. In strong sunshine clothing can protect the skin against UV-radiation and strong heat radiation.

Outdoor clothing – protection: In outdoor conditions where protection against the environment is required, this is generally provided by the outermost layer of the clothing. Thermal insulation against cold weather is achieved by entrapping air in the clothing, and particular attention has to be paid to the protection of head, hands and feet. Wind resistance is provided by very tightly woven outer fabrics. Water resistance of the outer fabric against rain can be achieved by a hydrophobic finishing treatment, but the best resistance is provided by plastic coated or plastic film laminated materials. Conventional coated fabrics are problematic in the sense that they are impermeable to water vapour from the inside (non-breathable), and can cause uncomfortable build up of moisture. However on today's markets several materials which combine watertightness and breathability are available.

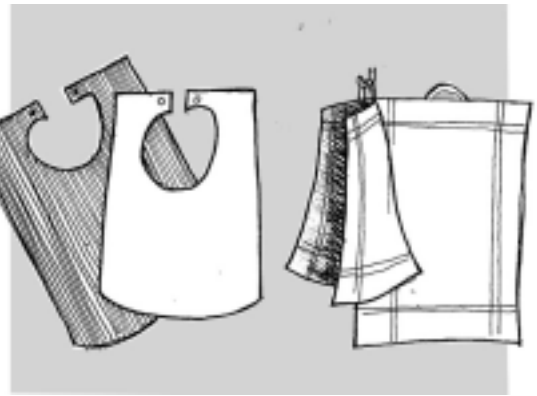
2.3.2 Textiles for personal and intimate care

There is a large variety of textile products that are used for the personal health and hygiene care. They include wipes, diapers, sanitary and incontinence products, as well as disposable bed linen, hospital staff uniforms and isolation ward protective clothing. They are often considered basic items because of their limited function, but even the simplest cleaning wipe can be made of a high specification material meeting stringent hygiene requirements. [14]

Incontinence diapers are used to absorb the involuntary loss of urine and fecal excrements. The diapers are categorized into light, moderate and heavy products, depending on the volume of moisture they can absorb. They can be either single-use, with a core of absorbing material and a soft nonwoven textile surface and a moisture barrier, or reusable. In the latter case the diaper is made of an absorbent woven or knitted fabric, which retains its properties after a large number of washings. [14]

The most important property of diapers is their ability to absorb and retain leaked body fluid away from the skin, and protect the clothing or bed linen from soiling. The diaper's surface should be soft and remain dry after absorption to avoid skin irritation and to keep the skin dry. To reduce any social distress, it should also form a barrier for odours and be as thin as possible in order not to show under the clothing. In addition a diaper should be easy to use to maintain the independence of the user as far as possible. There are a large number of different diaper designs for female and male users, to be used with or without support pants or incontinence briefs. [14] (See also chapter 3.4 Diapers.)

Absorbent underpads might be used for persons staying in bed, as an additional means to preserve the bed from wetness. They consist of a soft nonwoven coverstock, an absorbent core and a liquid-impermeable backsheet. [12, 14]



Feeding bibs protect the user's clothing against staining from food, and also protect the user against hot liquids. Bibs can be made of a cotton surface fabric with a moisture impermeable backsheet. Disposable nonwoven fabrics or paper cloths coated with a thin plastic layer can also be used. [14]

Paddings and protective shields are used for absorbing and attenuating shocks from falls and knocks e.g. sharp corners of furniture. Such protective devices can help to reduce the risk of slight injuries but cannot eliminate them. Different kinds of foamed rubbers are used as shock absorbing materials. [13]

The risk of fracture in the trochanteric area of the hip is a particular problem for elderly people. It has been proved that hip protectors, which are inserted into pockets over the trochanteric area of specially designed underpants, significantly reduce the number of hip fractures. As the fractures cause a persons long suffering and the community high costs in terms of healthcare, both health and economic savings can be achieved by using the hip protectors. [13] (See also chapter 3.3 Paddings.)

Supportive braces are used to give support for people with weak backs and reduce the stress forces to the back. They can be made of elastic or non-elastic fabrics, and are generally constructed of a soft inner layer (e.g. cotton flannel or tricot knit) and a firm outer layer fabric. Supporting garments for hand, wrist, neck, knees and ankles are also available to ease some health problems and restrict unwanted movements. Compression stockings and socks are used to enhance the blood circulation in the lower extremities. [13]

2.3.3 Textiles in the living environment

A variety of textiles are used in the living environment, both for decorative purposes to make the home more personal and cosy and to improve comfort and functionality.

Upholstery textiles are used as surface material on soft furniture. Besides the decorative function, fabric will be in close contact with the skin and has to feel pleasant. A general requirement is high durability, as replacement of upholstery fabric is expensive. If staining with food or excrement is a frequent problem, the cleaning properties of the upholstery material are critical. Coating with a conventional, non-breathable plastic has a negative effect on the comfort properties, but a removable and washable fabric can then be a solution to the problem. [12]

The surface material of wheelchairs and geriatric chairs is particularly crucial, as the persons often sit continuously on them and in many cases have skin or other problems. Waterproof seat cover materials in protect the seat cushion from soiling and make the seat easily cleanable but these materials normally have poor breathability properties, which makes them uncomfortable to sit on and increases the risk of pressure sores. Low friction between surface material and clothing fabric enhance slipping and the sitting position needs constant

alteration. On one hand this “pumping” effect may prevent pressure sores but on the other hand it requires abrasion resistant fabrics. [12, 2] (See also chapter 3.1 Sitting in a wheelchair.)

Hard furniture can be padded on protruding corners in order to decrease the risk of accidents caused by tripping or falling. [12, 13]

Bed textiles include sheets, pillows, blankets and quilts, bed protectors and pile pads, all with specific functional duties. Bedding should provide thermal comfort for resting persons, feel pleasant against the skin and not cause any allergic reactions. For people who are permanently staying in bed or spend most of the time in bed, the comfort properties are crucial, as the risk for bedsores is high. As heat production by the body is low when a person is resting, the thermal insulation of the bedding has to be at a higher level than for sitting or moving persons. All bed textiles have an influence on the total insulation but the most important is the blanket or quilt. It is also extremely important that the bed textiles transmit possible moisture from the skin. Slide sheets across the middle of the bed have low friction and make turning in the bed easier, and turn sheets can be used to ease the work of the carer when turning the patient. Transversal sheets (without moisture barrier) and bed protectors (with moisture barrier) can be used to protect the mattress from excretions. Pile pads or other anti-decubitus products reduce the static pressure of the patient and thus the risk of bedsores. [12]

Indoor decorative textiles (curtains, rugs and carpets, wall textiles, screens, table cloths, etc.) are mainly used to decorate the indoor environment and increase the psychological comfort by means of appearance and aesthetics However in addition textiles can be used to improve the acoustics of rooms by damping sounds. Textiles on cold outer walls or on cold floor also act as thermal insulators. For visually impaired persons colourful carpets and wall textiles can be actively used to outline the home or institution surroundings and help in orientation. Screens with textile surfaces are used to divide larger rooms into several units and give at least visual privacy e.g. in hospitals. [7, 12]

Aiding devices: Textile products are also used in a more technical context in the care of disabled patients. Transfer lifts and belts help to move the person e.g. from the bed to the toilet or into a chair. They can be manually or electrically

operating. A problem is that they might cause high pressure on the skin, which however can be eased by using correctly designed, padded belts. The mechanical strength of the textiles and other components has to be sufficient to ensure the safety of the persons. [12]

3. Specific considerations for people with disabilities

The individual requirements of disabled people regarding textiles and clothing are very much more diverse than for people without disabilities. Specific considerations concerning people with disabilities have been compiled in the following as a result of feedback from end users during the EASYTEX project. Feedback is still welcomed by the authors.

It is not only the needs of an individual but also the different types of care provided for that individual which will dictate the performance requirements for garments and textiles i.e. home care, care at a service home, institutional and hospital care have different requirements. In hospitals the hygiene requirements are very stringent and therefore textiles and clothes used in a hospital environment must endure higher washing temperatures. In the home environment the temperature requirements are normally lower when using domestic washing machines.

3.1 Sitting in a wheelchair

Wheelchair users are fairly well served with special garments. However more product ranges are needed to provide for the wide variety of individual needs. Also the prices may be considered too high, especially if the garments do not fit even after alterations. When designing clothing and choosing the materials for wheelchair users the most critical issue is the sitting posture, which must be taken into consideration.

In garment design both aesthetical and practical aspects should be fulfilled e.g. the bodyrise of trousers must be increased in the back and decreased in the front. Accumulation of excess fabric in the stomach area and exposure of the back area must be avoided to ensure a good fit and comfort in sitting. The leg length has to be adjusted according to the sitting posture. The body movement at rolling of a mechanical wheelchair requires fabric allowances in back and in sleeves of the garment. The garment design should also allow to dress up and undress independently or visit the toilet independently; a small decoration in the front of the garment to recognise the front piece (important especially for visually impaired persons), easy fastening systems in garments, openings for catheters etc. Thick and hard seams should be avoided in areas exposed to high pressure such as back and buttock areas because they can cause chafes and sores and which may lead into pressure sores in worst cases. [1, 2, 4, 6] (See also chapter 3.8 Non-standard body dimensions.)

