(REFEREED RESEARCH)

THE EFFECT OF DIFFERENT TYPES OF FABRIC ON THE CLOTHING COMFORT, SLEEP PATTERN AND SALIVA CORTISOL & MELATONIN LEVELS OF INFANTS*

FARKLI TİP KUMAŞLARIN BEBEKLERİN GİYİM KONFORU, UYKU PATERNİ VE TÜKÜRÜK KORTİZOL VE MELATONİN DÜZEYLERİ ÜZERİNE ETKİSİ

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ABSTRACT

Infants' health must be cared about in order to raise healthy generations. The way that infants can grow healthily is that they wear healthy, safe and comfortable clothes. The purpose of this study is to develop clothes intended for the clothing comfort of infants, to improve the product variety and quality of infant clothes, and also to research how the clothes affect infants. In conclusion of this study, it was confirmed that different fabrics had different reactions on the infants' bodies.

Keywords: Clothing comfort, subjective wear test, infant, melatonin, cortisol.

ÖZET

Sağlıklı nesiller yetiştirebilmek için bebeklerin sağlığına önem verilmelidir. Bebeklerin gelişimlerini sağlıklı bir şekilde sürdürebilmelerinin bir kolu da sağlıklı, güvenli ve konforlu giysiler giymeleridir. Bu çalışmanın amacı, 0-1 yaş aralığındaki bebeklerin giyim konforuna yönelik giysilerin geliştirilmesi, bebek giysilerinin ürün çeşidinin ve kalitesinin arttırılması, bunlara ek olarak giysilerin bebekleri ne şekilde etkilemekte olduğunun araştırılmasıdır. Sonuç olarak, birbirlerinden farklı kumaşların bebeklerin vücutları üzerinde farklı tepkiler oluşturdukları ve çalışma kapsamında geliştirilen çift katlı kumaş yapılarının bebeklerde olumlu yönde etkiler ortaya çıkardıkları tespit edilmiştir.

Anahtar Kelimeler: Giyim konforu, subjektif giyim denemeleri, 0-1 yaş arası bebek, melatonin, kortizol.

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1. INTRODUCTION

Clothing is an inseparable part of human life. Clothing comfort can be defined as that a person feels physiologically, psychologically and physically balanced and pleased in that clothes and under the current ambient conditions (1, 2). The way that infants can grow healthily is that they wear healthy, safe and comfortable clothes. Also, it is known that overheating harms an infant more than an adult, and that it even causes infant deaths. So, it is very important that infants must be worn properly.

In literature, although there are various studies about the clothing physiology and comfort, it is observed that the number of the studies about the clothing comfort of infants is limited (3, 4, 5, 6, 7, 8, 9).

Melatonin, secreted by the pineal gland, is a hormone that

transmits external light–dark cues as neuroendocrine information to the body. Melatonin is considered to play an important role in the sleep–wake rhythm and sleep quality (10). Because only the free melatonin in plasma is thought to be present in saliva, salivary melatonin levels reflect the proportion of free-circulating melatonin. Hence, the measurement of salivary melatonin levels represents an indirect, non-invasive method for the assessment of plasma melatonin levels (11).

When we analyze the literature referring to the effect of clothing and fabric on human body, the following studies stand out.

Scher et al. (2010) showed a relationship between quality/ pattern of sleep and salivary cortisol level (12). Also, salivary cortisol is considered an acceptable measure of infant stress reactivity (13). In infant and children, salivary cortisol measurement represents a noninvasive alternative approach to evaluating serum cortisol levels, and some reports have suggested that salivary cortisol measurement is more important than serum cortisol measurement (14).

Shinohara and Kodama (2011) researched the relationship between the night sleep pattern of infants and the melatonin hormone level in their bodies. Within the scope of the study, 67 infants in total between the ages of 3 months and 15 months were examined. As a result, it was observed that there was a negative correlation between the infant's melatonin hormone level in his/her saliva in the morning and his/her night sleep pattern. In other words, the fact that the melatonin hormone level in the body of the infant at the morning hours is low indicates the sleep during the night (10).

