(REFEREED RESEARCH)

DISPOSABLE UNDERARM PAD DESIGN

TEK KULLANIMLIK KOLTUKALTI TER PEDI TASARIMI

Telem GOK SADIKOGLU[1*], Omer Berk BERKALP[1], Gulname TURAN[2]

[1]Istanbul Technical University, Textile Technologies and Design Faculty, Textile Engineering Department, Istanbul, Turkey

[2]Istanbul Technical University, Architecture Faculty, Department of Industrial Product Design, Istanbul, Turkey

Received: 13.01.2011 Accepted: 28.06.2011

ABSTRACT

Sweating is a sign of healthiness, but it causes discoloration and a feeling of wetness. The modern man seeks solutions to these problems. This article discusses the design, production and performance analysis of a new disposable underarm pad. This pad is not designed to prevent sweating; rather, it absorbs sweat and provides a dry feel. The underarm pad consists of nonwoven fabrics and a polyethylene film. Objective and subjective tests were conducted to analyze the pad's performance. The objective tests included a strength test, a strike-through test, an absorption test and a wetback test. The subjective tests included trials with female and male subjects. The subjects tried the pads and evaluated their fit to the body, deformation during usage and feeling of dryness.

Key Words: Disposable, Underarm pad, Design, Performance analysis.

ÖZET

Terleme sağlıklı bir vücut aktivitesidir. Fakat terlemenin yarattığı ıslaklık hissi, kötü koku, giyside ıslak görünüm gibi olumsuzluklar kişinin yaşam kalitesini düşürmektedir. Bunun önlenmesi amacıyla pek çok yöntem kullanılmaktadır. Bu araştırma, yeni geliştirilmiş bir koltukaltı ter pedinin tasarım, üretim ve performans analizini kapsamaktadır. Bu ped terlemeyi önleme amaçlı değil, teri emip içinde hapsetme ve kullanıcıya kuruluk hissi verme amacıyla tasarlanmıştır. Koltukaltı ter pedi nonwoven kumaşlar ve polietilen filmden oluşmaktadır. Pedlerin performans analizi için objektif ve subjektif deneyler gerçekleştirilmiştir. Objektif deneyler mukavemet, sıvı geçiş hızı, emicilik ve tekrar ıslanma (wetback) deneylerini kapsamaktadır. Subjektif deneyler ise bayan ve erkek denekler tarafından pedlerin kullanımı ve vücuda uygunluk, kullanım esnasında deformasyon ve kuruluk hissi gibi unsurları irdeleyen anket sorularının cevaplanmasını kapsamaktadır.

Anahtar Kelimeler: Tek kullanımlık, Koltukaltı ter pedi, Tasarım, Performans analizi.

* Corresponding author: Telem Gök Sadıkoğlu, sadikoglut@itu.edu.tr, Tel: + 90 212 251 88 08 Fax: + 90 212 251 88 29

1 INTRODUCTION

Sweating, also called perspiration, is the release of a salty liquid from the body's sweat glands. Sweat commonly appears under the arms, on the feet, and on the palms of the hands, and sweating is an essential function that helps the body stay cool.

The number of sweat glands determines how much a person will sweat. Humans are born with approximately two to four million sweat glands, which become fully active during puberty. Women have more sweat glands then men, but men's glands are more active (1).

Sweating is related to a person's emotional state. When a person is nervous, anxious or afraid, sympathetic nerve activity and epinephrine secretions from the adrenal gland increase. These substances affect the sweat glands, particularly those on the palms of the hands and in the armpits, and stimulate the production of sweat. This prompts a "cold" sweat feeling. Furthermore, the increased sympathetic nerve activity in the skin changes its electrical resistance, which is the basis of the galvanic skin response.

