[Environmental Health and Preventive Medicine 6, 248–255, January 2002]

Original Article

Relation between Self-reported Weight Cycling History, Dieting and Bio-behavioral Health in Japanese Adult Males

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Abstract

Background: Epidemiological findings suggest that weight fluctuations are associated with unfavorable health outcomes compared with stable weight. However, the interrelationship between the weight cycling history and dieting status in a non-clinical male trial on the risk for bio-behavioral health is unclear.

Objective: The purpose of this study was to examine the relation between weight cycling history as a result of intentional weight loss and bio-behavioral health in Japanese adult males.

Method: A cross-sectional study was performed on a group of 146 Japanese working males (47.5±9.3 yr.). Each subject completed a series of self-reported questionnaires in which information about weight cycling history, current dieting practices, life-styles, and social background were assessed. Results of the physical check up were used to assess biological parameters. Self-reported weight cycling was defined as intentionally losing 10% of one's weight and regaining the lost weight.

Results: Cyclers reported a significantly greater incidence of current dieting and recent weight gain compared with non-cyclers. Taking regular meals, eating breakfast everyday, and not eating snacks between meals every day were significantly less frequent among cyclers compared with non-cyclers after controlling for BMI. The adjusted odds ratio for AST abnormality was 5.46 (95%CI: 1.08–27.67), ALT abnormality was 3.31 (95%CI: 1.24–8.78), and γ-GTP was 3.38 (95%CI: 1.07–10.67) among cyclers, compared with non-cyclers.

Conclusion: These findings suggest that a history of weight cycling in men, regardless of current weight status, is associated with adverse bio-behavioral health. The risk for several liver enzyme abnormalities associated with weight cycling history was substantial, independent of relative body weight and lifestyle factors.

Key words: weight cycling history, dieting, bio-behavioral health, Japanese adult males, cross-sectional study

Introduction

According to the 1998 National Nutrition Survey by the Ministry of Health and Welfare, the prevalence of obesity among Japanese adult males has been increasing over the past two decades[1)]. Obesity has been associated with coronary artery disease, hypertension, diabetes mellitus, and certain types of cancer[2)]. Many studies have reported that beneficial effects of weight loss include improvements in blood pressure[3,4)], lipid profile[5–8)] and glucose tolerance[9–11)]. In parallel with these findings, it has been reported that the physiological benefits of weight loss do not appear to translate into improvements in longevity[12)]. Even if individuals are successful in losing weight with any of the programs, few sustain weight loss for more than one year[13)]. Failure rates for dieting programs in the United States of America (USA) have been estimated to be as high as 90% to 95%[14)]. In addition, a number of adverse health effects have been hypothesized to be related to episodes of weight cycling. Several prospective, epidemiological studies relating weight cycling to mortality have been more consistently positive[15–18)]. These studies found that mortality was higher for persons with unstable body weight than for persons whose body weight was relatively stable, and the studies generally concluded that weight cycling resulted from unsuccessful dieting. However, since these studies did not ask people about their dieting and reasons for weight loss, it is unknown whether these factors cause increased health hazards.

It has been suggested that weight cycling may adversely affect specific weight- and eating-related variables (e.g. binge eating, body image, eating self-efficacy, unbalanced nutritional intake, and purging behaviors) in obese persons[19)] and in young women[20,21)]. In addition, the health effects of dieting itself have been questioned[22,23)]. Dieting often leads to problematic eating behavior independent of actual body weight via a cyclical pattern

Received Apr. 12 2001/Accepted Aug. 8 2001
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of severe food restriction and binge eating in young women[22,24–26]. An individual's perception of weight cycling defined as intentional weight loss and regain is related more to psychological problems such as body satisfaction, self-esteem, and life satisfaction than the actual weight lost and regained in a large sample of obese women[27]. Since weight cycling as a result of intentional weight loss is more prevalent in obese persons and young women, most research studies have mainly focused on these two groups. Therefore, much less is known about males in the non-clinical setting. Many results of weight cycling led us to consider whether weight cycling history as a result of intentional weight loss independently contributes to biological health after adjustment for weight status, current dieting and health related behavior in the average adult males.

Thus, this study was conducted for two purposes. The first was to examine the relations between weight cycling history and health related behavioral factors after controlling for the effects of weight status. The second was to investigate the relations between weight cycling history and biological factors such as lipids, glucose, and liver enzyme profiles after controlling for the effects of current dieting, life style factors and weight status.

