Waist to Hip Ratio and Psychosocial Factors in Adults With Insulin-Dependent Diabetes Mellitus: The Pittsburgh Epidemiology of Diabetes Complications Study

C.E. Lloyd, R.R. Wing, and T.J. Orchard

The relationship between waist to hip ratio (WHR) and psychosocial factors has seldom been investigated, although both may contribute to cardiovascular risk. Therefore, these variables were examined in adults with insulin-dependent diabetes mellitus ([IDDM] N = 592; mean age, 29 years; mean duration, 20 years), a population at increased risk of developing cardiovascular disease. Moreover, the association between changes in psychosocial factors and change in WHR was considered. After adjusting for body mass index (BMI), WHR in men was correlated with higher levels of depressive symptomatology ($r = .19$, $P < .001$), greater anxiety ($r = .13$, $P < .05$), less social support ($r = -.20$, $P < .01$), and lower type A scores ($r = -.25$, $P < .001$). In women, WHR was significantly correlated with higher levels of depressive symptomatology ($r = .18$, $P < .01$), greater stress ($r = .16$, $P < .01$), and alcohol consumption ($r = .12$, $P < .05$). For both sexes, smokers had a significantly greater mean WHR than nonsmokers ($P < .01$). For men, multiple regression analyses adjusting for BMI and age demonstrated that smoking, lower income, less exercise, and lower type A scores were the most significant variables associated with WHR. In women, the independent predictors of WHR were a history of smoking, lower educational level, and depressive symptomatology. The most significant independent predictors of change in WHR from baseline to 2-year follow-up study were change in weight (men), change in BMI (women), and change in depression scores (both sexes). These results suggest that psychosocial factors may affect cardiovascular disease risk through their influence on body fat distribution, and both may be important in identifying those most at risk for cardiovascular disease in populations with IDDM.

PREVIOUS STUDIES have demonstrated a link between central adiposity and an increased risk for cardiovascular and other diseases.[1-3] This association is independent of body weight or fatness, and may be mediated via the effects of upper-body fat on established cardiovascular risk factors.[4-6] Supporting this is strong evidence from a number of studies that waist to hip ratio ([WHR] a commonly used measure of central adiposity) is associated with blood pressure and lipoprotein levels.[5-7]

Determinants of WHR are varied and include genetic variables,[8] hormonal variables,[9] and behavioral factors such as smoking and exercise.[10-12] Psychological and psychosocial factors may also influence WHR, although little of such research has been performed to date. However, earlier investigations have suggested that higher WHR may be associated with lower social class, poorer education, and possibly psychiatric difficulties.[6,13] Bjorntorp[14] has hypothesized that certain stressful conditions could lead to neuroendocrine and endocrine responses that could result in increased visceral fat accumulation. However, as Bjorntorp states, there is little evidence as yet for these associations in the literature. In the few studies that address this issue, Wing et al[15] demonstrated that increased WHR was associated with higher levels of depression and anxiety but unrelated to increased stress in middle-aged women. In contrast, Rothschild et al[16] did not find any association between WHR and depression scores in men.

Individuals with insulin-dependent diabetes mellitus (IDDM) are at an increased risk of developing cardiovascular disease. Moreover, unlike the general population, the risk of cardiovascular disease in individuals with IDDM does not differ between the sexes.[17] Thus, investigation of determinants of WHR in this population may have implications for the prevention of cardiovascular disease. Data from the prospective Epidemiology of Diabetes Complications (EDC) study have provided an opportunity to examine associations between potential risk factors for cardiovascular disease in both men and women with IDDM. In a previous report from the EDC study, WHR was found to be associated with many of the risk factors for cardiovascular disease, for example, serum cholesterol and triglycerides, blood pressure, and fibrinogen.[18] Cross-sectional data from the EDC study have also provided evidence to support the hypothesis that the association between WHR and cardiovascular disease can be accounted for by its links with these other risk factors.[19]

The present report examines the relationship between psychosocial and behavioral factors and WHR in men and women with IDDM. This investigation is the first to assess prospectively the effects of psychosocial factors such as stress and depression on changes in WHR over time.

