

EVALUATING AND DEFINING BODY MEASUREMENTS ACCORDING TO ANTHROPOMETRIC MEASUREMENT TECHNIQUE FOR LOWER GARMENT PATTERN PREPARATION

VÜCUT ALTI GİYSİ KALIBI HAZIRLIĞINDA KULLANILAN ÖLÇÜLERİN ANTROPOMETRİK ÖLÇÜM TEKNİĞİNE GÖRE TANIMLANMASI

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ABSTRACT

In apparel industry, preparing garment patterns accurately is one of the most important factors in the production of fit garments. While body measurements are being taken, it is necessary to use the anthropometrical measurement technique which represents the human body in numerical units. Within the scope of this study, the Contec, Müller, Metric and Basic Blocks Pattern Preparing Systems, which are widely used, are examined and the measurements, which are required for lower body basic pattern preparation, are determined. These measurements' definitions are stated according to anthropometric measurement technique. Besides, new anthropometric points for two measurements, which are not defined in anthropometric technique, are defined. It is thought that these newly defined measurements will be used in preparation of lower garment pattern effectively. An implementation which shows the necessity for using the newly defined measurements is conducted in this study.

Keywords: Body Measurements, Anthropometrical Measurement Technique, Garment Pattern, Body Fit, Lower Garment.

ÖZET

Hazır giyim sanayinde, vücuda iyi uyum sağlayan giysilerin üretiminde en önemli faktörlerden biri giysi kalıbının doğru hazırlanmasıdır. Vücut ölçülerinin elde edilmesinde, insanın beden şeklini sayısal olarak ifade eden antropometrik ölçüm tekniğinden yararlanılması gerekmektedir. Bu çalışma kapsamında; dünya kapsamında yaygın olarak kullanılan Contec, Metrik, Müller ve Temel Bloklar Kalıp Hazırlama Sistemleri incelenmiş ve alt beden giysi temel kalıplarının hazırlığında gerekli olduğu düşünülen ölçüler belirlenmiştir. Bu ölçülerin tanımları, antropometrik ölçüm tekniği açısından değerlendirilmiştir. Ayrıca antropometrik ölçüm yöntemine göre tanımlanmayan iki ölçü için antropometrik ölçü noktaları tanımlanmıştır. Çalışmanın uygulama bölümünde ise yeni tanımlanan ölçülerin gerekliliği gösterilmiştir.

Anahtar Kelimeler: Vücut ölçüleri, Antropometrik Ölçüm Yöntemi, Giysi kalıbı, Vücuda uyum, Vücut altı giysileri.

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1. INTRODUCTION

What is critical to the development of an apparel pattern is the way in which the human body is measured, and how these measurements are interpreted. The measurements needed for apparel are unique because of the indispensable relationship between body and clothing. In order to translate a body measurement to a garment pattern, there is a need to identify consistent body landmarks that directly relate the body to the pattern (1).

In recent years, garment fit claims its place as an important factor in the selection of the garment, besides its color and model for production of better fitted garment, preparation of the garment patterns by using anthropometrical measurements is required. Anthropometry still plays an important role in the design of products and equipment (2). Anthropometry is a technique in which human body is represented numerically. It examines dimensions of the human body which are represented in metric and it is one of

the leading ergonomic criteria. Anthropometry is required to be taken into the consideration in the process of designing the product. When a product is designed and produced without using anthropometric measurements, the expected benefits from the product cannot be received, and the product cannot carry its ergonomical specialty(3) .

The measurements, which are acquired by the anthropometric measuring technique, should be defined well, standardized in technique, and carry out their functions clearly and simply (4). For a complete definition of the anthropometrical measurement, three given indications are utilized; Firstly, the Status Indication, which shows the status of body part or section to be measured. Secondly, Place Indication, which gives the body part or section to be measured which takes any point or plane as a reference point, and thirdly, Type Indication that represents the type of the measurements (5).

Thus, even if measurements are taken by different individuals, it is possible to acquire the same result.

Studies conducted on Anthropometry until the beginning of the XX. century were independent of each other. It is not possible to compare their results because of the reason that the used methods differ from researcher to researcher. Even though attempts for establishing international standards in order to ensure a common terminology and definitions among researchers were made, these efforts could not produce positive results. Despite the fact that there were such results at the beginning, the first standardization at the "head measurements" were observed in "International Anthropology Congress" at Moscow, in 1906. Second standardization study was conducted in International Congress at Geneva in 1912 (6). In this congress, agreement was made for anthropological measurements and studies put emphasis on drawing over voluntaries (7).

