ANTHROPOMETRIC CHANGES IN WOMEN'S BODY DIMENSIONS DURING PREGNANCY AND THE DESIGN OF AN IMPROVED PRENATAL SUPPORT DEVICE

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Abstract

The article presents a comprehensive analysis of anthropometric changes observed in the female body during pregnancy. The dynamics of body weight increase, as well as significant changes in chest, waist, abdominal, and hip circumferences, have been studied using experimental methods. The theoretical foundations for designing ergonomically and physiologically adaptable clothing structures for pregnant women are investigated. The paper provides data on the physical and mechanical properties of existing prenatal support devices, as well as technical sketches and advantages of an improved prenatal support device.

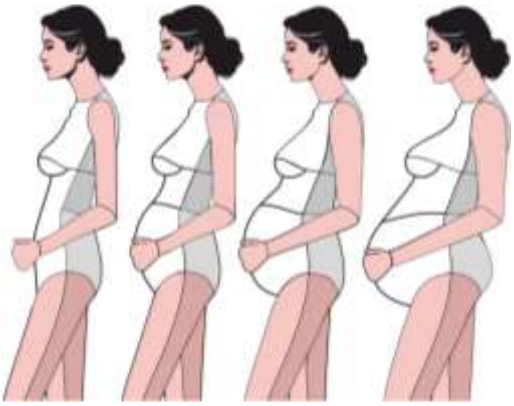
Keywords

Pregnancy, weight, anthropometric measurements, bandage, circumferences of chest, waist, hips, thighs, calf, and forearm, prenatal support device, technical sketch.

Introduction. During pregnancy, structural changes occur in a woman's body as a result of fetal growth and development. This process is primarily manifested by a noticeable enlargement of the breasts, waist, hips, lower abdominal region, as well as the circumferences of the thighs and forearms [1].

An increase in body weight is considered one of the principal anthropometric indicators of pregnancy. Under normal conditions, a woman gains on average 10–15 kg throughout the course of pregnancy; however, this indicator is directly dependent on the woman's pre-pregnancy Body Mass Index (BMI) [2].

Beginning from mid-pregnancy (the second trimester), the waist circumference gradually increases due to the expansion of the uterus. This process is associated with the accumulation of subcutaneous adipose tissue, which serves to create an energy reserve within the body. As a result, not only does body weight increase, but the overall silhouette of the female figure undergoes a complete transformation into a new morphological form (Figure 1) [3].



(10-19) (20-29) (30-37) (38-41)

Figure 1. Changes in the Female Body During Pregnancy.

In the final stages of pregnancy, edema observed in the upper and lower limb segments leads to unstable dynamics of body circumferences. Excessive weight gain beyond the normative range contributes to the development of a non-typical (non-standard) body shape, which limits the possibility of garment design based on standard pattern blocks [4]. As fetal growth progresses, the mechanical load on the vertebral column increases, resulting in pain in the lumbar, shoulder, and lower abdominal regions [5].

In order to address these issues, experimental studies were conducted to develop a prenatal supportive device that takes into account the characteristics of non-typical body morphology. The research included an analysis of anthropometric variable points that undergo significant changes in the bodies of pregnant women.

To determine the dynamics of morphological changes in pregnant women, anthropometric measurements were carried out among 300 women aged 18 to 35 residing in Namangan region, specifically in the city of Namangan and Pop district. Measurements were taken from the day of pregnancy registration until its completion. Beginning from the 10th–12th week of gestation and continuing at two-week intervals until the end of pregnancy, variable anthropometric points were monitored and measured in accordance with the requirements of GOST 31398-2009 [8].

The measurement program included 13 anthropometric parameters (2 height measurements, 10 circumferential measurements, and 1 arc measurement) (Figure 2) [6].