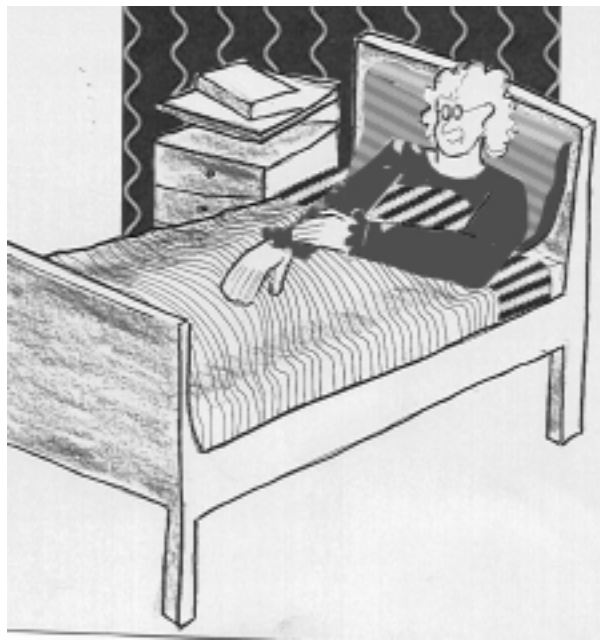
When choosing a fabric both the functional and aesthetical properties should be considered. For example, functional properties will include thermal properties and durability properties. Thermal unbalance and sweating increase not only the risk of getting cold outdoors in winter but also the risk of pressure sores. Therefore the breathability properties of both clothing and seat cover materials should be considered when selecting fabrics. Thermal properties are extremely important for wheelchair users because legs and lower bodies cool off quickly due to poor blood circulation and lack of adequate movement. [11] (See also chapters 2.3.3. Textiles in the living environment, 5.4 Comfort properties.)

Durable clothing materials are needed particularly in mechanical wheelchairs where the sleeves may rub against the rubber wheels. Continuous alterations in sitting posture abrades the back of the garment against the seat material and the garment is worn out quickly. Leaning against a table abrades the fabric in elbow areas. An optimum surface friction is needed for preventing sliding on the seat,

and allowing the transfer from wheelchair to bed or to car seat. [11, 15] (See also chapters 2.3.3. Textiles in the living environment, 5.2 Mechanical durability.)

Wrinkling of fabric causes mainly aesthetical problems. Wrinkles are formed by pressure, moisture and heat so sitting in a wheelchair can provide the optimum conditions (e.g. when hands are resting in lap). For part-time wheelchair users ie people who are able to stand and walk short distances, wrinkled clothes may be very disconcerting and detrack the overall appearance of a person. Very sharp wrinkles may cause skin problems if they press on skin while sitting or lying in bed. [11, 15] (See also chapter 5.3 Appearance.)

3.2 Staying in bed



For an individual who is lying in bed for prolonged times, the thermal balance between the body and the environment is critical. Generally there is a problem of maintaining the thermal balance at an optimum level. Disabled and elderly people who may have low heat production due to weakened blood circulation may need materials that have higher thermal resistance properties. The easiest way to prevent heat loss is to add clothing layers and blanket layers because the

air bound between the layers function as insulation. Thick, fluffy and airy materials which have a lot of air bound into their structure have higher thermal resistance than thin and smooth materials (see also chapter 2.3.1 Clothing). High heat production will cause sweating and wetting of the clothing and bed textiles. Under the static pressure caused by lying for long periods in bed, the poor blood circulation and moisture accumulation exacerbate decubitus problems especially in areas where the bones are near to the skin surface e.g. in heals, ankles, outer edge of foot. Therefore the decrease of the pressure load on the decubitus area and good moisture transmission properties of underwear and bed textiles that are in skin contact are essential. [11, 12, 13]

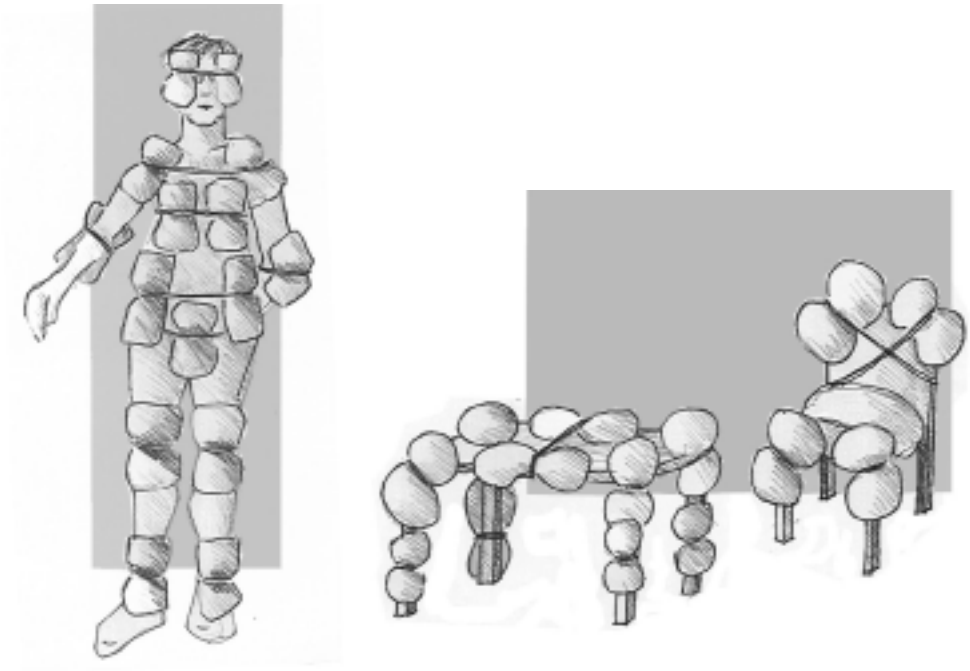
Non-breathable materials like plastic, thick multilayer fabrics or thick pile fabrics with poor moisture transmission properties have a tendency to increase the risk of decubitus. However, it is known that turning the patient in bed frequently will reduce the risk of bed sores. Special antidecubitus mattresses and seat cushions distribute the static pressure over a larger area and thus prevent areas of high pressure. Gel cushions and pillows can be filled with a stiff gel which conforms to the body shape, thereby distributing the pressure over a larger area. The problem of using gel cushions and pillows is that they are not breathable and they may become lumpy in use. Special sluggish foam rubbers are used in mattresses, seat cushions and pillows which help to distribute the pressure more evenly. Other filling materials used are grains or granules, air-filled tetrapacks and air. [4, 13, 14]

Peripheral blood circulation problems can be relieved using compression stockings. Their primary task is to stimulate the blood circulation and prevent swelling. Compression stockings are designed so that the pressure is highest in the ankle, gradually decreasing in the calf and thigh area. The pressure is achieved by making the garment suitably tight fitting along its length. [13]

When constantly lying in bed, clothing and bedding textiles have very close contact to the skin. Therefore the tactile properties of materials are extremely important. The surface roughness, raw material and finishing agents must not cause mechanical nor physiological allergic reactions (see chapter 2.1 Function – comfort). [11]

High friction between bed textiles and clothing material may prevent the patient turning around in bed and therefore low friction materials should be used when necessary. Special sheets are available which are constructed from smooth and slippery fabrics, and these are placed across in the middle of the mattress on top of the ordinary sheet to ease turning in bed. [11, 12]

3.3 Paddings



There are two basic ways to protect oneself from impacts. A person requiring such protection can either wear pads, or the living environment can be equipped with pads depending on the level of protection needed. It is possible to attenuate the impact force by using soft and absorptive padding materials (for example foam rubber) but when higher protection is needed to prevent severe injuries, such as bone fractures, then paddings covered with hard and rigid materials which absorb the impact force and distribute it into larger area are recommended. [13]

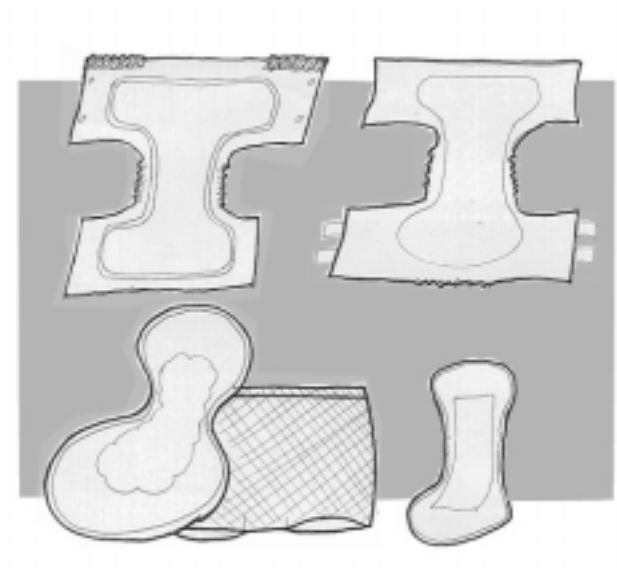
The problem of paddings and protectors is that they are uncomfortable to wear and they are not particularly aesthetic. The decision not to wear a protector is often due to undesirable image – people do not want to look different from others even at the expense of their safety. This offers a great challenge for protector manufacturers – to develop an attractive and comfortable method of protection. [13]

An example of a specially designed protector is a hip protector which has been developed to prevent hip fractures in elderly people. These are short trousers which have hard cell paddings in pockets in the hip area on both sides (see also chapter 2.3.2 Textiles for personal and intimate care). [13]

Protection may be needed for people who suffer from epilepsy or who have weakened balance. Epilepsy may cause different types of seizures that in consequence can cause sudden falling. For example falling on to the sharp edge of the table which may result into severe injuries to the head or face. With the help of medication the seizures may well be prevented but if the medication is insufficient or if there is no suitable medication available some external protection devices may be of some help for preventing severe injuries. In such cases for example, a special helmet may be needed that would protect the head during a fall, but that would look like an ordinary cap. Other technical solutions for head area protection have been investigated. A protector that senses the falling and activates the protector, for example by inflating air bags, is one solution. But so far these are not available. Another solution is to pad the table, closet and other furniture corners where it is possible.