Zimniewska and Kozlowski (2004) founded a laboratory, where the humidity and temperature rate of the ambience can be kept under control, in order to research the physiological effects of clothing and fabric on human body. In this laboratory, they examined the effects of bedding on human body under sleep conditions by doing tests with the bedding made of 100% cotton, 100% linen and 100% polyester fibers. During the study, the skin and interbody temperature saliva analyzes of the subjects were made, and their immunoglobulin A level was measured. At the end of the study, it was observed that the body temperatures of the subjects during sleep were lower in cotton and linen bedding compared to polyester bedding (15).

Within the scope of the same study, different subjects were required to wear clothing made of 100% cotton, 100% linen and 100% polyester fibers, and they were required to do medium-level physical exercise. According to the results of the study, it was observed that the clothing made of cellulosic-based fiber such as cotton and linen had positive effects on the physiological parameters of human body. When comparing the immunoglobulin A level, histamine, sebaceous gland activity and tonus values of the subjects, it was observed that the clothing made of polyester fiber had negative effects on human body contrary to the clothing made of linen and cotton fibers (15).

Zimniewska and Krucinska (2010) examined the effects of clothing on the activities of motor units of forearm muscles defined on the body via electromyography method. In the study, ten voluntary subjects participated, and clothing made of 100% linen, 100% polyester and the combination of both raw materials in different percentages were utilized. The test took five hours, and the subjects were not subjected to any physical activity during this period. The subjects read any books, played computer games or chatted. Also, the subjects' humidity and temperature rate on their back side were measured hourly. The comparative analyzes of the subjects' muscle electromyography parameters and body values measured before wearing the tested clothing and five hours after wearing the tested clothing were examined via statistical methods (16).

According to the results of electromyography parameters, it was observed that covering the body with clothing caused change on the muscles of the person. It was observed that the electromyography values of the subjects who wore clothing made of polyester fabric changed after five hours and that desynchronization occurred in their motor units. Also, it was discovered that the threshold value of mixing ratio of polyester fiber and linen fiber was 25% at least. In other words, it was confirmed that the clothing made of fabric mixed with 75% linen - 25% polyester provided optimum ease of use to the person, and that it also did not cause motor unit desynchronization on healthy muscles (16).

Under the light of the studied literature, it can be said that our clothing affects the physiology of our body. However, no similar study on infants was encountered.

The purpose of this study is to develop clothes intended for the clothing comfort of infants, to improve the product variety and quality of infant clothes, and also to research how the clothes affect infants. For this aim sleep pattern, saliva cortisol and melatonin levels of infants were investigated.

2. MATERIALS AND METHOD

It is known that mostly cotton fiber and knitted fabrics are used in infant underwear. Within the scope of this study, considering that different fibers and fabric structures can be used in infants' underwear, regenerated cellulose fibers such as bamboo, modal, Tencel LF® besides cotton fiber were utilized and two unique textile fabric structures were developed. As the developed fabrics were double-layer, it was assumed that the air layer between the fabric surfaces would form a comfortable atmosphere for infants. Within the scope of the study, fifteen types of textile fabric and eight types of knitted fabric, which are used in infants' underwear on the market, were produced under controlled conditions. The relationship between the physical parameters and thermal comfort characteristics of the manufactured fabrics was examined, comparative statistical analyses were performed and the fabrics with optimum comfort characteristics were tried to be defined. All the objective experiments on the fabrics were performed in the Textile Laboratories in Tampere Technical University in Finland and Ege University in Turkey. Fabric samples were conditioned by keeping under standard atmospheric conditions (20 ± 2°C temperature and 65% ± 5 relative humidity) for 24 hours before the experimental studies. Methods of measurements are given in Table 1.

The fabrics of D6-6 and D2-3 were manufactured in original modified twill structure (Figure 1). Modified twill structure was double-layered. While a double-layer structure was developed in the fabrics, among the self-tie methods, weft-joining method was used. The texture reports of the fabrics are equal; however, their junction points were changed in order to use different yarns on front and reverse sides.

The woven fabrics (D6, D6-6, D2-3) were washed in 50ºC water for 90 minutes without adding any substance, and they were left to dry. The knitted fabric (Ö4) was made to the commercial finishes used in the market. Grease remover, wetting, antipilling enzyme, acetic acid, fabric protector respectively were applied on it. After the wet finishes it was dried and sanforized.

Within the scope of the study, characteristics, technical data and thermal comfort properties of the underwear fabrics are given in Table 2 and 3.