Methods

Subjects

Data for this study were collected as a part of a work site cross-sectional study on health related psycho-behavior factors[28]. This survey was conducted on 317 white-collar workers in Tokyo, Japan in 1998. The response rate for the questionnaire was 80.1%. Exclusion criteria for the current study were 1) female, 2) age<30 or >65 year of age, 3) people who did not receive an annual health check up in May, 1998. The reason for excluding females in this study was because the purpose was to focus on the relations between weight cycling history and bio-behavioral health among males. The number of subjects included in this study was 146 male workers, and the mean age of the subjects was 47.5 years (SD=9.3).

Procedure

Questionnaires were distributed one week prior to the annual physical examination, and were collected personally by research staff after checking for omissions on the day of the physical examination. The details of the questionnaire and physical examination are described below.

Questionnaire

Demographic information: Demographic data were collected, including information on age, marital status, and education level.

Weight cycling history: Although there is no standardized definition for weight cycling, lifetime weight loss and regain of at least approximately 10 lb. (4.5 kg) or 10% of weight were the most common magnitude in the general population[19,26,29–32]. Taking into account these findings, we asked subjects for the frequency (0, 1, 2, 3+) of positive answers to the following question; "*Have you ever lost ten percent of your weight* (*through dieting or exercise for weight loss*) *and then re-gained it?*"

Intention to lose weight and current dieting: Intention to lose weight and current dieting were assessed with these two questions: (a) "*During the next six months, how do you intend to manage your weight?*" (Response options were "*I intend to lose weight*," "*I intend to maintain weight*" and "*I intend to gain weight*"); (b) "*Are you currently taking any action to manage your weight?*" (*yes or no*). On the basis of these responses, "thought of losing weight" and "action to lose weight" were defined as the current dieting category, the others as the non-dieting category.

Recent weight loss and weight gain episodes: Estimates of weight loss and weight gain episodes varied widely depending on the specific wording of the question. However, the definitions of weight loss or weight gain episodes of at least approximately 5 lb. (2.25 kg) were most common, in normal weight persons[32,33]. Taking previously published findings into account, recent weight loss≥2 kg and weight gain≥2 kg were assessed with the following question: "*Recently, how have you been managing your weight?*" Subsequently, the amount of weight loss or weight gain was asked.

Health related behavior: To assess the subjects' habitual health related behavior, the Health Practice Index (HPI) was conducted. HPI is a self-reported categorical questionnaire, composed of 11 items[34,35]. Good health practices in this study received a score of 1 for each of following items: 1) following a healthy daily routine, 2) exercising more than two days a week, 3) not drinking or drinking occasionally, 4) total nightly sleeping time between seven and eight hours, 5) taking regular meals, 6) having nutritionally balanced meals, 7) eating breakfast everyday, 8) working no more than nine hours per day, 9) feeling moderate subjective stress, 10) not eating between meals every day, 11) not smoking, including currently quitting. Other answers received a score of 0. All scores were summed to yield the HPI score.

Biological parameters

To assess body composition, height and weight measurements were taken. The body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Systolic and diastolic blood pressures were measured in the sitting position using a mercury sphygmomanometer (YAMASU MODEL No. 600, Japan). Blood sampling was carried out in the early morning after an overnight fast. Samples were collected in plain tubes (no anticoagulant) and after sitting for four hours centrifuged for 15 minutes at 3,000 rpm for serum total cholesterol (T-C), high-density-lipoprotein cholesterol (HDL-C), triglyceride (TG), aspartate aminotransferase (AST), alanine glutarate aminotransferase (ALT), γ-glutamyl transpeptidase (γ-GTP), total bilirubin (T-Bil), cholinesterase (ChE), total protein (TP), and albumin (Alb). Glyco hemoglobin A1c (HbA1c) was analyzed from the blood samples in the EDTA (K2). All blood samples were stored stationarily at 4°C until the next day and were analyzed at the Association for Preventive Medicine of Japan (Tokyo, Japan), and the enzymatic technique (T-C, TG, and ChE, and T-Bil), homogeneous technique (HDL-C), Biuret technique (TP), JSCC technique (AST and ALT), BCG technique (Alb), Szasz technique (γ-GTP), and the latex agglutinative technique (HbA1c) were employed for measurement of the respective parameters with autoanalyzers (Japan Electron Optics Laboratory: JEOL JCA-BM12, Tokyo, Japan). LDL-cholesterol (LDL-C) levels were calculated by Friedewald's equation[36], for subjects whose triglyceride values were 400 mg/dl or less. For subjects with a TG value greater than 400 mg/dl, LDL-C was calculated using the formula: LDL-C=TC-HDL-C (TG-0.16)[37].