Breathable, partly water permeable and antibacterial padding for shower chairs has been developed to meet both comfort and hygiene requirements, although combining very contradictory demands in one product has yet to be achieved.

3.4 Diapers



Different types of diapers are available and range from flat sheets to anatomically shaped disposable diaper pants in order to meet different incontinence levels. The most important properties for diapers are their ability to absorb moisture quickly even large amounts (liquid water transmission); to keep the surface dry; and absorb odour. Skin problems may occur if the absorption capacity is too high, which may keep the skin too dry and cause skin abrasion. From an aesthetic point of view diapers should be discrete and not visible through outer clothing, and be easy to use and change. Use of diapers may cause clothing problems. For example it may not be possible to wear tight fitting clothing, or a wheelchair user may only be able to wear the top half of the bikini. A possibility to buy only a top of bikini has been addressed by a young lady who is sitting in a wheelchair. [4, 11, 14] (See also chapter 2.3.2 Textiles for personal and intimate care.)

3.5 Crutches and other supporting devices

The use of crutches, body-worn supports, prostheses and other supporting devices has to be taken into consideration when designing clothing and choosing clothing materials. Walking and moving causes fabric abrasion against the devices and textiles can be exposed to severe abrasive forces. When using crutches the garments may need greater fabric allowances in back and in sleeves to allow enough space for arm movements. When walking with a rollator the hemlines may need compensating according to body position. Also other functional and aesthetical aspects may exist depending on the situation. [1, 11, 15]

Crutches for example, which have a metal bar, hard plastic handles, possibly padded with foam rubber and artificial leather, sharp edges and protrusive screws, may abrade shirt sleeves in underarm or wrist area, and possibly even trousers in the hip and leg area. Body-worn supports and prostheses contain rigid plastic parts or coarse surface material which can abrade the clothes especially in joints area. [1] (See also chapter 5.2 Mechanical durability.)

3.6 Shaking – bad coordination

Shaking and bad coordination may cause difficulties while eating, dressing and moving. Spillage of food and drink may cause difficult stains on clothing or furnishing materials such as seat covers. Therefore the cleaning properties of materials (stain removal, soil repellency) are critical when choosing the fabrics for clothing, protection and furnishing. Materials should be washable, for example seat cover materials are ideally removable and washable, feeding bibs or aprons should endure high washing temperatures and be durable. [11, 15] (See also chapters 5.3 Appearance, 5.5 Service properties.)

For some people, compulsory movements may be quite strong, sudden and uncontrollable and in such cases good seam strength in clothing, for example in joint seams of arms and legs, may be required. In some cases a good tear strength in clothing may be required. [11, 15] (See also chapter 5.2 Mechanical durability.)

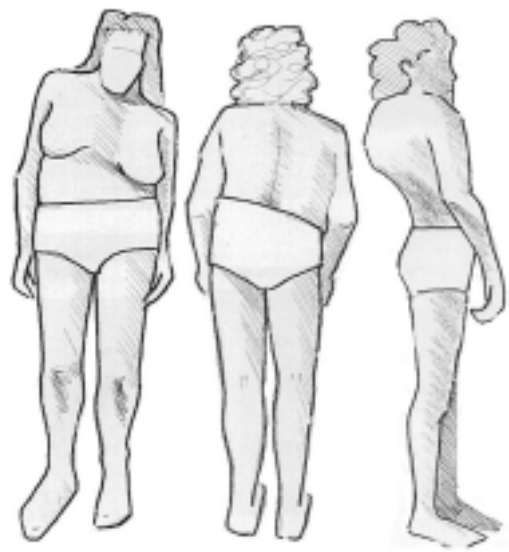
Stiffness in limbs and joints will necessitate easy dressing properties such as wide open sleeves, easy fastenings and elastic materials which must be taken into account during the design stage. [1]

3.7 Supersensitive skin

For some people, their supersensitive skin will require good tactile properties of fabrics. Diseases such as diabetes and muscle disease cause an increase in the sensitivity of the skin. However, such experiences are very subjective and individual and a person should learn which type of material he or she is able to wear and which is unsuitable. [11, 15]

For some people fibre materials of animal origin, such as wool and even silk can cause allergic reactions. This is caused by the protein contained in the fibres. The surface roughness of coarse fibre material may irritate the skin, and also deep dyed fabrics may present a problem due to the large quantity of dyeing pigment. Some finishing agents are known to cause allergy, such as formaldehyde which has formerly been used in resin finishing. Washing detergents may irritate if they are not rinsed out properly. Therefore light colours and mild detergents are recommended. Comfortable shoes and non-pressure stockings are extremely important for a diabetic because the disease causes problems with poor blood circulation in feet. [11, 15] (See also chapters 2.1 Function – comfort, 4.3 Dyeing and finishing, 5.4 Comfort properties.)

3.8 Non-standard body dimensions

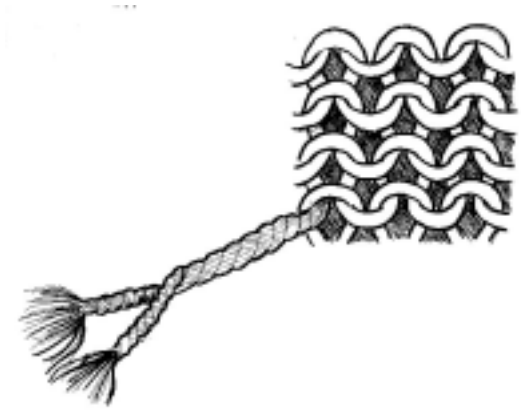


To find clothes in a retail store is a problem for quite a lot of individuals. The problem always exists because we wear clothes all the time. It is a very widespread problem, which can effect anyone, all depending on their figure, the supply of clothes in the stores, and the individual's demands. However, there are many individuals within the categories elderly, impaired, and/or disabled who have exceptional problems with finding suitable clothes. There are individuals with warped figures that have a balance problem with standard garments. The balance between right and left side of the garment does not harmonise with the figure. This can lead to a down-slanting hemline or uncomfortable gathers of fabric. Individuals with a prominent disfigurement have problem with the garment fit because the projection does not fit into the garment. Usually they have to select a garment with a larger size. The projection might fit into the garment but the larger size makes the garment too big in other areas. The adaptations need to enlarge the pattern over the prominent body part without enlarging the whole garment. The increase of the pattern can be made either lengthways, widthways, or with a combination of both. [6]

Before garments were produced in large quantities clothes were produced by tailors, seamstresses, and/or by a family member. The garments were automatically individualised according to the customer. Now there are very few tailors and seamstresses and they have difficulties to compete with the manufacturers low prices. The retail stores can attract more buyers due to greater quantities, lower prices, and more advertisement. Most people buy their clothes from retail stores. Today, it is possible to offer customers a garment to order according to their desires and body figure. The new, more automatic, equipment and software make the process faster and possible to realise for the industry. However it is important to have the basic knowledge about how to adapt the patterns according to the many variations of figures that exists. Pattern construction for unique figures is covered in a study carried out at Göteborg University, reported in the licentiate thesis Tailoring the unique figure by Niina Hernández. The main body of the study contains three main sections: body figure registration – including measurements, single pattern adaptations, and individual patterns. Automatic three-dimensional (3D) body measurement system, based on structured light, for made-to-measure clothing was studied at Chalmers University of Technology, Göteborg, Sweden. The results were reported in the licentiate thesis Range camera imaging with application to human body measurements by Gaël Neuez. The output of the study is a software application. [6, 8]

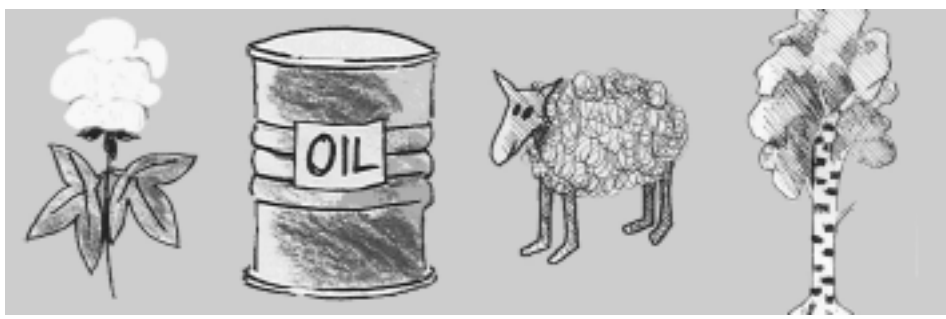
4. Textile materials

Fabric properties are dependent on fibre and yarn properties, such as fibre fineness, fibre structure, fibre length, fibre type, yarn count, yarn structure and yarn type. But they are also depend on the fabric density, thickness and any finishing treatments used in manufacturing process.