In order to test the fabrics on the infants, a unique subjective wear trial test systematic was developed under the guidance of clothing comfort, subjective wear trial tests and previous studies regarding the infants. When we check the studies related to the subjective wear trial tests, it is observed that these are the studies which examine the person's comfort feeling or the transition caused on human body by the clothes at the time when the fabric contacts the skin. Within the scope of the study, 8 infants in total (4 girls, 4 boys) between the ages of 6 months and 12 months were subjected to wear trial tests. Ethical permission for subjective wear trial tests was obtained from Ege University, Faculty of Medicine (Document date: 04.09.2012 and number: 12-9/55).

Wear trial tests method can be explained in short as follows: On the first night of the study, the infant slept in his/her own underwear. This underwear sample is the one that is commonly used on the market, produced from 100% cotton yarn as interlock fabric, sleeveless, tie-on bottom and that suits to the body size of the infant. On the nights of the study, the infant wore a two-piece (top and bottom) long sleeve pajama set made from 100% cotton knitted fabric which suits to his/her body size over his/her underwear.

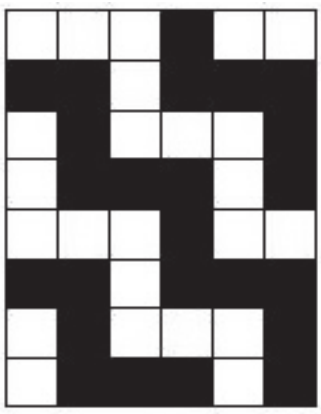

Figure 1. Modified-twill texture report

Table 1. Measurement methods of the fabrics

Value	Method
Weight	SFS 3192:1974 standard (17)
Thickness	SFS-EN ISO 5084:1997 standard (18)
Thermal resistance and conductivity	Alambeta (manufactured by Czech SENSORA Company (19)
Water vapor permeability	Gore cup method
Air permeability	SFS-EN ISO 9237:1996 (20)

Table 2. Characteristics of the fabrics

Fabric code	Fabric content	Fabric structure	Weft yarn count (Nm)	Warp yarn count (Nm)	Weft density (weft/cm)	Warp density (warp/cm)	Wales per cm	Courses per cm
D6	100% Cotton	Plain weave	80/2	80/2	23	25	-	-
D6-6	100% Cotton	First-type modified twill weave	20/1	80/2	24	29	-	-
D2-3	50% Cotton 25% Tencel LF® 25% Bamboo	Second-type modified twill weave	20/1	80/2	24	29	-	-
Ö4	100% Cotton	Interlock knitted	40/1	-	-	-	16	19

Table 3. Technical data and thermal comfort properties of the fabrics

Fabric code	Weight (g/m^2)	Thickness (mm)	Thermal resistance ($m^2.K/W$)	Thermal conductivity (W/m.K)	Water vapor permeability ($g/m^2.24h$)	Air permeability ($l/m^2.s$)
D6	69.9	0.30	0.009	0.042	5643	1610
D6-6	79.4	0.49	0.014	0.041	4961	2780
D2-3	142	0.61	0.019	0.047	4975	1345
Ö4	216	0.80	0.015	0.065	4663	390

On the first night of the study, the infant's saliva sample was collected in one of the tubes via a pipette before sleeping. Also, the infant's sleep time, body temperature measured through the armpit, current room temperature and moisture content were noted in the case report form. Wakeup times of the infant during the night, duration of being awake, current body temperature, room temperature and moisture content were followed by the mother. At the end of the first night, when the infant woke up at the morning hours, some of his/her saliva was collected in another tube by the mother. Again, the infant's wakeup time, body temperature measured through the armpit, current room temperature and moisture content were noted in the case report form.

On the second night of the study, the infant was dressed with the first underwear sample before the sleep, and the processes that were done on the first night and morning were repeated in the same way.

On the third night of the study, the infant was dressed with the underwear, which was used on the first night, in a clean state again. On the third night, no action was taken regarding the study. In this way, every other night, the infants were respectively dressed with the second underwear sample on the forth night of the study, with the third underwear sample on the sixth night of the study, and with the forth underwear sample on the eight night of the study. The study was completed in 8 nights per infant.

The wear trial tests within the study were performed under the controlled ambient conditions (the room temperature was between 22°C and 24°C and the moisture content ratio was between 40% and 65%). All infants were sleeping alone in their beds. Beddings were same for all of them. Their sheets and piques were made by cotton. The infant's own underwear, which he/she usually wore in daily life, was considered as the control group.

