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Determination of Suitable Fabric in Sportswear by Integrated SWARA-MABAC Approach

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Abstract

The concept of sports is one of the most important areas that contribute to the economic and social development of countries by enabling them to be healthy individuals by affecting the mental, physical and spiritual structures of people positively. In line with the technological developments, as a result of the increase in the living standards of people, the expectations from the clothes and other equipment they use while doing sports have gone beyond just being suitable for the strength, design and fashion elements, and the importance given to the performance and the comfort of the clothing has increased. Sportswear is expected to offer comfortable mobility to the body, not to hold sweat and water, and to have comfort features such as breathability. These functions, which are expected from the fabrics, make a visible contribution to the performances of sports people. In this study performance characteristic of fabrics used in activewear was measured by using SWARA and MABAC methods. The criteria are weighted by SWARA method and suitable fabric for active wear are determined according to the criteria were calculated by MABAC method.

Keywords: Textile and Clothing; Activewear; Multi Criteria Decision Making; SWARA; MABAC.

1. Introduction

Textile and garment manufacturers are in a difficult situation as a result of crises in the markets, increasing competition conditions and changing and diversifying customer demands in recent years.

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The most effective way to get rid of this difficult situation is to develop products with high added value. Instead of ordinary textile products, the textile and apparel industry should turn to original products that are obtained with intense technology and know-how, innovative, featured and based on design superiority. One of the important areas of textile products expected to develop in the coming period; sports textiles, which are a branch of technical textiles. Today, the need for sportswear is increasing by a more general audience as well as professional athletes. Regarding sports textiles, many studies are carried out by both industrial organizations and scientific circles. Clothing comfort is the most important feature expected from sports or casual wear. Comfort is defined as the complex effect of heat/moisture transfer properties and mechanical properties of fabrics and garments. An important consideration that is taken into consideration for the users' perception of comfort is that they constantly interact with the garments along with the body movement. However, physiological parameters such as skin temperature, sweating rate and moisture value on the skin surface also change during clothing, these effects lead to mechanical and thermal stimuli. Therefore, comfort becomes a complex structure between human and environment where many physical, psychological and physiological factors are effective. The performance of the athlete increases with the structures that increase the interaction between the fabric and the skin. Knitted fabrics are widely used in sports and daily wear, and are characterized by their flexible structure, softtness and draperies. Aesthetic and functional properties of knitted structures are increased with different knitting techniques and fiber usage. Types of knitted fabrics commonly used in sportswear are single jersey, ribana, futter, pique, interlock; fiber types are cotton, viscose, modal, tencel, wool, polyester, recycled polyester (r-PET), polyamide and elastane. Functional features required in active wear and sportswear fabrics; better cooling, UV shielding, thermal diffusivity, breathability, antibacterial and antimicrobial, blood flow improving structure, muscle supportive, bursting strength, dimensional stability, water absorption, dyeing ability, drape ability, air permeability, moisture transfer, soft and comfort hand [1]. Developing and changing fashion trends also affect active and sportswear products. In textile materials, besides the technical performance features, the necessary attention should be given to the aesthetic and design features. The coloring and patterning of the fabrics to be used in sportswear and the design of the models to be developed from these fabrics in accordance with the current trends are the factors that will provide an advantage in the commercialization of the product. As can be seen, the fact that changing criteria and a large number of alternatives are included in the evaluation of the performances of the fabrics and the fact that there is more than one decision maker in this evaluation process complicates the situation, therefore, it is appropriate to use multi-criteria decision-making (MCDM) methods for solving such problems. When the literature on SWARA (Step-Wise Weight Assessment Ratio Analysis) and MABAC (multi-attributive border approximation area comparison) methods, which we encounter as a new method among MCDM methods, is examined, it is seen that it is used in different sectors in solving many problems such as supplier, technology, personnel, location and material selection, sustainability assesment, performance determination and product design [2,3,4,5,6,7,8,9,10]. In the textile sector, it has been observed that traditional decision-making techniques have been applied in the studies carried out so far. The use of these methods in determining the most suitable fabric in terms of clothing comfort will contribute significantly to the field.

2. Objective, material and method

2.1. Objective of the study

In this study, the best fabric was determined in terms of fabric performance characteristics for sportswear with the multi-criteria decision making model consisting of SWARA and MABAC methods. Within the scope of this study, some physical and comfort tests were carried out with 34 different fabrics having a single jersey knit structure, which is widely used in sportswear. Polyester, recycle polyester, polyamide, linen, viscose, cotton, tencel, modal, lyocel and elastane fibers were used in single jersey structures that were plain dyed or all over printed. While criteria weights are obtained with the SWARA method, MABAC method has been used in the order of alternatives. These methods have been newly developed, combination of these methods with different methods and approaches have been used in many studies. However, there are few studies in the literature about the use of SWARA and MABAC methods together. This study aims to contribute to the literature by filling research gaps.

2.2. Material

34 different types of single jersey fabrics commonly used in sportswear are preferred for the study. Structural properties of fabrics are given in the Table 1. below.

Table 1: Composition of sample fabrics.