4.1 Raw materials

Textile fibres basically originate from vegetables, animals or oil. They can be divided into natural fibres and man-made fibres as shown in the following Figure 1. The type of fibre will determine the eventual properties of the fabric. For example, fabric properties vary a lot depending on the fibre raw material, fibre length, fibre fineness and fibre structure.



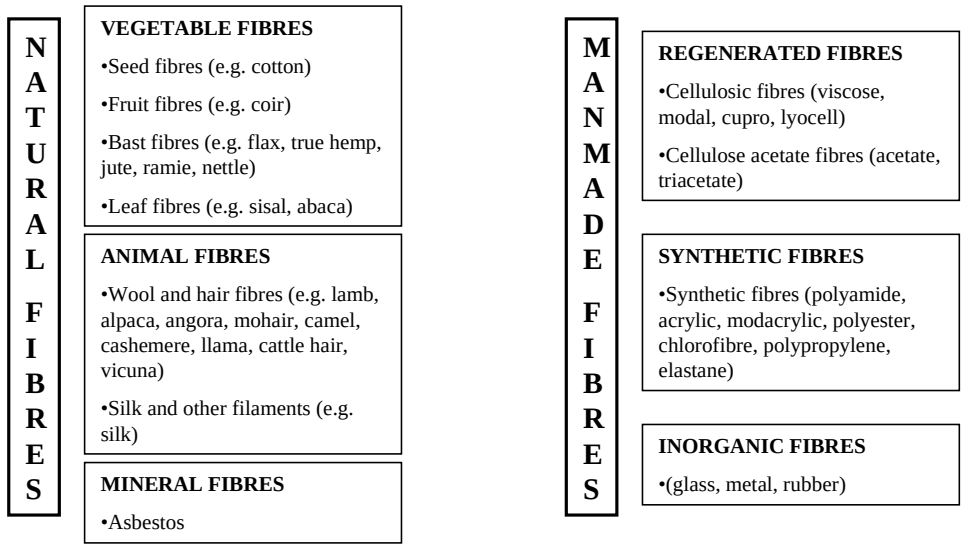


Figure 1. Fibre categorization.

A characteristic of **natural fibres** is that they generally absorb moisture very well but wrinkle easily. However these fibres have limited strength, except linen which has good strength properties. The caring (washing and drying) may be "difficult", e.g. wool and silk.

The properties of man-made fibres can be modified during the manufacturing process. Man-made fibres are classified into 3 groups: (i) regenerated fibres (ii) synthetic fibres and (iii) inorganic fibres.

(i) **Regenerated fibres**

The most common regenerated fibres are cellulose based (for example made from birch or spruce) and their properties are quite similar to vegetable fibres. They will absorb moisture very well.

(ii) **Synthetic fibres**

Synthetic fibres generally do not absorb moisture and they are considered easier to care for than natural fibres. For example polyester fibre dries quickly and normally does not need ironing.

(iii) **Inorganic fibres**

Inorganic fibres are used less (hardly at all) in consumer products. For example metal fibers are used mostly in technical textiles or for increasing electrical conductivity in carpets or to give lustre for apparels.

Manufacturers identify their fibre products, fabrics and finish agents by the use of trade names. The same fibre raw material e.g. polyester may have several trade names depending on its properties and the modifications made by the manufacturers. Examples of common trade names are in Table 1.1 in Annex 1.

4.2 Fabric structures

Fabrics can be divided into three main types: (i) woven fabrics (ii) knitted fabrics and (iii) nonwoven fabrics. They are made of either yarns or fibres or their combinations. Textile fibers are either filament or in staple form. Man-made fibres are produced as continuous filaments but can later in the process be cut to short staple fibres, whereas most natural fibres are naturally in staple form. However, silk is an exception, it can be derived in filament form also. The staple fibres are formed to yarns in the spinning process which joins the fibres together and gives them desired twist. Fibre length, fibre fineness and fibre raw material gives the yarn certain properties. For example short, coarse fibres form coarse yarns and they form thick and coarse fabrics whereas smooth and fine filament fibres give smooth and fine yarns and thus thin and dense fabrics may be achieved.

(i) **Woven fabrics**: Woven fabrics are formed of warpyarns (where parallel yarns lie side by side) and weftyarns (yarns lie perpendicular to the warp) which cross each other (figure 1b). The way the warps and wefts cross each other is called a weave. Weaves are different types but the most common types are plain

weave, twill and satin. Woven fabrics are not generally elastic but by using some weave structures (e.g. twill) and by adding small amount of elastic fibre (elastane) into the fabric in the manufacturing process it is possible to increase their elasticity to some extent. For example cotton 95%/lycra 5% fibre blends in jeans or wool 99%/lycra 1% in jackets and trousers or polyester 97%/lycra 3% in trousers. (See also chapter 5.1.)

(ii) **Knitted fabrics**: The basic element of knitted fabrics is a loop formed by a single yarn (figure 1a). There are two basic types: weft (such as knitting with knitting needles) and warp knitting (such as crocheting). Weft knits are elastic both in the length and in the width direction (e.g. tricot). Warp knits are generally elastic in the width direction only but their elasticity can be increased by adding an elastic fibre component into the fabric during the manufacturing process. For example polyamide 80%/lycra 20% fibre blends or polyester 90%/lycra 10% fibre blends in warp knits can be used in sportswear, such as shorts and T-shirts, in which high elasticity is needed. (See also chapter 5.1.)

(iii) **Nonwovens**: Nonwoven fabrics are composed of fibres (fibrous webs) that are mechanically, thermally or chemically bonded to each other (figure 2c). They are paperlike and sometimes it is difficult to distinguish between a nonwoven textile and a paper product. Nonwovens are widely used, for example in fusible interlinings, waddings, disposable single-use products, such as wiping cloths, operating room gowns and cloths, diapers, but normally ordinary garments are not made of nonwoven fabrics. (See also chapter 5.1.)

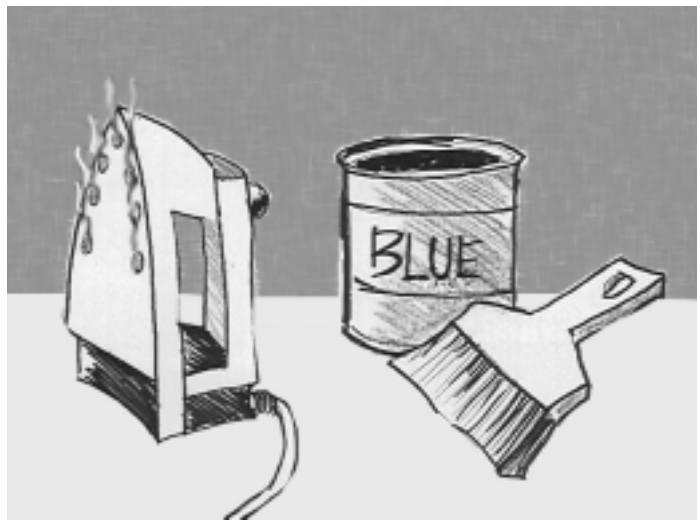
a) b) c)

Figure 2. Basic fabric structures: a) knitted fabric, b) woven fabric, c) nonwoven.

4.3 Dyeing and finishing

Dyeing and finishing give a fabric desired colour and properties. Dyeing and finishing agents may be applied to fibre, yarn or fabric. Some properties, such as fabric handle, performance, durability and dimensional stability for instance can be improved by use of finishing chemicals or physical treatments like heat and steam. The most common finishes are antistatic finish, water repellency, soil repellency, stain release, flame retardant and thermal treatment to fix a fabric to the desired end requirements and dimensions. Treatments applied on fabrics have a tendency to wear off during washing, and are more durable when applied on the fibre. Dyeing and finishing agents may irritate sensitive skin especially if the skin is abraded. On the other hand a totally unfinished material has poor fabric handle properties and is uncomfortable to wear. Examples of different finishing treatments are given in chapter 5 Textile properties. [11]

Products with so called “green labels” such as Ecolabel or Oeko-Tex are either ecologically produced or do not contain components which might be harmful for the user. Ecolabel is the European mark for ecological products, which requires a life cycle analysis of the total production, care and disposal process. Oeko-Tex certified products are tested and continuously controlled against limiting values for free formaldehyde, pH, colour fastness, etc., to ensure that it does not cause allergies or other health problems.



5. Textile properties

Textile properties have been categorised as the following:

Basic data
Basic data describes general information relating to textile products and this is usually provided by the manufacturer.

Mechanical durability
Mechanical durability describes the strength properties of fabric.

Appearance
Appearance presents the properties which will affect the aesthetical aspects.

Comfort
Comfort properties describe the different aspects affecting comfort in wear.

Service
Service properties concern the washability and dryability of fabrics and their ability to withstand the washing procedures.

Safety properties.
Safety properties concern fire safety and safety in clothing design.

