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AN INVESTIGATION OF THE RELATIONSHIP BETWEEN WAIST CIRCUMFERENCES AND WAIST-TO-HEIGHT RATIOS WITH DIFFERENT VARIABLES IN WOMEN WITH AGES BETWEEN 18 AND 53 YEARS

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Abstract:
The aim of this study is to investigate whether waist circumference and waist-to-height ratios in women are affected by such factors as age, marital status, age at first marriage, parental status, number of children, and regular physical activity. Furthermore, the relationship between chronic diseases and waist circumference and waist-to-height ratios will also be examined. A total of 111 women were randomly selected to participate in this study, of average age 32.26 ± 8.74 years, mean height 162.76 ± 5.44 cm, and average weight 67.38 ± 11.74 kg. In addition to height, weight, and age, waist circumferences and waist-to-height ratios were also determined. Questionnaires recorded the participants' marital status, age at first marriage, number of children, smoking status, exercise habits, and any chronic health conditions. ANOVA and the student's t-test were used to analyze these data. Results indicated that waist circumference was significantly associated with age, number of children, marital status, menopausal status, regular exercise, parental status, and the presence of a chronic health condition ($p < 0.01$), as well as with marital status ($p < 0.05$). Waist circumference was not found to have a statistically significant association with smoking status ($p < 0.05$). Waist-to-height ratios were determined to associated with age, marital status, menopausal status, regular exercise, parental status, and chronic health conditions ($p < 0.01$) and with age at first marriage ($p < 0.05$), while the relationships with number of children and smoking status were not found to be statistically significant ($p > 0.05$).

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Keywords: age, waist circumference, waist-to-height ratios, marital status, age at first marriage, physical activity

1. Introduction

Humans require energy for their survival. The energy that we need is acquired through food, which is processed by our bodies. When the energy obtained by the body is greater than the energy expended an increase in fat tissue in the body results. This is referred to as excess weight or obesity.

Obesity, although defined simply as increased fat tissue in the body, is the accumulation of fat (adipose) tissue in the body at an abnormal or excessive level that compromises health (1, 2, 3). It is a complex multifactorial chronic disease, thought to result from the interaction of social, behavioral, cultural, physiological, metabolic, and genetic factors (4, 5). It has been reported that obesity may lead to physical and psychological problems of a global dimension which are significantly associated with morbidity and mortality (1, 6).

There are various methods used to clinically evaluate obesity levels. Among these are Body Mass Index (BMI), waist circumference, waist-to-height ratio, body weight, and hip circumference (7, 8, 9, 10, 11, 12). These methods are more widely employed than others because they are simple and easy to use, have high correlation rates between them, and lower error rates versus other methods (7, 8, 9). However, BMI is not an optimal indicator of body fat, as it cannot distinguish fat from muscle tissue and bone. Because of this, reliance on BMI may result in incorrect classification of people as either overweight or obese. Furthermore, BMI is not a suitable method for distinguishing body fat distribution, being less sensitive than waist circumference and waist-to-height ratio (13). Waist circumference is a simple to use and practical method to measure fat content in the abdominal region (4, 5). The accumulation of fat around the abdomen occurs more frequently than in the hips and other areas of the body, and poses greater health risks (14, 15). Waist circumference best reflects accumulation in the abdominal region, internal organs and subcutaneous fat, as well as abdominal muscle tone (16, 17, 18) and is one of the criteria which should be taken into consideration in assessing overall health (19). In addition, although there are minor differences in their estimations of cardiovascular risk, waist circumference and waist-to-height ratio have been reported to better assess cardiovascular risk than BMI or waist/hip ratio (20).

Although the total amount of fat in the body is important, knowing where it is accumulated is more important. As noted above, the accumulation of fat in the abdomen is more common and carries greater health risks than fat in the hips and other

areas of the body (15). Abdominal fat is the second major risk factor for cardiovascular diseases (following smoking) and obesity (16, 21). A simple but effective method for evaluating this risk is measuring waist circumference. It should also be kept in mind that the relationship between waist circumference and risk of disease varies in different societies (21, 14).

The accumulation of body fat tissue in the upper body and abdominal region (central obesity) has been identified as being more risky from a health perspective, especially due to its part in the development of insulin resistance (15, 16). The World Health Organization (WHO) has deemed waist circumference greater than 80 cm in women and 94 cm in men to be risky in terms of metabolic diseases, and a waist circumference exceeding 88 cm for women and 102 cm for men is considered high risk. The risks associated with increased waist circumferences in men and women as described in different studies are shown in Table 1 (14, 19, 22).