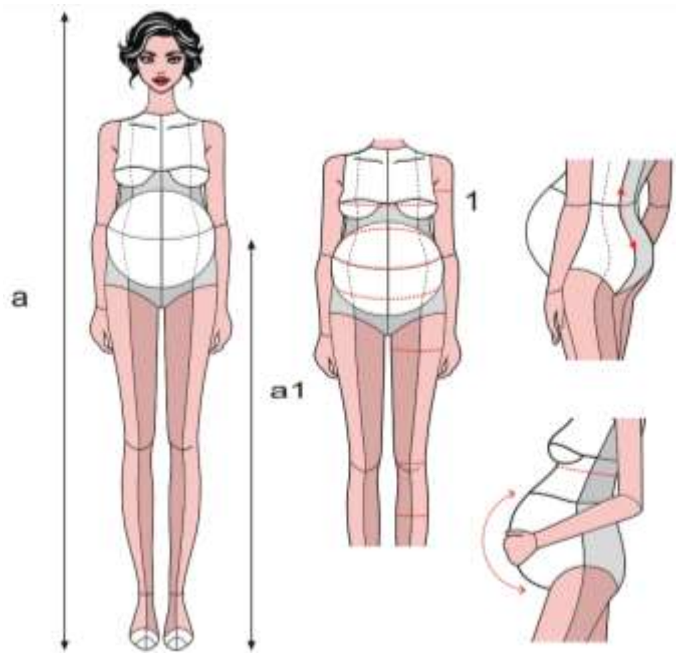


Figure 2. Sequence for Measuring Anthropometric Parameters During Pregnancy: a–a_1 – height; 1 – bust circumference; 6 – underbust circumference; 2 – abdominal circumference; 4 – lower abdominal circumference; 5 – upper abdominal circumference; 3 – hip circumference; 9 – thigh circumference; 10 – knee circumference; 11 – calf circumference; 12 – forearm circumference (circumferential measurements); 7 – arc measurement; 8 – length from the back waist to the hip.

As a result of the observations, the following key changes were recorded:

Body weight increased on average by 12 to 15 kilograms. Bust circumference expanded by an average of 8 to 12 centimeters, due to preparation for lactation and the growth of mammary gland tissues. Waist circumference increased by 10 to 15 centimeters, as a result of uterine enlargement and fat reserves accumulation. Abdominal circumference increased by an average of 12 to 18 centimeters, due to fetal growth and an increase in amniotic fluid volume. Thigh circumference grew by 3 to 6 centimeters, due to fluid retention and adaptive changes in the soft tissues around the pelvis. Calf and forearm circumferences increased by 3 to 5 centimeters, due to soft tissue adaptation, whereas no significant changes were observed

Table 1. Average Increment Values of Body Measurement Parameters at Different Weeks of Pregnancy.

№	10-	12-	14-	16	18-	19-	21	23-	25-	27-	29-	31-	33-	35-	37-	39-	Tot
Ог	10	10	105	10	106	106	10	107	10	108	109	109	110	110.	110.	111	**6**
Ог	10	10	108	10	110	110	11	111.	11	113	114	115	116	117	117.	118	**8**
Ог	10	10	103	10	104	103	10	104.	10	106	107	108	108.	108.	109	109	**6**
Ог	10	10	103	10	103	103	10	104.	10	106	106.5	107	107.	107.	108	108	**5**
О	10	10	110	11	111	112	11	114	11	116	117	118	119	120	120	121	**12**
О	10	10	109	10	110	110	11	112	11	112	113	114	115	116	117	118	**10**
О	10	10	109	10	110	110	11	111	11	113	114	115	116	116.	117	118	**10**
Об	10	10	109	10	109	109	11	110,	11	112	113	114	115	116	117	118	**9**
Об	60	60	60	60	60	60,	61	61	62	62	63	63	64	64	65	65	**5**
Ои	38	38	38	38	38	38	38	39	39	39	39	39	40	40	40	41	**3**
Оз	34	34	34	34	34	34	34	35	35	35	36	36	36	36	36	37	**3**
Вст	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	**-**

Based on the results presented above, it can be concluded that the physiological changes occurring in a pregnant woman's body may subsequently affect her health status. A prenatal supportive device should therefore serve to prevent such changes and reduce the risk of potential disorders that the pregnant body may encounter in the future.

The primary functions of the device include preventing excessive stretching of the abdominal muscles, the anterior and lateral abdominal walls, and the skin of the thighs; reducing the load exerted on the internal organs of the abdominal and pelvic cavities; alleviating stress on the lumbar spine; and facilitating the correct positioning of the fetus within the uterus. The effective performance of these functions depends primarily on the physical, mechanical, and hygienic properties of the materials used in the manufacture of the device.

The use of a prenatal supportive device may improve the physical condition of the pregnant woman, particularly in the later stages of pregnancy. It should enable the woman to maintain her usual level of physical activity without causing harm to the fetus. The development of an optimal material package for prenatal supportive devices is a complex process that involves not only technological considerations but also fundamental research and rigorous experimental testing stages. The principal objective of this process is to create a product that ensures maximum comfort, safety, and healthy development conditions for both the pregnant woman and her fetus.