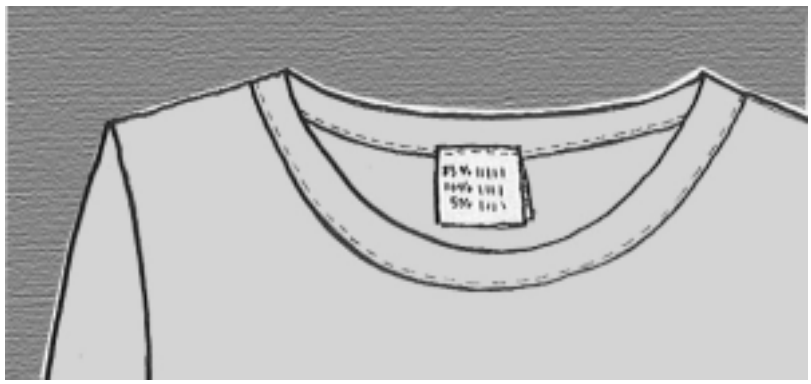
Based on these considerations, test methods have been selected and several tests have been carried out in order to give recommendations to meet the special needs of disabled and elderly people. The objective is that the end-user or carer can identify the fabric properties that would meet their special needs and choose appropriate fabrics or products. From the point of view of a fabric manufacturer, it will enable a correlation between their products and the required properties to be made.

5.1 Basic data [11]

Raw material defines the expected properties of a fabric. The raw material can be a pure synthetic fibre or a natural fibre or a blend. By blending synthetic fibres with natural fibres or by blending synthetic fibres with other synthetic

fibres, or natural fibres with other natural fibres, it is possible to influence the fabric performance. For instance improved abrasion resistance of wool is achieved by blending a sufficient proportion of polyamide with wool. Wrinkle recovery can be achieved by blending polyester with natural fibres.

The fibre content is generally marked on the product label. It states the proportion of the different fibre components in a fabric in per cent (%).



Mass per unit area describes the weight of fabric per specific area (g/m^2) and gives an idea whether it is a light or heavy material. This information is vital when it is necessary to minimize all extra weight, for example when designing a garment for a disabled or elderly person who has weakened strength and dexterity. A low value for mass per unit area suggests a thin and light fabric, and a high value denotes a thick, bulky and heavy fabric.

Thickness of fabric is affected by fabric and yarn construction but also the yarn density which is derived from the fineness of fiber. A thick fabric usually possesses better thermal insulation properties than a thin fabric but this largely depends on the amount of air bound into the fabric construction. Thick materials will affect a persons dexterity, especially in multilayer clothing.

Width of fabric is the dimension between fabric selvages measured when the finished fabric is in a relaxed state. The width of a fabric is determined in the fabric manufacturing stage but it can be affected by finishing treatments such as heat, steam and cutting. The width of a finished fabric is essential information for clothing manufacturers when constructing lay-out and cutting plans.

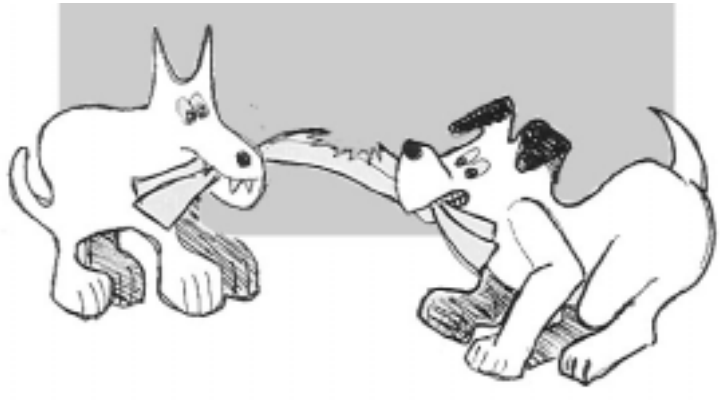
Origin (country) of the product is nowadays difficult to define because of global manufacturing policy. A fabric may be produced in one country, cutting carried out in another country and the garment assembly in a third country. This is partly due to well-developed logistics and transport chains which aim to lower the production costs and get production plants closer to market at the right time. The consumers consider this information very important; some people appreciate domestic products while others prefer brands or foreign products. Nowadays it is not necessary to state the country of origin and the manufacturer on product label.

Fabric construction is determined by factors like fibre fineness and yarn number and the production technology that has been used to make the textile. The main production processes are weaving, knitting and nonwoven technology each with a large number of different structures (plain, twill, satin, jacquard etc. weaves; single, double, piquet, etc. knits; thermally, chemically, mechanically etc. bonded nonwoven). The structure of a fabric surface can be plain, raised fiber surface, loose or tight depending on the type of bonding technique. A smooth fabric surface will have a large contact area with the skin while a rough surface will have fewer contact points with the skin. This affects the thermal comfort so that the more space and air that is present between the skin and fabric layer, the warmer the fabric feels to wear.

Intended time of use is the expected lifetime of a product. It depends on the raw material, purpose of use and care maintenance. The product can be either single-use which means that it is disposed of after a single use and usually it is not washable, or it is reusable which means that it can be used and washed numerous times. Disposable, single-use products are usually made of nonwoven textiles (e.g. diapers, incontinence products) while reusable textiles are made from woven and knitted textiles. Nowadays reusable washable nonwoven products have been developed but their service life is considerably shorter than with traditional reusables.

Care maintenance recommendations or **care instructions** must be labelled to each product to inform users about how to take care of the garment and thus extend its life. Main points are: optimum washing and ironing temperatures, drying technique and temperature, dry cleaning and bleaching chemicals.

5.2 Mechanical durability [11]



Abrasion resistance describes the ability of a material to withstand rubbing against another material, e.g. fabric, seams, skin, prosthesis, furniture, floor. As a result of abrasion the fabric surface changes visually and physically depending on the properties of the raw material: fibre ends raise from the surface of the fabric and cling to each other (pilling), fluff comes off, colours fade, the mechanical tenacity decreases and yarns snap causing holes to form in the fabric. Disabled and elderly people using a prosthesis or moving by crawling on all fours, or leaning their elbows on a table, face this abrasion problem when their clothing is exposed to strong rubbing especially in joints (knees, elbows). Certain disabilities may cause the need to constantly change the sitting position in a wheelchair which exposes the material to severe rubbing. Another example where strong abrasion might occur is when the rubber material of the wheel constantly rubs against garment sleeves when “rolling”. These special needs have to be considered when choosing fabrics.

Tear resistance of a fabric will need to be considered in some cases. For example when a disabled person who has spasms or whose limbs stiffen is dressing himself or is being dressed or undressed and garment fabric is exposed to sudden tension. Tear forces are concentrated on a single yarn at a time.

Breaking strength describes the ability of a fabric to withstand a steadily increasing pulling force until it breaks down. These kind of forces appear in aiding devices e.g. lifting belts and sheets and transfer lifts, which have to be able to carry heavy loads.

Seam strength is a problem with slippery fabrics such as lining materials or garments that are under continuous stress and movement e.g. trousers or tight fitting clothes (underwear, sportswear). The seam strength depends not only on the fabric construction and friction but also on the seam type and sewing thread that has been used to join two pieces together. Seams have to resist tension to all directions, rubbing, abrasion and elongation, e.g. the legseam in trousers.

Bursting strength describes the force that is needed to penetrate a fabric with a blunt object. It depends on the composition, the raw material and elasticity of fabric. Testing the bursting strength is carried out on many types of textiles but it is used especially for knitted fabrics to measure their strength, because the tear strength and breaking strength methods are unsuitable for those products.

Elastic properties are needed in garments that are exposed to bending and elongation e.g. knee and buttock areas in trousers or elbows in shirts. Elasticity describes the materials ability to stretch and recover from the stretched state. People who are sitting for long periods in a wheelchair but are also able to walk with walking sticks often face the problem of baggy knees in trousers. This means that the fabric has lost its recoverability. Elastic properties are needed in joint areas or in tight fitting clothing (underwear, sportswear) or clothing that holds on pads and protectors (hip protectors). Elastic properties are affected by fibre crimp (crimp: curliness of fibre), fibre raw material and fabric construction.

5.3 Appearance [11]

Colours may fade, bleed or peel off in use as a consequence of rubbing, washing, sunlight, perspiration, deodorants. **Colour fastness** depends on the raw material used in a fabric, the dye chemicals used and the care maintenance conditions. Dye behaviour affects not only the appearance and aesthetics of a garment but also safety and practicality. Fading colours make clothes and textiles look shabby and worn, bleeding colours can colour and irritate a persons skin, or they can colour other textiles in wear or in wash. Problems are also caused by strong sweating when sitting for long periods and holding the arms in the lap for a prolonged time. Colour fastness can be measured in many different ways, but the most common methods are: colour fastness against rubbing in dry and wet state, colour fastness against washing, against perspiration and against light are the most common methods.

Staining means that the fabric does not repel stains but on the contrary stains adhere to the fabric or are absorbed by the fibres, depending on their hygroscopic nature. Staining can be prevented by specific finishing chemicals that increase the fabric surface tension, thereby helping to repel stains. **Stain removal** defines how easily stains can be removed once they have adhered to a fabric. Common stains are food, blood, medicine, urine and excrement. Stain removal depends on the type of stain, the freshness of stain, the type of detergent used and washing temperature in addition to the hygroscopic nature of fibre material. Some resin treatments may hinder the stain removal. **Soil repellency** treatment or soil-resistant finishing protects textiles against soiling and stain-release finishing makes the cleaning easier (such treatments as Scotchgard®, Teflon®).