SUBJECTS AND METHODS

All adult (≥18 years) participants (N = 592) in the EDC study took part in a clinical examination and completed a series of questionnaires. The EDC study is an ongoing prospective investigation in which the participants were all diagnosed with IDDM before the age of 17, were seen within 1 year of diagnosis at the Children's Hospital of Pittsburgh between 1950 and 1980, and were on insulin therapy at discharge.[20] Upon acceptance of an invitation to participate in this study, subjects were mailed a series of questionnaires to complete prior to attending for a full clinical examination. These questionnaires included the Beck Depression Inventory,[21] a 21-item questionnaire that measures the presence of depressive symptomatology. The Beck Depression Inventory has been shown to have good validity and internal consistency, and also to differentiate depression from anxiety.[21] The Spielberger State-Trait Anxiety Inventory was also completed.[22] It has also been

From the Departments of Epidemiology and Psychiatry, University of Pittsburgh, Pittsburgh, PA.

Submitted April 4, 1995; accepted July 14, 1995.

Supported by National Institutes of Health Grant No. DK34818.

Address reprint requests to T.J. Orchard, MBBCh, Rangos Research Center, 5th Floor, 3460 Fifth Ave, Pittsburgh, PA 15213.

0026-0495/96/4502-0023$03.00/0

found to have high internal consistency and good test-retest reliability.[22] A five-point measure of perceived stress[23] was used, along with a 10-item measure of social support.[24] Both of these questionnaires were developed by Cohen et al,[23,24] and have been shown to possess good reliability and validity. The Bortner Type A Questionnaire, a standardized short rating scale to measure aspects of type A or coronary-prone behavior, was also completed by study participants.[25] The Bortner scale has been shown to have good test-retest reliability.[26] Finally, the Physical Activity Questionnaire was used,[27] which measures current and past activity levels at different ages. Kriska et al[27] have reported good reliability and internal validity. Full details of the clinical examination have been reported elsewhere,[20] but included measurement of WHR, which was calculated as the mean of two waist measurements divided by the mean of two hip measurements. Waist measurements were made at the midpoint between the upper iliac crest and the lower costal margin in the midauxiliary line. Hip measurements were made at the maximum hip circumference. All measurements were taken by trained investigators. All EDC study participants were invited to re-attend for a further clinical examination (exam 2) and to complete further questionnaires 2 years after their baseline examination (exam 1).

Statistical Analysis

Statistical analyses, using the Statistical Package for the Social Sciences (SPSSX; SPSS, Chicago, IL), included Student's *t* test and Pearson correlations. All analyses were performed separately for men and women, since there were significant sex differences in WHR and also in other variables being investigated. Since body mass index (BMI) was correlated with WHR in both men and women, analyses were repeated using partial correlations adjusting for this variable. Similarly, since age and duration were both highly correlated with WHR in men (but not in women), analyses were repeated adjusting for these two variables. To identify significant independent correlates of WHR at baseline, stepwise linear regression analyses were performed. The goodness of fit of each model was assessed by R^2. The correlates of change in WHR from exam 1 to exam 2 were evaluated by the method of residual change, which was used for both outcome (WHR) and predictor variables.[28] This method uses the residuals from a regression of exam 2 values on exam 1 values as the measure of change. This type of analysis corrects the observed change for the initial level of the variable; thus, the change between examinations is not attributable to the level at the first examination. Pearson and partial correlations were then performed on these residuals to examine the relationship between change in WHR and change in psychosocial factors. Finally, multiple regression analyses were performed to identify the significant independent predictors of change in WHR, with the goodness of fit of each model assessed by R^2.

RESULTS

Demographic details of the study population are given in Table 1, and show no difference in either age or duration of diabetes according to sex. As expected, women had a significantly lower mean WHR, even when adjusted for BMI ($P < .001$). Women reported a lower weekly alcohol intake ($P < .001$) but were similar to men in smoking history, education level, and household income. The relationship between WHR and age and duration of diabetes differed according to sex. For men, WHR increased with both age and duration of diabetes ($r = .40$ and $.35$, respectively, $P < .01$). In contrast, there was no significant association between WHR and either duration of disease or age for women ($r = .08$ and $.02$, NS). BMI was significantly correlated with WHR in both sexes ($r = .41$ for men and $.30$ for women, both $P < .01$).