The two types of sweat glands, eccrine sweat glands and apocrine sweat glands, produce different types of sweat and serve different purposes.. The sweat produced by the eccrine sweat glands, which are distributed over the entire body surface, is composed chiefly of water and various salts. These glands regulate body temperature. Apocrine sweat glands produce sweat that contains fatty materials. These glands are mainly

present in the armpits and around the genital area, and their activity is the main cause of sweat odor, which is caused by the bacteria that break down the organic compounds in the sweat from these glands. Emotional stress increases the production of sweat from the apocrine glands, and the sweat present in the tubules is expelled. Apocrine sweat glands also function as scent glands.

Excessive sweating on the palms of the hand or in the armpits that is not caused by emotional or physical activity is called diaphoresis or hyperhydrosis. It can be an embarrassing condition (2).

Prof. Dr. Ufuk Emekli considers sweating to be excessive (hyperhydrosis) if the body produces more than 1 milliliter of sweat per square meter of body surface in one minute. Hyperhydrosis can cause social problems. According to research conducted in the USA, 40 % of hyperhydrosis patients have problems with their private and professional social lives, 50 % lack confidence, 38 % feel that they are limited in their daily activities, and 50 % feel unhappy as a result of their hyperhydrosis problem (3).

According to Assoc. Prof. Dr. Nahide ONSUN, Head of the Dermatology Clinic at SSK Vakıf Gureba Hospital, most people with sweating problems do not go to the doctor. In Turkey, many people suffer from excessive sweating because Mediterranean people have fatty skin. Certain medications and surgical procedures are costly and not covered by governmental subsidies. Thus, our proposed product is an alternative solution for people with sweating problems (4).

Sweating is a healthy bodily activity, but the negative effects of sweating, such as wetness, unpleasant odors, and stained garments, are undesirable. One method for preventing these effects is the use of deodorants. Anti-perspirant deodorants prevent only some of the effects of sweating. Surgery is another method, but it is not a permanent solution, and it is expensive. These methods are not convenient for everyone.

Therefore, the objective of this research was to design and produce disposable user-friendly underarm pads capable of preventing the negative effects of sweating such as wetness and garment discoloration and thereby reducing dry cleaning costs.

Underarm pads first appeared on the market as washable and disposable alternatives (5, 6). Washable underarm pads are used with nightwear and dancing costumes and are produced from cotton fabric and fiberfill. Disposable pads are composed of coated or laminated nonwoven layers. Disposable hygiene products such as pads should have good absorbency and comfort properties and be aesthetically pleasing and protective. Designers of nonwoven hygiene products are faced with challenges such as wicking moisture (e.g., blood or sweat) to an absorbent layer where the liquid can be absorbed, distributed uniformly, and held inside the product. One produce must have all these properties. The aesthetic and comfort properties of a final product depend on its softness, protectiveness and ease of fit.

Inventor Peggy Faulkner developed disposable underarm pads that adhered to garments. Peggy Faulkner was inspired by pantyliners when designing the underarm pad. The product is composed of nonwoven layers. The top sheet, which touches the skin, is a polypropylene spunbonded absorbent nonwoven material that is thin, soft and airy. The second layer is an absorbent needle-punched rayon and polyester nonwoven material. The third retardant layer prevents sweat from penetrating and staining garments and is made from a spunbonded nonwoven material. An adhesive strip attached to the retardant layer allows the underarm pad to adhere to the sleeve and underarm of a garment, which prevents wadding. The edges of the pad are heat stacked to join the three layers together (7). The product contributes to personal hygiene. The pad's main function is to prevent the unpleasant odors caused by the reaction between sweat and certain types of fabrics such as polyester, satin, rayon, nylon, cotton and linen. The pad is designed to keep the wearer feeling fresh while preventing clothing discoloration.

As the demand for disposables increases in developed and developing countries, the disposable hygiene market is expanding and becoming highly competitive. New products are regularly entering the market, and the proposed product was designed for the Turkish and Middle Eastern markets. The design has been registered by The Turkish Patent Institute, and its Registration Number is 2005 04328 (8).