Alternative Code	Composition
N1	%100 Pes
N2	%95 Pes %5 Ea
N3	%98 Pes %2 Ea
N4	%92 Pes %8 Ea
N5	%87 Pes %13 Ea
N6	%65 Pes %35 Vis
N7	%50 Co %50 Pes
N8	%50 Rcy Pes %50 Co
N9	%50 Vis %30 Rcy Pes %20 Li
N10	%65 Rcy Pes %35 Vis
N11	%60 Vis %20 Li %20 Recycle Co
N12	%96 Pa %4 Ea
N13	%85 Pa %15 Ea
N14	%100 Co
N15	%95 Co %5 Ea
N16	%100 Vis
N17	%95 Vis %5 Ea
N18	%100 Lyocell
N19	%64 Cv %31 Lyocell %5 Ea
N20	%100 Tensel

N21	%50 Co %50 Tencel
N22	%100 Modal
N23	%50 Co %50 Modal
N24	%70 Modal %30 Pes
N25	%40 Co %40 Pes %20 Modal
N26	%63 Modal %33 Tencel %4 Ea
N27	%50 Co %50 Modal
N28	%70 Modal %30 Pes
N29	%96 Cv %4 Ea
N30	%50 Cv %50 Co
N31	%95 Co %5 Ea
N32	%95 Pes %5 Ea
N33	%65 Pes %35 Cv
N34	%51 Pes %49 Co

2.3. Method

Physical Testing of Fabrics

Sport textiles have different features and performances attributes according to the related activity [12,11]. Many different aspects have to be considered when designing clothing for a particular sport to increase the performance during the activity [13]. The following tests have been determined by considering indoor sports activities and were applied to the fabrics whose contents are given above.

Weight per unit area: Square meter weights (g/m^2) of the used fabrics were performed with five test samples according to TS 251 standard. They were cut with grammage stencil having an area of 100 cm^2 and weighed in precision balance.

Thickness: Digital Thickness Gauge Modal M034A machine is used in this analysis. Thickness test was performed according to TS 7128 EN ISO 5084 by applying 200 grams of load at 20 cm^2 area for 10 test samples of each sample.

Air permeability: Measurements of air permeability of clothes were performed by Fx 3300 Air Permeability Instrument. According to TS 391 EN ISO 9237 for Air permeability test; for 10 test samples of each sample, 100 Pascal pressure difference at 20 cm^2 area were applied.

Circular bending rigidity: In circular bending rigidity test were carried with using SDL Atlas stifness testser according to ASTM D 4032-94 test standart with 5 samples.

Stretch properties: Stretch properties of fabrics were performed according to the TS 10985 standard with two test specimens. The stretch value in the fabric is calculated in percent in the direction of both weft and warp for each test sample using the relevant formula separately.

Bursting strength: The bursting strength of fabrics was tested with 3 samples using James heal truburst tester according to ISO 13938-2 standard. *Pilling:* The pilling properties of the fabrics were tested with the ICI test device in 14400 revolutions with 3 samples each according to the ISO12945-1 standard.

Moisture transmission: Moisture transmission properties of the fabrics were measured with 5 test samples by MMT (Moisture Management Tester) instrument.

Thermal Properties: An Alambeta instrument was used to measure thermal conductivity, thermal absorbtivity, thermal resistance, thermal diffusity of the samples. The measurement was carried out contact pressure of 200Pa. The number of measurements for each sample was 10 for Alambeta.

SWARA Method

Step-Wise Weight Assessment Ratio (SWARA) was developed by Kersuliene, Zavasdkas and Turskis (2010). The SWARA steps are as follows [14]. Under the first step of the SWARA method, the evaluation criteria is sorted from the most important criterion to the least important criterion.

j: $the\ evaluation\ criterion\ from$ the most important criterion to the least important criterion

$j = 1,2,3, \dots, n$

l: $the\ expert; l = 1,2, \dots, L$

After sorting, an importance level is assigned to the criteria by using expert opinions.

s_{jl}: $the\ importance\ of\ j.evaluation\ criterion\ according\ to$

$(j+1).evaluation\ criterion\ according\ to\ expert\ l$

k_{jl} values have been calculated by using Equation 1.

$$k_{jl} = \begin{cases} j = 1 \Rightarrow 1 \\ j > 1 \Rightarrow s_{jl} + 1 \end{cases} \quad (1)$$

The compound function in Equation 2 gives q_{jk} values.

$$q_{jl} = \begin{cases} j = 1 \Rightarrow 1 \\ j > 1 \Rightarrow \frac{q_{jl-1}}{k_{jl}} \end{cases} \quad (2)$$

w_{jl}: $the\ importance\ level\ of\ j.evaluation\ criterion\ according\ to\ expert\ l; j = 1,2,3, \dots, n$

k: $evaluation\ criterion; k = 1,2,3, \dots, n$

Following this, the importance levels of the evaluation criteria are calculated with Equation 3.

$$w_{jl} = \frac{q_{jl}}{\sum_{k=1}^{n} q_{kl}} \quad (3)$$

Expert opinions are integrated in the last step of SWARA method. The integration of expert opinions is calculated with Equation 4.