Table 1: Classification according to waist circumference

Gender	Normal Waist Circumference (cm)	Increased Risk Waist Circumference (cm)	High Risk Waist Circumference (cm)
Woman	<80	80-87	>88
Men	<94	94-101	>102

In recent years, studies on hypertension, diabetes mellitus, and cardiovascular diseases have reported that a waist-to-height ratio greater than 0.50 is a risk factor for disease (23, 24, 25).

Regarding the epidemiology of obesity and its causes, obesity is currently one of the most frequently encountered nutritionally-based diseases in the world, and its incidence is increasing by the day. Obesity has seen a two-fold increase in frequency on a world scale since 1980 (26). In Turkey, as in the world at large, the obesity rate is gradually on the increase. According to the results of the Turkish Diabetes Epidemiology Study (TURDEP), the frequency of obesity in Turkey is 22% (27). In the study "Heart Diseases and Risk Factors in Turkish Adults" in the year 2000, the rate of obesity in women was found to be 43%. The obesity rate in Turkey has been demonstrated to be notably higher than world averages. High birth rates and low educational levels have been associated with obesity in women (28).

The goal of the present study is to investigate whether waist circumference and waist-to-height ratios in women are affected by such factors as age, marital status, age at first marriage, parental status, number of children, and regular physical activity. In

addition, the relationship of waist circumference and waist-to-height ratios to chronic diseases will be examined.

2. Methods

2.1 The Study Group

The study group consisted of 111 randomly selected women whose mean age, mean height, and mean weight were 32.26 ± 8.74 years, 162.76 ± 5.44 cm, and 67.38 ± 11.74 kg, respectively.

2.2 Method of Data Collection

Measurements of the subjects' height and weight were taken using a Jawon AVIS 333 PLUS brand Bioelectrical Impedance Analysis (BIA) device, while waist circumference was determined using a measuring tape. Personal information on the study participants' marital status, age at first marriage, number of children, and information on their smoking status, exercise habits, and chronic diseases were obtained via questionnaire.

2.3 Measurement Methods

2.3.1 Height

The height of the test subjects was measured in centimeters, with the subjects standing upright on the floor in bare feet.

2.3.2 Body mass

The weight of the participants was measured using a Jawon AVIS 333 PLUS brand Bioelectrical Impedance Analysis (BIA) device, again with the subjects barefooted.

2.3.3 Waist circumference

Waist circumference was measured around the smallest part of the waist, between the lowest rib and the anterior superior iliac spine, passing over the navel, and parallel to the floor.

2.3.4 Waist-to-height ratio

This was determined by dividing waist circumference by height.

2.3.5 Data analysis

The data obtained were entered into a computer and subsequently analyzed by using one-way ANOVA and the student's t-test using the SPSS statistical program.

3. Findings

Table 2: Range of waist circumferences of the participants

Waist circumference (cm)	**N**	**%**
<80	27	24,3
80-87	27	24,3
>88	57	51,4
Total	111	100,0

As shown in Table 2, 24.3% of the subjects had waist circumferences below 80 cm, 24% were between 80-87 cm, and 57% had waist circumferences exceeding than 87 cm.

Table 3: Range of waist-to-height ratios of the participants

Waist-to-height ratio (cm)	**N**	**%**
< ,40	2	1,8
,41- ,49	29	26,1
,50- ,60	53	47,7
,61 - >	27	24,3
Total	111	100,0

According to the data, only 1.8% of the participants had a waist-to-height ratio below 0.40, 26.1% had a ratio between 0.41 and 0.49, 47.7% were between 0.50 and 0.60, and 24.3% had a waist-to-height ratio greater than 0.60.

Table 4: Waist circumference and waist-to-height ratio ANOVA results with respect to certain variables

Variable	**Groups**	**N**	**Waist circumference (cm)**			**Waist-to-height ratio (cm)**		
			average ± standard deviation	**F**	**p**	**average ± standard deviation**	**F**	**p**
Age (years)	18-23	19	84,00 ± 8,70	4,794	,001	,51±,05	5,815	,000
	24-29	29	84,72 ± 12,18			,51±,07		
	30-35	22	87,95 ± 11,71			,55±,08		
	36-41	26	90,92 ± 13,28			,56±,09		
	42-47	7	101,00 ± 11,94			,63±,08		
	48-53	8	100,62 ± 7,69			,63±,05		
	1-2	32	88,25 ± 11,57	4,142	,010	,51±,06	,633	,597

Number of births	3-4	22	96,32±13,52			,51±,07		
	5-6	6	102,17±3,31			,54±,05		
	7-8	3	102,33±9,24			,54±,08		
Age of Marriage (years)	13-15	9	100,00±17,29	2,870	,022	,62±,11	3,060	,016
	16-18	14	97,57±10,23			,61±,07		
	19-21	11	94,09±10,88			,58±,07		
	22-24	12	87,50±9,95			,53±,07		
	25-27	14	87,50±11,57			,53±07		
	28-30	3	80,67±4,04			,53±10		

As seen in Table 4, waist circumference, age, number of children, and age at first marriage were associated with waist circumference ($p < 0.01$). The same table shows that there is a statistically significant relationship between waist-to-height ratio and age and age at first marriage ($p < 0.01$), although not with number of children ($p > 0.05$).