Table 2 shows sex-specific associations between WHR and demographic, psychosocial, and behavioral factors. Among men, those with lower income and less education (after adjusting for BMI) had higher WHRs. WHR was also significantly correlated with higher depression and anxiety scores in men, and with lower social support and type A scores and less physical activity. All of these associations remained significant when adjusted for BMI or for BMI and age. Men with a positive smoking history had a significantly greater mean WHR ($.88 \pm .05$ *v* $.87 \pm .06$, $P < .01$). Greater WHRs were observed in married versus single men ($.89 \pm .05$ *v* $.87 \pm .06$, $P < .01$).

Table 1. Baseline Characteristics of Study Participants by Sex (mean ± SD)

Baseline Characteristics	Men (n = 301)	Women (n = 291)
Age (yr)	29.0 ± 6.7	29.2 ± 7.0
Duration (yr)	20.6 ± 7.0	20.2 ± 7.3
WHR	0.89 ± .05‡	0.78 ± .06
BMI	24.0 ± 2.8	23.6 ± 3.3
Alcohol intake per week (drinks)*	6.2 ± 11.2‡	2.7 ± 5.8
Anxiety scores	19.1 ± 6.9	21.0 ± 7.1†
Beck Depression scores	5.5 ± 5.5	8.2 ± 6.7‡
Stress scores	12.2 ± 3.3	14.0 ± 3.9‡
Social support scores	7.0 ± 2.6	7.7 ± 2.2†
Bortner type A	188.1 ± 36.8	189.7 ± 35.4
No. of city blocks per day	16.5 ± 16.8	12.2 ± 16.2†
No. of flights of stairs per day	12.2 ± 14.0	7.9 ± 7.1‡
College education or higher		
%	64	62
No.	181	172
Income > $20,000		
%	58	54
No.	142	125
Positive history of smoking		
%	43	39
No.	122	109

*Drinks = 12 oz beer = 4 oz wine = 1 shot liquor.
†$P < .01$, ‡$P < .001$: *v* women: Student's *t* test.

Table 2. Relationship Between Psychosocial and Behavioral Factors and WHR

	Men		Women	
Factor	WHR	WHR Adjusted for BMI	WHR	WHR Adjusted for BMI
Education	.00	−.20†	−.15*	−.13*
Household income	−.14*	−.23†	−.20†	−.20†
Beck depression	.14*	.19†	.19†	.18†
Stress	.00	.05	.15*	.16†
Social support	−.18†	−.20†	−.05	−.05
Type A	−.22†	−.25‡	−.10	−.09
Anxiety	.13*	.13*	.04	.04
Weekly alcohol intake	.04	.00	.11	.12*
No. of city blocks per day	−.13*	−.12*	.04	−.05
No. of flights of stairs per day	−.09	−.12*	.04	−.04

*$P < .05$, †$P < .01$, ‡$P < .001$: Pearson's or partial correlations (education also adjusted for age).

For women, lower income and less education were again associated with WHR (Table 2). Unlike in men, a significant positive association was observed between WHR and stress, but no correlation was detected between WHR and anxiety, type A scores, physical activity, or social support scores. However, in common with men, higher depression scores were significantly correlated with greater WHR. Total weekly alcohol consumption was significantly related to WHR in women, but not in men. Women with a positive smoking history had a significantly greater mean WHR (.80 ± .06 *v* .77 ± .06, $P < .001$). WHR did not differ according to marital status for women (.77 ± .06 *v* .78 ± .06, NS).

Stepwise linear regression analyses (Table 3) showed that for men, lower income, a positive smoking history, less physical activity (no. of city blocks walked per day), and lower type A scores were all significantly associated with WHR, even after adjusting for the effects of BMI and age. For women, a positive smoking history, depressive symptomatology, and a lower level of education were the significant independent variables associated with WHR, after adjusting for the effects of BMI. For both men and women, the relative contribution of behavioral and psychosocial factors (based on R^2) is small but significant (Table 3).