$w_j: the\ integrated\ importance\ level\ of\ j.evaluation\ criterion; j = 1,2,3, \dots, n$

$$w_j = \sqrt[L]{\prod_{l=1}^{L} w_{jl}} \quad (4)$$

MABAC Method

Multi-Attributive Border Approximation Area Comparison (MABAC) is one of the multi criteria decision making methods for selecting the appropriate alternative. MABAC calculation process is as follows [15,16]. First of all, evaluation matrix has been constructed. Evaluation matrix can be seen on Equation 5.

$i: alternative; i = 1,2,3, \dots, m$

$x_{ij}: assessment\ information\ of\ alternative\ i$

$$\begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad (5)$$

Next step is to normalize the assessment information values. Normalization for benefit attributes is made with Equation 6.

$n_{ij}: normalized\ assessment\ information\ of\ alternative\ i$

$$n_{ij} = \frac{x_{ij} - \min_j x_{ij}}{\max_j x_{ij} - \min_j x_{ij}} \quad (6)$$

Normalization for cost attributes is made with Equation 7.

$$n_{ij} = \frac{x_{ij} - \max_j x_{ij}}{\min_j x_{ij} - \max_j x_{ij}} \quad (7)$$

Weighted normalized evaluation matrix has been constructed by using Equation 8.

v_{ij}: *weighted normalized assessment information of alternative i with respect to criterion j*

$$v_{ij} = w_j(n_{ij} + 1) \tag{8}$$

Next step is to calculate the values of border approximation area for each criterion by using Equation 9.

g_j: *border approximation area of criterion j*

$$g_j = \sqrt[m]{\prod_{i=1}^{m} v_{ij}} \; for \; \forall j \tag{9}$$

Next step is to calculate the distance of the alternatives from the border approximation area by using Equation 10.

q_{ij}: *the distance of alternative i according to criterion j from the border approximation area*

$$q_{ij} = v_{ij} - g_j \tag{10}$$

Then, the sum of the distance of the alternatives from the border approximation areas has been calculated by using Equation 11.

S_i: *the distance of alternative i from the border approximation areas*

$$S_i = \sum_{j=1}^{n} q_{ij} \tag{11}$$

According to Equation 11, the highest distance will show the best alternative in the problem.

3. Application

In the first phase of the application, selection critera have been determined by the experts. Criteria codes and criteria names can be seen in Table 2.

Table 2: Criteria codes and names.

Criterion Code	Criterion Name	Unit	Criterion Type
C1	Weight	gr/m²	Cost
C2	Thickness	mm	Cost
C3	Air permeability	$l/m^2/s$	Benefit
C4	Circular bending rigidity	N	Cost
C5	Flexibility (weft direction)	%	Benefit
C6	Flexibility (warp direction)	%	Benefit
C7	Bursting strength	kPa	Benefit
C8	Pilling	-	Benefit
C9	OMMC value	-	Benefit
C10	Thermal conductivity	W/mK	Benefit
C11	Thermal diffusivity	m^2s^{-1}	Benefit
C12	Thermal absorption	$Ws^{1/2}/m^2K$	Benefit
C13	Thermal resistance	m^2/KW	Cost

After determining the selection criteria, a question form has been constructed for finding the weights of these criteria. SWARA method has been used for finding these criteria. The calculations according to SWARA method from the viewpoint of expert 1 can be seen in Table 3 as an example.

Table 3: SWARA process for expert 1 opinion.

Criterion Code	s_{j1}	k_{j1}	q_{j1}	w_{j1}
3		1,0000	1,0000	0,0972
9	0,0700	1,0700	0,9346	0,0909
10	0,0500	1,0500	0,8901	0,0866
13	0,0300	1,0300	0,8642	0,0840
4	0,0600	1,0600	0,8152	0,0793
2	0,0400	1,0400	0,7839	0,0762
1	0,0200	1,0200	0,7685	0,0747
5	0,0300	1,0300	0,7461	0,0726
6	0,0000	1,0000	0,7461	0,0726
8	0,0600	1,0600	0,7039	0,0685
12	0,0200	1,0200	0,6901	0,0671
11	0,0100	1,0100	0,6833	0,0664
7	0,0400	1,0400	0,6570	0,0639

The values in Table 3 have been found with Equation 1, 2 and 3 respectively. This procedure has been repeated for finding the weights according to expert opinions. 12 experts from university and industry have filled the question form. Next step is to integrate these expert opinions by using Equation 4. Table 4 and 5 shows the weights according to expert opinions and integrated weight values.

Table 4: SWARA weights according to expert opinions.