Wrinkles are formed by the combination of heat, moisture and pressure. The thermoplastic and elastic properties of a fabric determine its wrinkling and recovery properties. Wrinkling is an aesthetic problem, wrinkled clothes do not look good on anybody. Wrinkles in clothing are a major problem for people who are sitting part of their time in wheelchair, and part of the time walking with crutches. People who lie in bed part of their time but are able to get up and walk short distances will also experience problems. Wrinkles can also cause skin irritation and bedsores if the wrinkles are strong and they press into the body for a long period. Wrinkling can be reduced by choosing appropriate fabric construction, finishing agents or by using appropriate fibre blends. **Crease resistant finish** is a resin finish which improves crease recovery.

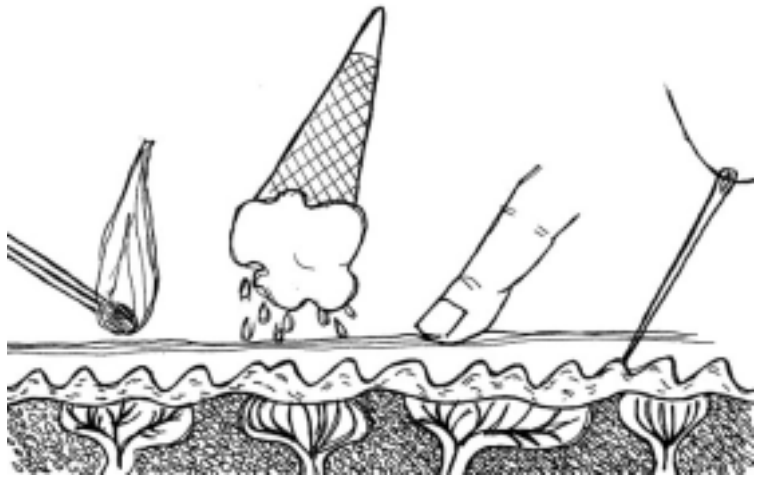
Seam puckering is a visual problem but it can also cause pressure on skin and thus skin irritation if it is very strong. Seam puckering means that the seam is tightened up and it is wrinkled. It derives from using the wrong type of sewing thread and too tensioned a stitch.

Drapeability lends aesthetical and practical aspects to a garment. Nondrapeable fabric is clumsy, hinders movement and is aesthetically unpleasing. The drapeability of a fabric depends on the fibre length in the yarn, yarn density and thus fabric density and fabric construction and the finishes. A too hard and dense fabric has poor drapeability properties. From the point of view of a user it is important that clothes drape well and look good without constant attention. Straightening of clothes is difficult for persons having weakened dexterity or using crutches. Clothing should not emphasize a persons physical weaknesses and disabilities.

Natural fibers and synthetic fibers have different tendencies to charge electrically when they are rubbed against each others and then separated. Natural fibres are water absorbent which makes them more electrically conductive than synthetic fibres. **Static electricity** in clothing and textiles causes materials to cling to each other or to the skin, which for instance may become a major problem for ladies wearing skirts particularly in the winter time. Also stains, soil and fluff will adhere easily to a fabric surface, and stains are difficult to remove and they look unaesthetic. Moreover, static electricity means that clothes feel uncomfortable to wear. Static electricity can be decreased by antistatic finishing treatments which increases the surface conductivity of a textile and thus prevents the build-up of electrostatic charges particularly in conditions where the relative humidity is lower than 30 %. Other possibilities are by adding an electrically conductive fibres into the fabric or increasing the relative humidity in the environment.

Pilling arises due to raised fibre ends on the fabric surface clinging to each other to form pills. Some materials have a strong tendency for pilling e.g. synthetic materials, and it is a common occurrence for products exposed to abrasion and made of short staple fibres.

5.4 Comfort properties [11]



Good thermal insulation properties are needed in clothing and textiles used in cold climates. The need for thermal insulation depends on the level of activity of a person and the climate (temperature and wind). Thermal insulation describes the ability to keep the person warm in a cold environment where a breeze or a wind can cool down skin temperature rapidly. Wheelchair users have difficulties in finding proper clothing for outdoors because their level of activity is very limited. This means that they have to dress up warmly when going outside and again undress all the extra clothing layers when entering indoors. So it is not easy to cope with maintaining the appropriate thermal balance (trying to avoid sweating and getting cold) and managing all the dressing and undressing procedures.

Water vapour transmission is essential in determining the **breathability** of clothing and textiles in outdoorwear as well as in indoorwear. A breathable textile allows extra heat loss by evaporation of moisture through the clothing layers. If clothing layers are impermeable the moisture is captured between skin and clothing and heat is accumulated in the body. As a consequence, heat and moisture build up, causing discomfort, wet skin and skin abrasion. This problem is emphasized with people who are permanently in a wheelchair or lying in bed. Moisture in the liquid state can be transported away from the skin using channel

shaped synthetic fibre material in fabric. The shape of the fibre cross section can be modified with synthetic fibres.

Air permeability describes the property of fabric to let through air. In outdoor clothing it is important that the air permeability is as low as possible because it should function as a wind protection.

Water resistance is needed in outdoor clothing for protection against rain and is a requirement for furniture and bed coverings to protect against liquid excretions. Textiles and clothing can be water repellency treated with finishing agents or they can be made totally water resistant with coatings or laminated membranes. **Water repellency** treatment modifies the surface tension properties of fibre or fabric so that they repell water drops. Treated fabrics are not absolutely impermeable to water. The treatment may also improve soil repellency.

Liquid water transmission is an important feature of diapers. It is the ability to absorb and capture liquid inside the fibres but not letting it escape. If sweat condenses to liquid it must be able to be transmitted away from the skin surface (see also chapter above `Water vapour transmission`).

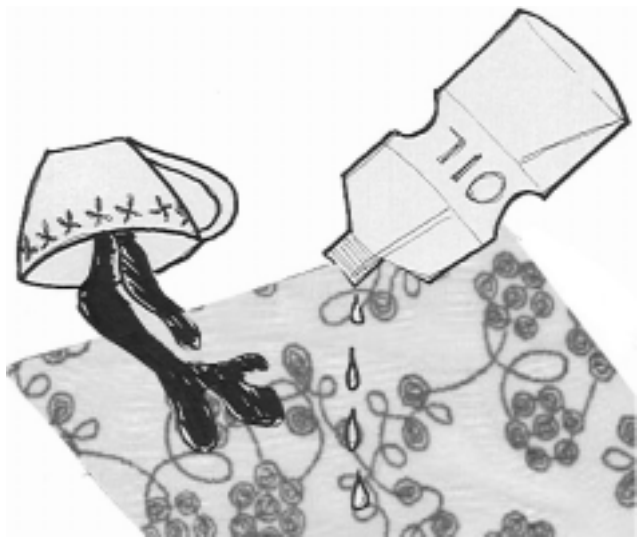
Hand properties describe the performance of a fabric on skin contact, and depend on the fibre material, the fabric construction (surface structure) and the fabric finishing treatments. The hand properties is a very complex concept, including dimensional changes at small forces (tensile, shear, compression, bending), surface properties (friction and roughness), and surface coolness or warmness. A smooth fabric surface has a large contact area with the skin and thus it may feel cool to skin because a thermal insulative airlayer is absent. Surface friction affects not only hand properties but also safety in use. Low friction suggests a slippery material, which although may improve its drapeability will decrease its safety (for example this would be an important consideration for socks).

Different finishing and dye chemicals, and detergents and conditioners used for the finishing and maintenance of textiles and clothing may cause **allergies** in sensitive persons. A finishing agent, formaldehyde, which has previously been used in resin finishing treatments and in some fire resistant finishings, is known

to have caused allergy. Therefore it is no more allowed to use in finishing processes or at least the end product may not release free formaldehyde. Oeko-Tex Standard 100 has limit values for formadehyde and for pH by product classes. The value of pH may depend on the finishing agents which have been used but also the pH of the washing processes. It describes whether the liquid or material is acidic, neutral or alkaline. Neutral or slightly acidic pH value is less irritating for skin. Taking medication may also cause an increased tendency for allergies which combined with mechanical abrasion (e.g. seams) can cause skin irritation. There are nonperfumed detergents and conditioners available on the market that can give some help for allergy sufferers. It is known that tumble drying, combined with the use of a fabric conditioner in rinsing water increases the softness of textiles. **Softening** treatment improves the handle of the fabric and wear comfort.

Different **antimicrobial finishing** treatments are used to decrease the bacterial growth in textiles and thus to prevent infection. Treatments are used in socks, sheets and carpets for instance. [5]

5.5 Service properties [11]



Shrinkage after washing and steaming is quite common especially with materials made of natural fibres and modified cellulose based fibres, but also with synthetic fibres. In addition to fibre material, the fabric construction and finishing treatments, washing and drying temperatures can also affect the shrinkage. To some extent it is normal that textiles and clothes shrink during washing and drying processes, and garments and textiles may even recover when in use. However severe shrinkage causes irreversible dimensional changes in the fabric and fitting problems. One special problem is the felting of woollen products which causes problems e.g. in laundries. **Dimensional stability** of woollen and cellulose fiber textiles is achieved by using a special shrinking process, for example “Sanforised” for cotton materials and decatizing for woollen materials. Textiles made of synthetic fibers are rendered dimensionally stable by heat setting.