The International Biological Programme (IBP), that brought scientists together from all over the world under the umbrella of research in "Human Biology" during the years 1962-1972, gave rise to one of the standard texts for research into human-centered biology sciences. IBP Handbook establishes itself as the reference source for many scientists who wish to use standard techniques that are applied in research related with applicability to humans. IBP was not attempting to illustrate the most appropriate techniques available which would allow the greatest degree of comparability (7).

According to techniques which are recommended by IBP, girth measurements should be taken with tape measure, height, length and depth measurements should be taken by anthropometric or caliper (8). If the measurements except girth are taken by tape measure, because of elasticity of tape measure, measurements could be taken by deviating from the median sagittal line which causes to get inaccurate measurements (9).

Garments, which are produced by using anthropometrical measurements, will fit the body well and will be more comfortable. Thus, refurbishment will not be required and both seller and buyer will not spend unnecessary time, money and material (9).

In apparel industry, it is known that measurements are not taken in a standard way. The Contec, Müller, Metric and Basic Blocks Pattern Preparing Systems, which are widely used all over the world were examined. It has been observed that each technique has used different measurement methods. The anthropometrical measurement method is not very well known, so this can be thought as reason that its usage is not widespread. As for the reasons for why the widespread usage of the method is prevented, the fact that the implementation of the method is not easy, the person who takes the measurement should be trained well in the field, and that redundant measurements should be done are given as reasons. However, studies on pattern preparation and measurement method show that there is tendency to use anthropometrical measurement method especially in the countries which are leader in the apparel industry.

In this study, the four pattern preparing systems were evaluated with respect to acquiring body measurements. It was observed that in each system the measurements for lower garments were named different. The equivalent measure of these measurements in anthropometric technique were determined, and the definitions of the measurements that are assigned different names but describe the distance between the same reference points in international platform were given. Besides, two new anthropometric points which do not have any definitions in anthropometric technique were defined. It is thought that these new defined points will be effectively used in preparation of basic garment pattern. An implementation, which shows the necessity for using the newly defined measurements, was conducted in this study.

2. MATERIAL AND METHOD

In this study, what is defined below was followed;

1. The Contec (10), Müller (11), Metric (12) and Basic Blocks Pattern Preparing Systems (13), which are widely used all over the world, are examined. Measurements that are used in preparation of lower garment patterns are determined. The equivalents of these measurements for each pattern preparing system are shown in Table 1.

2. Convenience of these measurements with the anthropometric method was assessed. As a requirement of the anthropometric measurement system, attention is paid to observing that these points indicate any anthropometric point or plane, and that they pay attention to identifying the body part or the body area, that is to be measured, in a correct manner. While evaluating the measurement devices and tools, attention is paid to whether anthropometric or calliper are used or not while height, length, and depth are measured, and whether tape is used while girth is measured.

In the assessment of the measurements that violate the rules of the anthropometry technique, International Biological Programme (IBP) (8) and Anthropometric Standardization Reference Manual (ASRM techniques) (14) were analyzed. For the definitions that are not included in these methods ISO 8559:1989 "Garment Construction and Anthropometric Researches – Body Size" standard was examined (15).

Table 1. Measurements that are used in lower garment patterns preparation in four pattern preparing systems

CONTEC	METRIC	MÜLLER	BASIC BLOCKS
Waist Girth	Waist	Waist Girth	Waist Girth
Hip Girth	Hips	Hip Girth	Hip Girth
Hip Height	Waist to Hip	Hip Depth	-
Sitting Length	Body Rise	Body Height	Crotch Depth
Knee Length	-	-	Knee Depth
Inside Leg Length	Waist to Floor	Crotch Length (Crotch – Foot Sole)	-
Bottom Side Length	-	Side Length	Side Seam Length
Ankle Girth	-	Ankle Girth	-
Knee Girth	-	-	-

3. For the measurements that have no equivalent in both sources, the measurements that have definitions in anthropometry technique were proposed by taking their measuring aims into account. Proposed measurements are not the exact equivalents of the measurements that are required for pattern drawing. Proposed measurements can be used via intentionally creating some differences in the pattern preparation phase.