	Expert 1	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**
Criterion Code	w_{j1}	w_{j2}	w_{j3}	w_{j4}	w_{j5}	w_{j6}
1	0,0747	0,0750	0,0768	0,0730	0,0886	0,0761
2	0,0762	0,0736	0,0791	0,0702	0,0930	0,1645
3	0,0972	0,0885	0,0932	0,1103	0,0976	0,1054
4	0,0793	0,0674	0,0640	0,0656	0,0527	0,0456
5	0,0726	0,0781	0,0609	0,0797	0,0805	0,0879
6	0,0726	0,0773	0,0591	0,0781	0,0805	0,0837
7	0,0639	0,0611	0,0807	0,0572	0,0700	0,0397
8	0,0685	0,0642	0,0553	0,0561	0,0580	0,0345
9	0,0909	0,0843	0,0970	0,0892	0,1123	0,1265
10	0,0866	0,0957	0,1028	0,0964	0,0667	0,0604
11	0,0664	0,0721	0,0738	0,0619	0,0667	0,0634
12	0,0671	0,0714	0,0710	0,0601	0,0667	0,0575
13	0,0840	0,0912	0,0863	0,1022	0,0667	0,0548

Table 5: SWARA weights and integration,

	Expert 7	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**	
Criterion Code	w_{j7}	w_{j8}	w_{j9}	w_{j10}	w_{j11}	w_{j12}	w_j
1	0,0695	0,0765	0,0866	0,0538	0,0997	0,0771	0,0765
2	0,0695	0,0750	0,0617	0,0538	0,0657	0,0749	0,0766
3	0,0844	0,0842	0,1144	0,1419	0,1196	0,0818	0,1002
4	0,0626	0,0714	0,0571	0,0385	0,0906	0,0667	0,0620
5	0,0788	0,0662	0,0953	0,1039	0,0788	0,1031	0,0812
6	0,0788	0,0513	0,0680	0,0904	0,0465	0,0734	0,0704
7	0,0730	0,0523	0,0444	0,0285	0,0553	0,0578	0,0550
8	0,0620	0,0601	0,0510	0,0259	0,0512	0,0607	0,0523
9	0,0931	0,0926	0,1315	0,1351	0,1495	0,0859	0,1053
10	0,0912	0,0926	0,0788	0,0861	0,0608	0,0802	0,0820
11	0,0869	0,0926	0,0750	0,0861	0,0608	0,0794	0,0731

12	0,0869	0,0926	0,0714	0,0861	0,0608	0,0794	0,0718
13	0,0632	0,0926	0,0648	0,0700	0,0608	0,0794	0,0750

After finding the weight of the selection criteria, alternatives have been tested and the evaluation matrix has been constructed according to the results of these tests. Table 6 and 7 shows the evaluation matrix.

Table 6: Evaluation matrix part 1.

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
N1	135	0,4206	2300	6,38	73	24	237,3
N2	210	0,731	1218	36,4	38	37	346,7
N3	200	0,7136	1232	27,94	35	72	275,3
N4	250	0,8666	2050	23,73	161	65	670,2
N5	115	0,3054	1602	4	93	63	134,5
N6	150	0,4778	1637	7,12	65	27	176,4
N7	180	0,5404	488,6	23,47	39	29	362,8
N8	270	0,4418	1533	6,72	104	27	144,4
N9	130	0,4488	2120	6,05	58	46	75,1
N10	140	0,4782	1520	9,11	59	32	213,1
N11	130	0,4342	1897	7,19	97	35	72,8
N12	200	0,4398	243,6	9,65	78	63	650,1
N13	250	0,6228	681,8	34,19	57	74	348,2
N14	120	0,4608	533,4	21,39	76	21	189,2
N15	175	0,607	578,5	12,66	82	77	90,3
N16	150	0,4354	1365	8,52	74	25	133
N17	140	0,5412	833	8,18	138	57	126,9
N18	150	0,34	1339	4,59	98	32	154,7
N19	130	0,4936	1645	12,85	87	56	93,1
N20	125	0,4314	959,5	9,72	50	37	149,9
N21	230	0,7138	540,9	44,48	44	21	320,1
N22	140	0,3736	1849	4,11	128	28	148,4
N23	130	0,4288	1500	8,52	63	23	114,9
N24	140	0,52	697,1	13,99	80	30	153,6
N25	130	0,507	1083	11,11	84	23	143,7
N26	130	0,6484	198,7	34,75	76	67	136,6
N27	125	0,4532	1208	9,64	84	30	128,2
N28	230	0,4754	942,1	7,51	95	33	155,7
N29	290	0,7078	100,2	42,75	79	113	377,4
N30	160	0,4278	658,7	15,48	42	18	158,6
N31	225	0,4506	728,6	11,18	80	60	229,3
N32	150	0,3736	457,1	4,65	98	90	483,1
N33	150	0,4214	1800	6,85	103	40	157,9
N34	160	0,6254	962	35,47	60	25	227

Table 7: Evaluation matrix part 2.