This study consisted of three parts: the design phase, the product performance phase and the design of a special material for hyperhydrosis patients.

2 MATERIALS AND METHOD

2.1 Material

As previously mentioned, this research was conducted in three steps. In each step, the product had the same layers: a top sheet layer, an absorbent layer and a back sheet layer (Figure 1). The thin and soft top sheet rapidly transfers liquid to the absorbent layer, which absorbs and retains liquid even under pressure. The breathable back sheet helps to prevent liquid from leaking out of the pad.

In the first step, fabrics A-F were tested for use as the top sheet, and fabrics G-H were tested for use as the absorbent layer; in the second part, fabrics J-M were tested for use as the top sheet, and fabrics N-R were tested for use as the absorbent layer; and finally, in the last part, fabric S was tested for use as the top sheet, and fabric T was tested for use as the absorbent layer. All fabrics are listed in Tables 1 and 2.

As shown in Table 1, Polypropylene (PP) nonwoven fabric is considered to be the best material for the top sheet in personal care products due to its wicking capabilities. Most top sheets tested were thermobonded carded polypropylene nonwoven fabrics. Nonwoven materials made from cotton, viscose, wood pulp/polypropylene/ polyethylene and viscose/super absorbent fibers were selected for the absorbent layer (Table 2). A breathable polyethylene (PE) film, a standard film used in baby-diapers to prevent liquid leaks, was used as the back sheet in all designs. An adhesive tape typically employed in hygienic pads was used on the back of the pads to fasten them to garments.

Table 1. Properties of the fabrics used for the top sheet.

Fabric code	Fiber type	Area weight (g/m^2)	Production method
A	Polypropylene	15	Spunbonded
B	Polypropylene	16	Thermobonded carded
C	Polypropylene	18	Thermobonded carded
D	Polypropylene	21	Thermobonded carded
E	Polypropylene	24	Thermobonded carded
F	Polypropylene	40	Thermobonded carded
J	Polypropylene	14	Thermobonded carded
K*	Polypropylene	22	Thermobonded carded
L	Polypropylene	32	Thermobonded carded
M	Polypropylene	22	Thermobonded carded
S	Polypropylene	20	Thermobonded carded

* With aloe vera finish

Table 2. Properties of the fabrics used for the absorbent layer.

Fabric code	Fiber type	Area weight (g/m^2)	Production method
G	Cotton	90	Spunlaced crosslaid
H	Viscose	90	Needle-punched crosslaid
N	WP* + PP/PE**	60	Chemical-bonded air-laid
P	WP* + PP/PE**	80	Chemical-bonded air-laid
R	WP* + PP/PE**	60	Thermobonded air-laid
T **	Viscose/SAF	155	Thermobonded air-laid

*WP = wood pulp; PP/PE = polypropylene/polyethylene; SAF = super absorbent fiber; ** PE film laminated absorbent layer.

2.2 Design

The objective of this research was to develop a practical solution for the discomfort associated with sweating. For the comfort of the user, products must have an appropriate form that fits the body and the clothing. The form of a product's design was realized by an industrial designer. Front and back views of the design are shown in Figure 1.

Underarm pads should fit the body lines to ensure comfort for the user, and they should fit the clothing. The adhesive tape in our pad is composed of three bands and located near the sides and middle of the pad. It is suitable for all types of fabric, sticks easily and can be removed without harming the fabric. Glue residue from the tape can be easily removed by washing. Colored lines were drawn on the pads to guide people in their placement.

The design is registered with The Turkish Patent Institute, and its Registration Number is 2005 04328.

2.3 Method

2.3.1 Strength Test

Because the underarm region is active during the daytime, pads are deformed and damaged during use. Therefore, the pad material should be strong enough to provide resistance for a certain amount of time. In our study, we used an estimated usage time of 6-9 hours. A strength test was performed using Zwick Z010 strength equipment according to EDANA 20, 2-89 (9).