To achieve this, all fabrics potentially suitable for the production of prenatal supportive devices are initially subjected to laboratory testing. The experiments require evaluation of a number of significant physical-mechanical and hygienic properties in accordance with established GOST standards, including:

- Air permeability (GOST 12088-22);
- Thickness;
- Tensile strength and elongation (GOST 28554);
- Elastic and residual deformation (GOST 28882);
- Abrasion resistance (GOST 16486);
- Fabric stiffness.

For this purpose, material samples from four manufacturers of prenatal supportive devices were tested in accordance with GOST standards: Variant I (China), Variant II (Uzbekistan), Variant III (Uzbekistan), and Variant IV (Uzbekistan). This made it possible to determine their suitability for use in the production of maternity support bandages.

The experimental results clearly identified the advantages and disadvantages of each material, thereby providing a foundation for the development of an improved bandage design in the future (Table 2).

Table 2. Physical and Mechanical Properties of Bandage Fabrics Currently in Practical Use.

Indicators		Variants				
		I	II	III	IV	Standards
1	**Air Permeability V (cm³/cm² s)**					GOST 12088-)-100
	Base	472,32	30,29	86,35	24,38	
	Additional	171,76	-	47,47	7,73	
	Mesh-	-	290,56	-	-	
	Elastic	-	8,23	-	-	
2	**Thickness (mm)**					
	Base	1.4	0.8	2.7	1.7	
	Additional	5.04	-	2.2	1.4	
	Mesh-	-	0.3	-	-	
	Elastic	-	1.5	-	-	
3	**Tensile Strength R (N)**					At least 80 N

	Base	Lengthwise	594	-	388	353	ST 28554)
		Crosswise	501	1103	281	958	
	Additional		813	-	-	-	
	Mesh-		-	116	-	-	
	Core		104	341	-	-	
4	**Elongation at Break L (%)**						0 to 100 % ST 28554, es I and II)
	Base	Lengthwise	32.1	-	49.9	12	
		Crosswise	307.5	34.5	474	423	
	Additional		134.8	-	-	-	
	Mesh-		-	21.4	-	-	
	Core		384.3	48.9	-	-	
5	**Elastic overable) ormation ε_0 (%)**	Lengthwise	5,6	20	0,1	18	Up to 20 % ST 28882)
		Crosswise	20	22	1,9	14	
		Lengthwise	94,4	80	99,9	82	Above 80 % ST 28882)
		Crosswise	80	78	98,1	86	
6	**Abrasion Resistance I (thousand es)**		44,7	60,1	55,4	57,8	GOST 16486)
7	**Fabric stiffness B_{fab}(μH*m)**		190,27	13,11	84,44	145,42	

Based on the results of the conducted research, among the fabrics of the specialized prenatal supportive devices currently used in practice, Samples IV and III demonstrated the highest performance indicators in tests assessing physical-mechanical and hygienic requirements. These samples were found to possess high durability, strength, good air permeability, and excellent shape retention properties. Although Samples I and II satisfied the minimum required standards, their application is not recommended due to unsatisfactory results in terms of strength and, in particular, irreversible deformation.

In improving the quality of life and safeguarding the health of pregnant women, the capabilities of traditional prenatal supportive devices are insufficient to meet contemporary requirements. Eliminating the shortcomings of materials currently used in practice, as well as developing advanced prenatal supportive device systems capable of real-time monitoring of maternal and fetal conditions, represents a priority task at the intersection of modern medicine and light industry. Such innovative devices, equipped with intelligent measuring systems, perform not only a mechanical support function but also contribute to the prevention of potential complications through continuous monitoring of physiological parameters.

Within the framework of the study, the anthropometric measurements of pregnant women were analyzed, and changes in body dynamics were systematized. The physical-mechanical properties of fabrics used in existing prenatal supportive devices were examined under laboratory conditions, and their deficiencies were identified. Based on the collected data, a social survey was conducted among 300 respondents. According to the results of the marketing analysis, key consumer requirements were identified (83.3% preference for natural fabrics, 33.6% demand for fetal monitoring capability, and 40.2% need for lumbar-shoulder fixation). Taking these findings into account, consumer opinions regarding prenatal supportive devices were analyzed, and two technical sketch designs of an improved prenatal supportive device were developed (Figure 3).