Statistical analyses

All analyses were conducted using the SPSS 10.0 statistical software package (SPSS Institute, 1999). Subjects were divided into two weight cycling groups. “Non-cyclers” (n=109) were individuals who reported never losing more than ten percent of their weight (through dieting or exercise to lose weight) and regaining it. “Cyclers” (n=37) were individuals who reported losing more than ten percent of their weight and regaining it more than one to three times or more in their lives.

In the first analyses, age, weight-related measures such as BMI, prevalence of obesity, weight loss intention, current dieting, recent weight change patterns, and behavioral measures were analyzed to examine the differences between weight cycling groups. T tests for age and BMI, and chi-square tests for the prevalence of weight/dieting related quantitative variables were conducted to evaluate the differences between the two weight cycling groups. The Cochran-Mantel-Haenszel tests with BMI adjustment were used to evaluate the differences between weight cycling groups on weight/dieting related quantitative variables and 10 categorical variables measured by HPI. For the HPI total score, Analysis of Covariance (ANCOVA) controlling for BMI was conducted.

In the second set of analyses, biological variables were analyzed to examine differences between the weight cycling groups. The distributions of TG, AST, ALT, γ-GTP and LDL-C levels were subjected to common logarithmic transformation to reduce the skewness and kurtosis of the distribution prior to statistical parametric analysis. For the fourteen quantitative biological variables, Analyses of Covariance (ANCOVA) controlling for BMI were conducted.

Finally, to assess the independent association of weight cycling history for biological risk factors, logistic regression analyses were performed. In these analyses, model fit was assessed by the 2-log likelihood statistic. All statistical significances were considered at a type 1-error level of 0.05 (two-tailed).

Results

1. Demographics

Table 1 presents selected demographic characteristics of the subjects. The majority of the subjects were married (91.8%), and had at least some college education (78.7%). Mean BMI was 23.8 kg/m^2 (SD=2.8; range 17.5 to 31.4), 2.7% were thin, 66.5% were normal, and 30.8% were obese (according to the guidelines set by the Japan Society for the Study of Obesity, 2000). Approximately one quarter of the subjects (25.4%) had a weight cycling history. Although eighty-four subjects (57.5%) reported intending to lose weight, of these only 47 subjects reported that they were currently dieting. About one half of those who intend to lose weight (47/84=55.9%) were current dieters. Twelve subjects (8.2%) reported intentionally losing weight≥2 kg recently, and thirty-seven subjects (25.3%) reported gaining≥2 kg recently.

2. Comparison of weight/behavioral measures between weight cycling groups

Comparisons of weight/diet-related measures and health behaviors in the weight cycling versus non-weight cycling groups are shown in Table 2. Both BMI and the percentage of obesity were significantly higher in the weight-cyclers than in non-weight-cyclers (both, p<0.001). About twice as many cyclers intended to lose weight compared with non-cyclers (91.9% vs. 45.9%, respectively, p<0.001). Current dieting in cyclers was also more frequent than in non-cyclers (54.1%, 24.8%, respectively, p=0.001). Experience of recent weight gain was more prevalent in cyclers compared with non-cyclers (56.8%, 14.7%, respectively, p<0.001). Weight cycling also had significant relations with the above three weight/dieting related measures such as weight loss intention, current dieting, and recent weight gain. These were established using the Mantel-Haenszel method with BMI adjustment (p=0.001, p=0.017, p<0.001, respectively). Weight cycling had significant relations with regular meals, eating breakfast, and eating snacks between meals after adjustment for BMI. Cyclers reported significantly fewer regular meals and eating breakfast less regularly (p=0.013, p=0.038, respectively). Not eating between meals every day was also less frequent in cyclers compared with non-cyclers (p=0.045). ANCOVA of HPI score controlling for BMI was significant, F=8.39, p=0.004, and cyclers showed lower HPI scores than non-cyclers.