2.3.2 Strike-Through Test

The most important property of the top sheet in an underarm pad is the speed at which it transfers liquid to the next layer. To assess this property, a strike-through test was performed with a Lister strike-through apparatus according to EDANA 150.3-96 (10).

2.3.3 Wetback Test

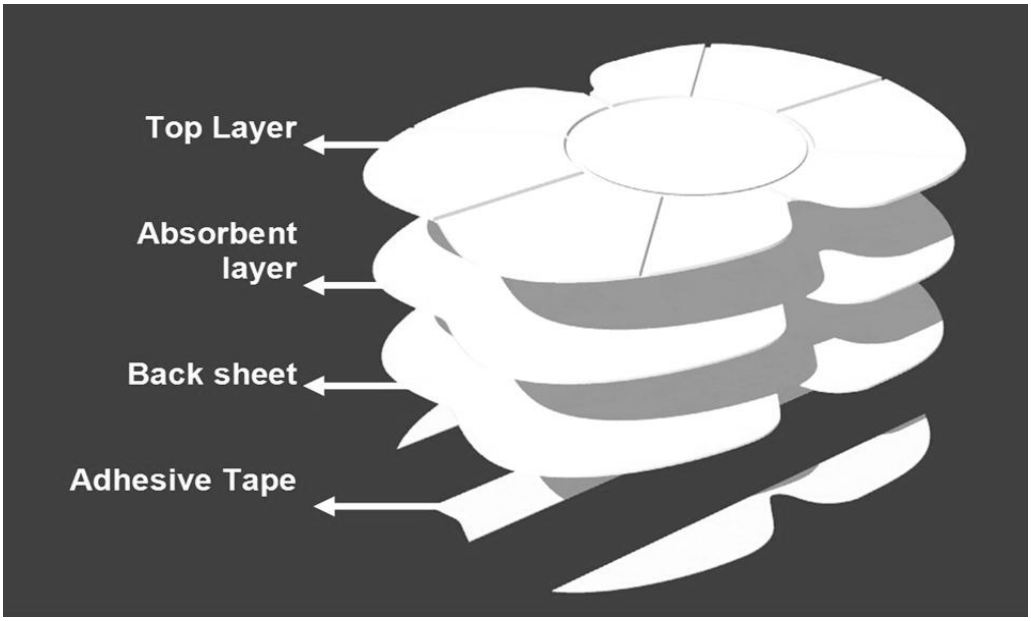
Another important function of the top sheet is to prevent liquid from escaping the absorbent layer. To analyze this aspect, a wetback test was performed according to EDANA 151.1-96 (11).

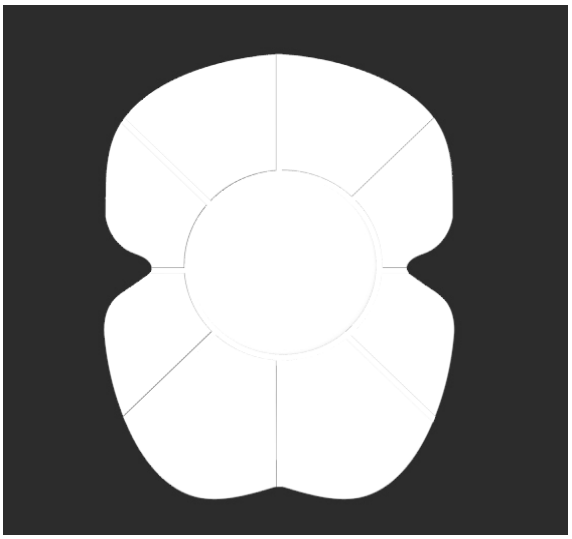
2.3.4 Absorption Test

The absorbent layer must absorb and contain excess sweat. A pad's absorption capacity should last for a determined amount of time (6-9 hours). An absorption test was performed according to EDANA 10.3.99 (12).