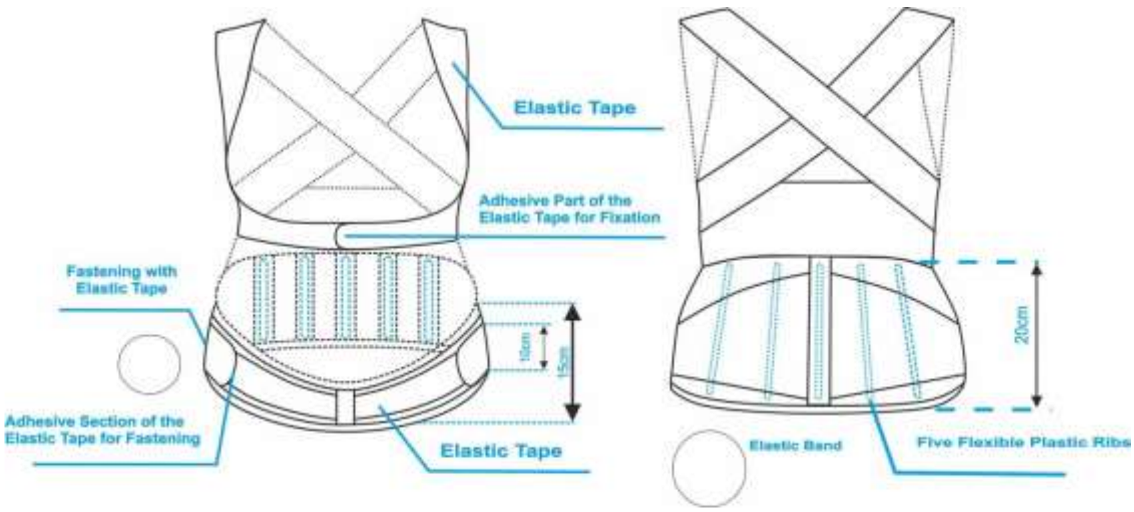


Figure 3. Improved Prenatal Supportive Device (Sample 1).

The proposed model was developed in accordance with the principle of an improved prenatal supportive device. In this design, the primary support component stabilizes the lower abdominal region beginning from the 4th–5th month of pregnancy, while additional shoulder straps provide lumbar and shoulder posture support, as requested by 40.2% of respondents.

In the sketch, a perforated elastic band ensuring air permeability—identified as a requirement by 63% of respondents—was selected as the main material for the inner layer of the device. The technical drawing incorporates adjustable elements that accommodate non-typical morphological changes of the female body, as well as flat seams to enhance comfort and prevent skin irritation.

The cream color palette preferred by 50% of respondents, along with the possibility of wearing the device over clothing, contributes to the prevention of potential dermatological conditions that may arise during prolonged use.

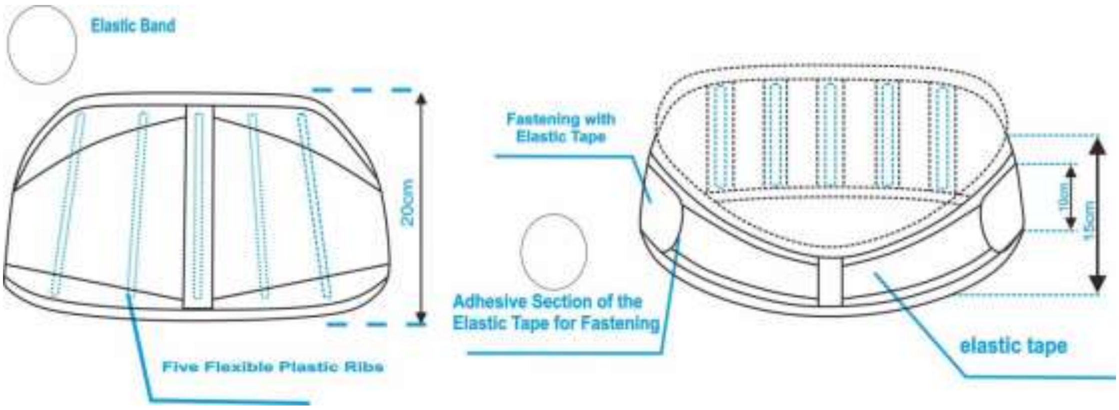


Figure 4. Improved Prenatal Supportive Device (Sample 2).

The second prototype developed within the study focuses specifically on maintaining biomechanical balance in the lumbar and abdominal regions of pregnant women and enabling digital monitoring of these areas. Unlike Sample 1, this design eliminates the shoulder-support straps and allows the device to be worn over clothing. The technical sketch features an ergonomic shape that covers only the lumbar and abdominal segments. This construction addresses the highest reported need among respondents for lumbar support (46.8%).