	C8	**C9**	**C10**	**C11**	**C12**	**C13**
N1	4,5	0,8011	48,2	0,111	145	9,5
N2	2	0	51,8	0,101	163	15,4
N3	4	0	53	0,144	139	15
N4	4,5	0	79,7	0,137	215	11,2
N5	4,5	0,3609	49,1	0,098	157	6,8
N6	1,5	0,0139	49	0,129	137	14,1
N7	1	0,825	49,7	0,073	183	14,3
N8	2	0,2674	43,6	0,105	135	13,8
N9	2	0,607	56,3	0,12	163	10,5
N10	2	0,1405	47,6	0,13	132	13,7
N11	2,5	0,587	48,6	0,118	141	13
N12	4,5	0,0071	62,7	0,072	234	8,4
N13	4,5	0,359	77,4	0,114	230	8,6
N14	4,5	0,7618	60,7	0,123	174	10,3
N15	3	0,4724	52,2	0,126	148	16,5
N16	1,5	0,4906	54,8	0,098	175	11,1
N17	1,5	0,2592	50,6	0,091	168	15
N18	2	0,1611	46,8	0,07	177	8,9
N19	4	0,3046	43,5	0,167	106	18
N20	2	0,4002	48,7	0,141	130	15
N21	2,5	0,0571	53,6	0,104	167	17,5
N22	2	0,3019	51,9	0,094	169	9,7
N23	3	0,6415	48	0,112	144	13,1
N24	4	0	54	0,077	195	10,5
N25	1,5	0,3853	47,7	0,148	124	16,2
N26	4,5	0,4726	60	0,145	158	15
N27	3	0,0215	49,3	0,11	149	13,3
N28	3,5	0,7954	49,5	0,104	154	11,4
N29	1,5	0,393	58,8	0,081	208	16,8
N30	4	0,4067	52,1	0,098	166	12,1
N31	4,5	0,8215	60,6	0,128	170	9,2
N32	4,5	0,5385	54,7	0,092	181	8
N33	3	0,6001	42	0,11	126	15,1
N34	4	0,103	51,2	0,11	154	12,7

Next step is to normalize the assessment information values by using Equation 6 and 7. Table 8 and 9 shows the normalized assessment information values

Table 8: Normalized values part 1.

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
N1	0,8857	0,7947	1,0000	0,9412	0,3016	0,0632	0,2754
N2	0,4571	0,2416	0,5081	0,1996	0,0238	0,2000	0,4585
N3	0,5143	0,2726	0,5145	0,4086	0,0000	0,5684	0,3390
N4	0,2286	0,0000	0,8864	0,5126	1,0000	0,4947	1,0000
N5	1,0000	1,0000	0,6827	1,0000	0,4603	0,4737	0,1033
N6	0,8000	0,6928	0,6986	0,9229	0,2381	0,0947	0,1734
N7	0,6286	0,5813	0,1766	0,5190	0,0317	0,1158	0,4854
N8	0,1143	0,7569	0,6513	0,9328	0,5476	0,0947	0,1199
N9	0,9143	0,7445	0,9182	0,9494	0,1825	0,2947	0,0039
N10	0,8571	0,6921	0,6454	0,8738	0,1905	0,1474	0,2349
N11	0,9143	0,7705	0,8168	0,9212	0,4921	0,1789	0,0000
N12	0,5143	0,7605	0,0652	0,8604	0,3413	0,4737	0,9664
N13	0,2286	0,4344	0,2644	0,2542	0,1746	0,5895	0,4610
N14	0,9714	0,7231	0,1969	0,5704	0,3254	0,0316	0,1948
N15	0,6571	0,4626	0,2174	0,7861	0,3730	0,6211	0,0293
N16	0,8000	0,7684	0,5750	0,8883	0,3095	0,0737	0,1008
N17	0,8571	0,5798	0,3331	0,8967	0,8175	0,4105	0,0906
N18	0,8000	0,9383	0,5631	0,9854	0,5000	0,1474	0,1371
N19	0,9143	0,6646	0,7022	0,7814	0,4127	0,4000	0,0340
N20	0,9429	0,7755	0,3906	0,8587	0,1190	0,2000	0,1291
N21	0,3429	0,2723	0,2003	0,0000	0,0714	0,0316	0,4140
N22	0,8571	0,8785	0,7950	0,9973	0,7381	0,1053	0,1265
N23	0,9143	0,7801	0,6363	0,8883	0,2222	0,0526	0,0705
N24	0,8571	0,6176	0,2713	0,7532	0,3571	0,1263	0,1353
N25	0,9143	0,6408	0,4468	0,8244	0,3889	0,0526	0,1187
N26	0,9143	0,3888	0,0448	0,2404	0,3254	0,5158	0,1068
N27	0,9429	0,7366	0,5036	0,8607	0,3889	0,1263	0,0927
N28	0,3429	0,6971	0,3827	0,9133	0,4762	0,1579	0,1388
N29	0,0000	0,2830	0,0000	0,0427	0,3492	1,0000	0,5099
N30	0,7429	0,7819	0,2539	0,7164	0,0556	0,0000	0,1436
N31	0,3714	0,7413	0,2857	0,8226	0,3571	0,4421	0,2620
N32	0,8000	0,8785	0,1622	0,9839	0,5000	0,7579	0,6868
N33	0,8000	0,7933	0,7727	0,9296	0,5397	0,2316	0,1425
N34	0,7429	0,4298	0,3918	0,2226	0,1984	0,0737	0,2581

Table 9: Normalized values part 2.