4. For the two measurements, which are considered as a requirement at the pattern preparing phase but not defined in either measurement source, anthropometric points were defined. In these definitions; aim of the usage of the measurement, position of the voluntaries while measuring, reference points of the measurement over the body, and measurement tool were stated.

5. Within the scope of the research, in order to evaluate the necessity of the developed measuring systems, aging 18 to 40, with 35 female volunteers, a side study that collected the used measurements while preparing.... When previous studies in the literature are examined, it is seen that Sunyoon and Ashdown (2011) have used 25 female volunteers to analyze lower body measurements (16). It is observed that Hung et al. (2004) took 10 anthropometric measures on 20 male volunteers in order to identify the difference between manually measured subjects and subjects measured via the computerized system (2), and that Hyunsook et al. (2010) have taken anthropometric measurements on 50 female volunteers in a similar study in order to show the difference between manually measuring the subjects and using a computerized system(17). In the study conducted by Herianto et al. (2010), it is seen that they took 11 anthropometric measurements on 30 female

volunteers in order to mark the difference between the manually taken anthropometric girth measurements, and the same measurements taken by a computerized system (18). Additionally it is observed that Ozeren (2012) took 12 measures on 20 female volunteers in order to develop a new basic dartless bodice pattern drafting technique (19).

6. Obtained data has been assessed by PASW 18.0 statistical analysis programme.

3. RESULTS

In the conducted research, measurements that are used in lower body were assessed to see whether they are appropriate for anthropometric technique or not (Table 2). In this evaluation, it is observed that, in none of the are as they should be according to the anthropometric measurements identifications. Also, in measuring Hip Lowness, Knee Height, Side Length, Crotch Length, and Sitting Height, tape measure is used instead of anthropometry even though these are linear measures.

The equivalent of measurements in anthropometric measuring technique, resources of the measurements and measuring tools considered in the study that was carried out for each lower garment's measurements in four pattern preparing systems are shown in the Table 3.

Intended purpose of the measurements that are not included in IBM and ASRM Techniques and "ISO 8559:1989 Garment Construction and Anthropometrical Researches – Body Size standard" are determined. The equivalent measurements according to anthropometric measuring technique are recommended instead of these measurements (Table 4).

Table 2. Applicability Assessment of Measurements that are used in the Lower Garment Pattern to Anthropometric Measuring Technique

Measurements that are used in Pattern Preparing Systems	Anthropometric Assessment
Waist Girth	Reference point is not defined.
Hip Girth	Reference point is not defined.
Hip Lowness	Suitable measuring tool is not used (tape measure is used) Reference point is not defined.
Knee Height	Suitable measuring tool is not used (tape measure is used) Reference point is not defined.
Side Length	Suitable measuring tool is not used (tape measure is used) Reference point is not defined.
Crotch Length (Crotch – Foot Sole)	Suitable measuring tool is not used (tape measure is used) Reference point is not defined.
Sitting Height	Suitable measuring tool is not used (tape measure is used) Reference point is not defined.
Ankle Girth	Appropriate (But reference points can be defined in more detail.)
Knee Girth	Appropriate (But reference points can be defined in more detail.)

Table 3. Equivalent measurements in anthropometric measuring technique, measurement resource and measuring tools.

Name of the Measurements Used in the Pattern Preparing Systems	Equivalent Measurements in Anthropometric Measuring Technique	Measurement Resource	Measuring Tool
Waist Girth	Waist Girth	IBP - ASRM	Tape Measure
Hip Girth	Hip Girth	IBP - ASRM	Tape Measure
Hip Lowness	No Equivalence	-	-
Knee Height	Lower Leg (Tibiale) Height	IBP - ASRM	Anthropometer
Crotch Length	Crotch Height	IBP - ASRM	Anthropometry
Side Height	No Equivalence.	-	-
Sitting Height	No Equivalence.	-	-
Ankle Girth	Ankle Girth	IBP - ASRM	Tape Measure
Knee Girth	Knee Girth	ISO 8559:1989	Tape Measure

Table 4. The Measurements, Intended Purpose of the Measurements, Recommended Measurements

The Measurements	Usage Purpose of the Measurements	Recommended Measurements
Hip Lowness	Determination of the axis of the hip	Trochanter (Bottom Part – Hip) Height
Sitting Height	Determination of the axis of the crotch	Crotch Height
Side Length	Determination of the axis of the waist	Waist Height
-	Determination of the depth of the hip	Hip Depth