Table 5: T-test results for waist circumference and waist-to-height ratio with respect to certain variables

Variable	**Groups**	**N**	**Waist circumference (cm)**			**Waist-to-height ratio (cm)**		
			average ± standard deviation	**t**	**p**	**average ± standard deviation**	**t**	**p**
Marital status	Married	67	92,27±12,27	4,140	,000	,57±,08	4,271	,000
	Single	43	82,95±10,22			,51±,07		
Smoking status	Yes	32	89,25±12,80	,205	,838	,55±,08	,671	,504
	No	79	88,71±12,51			,54±,08		
Menopausal status	Yes	7	100,14±8,53	2,518	,013	,63±,05	2,770	,007
	No	104	88,10±12,42			,54±,08		
Regular sports	Yes	47	83,68±11,15	-3,977	,000	,51±,07	-4,324	,000
	No	64	92,67±12,20			,57±,08		
Chronic disease	Yes	34	94,59±12,52	3,341	,001	,59±,08	3,946	,000
	No	77	86,34±11,76			,53±,08		
Having children	Yes	63	93,08±12,59	-4,381	,000	,51±,07	-4,327	,000
	No	48	83,33±10,18			,57±,08		

When the relationships between the variables and waist circumference presented in Table 5 are examined, an association is observed between waist circumference and marital status, menopausal status, exercise habits, chronic disease, and maternal status ($p < 0.01$). As shown in the same table, waist-to-height ratios were determined to be associated with marital status, menopausal status, exercise habits, chronic disease, and maternal status ($p < 0.01$). Smoking status was not found to be associated with either waist circumference or waist-to-height ratio ($p > 0.05$).

4. Discussion

In the present study, it was demonstrated that such factors as marital status, age at first marriage, maternal status, number of children, exercise habits, and menopausal status have an effect on waist circumference, while smoking does not. In addition, another result obtained was that study participants with chronic diseases were found to have larger waist circumferences than those without.

Pi-Sunyer reported using waist circumference to determine abdominal (or central) obesity (21). The mean waist circumference of all participants in the present study was 88.86 ± 12.53 cm. As shown in Table 1, these data were group according to waist circumference. Based on such this classification, 24.3% were found to have a waist circumference below 80 cm (the mean for this group being 73.07 ± 4.45 cm), 24.3% were between 80-87 cm (with a mean of 83.52 ± 2.56 cm), and 51.4% had a waist circumference of 88 cm or above (with a mean of 98.87 ± 7.77 cm). Ergün and Erten found that female university students of average age 19.8 ± 1.1 years had a mean waist circumference of 67.02 ± 6.36 cm. In their study of females aged 19 – 35, Erçim and Pekcan reported a mean waist circumference of 71.6 ± 8.1 cm. the difference in the results of the present study when compared with those of the other studies may be attributed to the differences in the mean ages of the study participants (29, 30).

When the participants' waist circumferences were examined with respect to age, the mean for those aged 18 - 23 was 84.00 ± 8.70 cm, 87.95 ± 11.71 cm for those aged 30 - 35, and 100.62 ± 7.69 cm for those aged 48 - 53. Comparison of these values revealed that the differences between the age groups were statistically significant ($p<0.01$).

Regarding the effect of number of children on waist circumference, it was observed that with increasing number of children waist circumference also increased. Mean waist circumference was 88.25 ± 11.57 cm for participants with 1 - 2 children, 90.92 ± 13.28 cm for those with 3 or 4 children, and 102.33 ± 9.24 cm for subjects who had 7 - 8 children. Although differences in mean waist-to-height ratios between the three groups were observed, they were not statistically significant ($p > 0.05$). Subjects with 1 – 2 children had a mean waist-to-height ratio of 0.51 ± 0.06, the ratio for those with 3 – 4 children was 0.51 ± 0.07, while women with 7 - 8 children had a mean waist-to-height ratio of 0.54 ± 0.05. The results of our study are in accordance with those of previous studies that found an increase in waist circumference with increasing number of children (31, 32). Although there is an association between number of children and waist circumference, it cannot solely be attributed to weight gain during pregnancy due to increased appetite and reduced activity levels. Not only does an increase in weight accompany every pregnancy, the stomach muscles are also deformed and incidence of

prolapse increases. However, weight loss may occur following pregnancy as a result of breast-feeding. With an increase in activity and attention to diet, this process can be accelerated. If weight loss is supported by a suitable exercise regime, this can be effective in preventing abdominal obesity which occurs during pregnancy.