	C8	**C9**	**C10**	**C11**	**C12**	**C13**
N1	1,0000	0,9710	0,1645	0,4227	0,3047	0,7589
N2	0,2857	0,0000	0,2599	0,3196	0,4453	0,2321
N3	0,8571	0,0000	0,2918	0,7629	0,2578	0,2679
N4	1,0000	0,0000	1,0000	0,6907	0,8516	0,6071
N5	1,0000	0,4375	0,1883	0,2887	0,3984	1,0000
N6	0,1429	0,0168	0,1857	0,6082	0,2422	0,3482
N7	0,0000	1,0000	0,2042	0,0309	0,6016	0,3304
N8	0,2857	0,3241	0,0424	0,3608	0,2266	0,3750
N9	0,2857	0,7358	0,3793	0,5155	0,4453	0,6696
N10	0,2857	0,1703	0,1485	0,6186	0,2031	0,3839
N11	0,4286	0,7115	0,1751	0,4948	0,2734	0,4464
N12	1,0000	0,0086	0,5491	0,0206	1,0000	0,8571
N13	1,0000	0,4352	0,9390	0,4536	0,9688	0,8393
N14	1,0000	0,9234	0,4960	0,5464	0,5313	0,6875
N15	0,5714	0,5726	0,2706	0,5773	0,3281	0,1339
N16	0,1429	0,5947	0,3395	0,2887	0,5391	0,6161
N17	0,1429	0,3142	0,2281	0,2165	0,4844	0,2679
N18	0,2857	0,1953	0,1273	0,0000	0,5547	0,8125
N19	0,8571	0,3692	0,0398	1,0000	0,0000	0,0000
N20	0,2857	0,4851	0,1777	0,7320	0,1875	0,2679
N21	0,4286	0,0692	0,3077	0,3505	0,4766	0,0446
N22	0,2857	0,3659	0,2626	0,2474	0,4922	0,7411
N23	0,5714	0,7776	0,1592	0,4330	0,2969	0,4375
N24	0,8571	0,0000	0,3183	0,0722	0,6953	0,6696
N25	0,1429	0,4670	0,1512	0,8041	0,1406	0,1607
N26	1,0000	0,5728	0,4775	0,7732	0,4063	0,2679
N27	0,5714	0,0261	0,1936	0,4124	0,3359	0,4196
N28	0,7143	0,9641	0,1989	0,3505	0,3750	0,5893
N29	0,1429	0,4764	0,4456	0,1134	0,7969	0,1071
N30	0,8571	0,4930	0,2679	0,2887	0,4688	0,5268
N31	1,0000	0,9958	0,4934	0,5979	0,5000	0,7857
N32	1,0000	0,6527	0,3369	0,2268	0,5859	0,8929
N33	0,5714	0,7274	0,0000	0,4124	0,1563	0,2589
N34	0,8571	0,1248	0,2440	0,4124	0,3750	0,4732

Then, weighted normalized evaluation matrix has been constructed by using Equation 8. SWARA weight values are integrated in this phase with MABAC method. Next step is to calculate the values of border approximation area for each criterion by using Equation 9. Border approximation areas for each criterion can be seen in Table 12.

Table 10: Border approximation areas.

Criterion Code	g_j
1	0,1276
2	0,1238
3	0,1448
4	0,1043
5	0,1080
6	0,0883
7	0,0678
8	0,0808
9	0,1477
10	0,1050
11	0,1027
12	0,1021
13	0,1091

Then, the distance of the alternatives from the border approximation area is calculated by using Equation 10. Table 13 and 14 shows the distance of the alternatives from the border approximation area.

Table 11: Distance values part 1.

	C1	C2	C3	C4	C5	C6	C7
N1	0,0167	0,0136	0,0556	0,0160	-0,0023	-0,0135	0,0024
N2	-0,0161	-0,0288	0,0063	-0,0300	-0,0249	-0,0038	0,0125
N3	-0,0117	-0,0264	0,0070	-0,0170	-0,0268	0,0221	0,0059
N4	-0,0336	-0,0473	0,0442	-0,0106	0,0544	0,0169	0,0423
N5	0,0255	0,0293	0,0238	0,0196	0,0106	0,0154	-0,0070
N6	0,0102	0,0058	0,0254	0,0148	-0,0075	-0,0112	-0,0032
N7	-0,0030	-0,0028	-0,0269	-0,0102	-0,0242	-0,0098	0,0140
N8	-0,0423	0,0107	0,0207	0,0154	0,0177	-0,0112	-0,0061
N9	0,0189	0,0097	0,0474	0,0165	-0,0120	0,0028	-0,0125
N10	0,0145	0,0057	0,0201	0,0118	-0,0113	-0,0075	0,0002
N11	0,0189	0,0117	0,0373	0,0147	0,0131	-0,0053	-0,0127
N12	-0,0117	0,0110	-0,0381	0,0110	0,0009	0,0154	0,0405
N13	-0,0336	-0,0140	-0,0181	-0,0266	-0,0126	0,0236	0,0126
N14	0,0233	0,0081	-0,0249	-0,0070	-0,0004	-0,0157	-0,0020
N15	-0,0008	-0,0119	-0,0228	0,0063	0,0035	0,0258	-0,0111
N16	0,0102	0,0116	0,0130	0,0127	-0,0017	-0,0127	-0,0072
N17	0,0145	-0,0029	-0,0112	0,0132	0,0396	0,0110	-0,0077
N18	0,0102	0,0246	0,0118	0,0187	0,0138	-0,0075	-0,0052
N19	0,0189	0,0036	0,0258	0,0061	0,0067	0,0102	-0,0109
N20	0,0211	0,0121	-0,0054	0,0108	-0,0171	-0,0038	-0,0056
N21	-0,0248	-0,0264	-0,0245	-0,0424	-0,0210	-0,0157	0,0101