In defining the hip lowness and sitting height measurements, the anthropometrical points are not used as reference points, and the measuring tools are not suitable. For this reason, it was recommended to use trochanter (Lower part - Hip) measurement and crotch height, which are defined in IBM and ASRM techniques, instead of hip lowness and sitting height measurements. When the definition of the sitting height measurement in the pattern preparation systems was examined, it has been seen that this measurement is used for determining the place of crotch line. There is no equivalence of this measurement in Anthropometry technique. For this reason, it was proposed, in order to determine this axis, that crotch (perineum) height measurement could be used which is defined in IBP and ASRM techniques and pattern preparing processes should be arranged according to crotch (perineum) height measurement.

Hereby definitions of measurements that are designated in the light of conducted research, and used in lower garment patterns are given on Table 5 according to anthropometric technique.

Side length measurement is used for determination of the waist axis. It was named as Waist Height (2.2.3.) in ISO 8559:1989(E) and it was defined as the distance between foot sole and natural waist height. Since the reference points are not defined clearly enough, the definition is not sufficient for anthropometric measuring technique. Either in preparation of lower body or upper body garment patterns, determining the waist axis has great importance for the best garment fit. Therefore, a new definition for this measurement was recommended below. In this new definition, the name of the measurement is left as it is, and that is, as waist height and the waist girth measurement. The definitions given in IBM and ASRM techniques were taken into account while creating the new ones below.

Waist Height: While measuring this measurement, experimental subject must be in anatomical position. Measurement must be done by one person, and this person should stand to the left of the experimental subject. For thin individuals, anthropometry's horizontal arm should be placed on the point that has the most intrusion on the waist area, and then the distance from this point to the floor should be measured. If the experimental subject is overweight, then the horizontal arm of the anthropometry should be positioned on the midpoint of the distance between the last rib bone and the top of the crista ilicia, and then the distance between this point and floor should be measured (Figure 1)(9).

Used Tool: Anthropometer

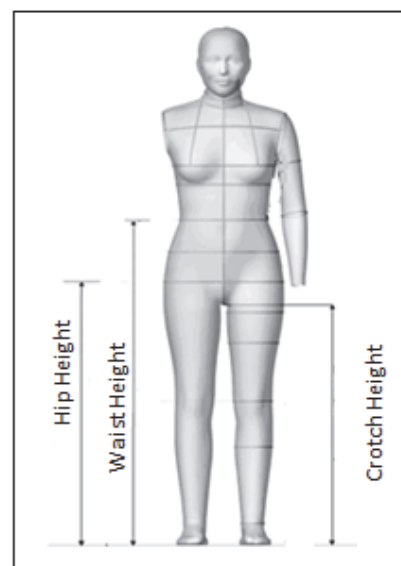


Figure 1. Anthropometric Height Measurements that were used during study (9).

Tablo 5. Kalıp Hazırlama Sistemlerinde Alt Beden Temel Kalıplarında Kullanılan Ölçülerin Antropometri Tekniğine Göre Tanımları

The Equivalent Measures in the Anthropometric Measurement Technique	Definition
Waist Girth	It is measured through standing in front of the subject. Tape measure must be held parallel to the ground. For thin individuals the tape must be held on where the indentation of waist region is the most. For individuals who weigh heavier, the tape measure must be laid on between the last rib and the top of crista iliaca.
Hip Girth	It is measured through holding the tape measure on the skin where it aligns with the trochanterion points of the subject's femurs. Tape must be held parallel to the ground, and the surface should be slightly stretched, yet not restrained. This measurement measures the widest points of hip circumference.
Tibial Height	The distance between the ground and the subject's trochanterion point, which is on the trochanter major of femur, is measured by anthropometer.
Crotch Height	Horizontal arms of the anthropometer is placed inside where two feet meet, and the distance between the ground and perineum is measured.
Ankle Girth	It is measured around the ankle circumference, slightly above the malleolus of the subject. The tape measure must be held parallel to the ground.
Knee Girth	It is measured around the knee circumference, on the tibial level of the subject. The tape measure must be held parallel to the ground.