Since data on some of the psychosocial variables (ie, depression, social support, stress, and physical activity) were also collected at the first 2-year follow-up examination, it was possible to examine whether changes in these factors were related to change in WHR over time. Approximately one third of both men (34%) and women (35%) increased their WHR over the follow-up period. The mean increase in WHR was .02 (±.02) for both sexes. Increases in WHR were significantly correlated with increases in both BMI and weight for both men and women ($P < .001$; Table 4). Similarly, increases in WHR were also significantly correlated with increases in depression scores for both sexes. Increases in WHR were also associated with decreases in social support for men and decreases in physical activity for women. Finally, sex-specific multiple regression analyses were performed to identify significant independent correlates of change in WHR. Whereas the best model for men included a change in weight and the best model for women included a change in BMI (change in weight yielded a slightly poorer R^2), a change in the depression score was a significant independent predictor of change in WHR for both sexes (Table 5).

Table 3. Stepwise Linear Regression Analyses to Identify Independent Correlates of WHR

Significant Variable	Standardized Coefficient	Standard Error	*P*	Change in R^2
Men				
BMI	.49	.00	.0000	.22
Age	.29	.00	.0000	.12
Income	−.20	.00	.0008	.07
Smoking history	.16	.01	.0063	.02
No. of city blocks per day	−.13	.00	.0232	.01
Type A behavior	−.12	.00	.0456	.02
		Total R^2 = .46		
Women				
BMI	.29	.00	.0000	.08
Smoking history	.18	.01	.0021	.05
Depression	.15	.00	.0109	.03
Education	−.13	.00	.0235	.01
		Total R^2 = .17		

Table 4. Correlates of Change in WHR

Change in	Men	Women
BMI	.32†	.30†
Weight	.33†	.29†
Depression	.14*	.13*
Stress	.08	.10
Social support	−.13*	.03
Alcohol intake	.00	−.05
Physical activity (no. of city blocks per day)	−.11	−.15*

*$P < .05$, †$P < .001$: partial correlations (psychosocial factors adjusted for change in BMI).

DISCUSSION

Although few data are available, it has been shown previously that socioeconomic status, physical activity, and smoking status may be associated with WHR,[10-13,29] and our results support these findings. However, we have been able to show that other factors may also be associated with WHR. In particular, depressive symptomatology, anxiety, personality type, stress, and social support appear to be related, albeit differently by gender. To our knowledge, the inverse relationship between type A behavior and WHR has not been reported; however, this association may be confounded by other factors such as socioeconomic status or symptoms of depression. Matthews et al[30] demonstrated that a lower education level was significantly correlated with lower type A scores, and we are able to confirm this in our IDDM population. A lower education level may be a marker for other factors known to affect WHR, such as diet, alcohol consumption, or smoking. However, interestingly, we did not find any association between caloric intake and WHR in this study population. Furthermore, in women, we did not find any relationship between caloric intake and any of the psychosocial factors measured in this study. In men, some correlations were observed, but these were not consistent over all the psychosocial measures. Other dietary indicators, not available to us, may more accurately reflect the known association between WHR and diet. Lower type A scores might be a marker for depression, which has been associated with increased risk of cardiovascular disease.[31,32] In a cross-sectional analysis of data from the same study

Table 5. Multivariate Analysis to Identify Independent Correlates of Change in WHR

Significant Variable	Standardized Coefficient	Standard Error	*P*	R^2
Men				
Change in weight	.29	.00	.0004	.09
Change in depression scores	.14	.00	.0462	.02
		Total R^2 = .11		
Women				
Change in BMI	.38	.00	.0000	.10
Change in depression scores	.24	.00	.0042	.05
		Total R^2 = .15		

population, we have previously demonstrated a link between development of cardiovascular disease in adults with IDDM and both lower type A scores and greater depressive symptomatology.[33]

In what seems to be the first report of its kind, our prospective study has demonstrated that increases in depressive symptomatology and weight gain are associated with worsening WHR. Although increased BMI was shown to be a slightly better predictor of change in WHR in women, BMI and weight were correlated, an observation in concordance with previous studies.[11,15] It is unlikely that any significant increase in height (the other factor determining BMI) would have occurred during the 2-year follow-up period in this adult study population. Changes in weight have been associated with changes in WHR in the past, although this has not always been observed, and may be stronger in men than in women.[15,34]