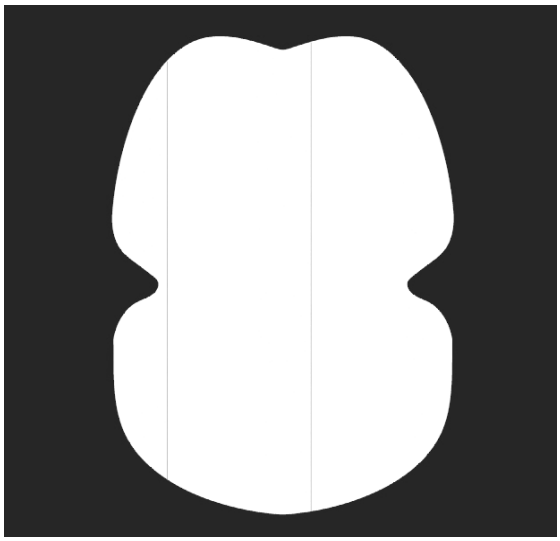
2.3.5 Subjective Evaluation

To subjectively evaluate the performance of the pads, 8 female and 6 male subjects tried the pads in their daily lives. The pads' fit to the body, deformation characteristics and wetting properties were examined by the users. The subjects used five specimens of each product and used one specimen per day during the daytime. A questionnaire, shown in Table 3, was prepared for the subjects in Parts 1 and 2 of the study. Four more questions were added to this questionnaire for the subjects in Part 3 of the study (Table 4).





Top view



Back view

Figure 1. Views of the underarm pad (layers, top view and back view).

Table 3. Questionnaire for Parts 1, 2, and 3 of the study.

1) Dryness 1- dry 2-a little humid 3-humid 4-very humid 5-wet
2) Fit to the body 1-very disturbing 2-medium 3-comfortable
3) Does it fit on the clothing? A) Yes B) No
4) How many hours does it last? A) 0-3 hours B) 3-6 hours C) 6-9 hours D) 9-12 hours
5) During usage, is there any shape change and deformation? A) Yes B) No
6) Is there any wetness in the clothing? A) Yes B) No
7) Does it cause an unpleasant odor? A) Yes B) No
8) Is it seen under the clothing? A) Yes B) No
9) Does the product give you an idea how it should be placed onto your clothing? A) Yes B) No
10) Is it placed on the clothing easily? A) Yes B) No
11) Is it removed easily after use? A) Yes B) No

Table 4. Added questions for Part 3 of the study.

12) To what extent did it help hyperhydrosis? A) very well B) well C) medium D) bad
13) Will you prefer it to the other solutions? A) Yes B) No
14) Did it help in diminishing your psychological problems? A) Yes B) No
15) How will you rate it? A) very good B) good C) medium D) bad

3. RESULTS AND DISCUSSION

As previously mentioned, this study was conducted in three parts: the design phase, the phase in which different materials were analyzed, and the phase in which hyperhydrosis patients used the pad.

In Part 1, six nonwoven and two nonwoven fabrics were tested for the top sheet and the absorbent layer, respectively. The results of the strength test are given in Table 5. Specimens A, B, C and D are fabrics commonly used as top sheets in the personal care products industry. Samples E and F are fabrics commonly used as interlinings in the readymade garment industry. Samples G and F are fabrics used as cleaning wipes. The acceptable strength value changes according to the area weight for different end-uses. For example, for PP samples, the strength value for a top sheet should be greater than 6±1 N/cm and 9 ±1 N/cm for areas of 15 g/m^2 and 40 g/m^2, respectively. The strengths of the selected fabrics were satisfactory for usage in under arm pads.

The strike-through times of the six nonwoven top sheet fabrics are given in Table 6. The acceptable strike-through time for personal care products, such as baby diapers and femcare products, is less than 3 seconds. Sweat is secreted in smaller quantities than urine and menstrual blood, so values below 4 seconds were deemed acceptable in this study. Although the strike-through times of specimens D, E and F were less than the times of the others, specimens A and B were selected for use due to their light weight and cost.