In order to wrap 3-dimension body forms with 2-dimension fabric, reflecting body depth to pattern is important. Especially in the preparation of the lower body garment patterns like pants and shorts using the "hip depth" measurement in order to ensure better fitted garment plays an important role. In this study, this measurement was planned to use in pants basic pattern for creation of the crotch depth. The definition of this measurement could not be found in IBP and ASRM Techniques and ISO 8559:1989 (E). In order to develop a definition for this measurement, the anthropometric techniques have been taken into account. The definition of this new measurement is proposed below:

Hip Depth: While measuring this measurement, experimental subject must be in anatomical position. Measurement must be done by one person, and this person should stand to the left of the experimental subject. The distance between the points, one of which is the maximum protrusion point on back of hip of the experimental subject; the other is the endpoint of the horizontal projection point of it, should be measured. Arms of the anthropometer should be held parallel to the floor (Figure 2)(9).

Used Tool: Anthropometer

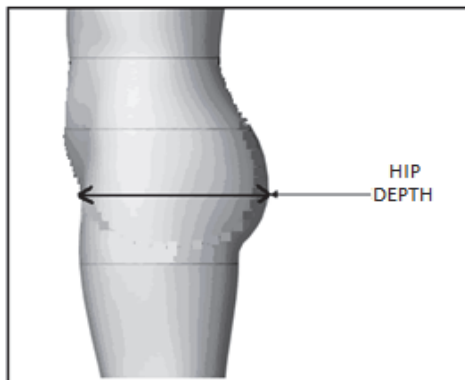


Figure 2. Hip Depth Measurement (9).

In order to assess the necessity of the measurements that were developed during the study, a research was conducted

with 11 volunteer women with size 36, 13 volunteer women with size 38 and 11 volunteer women with size 40. The measurements were taken from volunteer women. The obtained data were analyzed by using PASW Statistics 18.0 software. The demographic features of volunteers were shown in Table 4.

Table 4. Volunteer's age, height, weight and BMI distributions depending on their age.

Size		Frequency	Mean	Std. Deviation
36	Age	11	23.18	4.45
	Height	11	160.66	4.02
	Weight	11	51.06	3.70
	BMI	11	19.80	1.65
38	Age	13	24.62	6.41
	Height	13	162.00	6.16
	Weight	13	58.62	4.99
	BMI	13	22.33	1.32
40	Age	11	25.99	5.94
	Height	11	163.84	7.11
	Weight	11	61.60	3.70
	BMI	11	23	1.5

The descriptive statistical data of the measurements that are used in the basic pattern preparation of the lower body garments are shown in table 5.

Table 5. Descriptive statistical data of the Measurements.

Measurements	Frequency	Mean	Std. Deviation
Ankle Girth	35	22.026	1.6484
Knee Girth	35	34.600	2.3540
Waist Girth	35	71.486	4.5657
Hip Girth	35	96.797	5.1119
Hip Depth	35	21.960	1.5628
Hip Height	35	80.200	3.1776
Crotch (Perineum) Height	35	73.294	3.9768
Waist Height	35	102.860	3.9004
Knee Height	35	40.443	2.1611

The relation between hip girth and hip depth measurements were assessed (Table 6). In the assessment, the EN 13402-3 standard (19), in which the difference between hip girth measurements for each body sizes is 4 cm, was taken into account and the hip girth measurement groups were created. After grouping the hip girth measurements, the assessment was carried out by using One-Way ANOVA statistical analysis method. According to this, there was statistically significant difference between hip girth measurement groups depending on the size and hip depth measurements. This shows that individuals who are in the same size group can have different hip depth measurements. For this reason it can be said that the hip depth measurement should be taken into account in the preparation of the lower garment patterns.

The relationship between height groups according to body sizes and waist height measurements of the volunteers was examined (Table 7). In the assessment, for grouping the height measurements, the EN 13402-3 standard, in which the difference between height measurements for each body size is 4 cm, was utilized. After grouping the height measurements, the assessment was carried out by using One-Way ANOVA statistical analysis method. It was obtained that, there was statistically significant difference between height groups of volunteers and waist height measurements. For this reason, using the waist height measurement which is obtained in accordance with the anthropometric technique was proposed both for the preparation of the lower and the upper body patterns.