	C1	C2	C3	C4	C5	C6	C7
N22	0,0145	0,0200	0,0351	0,0194	0,0331	-0,0105	-0,0058
N23	0,0189	0,0125	0,0192	0,0127	-0,0088	-0,0142	-0,0088
N24	0,0145	0,0000	-0,0174	0,0043	0,0022	-0,0090	-0,0053
N25	0,0189	0,0018	0,0002	0,0087	0,0048	-0,0142	-0,0062
N26	0,0189	-0,0175	-0,0401	-0,0275	-0,0004	0,0184	-0,0068
N27	0,0211	0,0091	0,0059	0,0110	0,0048	-0,0090	-0,0076
N28	-0,0248	0,0061	-0,0062	0,0142	0,0119	-0,0068	-0,0051
N29	-0,0511	-0,0256	-0,0446	-0,0397	0,0015	0,0525	0,0153
N30	0,0058	0,0126	-0,0192	0,0020	-0,0223	-0,0179	-0,0048
N31	-0,0226	0,0095	-0,0160	0,0086	0,0022	0,0132	0,0017
N32	0,0102	0,0200	-0,0283	0,0186	0,0138	0,0354	0,0251
N33	0,0102	0,0135	0,0328	0,0152	0,0170	-0,0016	-0,0049
N34	0,0058	-0,0144	-0,0053	-0,0286	-0,0107	-0,0127	0,0015

Table 12: Distance values part 2.

	C8	C9	C10	C11	C12	C13
N1	0,0237	0,0598	-0,0095	0,0013	-0,0085	0,0228
N2	-0,0136	-0,0425	-0,0017	-0,0062	0,0016	-0,0167
N3	0,0162	-0,0425	0,0009	0,0262	-0,0118	-0,0140
N4	0,0237	-0,0425	0,0590	0,0209	0,0308	0,0114
N5	0,0237	0,0036	-0,0076	-0,0085	-0,0017	0,0409
N6	-0,0211	-0,0407	-0,0078	0,0149	-0,0129	-0,0080
N7	-0,0286	0,0628	-0,0063	-0,0273	0,0129	-0,0093
N8	-0,0136	-0,0083	-0,0196	-0,0032	-0,0141	-0,0060
N9	-0,0136	0,0350	0,0081	0,0081	0,0016	0,0161
N10	-0,0136	-0,0245	-0,0109	0,0156	-0,0157	-0,0053
N11	-0,0062	0,0324	-0,0087	0,0066	-0,0107	-0,0006
N12	0,0237	-0,0416	0,0220	-0,0281	0,0415	0,0302
N13	0,0237	0,0033	0,0540	0,0036	0,0392	0,0288
N14	0,0237	0,0547	0,0176	0,0104	0,0078	0,0174
N15	0,0013	0,0178	-0,0008	0,0126	-0,0068	-0,0241
N16	-0,0211	0,0201	0,0048	-0,0085	0,0084	0,0121
N17	-0,0211	-0,0094	-0,0043	-0,0137	0,0044	-0,0140
N18	-0,0136	-0,0219	-0,0126	-0,0296	0,0095	0,0268
N19	0,0162	-0,0036	-0,0198	0,0435	-0,0303	-0,0341
N20	-0,0136	0,0086	-0,0085	0,0239	-0,0169	-0,0140
N21	-0,0062	-0,0352	0,0022	-0,0040	0,0039	-0,0308

	C8	C9	C10	C11	C12	C13
N22	-0,0136	-0,0039	-0,0015	-0,0115	0,0050	0,0215
N23	0,0013	0,0394	-0,0100	0,0021	-0,0090	-0,0013
N24	0,0162	-0,0425	0,0031	-0,0243	0,0196	0,0161
N25	-0,0211	0,0067	-0,0106	0,0292	-0,0202	-0,0221
N26	0,0237	0,0178	0,0161	0,0269	-0,0012	-0,0140
N27	0,0013	-0,0397	-0,0072	0,0006	-0,0062	-0,0026
N28	0,0088	0,0590	-0,0067	-0,0040	-0,0034	0,0101
N29	-0,0211	0,0077	0,0135	-0,0213	0,0269	-0,0261
N30	0,0162	0,0094	-0,0011	-0,0085	0,0033	0,0054
N31	0,0237	0,0624	0,0174	0,0141	0,0056	0,0248
N32	0,0237	0,0263	0,0046	-0,0130	0,0117	0,0328
N33	0,0013	0,0341	-0,0230	0,0006	-0,0191	-0,0147
N34	0,0162	-0,0293	-0,0030	0,0006	-0,0034	0,0014

The last step of MABAC method is to calculate the sum of the distance of the alternatives from the border approximation areas by using Equation 11. According to MABAC method, the highest distance will show the best alternative in the problem. Table 15 shows the sum of the distance of the alternatives from the border approximation areas and the ranks of the alternatives.