In the design phase, fabrics G and H were used as the absorbent layer because they are water absorbent fabrics. This choice was more of a design trial rather than a performance decision. Four different underarm pads (Table 7) were manufactured and tested.

Table 5. Strength of the specimens in Part 1.

Fabric code	MD* Breaking strength (N/cm) (Mean, SD***)		MD Elongation (%) (Mean, SD)		CD** Breaking strength (N/cm) (Mean, SD)		CD Elongation (%) (Mean, SD)	
A	6,05	0,26	53,61	2,94	3,23	0,01	59,25	5,12
B	5,86	0,29	67,76	8,76	2,21	0,23	101,42	13,02
C	6,27	0,25	76,62	7,42	11,67	0,65	101,53	8,56
D	7,6	0,63	82,97	13,06	2,76	0,14	115,58	11,48
E	8,87	1,47	97,45	21,74	3,06	0,52	86,29	18,58
F	7,37	0,28	36,16	5,21	1,78	0,18	52,33	9,71
G	26,57	0,98	43,46	6,4	7,6	0,87	107,25	4,65
H	15				28			

*MD = machine direction; **CD = cross direction; ***SD = standard deviation

Table 6. Strike-through times for the specimens in Part 1.

Fabric code	Strike-through time (sec) (Mean, SD)
A	3,462(0,318)
B	3,080(0,068)
C	3,880(0,400)
D	2,522(0,103)
E	2,756(0,152)
F	2,496(0,287)

Table 7. Fabric combinations used in the products in Part 1.

Specimen name	Top layer material	Middle layer material
A1	B	H
B1	B	G
C1	A	H
D1	A	G

Three female and two male subjects, aged 23 to 35, tested the underarm pads in their daily lives. The subjective tests were conducted at a temperature of 20-25°C in 63-65 % relative humidity. One subject sweated more than the others, and the others sweated similarly. Four subjects evaluated the pads as “a little humid”, whereas the excessively sweaty one evaluated the pads as “humid”. No considerable differences were observed between the pads in term of dryness. Each pad gave the same type of dry feeling to the user.

All the pads were found to be comfortable by all the users. Each subject agreed that the pads remained affixed to their clothing, but it was noted that the pads fit better on woven fabrics than on knitted ones. The pads were used for 6-9 hours by the four subjects, whereas the more sweaty subject used the product for 4 hours. The shape change and deformation properties of all specimens were acceptable.

The pads did not cause any bad smells, and they were not generally noticed in the clothing. Because all pads were white in color, they could be seen in light-colored garments. The colored line on the specimens helped the subjects to place the pads correctly. The specimens fit the garments, especially woven ones. Removing the tape from the fabric was easy, and no glue stains were observed on garments. All subjects were satisfied with the product, and they stated that they could use it in their daily-lives.

The design of the underarm pad was approved in the fabric performance tests and the subjective trials in Part 1, but one of the excessively sweaty subjects noted that she could only use the pad for 4 hours due to a slightly humid feeling. To overcome this result, the aim of Part 2 was to increase the absorbency capacity and thereby improve the pad’s dry feel.

After the first part of the study was completed, the design of the underarm pad was selected. The absorbency capacity of the pad was increased with air-laid fabrics such as wood pulp. Four nonwoven and three nonwoven fabrics were tested for the top sheet and the absorbent layer, respectively.

The strength test results of the specimens for the absorbent layer are given in Table 8. Specimens J, K, L and M are commonly used for top sheets in the personal care products industry. Specimens N, P and R contain short wood pulp fibers and PP and PET fibers that are used as absorbent layers in hygienic products. The strength values for an absorbent layer do not need to be as high as the values for top sheet fabrics because the absorbent layer is placed between the top sheet and the back sheet layers in an absorbent product. Furthermore, its function is to absorb liquid. The strength values of all specimens were acceptable.