Table 6. The Difference Between Hip Girth Measurement Groups and Hip Depth Measurements According to Body Size

Body Size	Hip Girth (cm)	N	Mean	Std. Deviation	F	df ₁	df ₂	P
36	86 – 89.9	4	19.950	0.8226	5.914	4	6	0.028
	90 – 93.9	3	20.233	0.3512				
	94 – 97.9	1	21.500	-				
	98 – 101.9	2	21.850	0.9192				
	102– 105.9	1	23.200	-				
	Total	11	20.809	1.2421				
38	86 – 89.9	-	-	-	12.203	3	9	0.002
	90 – 93.9	1	21.200	-				
	94 – 97.9	6	21.633	0.6501				
	98 – 101.9	3	23.000	0.6245				
	102– 105.9	3	23.833	0.2309				
	Total	13	22.423	1.1256				
40	86 – 89.9	-	-	-	8.709	3	7	0.009
	90 – 93.9	1	19.500	-				
	94 – 97.9	2	21.000	0.7071				
	98 – 101.9	5	22.700	0.8367				
	102– 105.9	3	24.400	1.2767				
	Total	11	22.564	1.7620				

Table 7. The Difference Between Height Measurement Groups according to Size and Waist Height Measurements.

Body Size	Height (cm)	N	Mean	Std. Deviation	F	df ₁	df ₂	P
36	150-153.9	1	98.300	-	6.886	4	6	0.020
	154-157.9	2	97.650	0.4950				
	158-161.9	2	101.100	2.4042				
	162-165.9	5	103.120	1.4237				
	166-169.9	1	104.900	-				
	Total	11	101.482	2.8110				
38	150-153.9	1	93.300	-	27.840	5	7	0.000
	154-157.9	1	99.700	-				
	158-161.9	6	101.867	1.4052				
	162-165.9	2	106.350	1.2021				
	166-169.9	2	107.750	1.0607				
	174-	1	111.300	-				
Total	13	103.362	4.6538					
40	150-153.9	-	-	-	6.226	3	5	0.038
	154-157.9	1	99.000	-				
	158-161.9	3	100.000	0.5000				
	162-165.9	3	103.967	3.5162				
	166-169.9	3	106.567	0.5132				
	170-173.9	1	109.500	-				
	Total	11	103.645	3.8391				

CONCLUSION

When body measuring techniques of four Pattern Preparation Techniques were examined, it was observed that these systems are not appropriate for the rules of the anthropometric techniques. In the measurements that are defined in these systems, the position of individual and the stable measuring points are not indicated. As a result of this, it can be said that different researchers can acquire different measurement results.

To prepare garment patterns in a correct way, it is suggested that anthropometric measuring techniques should be used. However, in this study it was determined that, all necessary measurements to prepare garment patterns are not included in IBP and ASRM techniques and ISO 8559:1989 (E) standard. In this study, in order to determine the place of the hip axis, usage of the trochanter (Lower part -hip) height measurement, which is defined in IBP and ASRM techniques, was suggested instead of hip lowness measurement. In the same way, in order to determine the place of the crotch line, instead of the sitting height measurement, usage of the crotch (perineum) height measurement, which is defined in IBP and ASRM techniques, is advised. Nevertheless, by examining two measurements, which are "waist height" and "hip depth" and which are thought to be a requirement for preparation of lower body basic patterns, anthropometric points are defined. Thus two new measurements were brought to the literature which can be used during pattern preparation. In these definitions, the intended purpose of the measurement, the position of the experimental subject while getting measures, the reference points that are used while measuring and the measuring tools were declared.

Different from the other pattern preparation systems, "Hip depth" measurement reflects the third dimension of the body. As it is seen in this study, individuals who are in the same size group can have different hip depth. For this

reason, hip depth measurement should have an effect while calculating pant's crotch depth. It is argued that, by the usage of this measurement in preparation of basic pants patterns, the perfect fit will be provided. Also it will provide a basis for three dimensional patterns which will be prepared in the future.

The statistically significant difference between height groups of volunteers and waist height measurements was analyzed. This shows that, individuals who are in the same size groups may have different waist height measurements. So it is suggested that waist height measurement, which is obtained according to anthropometric measuring technique, should be used both in lower and the upper body pattern preparation.