Table 13: Total distance values and ranks.

	S_i	Rank		S_i	Rank
N1	0,1781	2	**N18**	0,0250	17
N2	-0,1638	33	**N19**	0,0324	16
N3	-0,0719	30	**N20**	-0,0084	20
N4	0,1697	3	**N21**	-0,2147	34
N5	0,1675	4	**N22**	0,1018	8
N6	-0,0414	27	**N23**	0,0539	13
N7	-0,0587	28	**N24**	-0,0224	25
N8	-0,0600	29	**N25**	-0,0242	26
N9	0,1262	6	**N26**	0,0144	18
N10	-0,0210	24	**N27**	-0,0187	22
N11	0,0906	9	**N28**	0,0530	14
N12	0,0766	11	**N29**	-0,1120	32
N13	0,0840	10	**N30**	-0,0189	23
N14	0,1131	7	**N31**	0,1446	5

	S_i	Rank		S_i	Rank
N15	-0,0109	21	**N32**	0,1809	1
N16	0,0417	15	**N33**	0,0614	12
N17	-0,0017	19	**N34**	-0,0820	31

According to the results of SWARA-MABAC integrated calculation process, the best alternative is “N32”, the second one is “N1” and the third one is “N4”.

4. Conclusion

In parallel with the developing technology, the expectations of individuals from clothing and textile products are increasing day by day, and this increase trend causes companies in textile and apparel production to carry out studies on different product groups. Now, it is seen that in the production of textile products, besides its decorative and aesthetic features, superior performance features come to the fore. With the rising trend of healthy living in recent years, the demand for sports textile products has also increased. Today, expectations from the fabric structures used in active sportswear are to fulfill different functions and at the same time provide comfort to the user. The use of innovative approaches in textile technology in the production of sportswear meets the expectations of people doing sports. The selection of fiber and fabric structures used in sportswear is one of the most important factors affecting performance, efficiency, protection and physical comfort. In the study, in order to determine the most suitable fabric for expected properties and comfort level in case of a large number of alternatives, firstly, various criteria were determined and physical fabric tests were carried out. According to the determined criteria, SWARA based MABAC method was preferred in evaluating the most suitable fabric. The weighting of the criteria with the SWARA method was done by taking the opinions of the experts in the relevant field. It was concluded that the criterion with the highest significance was the “moisture transfer” criterion and the criterion with the lowest significance was the “pilling” criterion. Moisture transmission behavior of a garment plays an essential role in influencing its efficiency regarding both thermo-physiological and sensorial body comfort. Moisture management feature that shows the comfort level of that fabric is a significant aspect of any fabric using for apparel. Since there is constant movement while doing sports, you need clothes that will not limit your performance and freedom of movement, but also manage the sweat you throw out properly and keep you dry. MABAC method was used in determining and ordering the best among sample fabrics. According to the results of the evaluation made in the light of the determined criteria weights, it has been reached that the N32 coded fabric is the best among the options. This fabric sample manufactured with 50D/27F polyester yarn, has warp density 12 threads/cm and weft density 17 threads/cm. Air permeability and moisture transmission values which were determined the two most important criteria of this sample were determined to be good. Sports activity can be done in comfort with synthetic sportswear designed with special technologies. By transferring the sweat formed due to its polyester structure to the outer surface of the fabric, it removes it from your body and the sweat carried to the outer surface of the fabric dries by contacting with air. For this reason, it will be a very good choice for our health to prefer polyester-containing clothes while avoiding Cotton Clothes while doing sports activities. Sports brands prefers polyester fabrics in their collections both for athlete's health and to increase athlete performance. When the 2019 sportswear production of one of the Turkish supplier companies producing for one of the leading garment brands of Europe is examined, it was determined that the top three fabric compositions in the order of 3 million pieces were 100% PES, 100% recycle PES and PES-VİS. The quality of the polyester fabrics varies considerably according to the yarns used and the processes applied. For this reason, in order to get the desired efficiency from polyester products, especially the fabric properties used should be examined well. It has been determined that the methods used give successful results on the decision making problem that is the subject of the study. In the literature, it is thought that the current study will contribute to the literature in terms of not finding any studies on the evaluation of fabric performance with SWARA and MABAC methods. The fabric types used in the study and the comfort tests applied to the fabrics were determined within the limits of the study. In the following studies, criteria suitable for the performance characteristics expected from the fabric can be determined according to the sport branch of interest and it may also be possible to use different methods.

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