Table 8. Strength test results of the specimens used in Part 2.

Fabric Code	MD Breaking Strength (N/cm) (Mean, SD)		MD Elongation (%) (Mean, SD)		CD Breaking Strength (N/cm) (Mean, SD)		CD Elongation (%) (Mean, SD)	
J	4,14	0,77	11,36	0,19				
K	6,15	0,37	51,71	2,55				
L	8,16	1,52	14,48	0,41				
M	6,504	0,78	46,37	4,40				
N	3,39	0,07	2,16	0,24	3,00	0,009	2,90	0,26
P	2,91	1,03	3,30	0,12	1,77	0,09	3,69	0,32
R	3,33	0,25	2,94	0,15	2,33	0,19	6,08	0,34

Strike-through times of the four nonwoven fabrics for the top sheet are given on Table 9. All values are below 4 seconds.

Table 9. Strike-through times of the four nonwoven fabrics used for the top sheet in Part 2.

Fabric code	Strike-through time (sec) (Mean, SD)
J	2,585 (0,43)
K	1,617 (0,15)
L	2,213 (0,27)
M	1,671 (0,29)

The absorbency capacities of fabrics N, P and R are given in Table 10. The limiting absorbency capacity is taken as 4 g/g for moderately absorbent products, such as baby diapers or femcare products. All the tested specimens had higher values than this limiting value.

Table 10. Absorbency capacity of the fabrics used for the absorbent layer in Part 2.

Fabric code	Absorbency capacity (g/g)(Mean, SD)
N	6,73 (0,18)
P	8,67 (0,98)
R	8,71 (0,47)

The fabric combinations used in Part 2 are given in Table 11. Four female and three male subjects, three of who also participated in Part 1, with different perspiration degrees and with ages between 23 and 36 years, used the underarm pads in their daily lives. The subjective tests were conducted in a temperature range of 20-25°C in 63-65 % relative humidity. Two subjects sweated more than the others, and the others sweated similarly. As in the first part of the study, all subjects except for one female evaluated the pads as "dry". One excessively sweaty female subject evaluated the pads C2 and F2 as "a little humid". Thus, no considerable differences were observed between the pads in term of dryness.

Table 11. Fabric combinations used in the product in Part 2.

Specimen name	Top layer material	Middle layer material
A2	J	N
B2	J	R
C2	K	P
D2	K	R
E2	L	R
F2	M	R

D2 was considered to be very uncomfortable by all users, whereas the other materials were considered to be comfortable. The top layer of D2 is a thermobonded-carded nonwoven fabric (22 g/m^2), with a soft aloe vera finish. The absorbent layer of D2 is a chemical-bonded airlaid nonwoven fabric (60 g/m^2) that was harsher than the other absorbent layers. Although a soft fabric was used as the top sheet, the harshness of the absorbent layer caused A2 to be ranked as uncomfortable.

Three subjects also tested the pads in Part 1, and they were asked to compare the pads in both Parts. All three stated that the pads in Part 1 were more comfortable than the pads of Part 2.

Each subject agreed that all pads except D2 remained affixed to their clothing, but some of them noted that the pads fit better on woven fabrics than on knitted ones. The pads were used for 6-9 hours by all subjects. The subjects stated that deformation occurred during usage, but the shape change and deformation properties of all specimens were acceptable according to the products' performance.

As in Part 1, the pads did not cause any bad smells, and they were not generally noticed in the clothing. The colored lines on the specimens helped the subjects to place the pad correctly. Removing the tape from the fabric was easy, and no glue stains were observed on garments. All subjects were satisfied with the product and stated that they could use it in their daily lives.

In Part 3, a special underarm pad was designed for hyperhydrosis patients. Hyperhydrosis can cause both physiological and psychological problems. A specially designed underarm pad could be a solution for people suffering from this condition. A fabric manufactured from a blend of viscose and super absorbent fibers was used as the absorbent layer and combined with a PP nonwoven top sheet. The strength, strike-through and wetback, and absorbency capacity test results are given in Tables 12, 13 and 14, respectively. The test values are acceptable for the intended use, as explained previously.