Conducted study leads us to think that the other measurements that are required for the preparation of the basic pattern for different garments should be determined and defined according to anthropometric measuring techniques. However, it has been observed that some measurements that are used to present pattern preparation techniques cannot be defined according to these rules. For this reason, it is suggested that pattern preparation steps should be revised properly, and anthropometric measurements or new measurements should be defined in the basis of these measurements' definitions. It is considered that, when the height measurements are being taken, which are taken by anthropometric techniques and used in garment pattern preparation, the body depth should be taken into account.

Measuring by using anthropometric technique needs expertness, and individuals who prepare garment patterns should know how to measure according to this technique. It is obvious that, the institutes who give training in the field of apparel should incorporate new courses related to anthropometry and anthropometric measuring techniques into their training programs.

REFERENCES

1. Bye E., Labat K.L., Delong M.R., 2006, "Analysis of Body Measurement Systems for Apparel", Clothing and Textiles Research Journal, March 2006 , vol. 24 no. 2 66-79
2. Hung, P. C., Witana, C. P., & Goonetilleke, R. S., 2004, "Anthropometric Measurements from Photographic Images", Human Performance Laboratory, Hong Kong./ <http://www.researchgate.net/publication/252610176>
3. Akin, G., Gültekin, T. and Bektaş, Y., 2004, Üniversite Öğrencilerinde Bazı Antropometrik Boyutların Tespiti, 10. Ergonomics Congress, 7-9 October 2004, Bursa, Turkey.
4. Akin, G., 2001, Antropometri ve Ergonomi, Ankara, Turkey, pp:7.
5. Ercan, E., 1994, "Türk Bayan Ölçülerine Dayalı Yeni Bir Giysi Kalıp Çizim Sisteminin Geliştirilmesi", Ph.D. Thesis, Ege University, Institute of Science, İzmir, Turkey, pp.250.
6. Su, B.A., 2001, "Ergonomi", Ankara, Turkey.
7. Muehlenbein, M.P., 2010, "Human Evolutionary Biology", Cambridge University, pp.92.
8. Weiner, J.S. and Lourie, J.A., 1969, "In Human Biology: A Guide to Field Methods. I.B.P. Handbook", No. 9; Oxford:Blackwell Scientific Publications.
9. Kılıç, A., 2011, Antropometrik Ölçüm Sisteminden Yararlanarak Kadınlara Yönelik Yeni Bir Etek ve Pantolon Giysi Kalıbı Hazırlama Yönteminin Geliştirilmesi, Ph.D. Thesis, Ege University, Institute of Science, İzmir, Turkey, pp. 97,105,106,184.
10. Detering, U. and Schierling, R., 2003, Contec Giyim Konstrüksiyonu Bayan Üst Giysi, Mönchengladbach.
11. Krolopp, L., 1996, Schnittkonstruktionen für Röcke und Hosen: System M. Müller und Sohn; München Deutsche Bekleidungs-Akademie, 23. Verlage, München, 183s.

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12. Aldrich W., 2004, *Metric Pattern Cutting*, Blackwell Publishing, Oxford, 199p.
 13. Handford J., 1984; *Professional Patternmaking for Designers: Women's Wear and Men's Casual Wear*, USA.
 14. Lohman TG, Roche AF, Martorell R; (1988) *Anthropometric Standardization Reference Manual*. Human Kinetics Books, Illinois
 15. *ISO 8559:1989 Garment construction and anthropometric surveys -- Body dimensions; First Edition, Geneve*
 16. Sunyoon C, Ashdown S.,(2011), "3D body scan analysis of dimensional change in lower body measurements for active body positions", *Textile Research Journal*, January 2011, vol. 81 no. 1, 81-93
 17. Hyunsook H, Yunja N., Kyungmi C., 2010, "Comparative analysis of 3D body scan measurements and manual measurements of size Korea adult females", *International Journal of Industrial Ergonomics*, Volume 40, Issue 5, September 2010, Pages 530–540
 18. Herianto, Probandari S, Darmawan A., 2010,"*Development of Digital Anthropometric Circumferential Measurement System Based on Two Dimensional Images*", *The 11th Asia Pacific Industrial Engineering and Management Systems Conference*, Melaka, 7 – 10 December 2010
 19. Ozeren, F., 2012, "Pattern Drafting For Women By Using Individual Measurement - Dartless Pattern Model For Different Body Shapes"; *Tekstil ve Konfeksiyon*, Vol.2, pp.144-151.
 19. EN 13402-3:2013: *Size designation of clothes. Body measurements and intervals*, Geneve