Saliva samples, which were collected in tubes by mothers, was maintained at -20°C ambient temperature. Tubes of frozen saliva samples were delivered to laboratory in a week with the help of a thermos for analyzing. All analyzes were performed at Department of Biochemistry laboratory in Ege University, Faculty of Medicine. In order to analyze melatonin hormone of saliva samples "Non-extraction Saliva Melatonin ELISA" kits with lot numbers ESM121, and to analyze cortisol hormone of saliva samples "HS Salivary Cortisol ELISA" kits with lot numbers 63K092 were used. Kits were proprietary to DRG Diagnostics Company.

Plan of the order of the underwear samples for the wear trial test and collection of saliva sample of the infant during the night is shown in Table 4. On the other hand, the model of the underwear is shown in Figure 2.

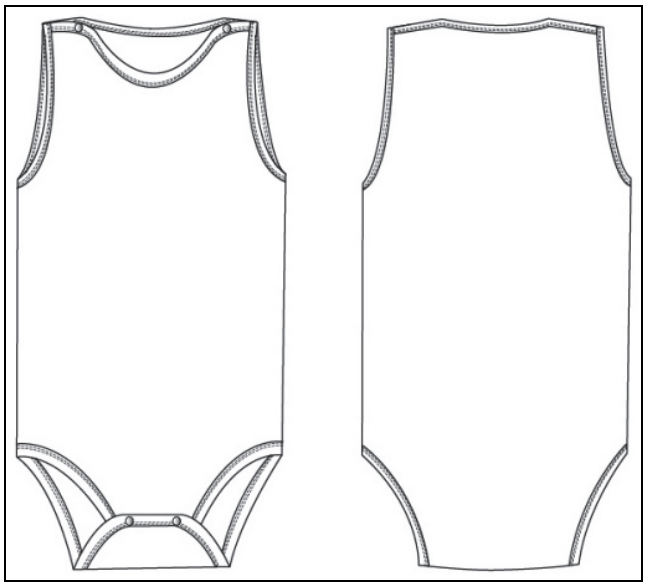

Figure 2. Front and back views of the underwear model

Table 4. Plan of the order of the underwear samples for the wear trial tests and collection of saliva samples

Night order	Underwear sample for the clothing test	Collection of saliva sample from the infant
1st night	Own underwear	Saliva sample of the infant would BE COLLECTED both before sleeping at night and after waking up in the morning.
2nd night	1st underwear sample (Produced from the fabric code: D6)	Saliva sample of the infant would BE COLLECTED both before sleeping at night and after waking up in the morning.
3rd night	Own underwear	Saliva sample would NOT BE COLLECTED from the infant.
4th night	2nd underwear sample (Produced from the fabric code: D6-6)	Saliva sample of the infant would BE COLLECTED both before sleeping at night and after waking up in the morning.
5th night	Own underwear	Saliva sample would NOT BE COLLECTED from the infant.
6th night	3rd underwear sample (Produced from the fabric code: D2-3)	Saliva sample of the infant would BE COLLECTED both before sleeping at night and after waking up in the morning.
7th night	Own underwear	Saliva sample would NOT BE COLLECTED from the infant.
8th night	4th underwear sample (Produced from the fabric code: Ö4)	Saliva sample of the infant would BE COLLECTED both before sleeping at night and after waking up in the morning.

3. RESULTS

The infants' body temperature, sleep times during night, and the cortisol and melatonin hormone values in their saliva sample during the wear trial tests were investigated and the results were compared.

Obtained data was evaluated by using SPSS 15.0 statistical package program. Friedman analysis technique was applied and the level of significance was accepted as 0.05 in the study. If significance level (p) of a parameter was greater than 0.05 ($p > 0.05$), it was interpreted that the parameter was not made statistically significant differences.

The average of the body temperature values of the infants at the end of the eight measurements is shown as ºC in Table 5. When we check the results of Friedman Test (p_{night}=0.902 and $p_{morning}$=0.959), there is no significant difference between the fabrics in terms of the body temperatures.

The average of the sleep duration of the infants during night at the end of the eight measurements is shown in minutes in Table 6. According to the results of Friedman Test (p=0.037), there are significant differences between the fabrics in terms of the sleep duration at night.