The absence of shoulder straps facilitates ease of wearing and provides a high level of aesthetic compatibility when worn over everyday clothing, particularly for working women (professionals and students). To ensure air permeability, a perforated elastic band—preferred by 63% of respondents—was selected as the primary material. The fastening system allows individual adjustment of the abdominal circumference according to non-typical body shape changes (Figure 3).

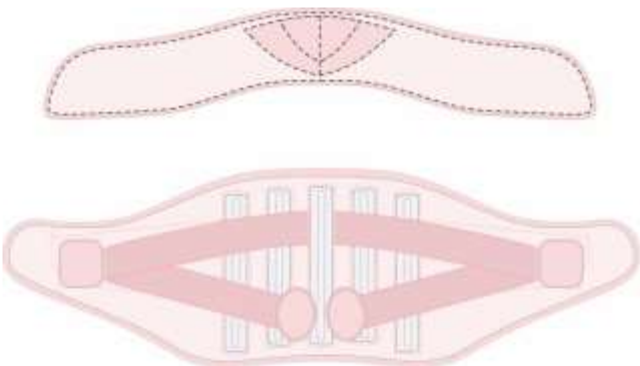


Figure 3. Unfolded View of the Improved Prenatal Supportive Device.

This proposed model integrates biomechanical support and digital monitoring functions while taking into account the non-typical body changes of pregnant women. The main structural solutions of the design are as follows:

The V-shaped seams located at the center of the front abdominal panel are not merely decorative; they function as special internal pockets intended for the installation of sensory elements (sensors). This design ensures that the sensors remain close to the abdominal surface, providing accurate data collection. On the back panel, X-shaped elastic straps allow the device to “grow” proportionally with the wearer’s body size.

These straps enable each woman to adjust the device individually according to her body shape. Circular points at the center of the sketch serve as fastening elements that secure the elastic straps in the desired position. Five vertical ribs positioned in the lumbar area distribute the load exerted on the spine evenly. This structural framework is considered the primary mechanical factor in reducing lumbar pain, a concern reported by 46.8% of respondents.

Conclusion. Our research demonstrates that changes in body measurements during pregnancy are not merely external phenomena but represent adaptations of the musculoskeletal system to increasing loads. The digital monitoring of these anthropometric parameters holds strategic significance, not only in obstetric practice but also in the individualized design of smart garments.

According to the study results, smart bandages developed for pregnant women must be fully adaptable to each woman’s unique body structure (somatotype). The application of a “flexible design” approach ensures that the bandage expands in proportion to the abdominal volume without exerting excessive pressure on the body. Such intelligent systems help maintain proper body balance throughout all stages of pregnancy, which, in turn, contributes to a significant reduction in pain in the lumbar and pelvic regions.

REFERENCES:

1. Axmatova, D. J. (2025). Homiladorlik davrida organizmning fiziologik oʻzgarishlari [Physiological changes of the body during pregnancy]. Part-44, Issue-1, May-2025.

2. Poston, L. (2018). Gestational weight gain. In *UpToDate*. Retrieved October 7, 2018, from https://www.uptodate.com/contents/gestational-weight-gain

3. Apollo Hospitals. (n.d.). Polyhydramnios. Retrieved from https://www.apollohospitals.com/uz/diseases-and-conditions/polyhydramnios

4. Vaxidova, U. A. (2022). *Sovershenstvovanie metodov proektirovaniya komfortnoy odezhdy dlya beremennykh zhenshchin* [Improving methods of designing comfortable clothing for pregnant women] (PhD dissertation).

5. Usmanova, D., & Mahsudov, Sh. (2025). Kiyimlarni loyihalashda notipavoy qomatlar va ularning oʻzgarishi tadqiqi [Study of atypical figures and their changes in clothing design]. *Mashinasozlik ilmiy-texnika jurnali*, (2), 816–819.

6. GOST 31398-2009. (2009). *Klassifikatsiya tipovykh figur beremennykh zhenshchin* [Classification of typical figures of pregnant women]. Standartinform.

7. Anita Maternity. (n.d.). Anita maternity microfiber style [Product description]. Retrieved from https://www.amazon.com/Anita-Maternity-Microfiber-Style

8. Rodriguez, C. Q., & Troynikov, O. (2019). The effect of maternity support garments on alleviation of pains and discomforts during pregnancy: A systematic review. *Journal of Pregnancy*, 2019