Colour fastness regarding service properties has been referred in chapter 4.3 Appearance. Colour fastness to washing requires adequate washing temperatures and optimal dosage of detergents and conditioners. Fastness to dry cleaning demands the use of appropriate chemicals if it is permitted at all. The correct temperature needs to be taken into consideration also for colour fastness to ironing and pressing.

If textiles and clothes easily suffer from **wrinkling** after the washing procedure it is not only a visual but also a mechanical strength problem. Wrinkles are sharp creases that hinder fabric elasticity and weaken the mechanical strength in the long term. Removal of wrinkles also mean extra work and extra stressing to a fabric because of ironing heat, pressure and moisture.

Permanent press is a crease that should not diminish after repeated washings. As an example the process is used in womens' pleated skirts and mens' trousers.

5.6 Safety properties [11]

Flame retardance is an important requirement for clothing and interior design textiles such as curtains, furniture covers and bed textiles. It is essential in textiles in public places or caring institutions where it is not prohibited to handle fire. In caring institutions such as old peoples homes there is a different

approach to fire safety. The risk of fire is minimised by such procedures as prohibiting smoking, the use of candles in rooms and limiting the use of a persons own electric apparatus, not by using flame retarded textiles. Different countries have different laws which determine flame retardance regulations. In Sweden for instance they have very strict laws about this. Fabrics may be treated by **flame-retardant** finishing, for example Proban®, or they may be made from fibers that are not easily ignitable such as wool or flame-retardant polyester Trevira CS.

During the process of **clothing design** the practical aspect of clothing must be considered. This means from initial fabric choice through to design. Fabric sticking to the skin can have a harmful effect since it may cause severe problems with safety. Material may stick to skin and thus hinder movements e.g. a long skirt which clings to the feet may cause stumbling, or a night dress that clings to the body will hinder a person turning when in bed. When designing a garment attention must be given to such garment features as the end of the sleeves, or the height of the pockets, because they may stick to door handles. Friction is needed in socks, sneakers and seat covers to hinder slipping. [11]

6. Requirements

In the following chapter the special recommendations for products are defined which will meet the special needs of disabled and elderly people. The work within this EASYTEX project is based on the long test series performed for several different types of fabrics in the participating laboratories and analyses of the test results and existing recommendation proposals and limit values in workshop panels.

Altogether 136 knitted and woven test fabrics were acquired from the industry in Finland and in Greece. Since only a few manufacturers are manufacturing products for the needs of the disabled and elderly, the manufacturers were asked to send the products which might meet the special needs of these user groups in their opinion. The fabrics were for undergarments, night dresses and other clothing items such as blouses and trousers, shirts, jackets, bed covers, sheets, etc.

The participating laboratories performed long test series for each sample and measured the basic, mechanical, appearance, comfort, service and safety properties on these fabrics according to standard test methods and following the care instructions of the products. Interlaboratory tests have been used for the cross-checking of the results and test methods. The choice of the critical fabric properties and relevant test methods was based on the survey of the user needs and the expertise the laboratories have on testing. It was presented in the report *D5.1 Definition of critical fabric properties and relevant test methods*. [11]

The results of the laboratory tests were evaluated and the importance of the properties were discussed in one day workshop panel meetings in Finland and in Greece. The participants represented experts from industry, care, end users and research sectors. The test results were compared to existing recommendation proposals of ECLA and limit values of Oeko-Tex Standard 100 and suggestions for limiting values were given. European Clothing Association, ECLA, which no longer exists and has been replaced by EURATEX, has published in October 1996 a proposal of recommendations concerning characteristics and faults in fabrics to be used for clothing. [10] Oeko-Tex Standard 100 defines the limit values for free formaldehyde, pH, colour fastnesses etc. to ensure that it does not cause allergies or other health problems. [9]. The test results and the results of workshop panels, the special recommendations are presented in report *D5.3*

Results of laboratory tests, suggestions for limiting values [15]. The special recommendations are also presented in the following chapter 6.1 and the summary of them is also gathered in Table 2 in Annex 1.

6.1 Special recommendations [15]

6.1.1 Special recommendations for basic data

Mass per unit area and thickness: No general recommendation for clothing and interior textiles can be given, as the optimal mass per unit area and thickness strongly depends on the purpose of use of the textile. As the durability of fabrics is depending on the mass per unit area, a minimum recommendation of 180 g/m^2 for 100 % cotton and 120 g/m^2 for 50 % CO / 50 % PES sheets is given in the Finnish standards for hospital textiles. This can also be taken as a general recommendation for the sheets for disabled and elderly people.

6.1.2 Special recommendations for mechanical durability

Abrasion resistance: The workshop panel recommended for heavy use 40 000 r (Martindale) for clothing materials and 50 000 r for furnishing materials. Knitted fabrics (unless they are specially designed for resisting high abrasion) are not recommended in areas that are exposed to heavy rubbing.

Tear resistance: It is recommended for heavy use that tear resistance for woven clothing fabrics is at least 25 N when using Elmendorf method.

Breaking strength: Sheet fabrics for demanding use should have a minimum breaking strength of 350 N for cotton polyester blended (50%/50%) sheets and 450 N for cotton sheets. Special recommendations for clothing fabrics are not given.

Seam slippage and strength: A special recommendation value is not given for seam strength because it has not been experienced a special problem.

Bursting strength: It is not given any special recommendation value for bursting strength because it was not considered a special problem by the workshop panel.

6.1.3 Special recommendations for appearance

Colour fastness against rubbing [1]: Oeko-Tex Standard has limit values for colour fastness against rubbing 4 for dry and 2–3 for wet. ECLA's proposal for clothing fabrics for dry and wet is 4. The limit values in Oeko-Tex Standard 100 can be considered as minimum values. Light colours are recommended for persons who have very sensitive skin.

Colour fastness against washing [1]: It is recommended for colour fastness to washing value 4 according to ECLA's proposal.

Colour fastness to perspiration [1]: It is recommended value 4 for minimum value for colour fastness to perspiration according to ECLA's proposal.

Colour fastness against light [2]: A minimum value 5 is recommended for clothing fabrics. For furnishing fabrics no special recommendations are given.

Stain removal: No special recommendations are given based on these test methods.

Wrinkling and wrinkle recovery: It is recommended for clothing fabrics at least value 4.

Smoothness after washing and drying: For a private user this property is very important. No absolute recommendation value is given.

Bending stiffness: No special recommendation value is given by the workshop panel.

Electrical resistance: Not able to give any special recommendation values.

Pilling [1]: It is recommended that the pilling for clothing fabrics is 4 at least.

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[1] The grading scale is 1–5, where the grade 5 is the best (no change).

[2] The grading scale is 1–8, where the grade 8 is the best (no change).

6.1.4 Special recommendations for comfort properties

Thermal resistance: The need for proper thermal insulation is particularly important for persons with low physical activity in cold outdoor environments, e.g. wheelchair users. Indoors at +20 °C a person at rest requires an insulation of 0,155 K*m^2/W (=1clo). Outdoors with no wind the value is at +10 °C ~ 0,4, at ±0 °C ~ 0,6, at –10 °C ~ 0,8, and at –20 °C ~ 0,95 K*m^2/W, respectively. Wind and humidity decrease the thermal resistance of the clothing. If the activity increases the need for thermal resistance decreases.

Note: Within the project the thermal resistance of materials was measured. The thermal resistance of clothing is affected by all clothing layers and the air layers inbetween.

Breathability: It is recommended that the breathability of woven and knitted clothing fabrics is at least 5000 g/m^2*24 h. No special recommendation is given for furnishing fabrics. The breathability of seat covers depends also on the breathability of the filling material beneath the cover material.

Air permeability: If some degree of protection against wind is needed an air permeability of less than 150 l/m^2*s is recommended. If windproof material is needed, then the recommended value for air permeability < 20 l/m^2*s. However, these recommendation values are only valid for those results that have been measured using pressure drop 100 Pa and test surface area 20 cm^2.

Water resistance: No special recommendation values are given based on the test results.

Hand properties: No special recommendation values are given because the materials vary and each of them should be analysed separately. (Kawabata measurements)

Formaldehyde and pH: Oeko-Tex Standard 100 has limit values for formaldehyde as follows: for babies 20 ppm (product class I), in direct contact with skin 75 ppm (product class II), with no direct contact with skin 300 ppm (product class III) and decoration material 300 ppm (product class IV).

The international limit values of Oeko-Tex Standard 100 for formaldehyde are recommended.

Oeko-Tex Standard 100 sets limits for pH-values as follows: for product classes I, II (babies and in direct contact with skin) 4.0–7.5 and 4.0–9.0 for product classes III, IV.

The international limit values of Oeko-Tex Standard 100 for pH are recommended.

6.1.5 Special recommendations for service properties

Dimensional changes: According to ECLA's proposal it is recommended for knitted fabrics –6…+2 % and for woven fabrics –1.5 % after 1 washing cycle.