We have observed an inverse relationship between changes in physical activity level and changes in WHR in women but not in men, supporting an earlier study of women.[15] In this previous study,[15] the effects of change in psychosocial factors such as depression or stress on changes in WHR were not assessed. In the current study using the method of residual change,[28] it has been possible to examine psychosocial correlates of change in WHR. Our analysis showed that regardless of baseline WHR or baseline level of depression (which are both accounted for in residuals analysis), increases in depressive symptomatology were significantly and independently associated with increases in WHR for both men and women.

The potential pathological mechanism relating depression to WHR has been described in detail by Bjorntorp.[5,14] He has suggested that chronic stress, often leading to feelings of depression, leads to the defeat reaction of the hypothalamus. This reaction is characterized by increased levels of cortisol and decreased levels of sex steroid hormones circulating in the body. In turn, cortisol increases lipid-accumulating enzymes of visceral fat tissue, affecting fat accumulation. Since corticosteroid hormone receptors are higher in density in abdominal tissue, the increased cortisol could potentially lead to greater fat accumulation in the abdominal area. This whole process leads to increased levels of free fatty acids and subsequently, perhaps through insulin resistance and hepatic effects, to increased triglycerides and cholesterol and risk of cardiovascular disease. As discussed earlier, previous findings from the EDC study,[18] which demonstrated significant associations between WHR and various cardiovascular risk factors, lend support to Bjorntorp's hypothesis. Although the EDC study population has diabetes, the etiology (type I—autoimmunity) is not associated with adiposity and fat distribution, and thus this population provides a unique model in which to study these effects.

In summary, this study has demonstrated that psychosocial factors, particularly depressive symptomatology, are significantly correlated with WHR in adults with IDDM. More importantly, the results of this investigation have also suggested that changes in WHR may be influenced by changes in depressive symptomatology. Since WHR has been shown to be a significant risk factor for cardiovascular disease, it remains an important goal to identify factors that influence central adiposity if we are to design intervention strategies to reduce overall cardiovascular risk.

Psychosocial factors such as depression are amenable to intervention, and may thus provide at least one of the keys to these prevention strategies.

REFERENCES

1. Larsson B: Regional obesity as a health hazard in men—Prospective studies. Acta Med Scand [Suppl] 723:45-51, 1988
2. Larsson B, Svardsudd K, Welin L, et al: Abdominal adipose tissue distribution, obesity and risk of cardiovascular disease and death: 13 year follow-up of participants in the Study of Men Born in 1913. Br Med J 288:1401-1404, 1984
3. Lapidus L, Bengtsson C, Larsson B, et al: Distribution of adipose tissue and risk of cardiovascular disease and death: A 12 year follow-up of participants in the population study of women in Gothenburg, Sweden. Br Med J 289:1257-1261, 1984
4. Depres JP, Moorjani S, Lupien PJ, et al: Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease. Arteriosclerosis 10:497-511, 1990
5. Bjorntorp P: The associations between obesity, adipose tissue distribution and disease. Acta Med Scand [Suppl] 723:121-134, 1988
6. Larsson B, Seidell J, Svardsudd K, et al: Obesity, adipose tissue distribution and health in men—The Study of Men Born in 1913. Appetite 13:37-44, 1989
7. Anderson AJ, Sobocinski KA, Feedman DS, et al: Body fat distribution, plasma lipids and lipoproteins. Arteriosclerosis 8:88-94, 1988
8. Bouchard C: Genetic factors in the regulation of adipose tissue distribution. Acta Med Scand [Suppl] 723:135-141, 1988
9. Lemieux S, Despres JP, Moorjani S, et al: Are gender differences in cardiovascular disease risk factors explained by the level of visceral adipose tissue? Diabetologia 37:757-764, 1994
10. Barrett-Connor E, Khaw KT: Cigarette smoking and increased central adiposity. Ann Intern Med 111:783-787, 1989
11. Laws A, Terry RB, Barrett-Connor E: Behavioral covariates of waist-to-hip ratio in Rancho Bernado. Am J Public Health 80:1358-1362, 1990
12. Selby JV, Newman B, Quesenberry CP, et al: Genetic and behavioral influences on body fat distribution. Int J Obes 14:593-602, 1990
13. Bjorntorp P: Abdominal fat distribution and disease: An overview of epidemiological data. Ann Med 24:15-18, 1992
14. Bjorntorp P: Visceral fat accumulation: The missing link between psychosocial factors and cardiovascular disease? J Intern Med 230:195-201, 1991
15. Wing RR, Matthew KA, Kuller LH, et al: Waist to hip ratio in middle-aged women. Associations with behavioral and psychosocial factors and with changes in cardiovascular risk factors. Arterioscler Thromb 11:1250-1257, 1991
16. Rothschild M, Peterson HR, Pfeifer MA: Depression in obese men. Int J Obes 13:479-485, 1989
17. Barrett-Connor E, Wingard DL: Sex differential in ischemic heart disease mortality in diabetics: A prospective population-based study. Am J Epidemiol 118:489-496, 1983
18. Stuhldreher WL, Orchard TJ, Ellis D: The association of waist-hip ratio and risk factors for development of IDDM complications in an IDDM adult population. Diabetes Res Clin Pract 17:99-109, 1992