Table 12. Strength of the specimens in Part 3.

Fabric code	MD Breaking strength (N/cm)	MD Elongation (%)	CD Breaking strength (N/cm)	CD Elongation (%)
S	5,92	54,7	2,64	94,7
T	8,48	20,6	7,88	19,8

Table 13. Strike-through and wetback test results for top sheet (S) in Part 3.

	(Mean, SD)
Strike-through time (sec)	2,58 (0,12)
Wetback time (min)	0,1 (0,01)

Table 14. Absorbency capacity of the fabrics in Part 3.

Fabric code	Absorbency capacity (g/g) (Mean, SD)
S	4,31 (0,11)
T	13,73 (0,38)

Three female and two male subjects, with ages ranging from 22 to 45 years, tried the pads. Two of the subjects were hyperhydrosis patients. The subjective tests were conducted at a temperature of 20-25°C in 63-65 % relative humidity. In terms of dryness, subjects evaluated the pads as being a "little humid". The fabric used in the study was heavy compared to other absorbent layer fabrics. Nonwoven SAF fabrics are not widely manufactured and are typically used for packaging. Although it was considered to be a heavy fabric, it was also considered to be "comfortable". Even the hyperhydrosis patients were satisfied with the product and stated that they would use it. As in Parts 1 and 2, the pads did not cause any bad smells, and they were not generally noticed in long sleeve clothing. The colored line on the specimens helped the subjects to place the pad correctly. Removing the tape from the fabric was easy, and no glue stains were observed on garments. All subjects were satisfied with the product and stated that they could use it in their daily lives.

4. CONCLUSION

Low-weight polypropylene fabric is adequate as a top sheet for the type of product described in this article. Because of their softness, lightweight spunlace cotton and viscose nonwoven fabrics can be used as the absorbent middle layer. Using natural fibers in the middle layer is advantageous for manufacturers because consumers prefer natural products. Nonwovens that contain SAF can be used in arm pads for hyperhydrosis patients, but this design must be improved. A lightweight fabric should be used. Underarm pads can be made according to a person's size and degree of perspiration. In the trials, all subjects used deodorant daily to prevent the bad smells caused by sweating, and this could have been the reason why no bad smells were observed. Pad use without deodorant should be investigated. Either perfumed or antibacterial-treated fabrics could be used to prevent bad smells. Different colored pads could be manufactured. Underarm pads seem to be a healthy, cheap and easy solution for hyperhydrosis patients and people concerned with their looks. Underarm pads are sold in countries including the US, and with an effective marketing strategy, they can find a niche in developing markets.

ACKNOWLEDGEMENTS

The authors would like to thank Istanbul Technical University and the Telasis Company for funding, Assoc. Prof. Dr. Nahide ONSUN, Head of the Dermatology Clinic at SSK Vakıf Gureba Hospital for her assistance, Yasemin OZTURK, Ipek LALELI, Buket CABUK, Nazlı Irem ODABAS, Emel URAZ, Cigdem ULUSAHIN, Evrim BUYUKASLAN, Ilke KUMRAL and Ipek YALCIN for their assistance in testing, and Hassan, Mogul, Hayat Kimya, Avery Dennison, Saaf Advanced Fabrics, Nikoo Group, UNIREP and SANDLER for supplying the fabrics used in this project.

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*Bu araştırma, Bilim Kurulumuz tarafından incelendikten sonra, oylama ile saptanan iki hakemin görüşüne sunulmuştur. Her iki hakem yaptıkları incelemeler sonucunda araştırmanın bilimselliği ve sunumu olarak **"Hakem Onaylı Araştırma"** vasfıyla yayımlanabileceğine karar vermişlerdir.*