6.1.6 Special recommendations for safety

Fire safety: It is not possible to give an absolute recommendation value for flame spread time because 15–60 s is so short time that it will not help people with disabilities. Disabled or elderly people can not extinguish or take off the burning clothing fast enough. Fire safety of garment depends first on fabric properties, such as fibre, square weight, structure, but also on design of garment. Skintight garments are more safe than loose design garments. Two-piece garments are more safe than one-piece garment because of slower burning. A belt in one-piece loose garment slowes the burning rate. Pile or nap fabrics are not recommended. Thermoplastic fibres, such as polyester and polyamide, melt away from the flame but the molten drops can cause serious skin burns. [15, 3]

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Annex 1 Examples of trade names and summary of special recommendations

Table 1. *Examples of most common trade names.*

TRADE NAME	SHORT DESCRIPTION	MANUFACTURER
Fibres		
Tencel	Lyocell, a regenerated cellulosic man-made fiber, cellulose from wood	Courtaulds Fibers, Inc., USA
Bemberg [1)], Cupro [2)]	A regenerated cellulosic fiber, is said to have "silk-like" feel	[1)]Bemberg SpA, Italy, [2)]Asahi Chemical Industry, Japan
Polynosic	Modified modal fibers, e.g. good shape and dimensional stability	
Rhovyl	Chlorofiber, polyvinylchloride (PVC)	Rhovyl SA, France
Trevira	Polyester (polyethyleneterephtalate), synthetic fiber, do not shrink and felt, hardly crease, easy to wash, dry quickly	Hoechst Celanese Corporation
Trevira CS	Polyester, synthetic fiber, flame retardant	Hoechst Trevira GmbH, Germany
Lycra	Elastane, synthetic filament yarns with high elastic stretch and recover	Du Pont (U.K.) Ltd., Great Britain
Microfibres	Polyester, polyamide; man-made fibers, mainly filament but also staple fibers, individual titer 1.0–0.3 dtex, finer than silk, light and dense fabrics with water repellent but breathable properties	
Nylon	Earlier patented brand name for polyamide PA 66 fibers of Du Pont, nowadays in the USA generic term for polyamide fibers	

Dacron	polyester	Du Pont
Coolmax	Specially shaped polyester fiber that is said to have good moisture transfer properties	Du Pont
Thermastat	Hollow polyester fiber that is said to have good thermal properties	Du Pont
Woolmark	Pure new wool	IWS (International Wool Secretariat)
Finish treatments		
Scotchgard	Fluorocarbon treatment, water and stain repellent	3M
Sanitized	Antibacterial treatment	Sanitized marketing AG
Sanforised	Low shrinkage treatment for cotton	The Sanforised Company
Coated or laminated fabrics		
Goretex	Polytetrafluoroethylene (PTFE), microporous film	W. L. Gore
Sympatex	Polyurethane (PU), hydrophilic film	Akzo
“Green” labels		
Oeko-Tex Standard 100	The end product not harmful for user	
Ecolabel	Ecologic production process	

Table 2. *Special recommendations according to deliverable D 5.3 Results of laboratory tests, suggestions for limiting values [15].*

THE MEASURED PROPERTY	**SPECIAL RECOMMENDATION**
3.1.2.1 Mass per unit area and thickness	180 g/m^2 for 100 % cotton and 120 g/m^2 for 50 % CO / 50 % PES sheets.
3.2.1.1 Abrasion resistance	For heavy use 40000 r (Martindale) for clothing materials and 50000 r for furnishing materials Knitted fabrics are not recommended in areas that are exposed to heavy rubbing. No special recommendation values for carpets.
3.2.2.1 Tear resistance	For heavy use the tear resistance for woven clothing fabrics at least 25 N (Elmendorf method).
3.2.3.1 Breaking strength	Sheet fabrics for demanding use should have a breaking strength of min. for cotton polyester blended (50%/50%) sheets 350 N and for cotton sheets 450 N. No special recommendations for clothing fabrics.
3.2.4.1 Seam slippage and strength	No special recommendation value because it has not been experienced a special problem.
3.2.5.1 Bursting strength	No special recommendation value because it has not been experienced a special problem.
3.3.1.1 Colour fastness against rubbing[2)]	The limit values 4 for dry and 2–3 for wet in Oeko-Tex Standard 100 can be considered as minimum values. Light colours for persons who have very sensitive skin.
3.3.2.1 Colour fastness against washing[2)]	Value 4 according to ECLA [1)].
3.3.3.1 Colour fastness to perspiration[2)]	Value 4 for minimum value according to ECLA [1)]
3.3.4.1 Colour fastness against light[3)]	A minimum value 5 for clothing. For furnishing fabrics no special recommendations.
3.3.5.1 Pilling[2)]	At least 4 for clothing fabrics
3.3.6.1 Stain removal	No special recommendations are given based on these test methods.
3.3.7.1 Smoothness after washing and drying	For private user this property is very important. No absolute recommendation value is given.
3.3.8.1 Wrinkling and wrinkle recovery	For clothing fabrics at least value 4.

3.3.9.1 Bending stiffness	No special recommendation values.
3.3.10.1 Electrical resistance	Not able to give any special recommendation values.
3.4.1.1 Thermal resistance	Indoors at +20 °C a person at rest need an insulation of 0,155 K*m^2/W (=1clo). Outdoors with no wind the value is at +10 °C ~ 0,4, at ±0 °C ~ 0,6, at –10 °C ~ 0,8, and at –20 °C ~ 0,95 K*m^2/W, respectively. Wind and humidity decrease the thermal resistance of the clothing. If the activity increases the need for thermal resistance decreases.
3.4.2.1 Breathability	Woven and knitted clothing fabrics is at least 5000 g/m2*24 h. No special recommendation for furnishing fabrics.
3.4.3.1 Air permeability	If some degree of protection against wind is needed an air permeability of less than 150 l/m^2*s is recommended. If windproof material is needed, then it is recommended for air permeability < 20 l/m^2*s. (pressure drop 100 Pa and test surface area 20 cm^2.)
3.4.4.1 Water resistance	No special recommendation values are given based on the test results.
3.4.5.6 Hand properties (Kawabata)	No special recommendation values are given.
3.4.6.1 Formaldehyde and pH	For babies 20 ppm (product class I), in direct contact with skin 75 ppm (product class II), with no direct contact with skin 300 ppm (product class III) and decoration material 300 ppm (product class IV) according to Oeko-Tex Standard 100. For product classes I, II (babies and in direct contact with skin) 4.0–7.5 and for product classes III, IV (with no direct contact with skin and decoration material) 4.0–9.0 according to Oeko-Tex Standard 100.
3.5.1.1 Dimensional changes	For knitted fabrics –6…+2 % and for woven fabrics –1.5 % after 1 washing cycle.
3.6.1.1 Fire safety	Recommendations and information will be given in the brochure.

1) ECLA – European Clothing Association no longer exists, replaced by EURATEX

2) The grading scale is 1–5, where the grade 5 is the best (no change).

3) The grading scale is 1–8, where the grade 8 is the best (no change).

Published by

Vuorimiehentie 5, P.O.Box 2000, FIN–02044 VTT, Finland
Phone internat. +358 9 4561
Fax +358 9 456 4374

Series title, number and report code of publication

VTT Research Notes 2143
VTT–TIED–2143

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Title

Clothing and textiles for disabled and elderly people

Abstract

The quality of life for disabled and elderly people can in many cases be substantially improved by a better choice of good looking and functional clothing and other textile products.

Disabilities often lead to special functional requirements of clothing and other textile products in living environment. Persons with highly sensitive skin have to consider the skin contact or tactile properties and avoid clothing with hard seams. For wheelchair users and for persons lying prolonged time in bed, who have a relatively low heat production, the thermal comfort properties are important. The transmission of moisture (sweat) from the skin is also a frequent problem. Also the mechanical durability of the materials in certain parts of the products can be a problem in many cases.

This leaflet was written as a part of the European EASYTEX project. The objective is to identify the problems that can occur concerning clothing and textiles for disabled and elderly people and to suggest solutions to these problems where possible.

Keywords
textiles, clothing, handicapped persons, elderly persons, EASYTEX, recommendations, thermal insulation, durability, comfortability, safety

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VTT Processes, Sinitaival 6, P.O.Box 1402, FIN–33101 TAMPERE, Finland

ISBN	Project number
951–38–5897–9 (soft back ed.) 951–38–5898–7 (URL:http://www.inf.vtt.fi/pdf/)	DE 3002

Date	Language	Pages	Price
May 2002	English	57 p. + app. 4 p.	B

Name of project	Commissioned by
EASYTEX (Aesthetical, adjustable, serviceable and mainstay textiles for disabled and elderly)	European Commission

Series title and ISSN	Sold by
VTT Tiedotteita – Research Notes 1235–0605 (soft back ed.) 1455–0865 (URL: http://www.inf.vtt.fi/pdf/)	VTT Information Service P.O.Box 2000, FIN–02044 VTT, Finland Phone internat. +358 9 456 4404 Fax +358 9 456 4374

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Tätä julkaisua myy
VTT TIETOPALVELU
PL 2000
02044 VTT
Puh. (09) 456 4404
Faksi (09) 456 4374

Denna publikation säljs av
VTT INFORMATIONSTJÄNST
PB 2000
02044 VTT
Tel. (09) 456 4404
Fax (09) 456 4374

This publication is available from
VTT INFORMATION SERVICE
P.O.Box 2000
FIN–02044 VTT, Finland
Phone internat. + 358 9 456 4404
Fax + 358 9 456 4374

ISBN 951–38–5897–9 (nid.)
ISSN 1235–0605 (nid.)

ISBN 951–38–5898–7 (URL: http://www.inf.vtt.fi/pdf/)
ISSN 1455–0865 (URL: http://www.inf.vtt.fi/pdf/)