The averages of ng/dL analysis results of cortisol hormone of the infants at the end of the eight measurements are shown in Table 7. According to the results of Friedman Test (p_{night}=0.894 and $p_{morning}$=0.150), there is no significant difference between the fabrics in terms of the cortisol hormone values.

The averages of pg/ml analysis results of melatonin hormone of the infants at the end of the eight measurements are shown in Table 8. According to the results of Friedman Test (p_{night}=0.960 and $p_{morning}$=0.084), there is no significant difference between the fabrics in terms of the melatonin hormone values.

Table 5. Body temperature values of the infants during the wear trial tests

Fabric codes of the tested clothes	Average of body temperatures (ºC)					
	N	Night	Standard deviation	N	Morning	Standard deviation
Own underwear	8	36.2	0.424	8	36.5	0.470
D6	8	36.3	0.238	8	36.3	0.324
D6-6	8	36.2	0.442	8	36.3	0.298
D2-3	8	36.3	0.185	8	36.2	0.518
Ö4	8	36.4	0.223	8	36.3	0.302
Significance level (p) - Night=0.902; Morning=0.959						

Table 6. Sleep duration of the infants at night during the wear trial tests

Fabric codes of the tested clothes	N	Average of sleep duration during night (minute)	Standard deviation
Own underwear	8	706	53.615
D6	8	659	60.822
D6-6	8	715	46.664
D2-3	8	700	77.068
Ö4	8	665	82.412
Significance level (p)=0.037			

Table 7. Cortisol hormone values measured during the wear trial tests

Fabric codes of the tested clothes	Average of cortisol hormone value (ng/dL)					
	N	Night	Standard deviation	N	Morning	Standard deviation
Own underwear	8	1.29	0.927	8	7.59	3.878
D6	8	1.84	2.021	8	10.14	10.156
D6-6	8	1.06	0.524	7	4.03	2.036
D2-3	8	0.92	0.234	8	4.90	3.356
Ö4	8	1.38	1.230	8	3.02	2.404
Significance level (p) - Night=0.894; Morning=0.150						

Table 8. Melatonin hormone values measured during the wear trial tests

Fabric codes of the tested clothes	Average of melatonin hormone value (pg/ml)					
	N	Night	Standard deviation	N	Morning	Standard deviation
Own underwear	8	32.78	19.602	8	50.96	26.672
D6	8	47.74	26.349	8	53.01	27.620
D6-6	8	34.84	19.030	7	29.51	16.663
D2-3	8	42.88	38.789	8	44.20	52.640
Ö4	8	34.56	25.484	8	28.70	21.715
Significance level (p) - Night=0.960; Morning=0.084						

4. DISCUSSION

It is known that the saliva cortisol level in the body is low under comfortable conditions.

The average cortisol hormone values in the saliva of the infants within the study in the morning can be sorted according to the fabric codes as follows:

D6 > Own underwear > D2-3 > D6-6 > Ö4

According to the results of the Friedman Test, it is observed that the difference between the morning values of the cortisol hormones of infants is much more significant than the late hours. It can be observed that fabrics cause different reactions on the bodies of infants; however, these reactions are not statistically significant in terms of cortisol hormone values. This may be due to the low number of the subjects.

The average melatonin hormone values in the saliva of the infants within the study in the morning can be sorted according to the fabric codes as follows:

D6 > Own underwear > D2-3 > D6-6 > Ö4

In accordance with these obtained values and based on the above mentioned literature, night sleeps of the infants can be sorted among themselves from good to bad according to the fabric codes as follows:

Ö4 > D6-6 > D2-3 > Own underwear > D6

Regarding the comfort feeling of the infants, it is obvious that the relationship between the sleep duration at night and the melatonin hormone in the body is parallel only if the infant's own underwear is replaced with the fabric code: Ö4. In this case, the results of our study are consistent with the previous literature.

According to the results of the Friedman Test, it is observed that the difference between the morning values of the melatonin hormones of infants is much more significant than the night hours. It can be observed that fabrics cause different reactions on the bodies of infants; however, these reactions are not statistically significant in terms of melatonin hormone values. This may be due to the low number of the subjects.

In conclusion of this study, it was confirmed that different fabrics had different reactions on the infants' bodies. It can be said that different fibers and fabric structures besides cotton fiber and knitted fabric can be used in infants' underwear. Following this study, it is planned to improve different kinds of comfortable clothes for infants.

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