Data pertaining to age at first marriage and waist circumference and waist-to-height ratio are presented in Table 3. The mean waist circumference for those married between the ages of 13 – 15 was 100.00 ± 17.29 and the waist-to-height ratio was 0.62 ± 0.11, while those values for women married between the ages of 16 -18 were 97.57 ± 10.23 and 0.61 ± 0.07, respectively. The mean waist circumference for women married between the ages of 19 – 21 was 94.09 ± 10.88 cm, while their mean waist-to-height ratio was 0.58 ± 0.07. For women married between the ages of 25 – 27, the mean waist circumference was 87.50 ± 11.57 cm and their mean waist-to-height ratio was 0.53 ± 0.07. Age at first marriage was found to be significantly associated with waist circumference ($p < 0.05$). This significance is inversely proportional; in other words, waist circumference decreases as age at first marriage increases. The same situation is also valid for age at first marriage and waist-to-height ratio: the latter decreases with increasing age at first marriage. These values are significant ($p < 0.05$).

Regarding marital status, participants who were married had a mean waist circumference of 92.27 ± 12.27 cm and waist-to-height ratio of 0.57 ± 0.08, while those values for unmarried women were 82.95 ± 10.22 cm and 0.51 ± 0.07, respectively. When the mean values for both of these variables for the two groups were compared, the difference was observed to be statistically significant ($p < 0.01$).

Comparing smokers and non-smokers among the women who participated in the study, the former group had a mean waist circumference of 89.25 ± 12.80 and mean waist-to-height ratio of 0.55 ± 0.08, while those values for non-smokers were 88.71 ± 12.51 and 0.54 ± 0.08, respectively. These differences were determined not to be statistically significant ($p > 0.05$). In their study reported no association between smoking status and waist circumference (33).

When waist circumference and waist-to-height ratios were evaluated based on menopausal status, the mean waist circumference for those who had entered menopause was 100.14 ± 8.53 cm, and their mean waist-to-height ratio was 0.63 ± 0.05, while those values for subjects who had not begun menopause were 88.10 ± 12.42 and 0.54 ± 0.08, respectively. Comparing the mean waist circumference values for each group, the difference was determined to be statistically significant ($p < 0.01$). A statistically significant difference in mean waist-to-height ratios between the two groups was also observed ($p < 0.01$).

Concerning the waist circumferences and waist-to-height ratios of women who participated in the present study with respect to exercise habits, the mean waist circumference of participants who exercise regularly was 83.68 ± 11.15 cm and their mean waist-to-height ratio was 0.51 ± 0.07, while those values for participants who do not engage in regular exercise were 92.67 ± 12.20 cm and 0.57 ± 0.08, respectively. Comparing the mean values between the two groups, there were significant differences for both waist circumference and waist-to-height ratios. The findings of the present study are in accordance with the literature. This can be explained by the simple fact that with an increase in physical activity there is a corresponding increase in energy expended.

Examining the waist circumference and waist-to-height ratios with regard to parental status, the mean waist circumference of women with children was 93.08 ± 12.59 and their mean waist-to-height ratio was 0.57 ± 0.08. In contrast, those values for women without children were 83.33 ± 10.18 and 0.51 ± 0.07, respectively.

When values for waist circumference and waist-to-height ratio were considered with respect to the presence of chronic diseases, those with chronic health problems had a mean waist circumference of 94.59 ± 12.52 and mean waist-to-height ratio of 0.59 ± 0.08, while the mean values for those without were 86.34 ± 11.76 and 0.53 ± 0.08, respectively. These differences were determined to be statistically significant ($p < 0.01$). The storage of fat tissue in the region of the internal organs characterized by upper body obesity contributes in large measure to the development of hypertension, insulin resistance, diabetes mellitus, and dyslipidemia (34). A found a waist circumference greater than 110 cm in men and over 95 cm in women to be associated with an increase in mortality (35). Furthermore, reported that a waist-to-height ratio exceeding 0.55 could increase the chance of coronary artery disease by 3 to 7 times (36). As overweight and obese people tend to have limited daily physical activity, the resulting fattening of the internal organs impedes their proper functioning, leading to a number of negative outcomes.

5. Conclusion

A majority of participants in the present study (51.4%) were observed to have waist circumferences deemed high risk, while a total of 72% had waist-to-height ratios above 0.50, which is considered risky. Educational and health organizations as well as the media should emphasize what these values mean and what factors affect them, so that the general public is aware of the associated risks. In order to possibly prevent or at

least minimize these negative health risks, we believe that it is necessary to emphasize the importance of exercise and encourage the public to increase their physical activity.

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