19. Stuhldreher WL, Becker DJ, Drash AL, et al: The association of waist/hip ratio with diabetes complications in an adult IDDM population. J Clin Epidemiol 47:447-456, 1994

20. Orchard TJ, Dorman JS, Maser RE, et al: Prevalence of complications in IDDM by sex and duration. Pittsburgh Epidemiology of Diabetes Complications Study-II. Diabetes 39:1116-1124, 1990

21. Beck AT, Garbin MG: Psychometric properties of the Beck Depression Inventory: 25 years of evaluation. Clin Psychol Rev 8:77-100, 1988

22. Spielberger CD, Gorsuch RL, Lushene RE: STAI Manual for the State-Trait Anxiety Inventory. Palo Alto, CA, Consulting Psychologists, 1970

23. Cohen S, Kamarck T, Mermelstein R: A global measure of perceived stress. J Health Soc Behav 24:385-396, 1983

24. Cohen S: Measuring the functional components of social support, in Sarason IG, Sarason B (eds): Social Support: Theory, Research and Applications. The Hague, The Netherlands, Martinus Nijhoss, 1985, pp 73-94

25. Bortner RW: A short rating scale on a potential measure of pattern A behavior. J Chronic Dis 22:87-91, 1969

26. Matthews KA, Haynes SG: Type A behavior pattern and coronary disease risk. Am J Epidemiol 123:923-960, 1986

27. Kriska AM, LaPorte RE, Patrick SL, et al: The association of physical activity and diabetic complications in individuals with insulin-dependent diabetes mellitus: The Epidemiology of Diabetes Complications Study-VII. J Clin Epidemiol 44:1207-1214, 1991

28. Rosner B: The analysis of longitudinal data in epidemiologic studies. J Chronic Dis 32:163-173, 1979

29. Kaye SA, Folsom AR, Prineas RJ, et al: The association of body fat distribution with lifestyle and reproductive factors in a population study of postmenopausal women. Int J Obes 14:583-591, 1990

30. Matthews KA, Kelsey SF, Meilahn EN, et al: Educational attainment and behavioral and biologic risk factors for coronary heart disease in middle-aged women. Am J Epidemiol 129:1132-1144, 1989

31. Powell L, Shaker LA, Jones BA, et al: Psychosocial predictors of mortality in 83 women with premature acute myocardial infarction. Psychosom Med 55:426-433, 1993

32. Lloyd CE, Kuller LH, Ellis D, et al: Coronary artery disease in IDDM: Gender differences in risk factors but not risk. (submitted)

33. Lloyd CE, Matthews KA, Wing RR, et al: Psychosocial factors and complications of IDDM. Diabetes Care 15:166-172, 1992

34. Wing RR, Jeffery RW, Burton LR, et al: Change in waist-hip ratio with weight loss and its association with change in cardiovascular risk factors. Am J Clin Nutr 55:1086-1092, 1992