Table 1 Subjects Characteristics

Variables	M	SD	%	n
Age (years)	47.5	9.3		
Marital status				
Unmarried			6.8	10
Married			91.8	134
Divorced			0.7	1
Widowed			0.7	1
Educational level (Highest level completed)				
Junior high school graduate			2.1	3
High school graduate			19.2	28
College graduate			75.3	110
Master’s degree or Doctoral degree			3.4	5
BMI (kg/m^2)[a]	23.8	2.8		
Thin (<18.5)			2.7	4
Normal (18.5≤, <25)			66.5	97
Obese (25≤)			30.8	45
Total number of weight cycles				
Never			74.6	109
Once			11.0	16
Twice			10.3	15
Three times or more			4.1	6
Intention to lose weight (% yes)			57.5	84
Dieters (% yes)			32.2	47
Recent weight change				
Weight loss≥2 kg			8.2	12
Weight gain≥2 kg			25.3	37

Note. [a] according to the guidelines set by the Japan Society for the Study of Obesity, 2000)

3. The comparison of biological factors between weight cycling groups

Adjusted means and standard errors for fourteen biological measures of cyclers compared with non-cyclers are shown in Table 3. Four ANCOVAs with adjustments for BMI showed that T-C, LDL-C, AST, and ALT were significantly higher in weight cyclers than in non-cyclers (p=0.046, p=0.040, p=0.016, p=0.006, respectively).

4. Independent association of weight cycling history for biological factors

Finally, logistic regression analyses were carried out to determine the independent association between weight cycling history and biological factors. Based on univariate results, weight cycling

Table 2 Weight/Diet Related-measures and Behavioral Parameters (Mean, Standard Errors, or %) for Cyclers Compared with Non-cyclers

Characteristic	Non-cyclers[a]				Cyclers[b]				Statistic	p
	M	SE	%	n	M	SE	%	n		
Age (yrs.)	48.0	0.9			45.8	1.6			t=1.26	0.214
BMI (kg/m^2)	23.0	0.2			26.2	0.4			t=6.98	<0.001
Obese (%)			19.3	21			64.9	24	χ^2=26.94	<0.001
Weight loss intention (%)			45.9	50			91.9	34	χ^2=11.50	0.001
Current Dieting (%)			24.8	27			54.1	20	χ^2=5.66	0.017
Recent weight change										
Weight loss≥2 kg			9.2	10			5.4	2	χ^2=0.25	0.617
Weight gain≥2 kg			14.7	16			56.8	21	χ^2=15.90	<0.001
Health Practice Index										
General lifestyle (Following a daily healthy routine)			70.6	77			67.6	25	χ^2=0.204	0.651
Exercise (Twice a week or more)			18.3	20			18.9	7	χ^2=0.001	0.982
Alcohol consumption (Sometimes or not)			48.6	53			43.2	16	χ^2=0.29	0.591
Smoking status (Not smoking)			50.5	55			48.6	18	χ^2=0.01	0.933
Sleeping pattern (7 or 8 hr/night)			47.7	52			43.2	16	χ^2=0.02	0.885
Meals (Regular)			74.3	81			54.1	20	χ^2=6.15	0.013
Nutritional balance (Balanced)			36.7	40			27.0	10	χ^2=0.50	0.478
Eating breakfast (Every day)			89.9	98			73.0	27	χ^2=4.29	0.038
Working hours (≤9 hr/day)			83.5	91			78.4	29	χ^2=0.95	0.330
Subjective stress (Moderate)			60.6	66			43.2	16	χ^2=2.51	0.113
Eating snacks between meals (not eating between meals every day)			79.8	87			56.8	21	χ^2=4.52	0.033
HPI score	7.9	0.2			6.5	0.4			F=8.39	0.004

Note. [a] n=109. [b] n 37. t value from t test. Chi-square value for weight status from chi-square test. Chi-square value for other categorical variables from Mantel-Haenszel chi-square test with BMI adjustment. F-value from ANCOVA with BMI as covariance. Means and standard errors were adjusted for BMI.

Table 3 Biological Parameters (Adjusted Mean, Standard Errors) for Cyclers Compared with Non-cyclers

Parameter[c]	Non-cyclers[a]		Cyclers[b]		Statistic	p
	M	SE	M	SE		
SBP (mmHg)	127.3	1.7	126.1	3.1	*F*=0.115	0.735
DBP (mmHg)	75.8	1.1	78.5	2.1	*F*=1.258	0.264
T-C (mg/dL)	200.1	3.0	213.6	5.6	*F*=4.038	0.046
HDL-C (mg/dL)	55.5	1.4	56.8	2.6	*F*=0.182	0.671
LDL-C (mg/dL)	117.9	2.8	130.5	5.2	*F*=4.317	0.040
TG (mg/dL)	134.5	8.6	153.1	15.9	*F*=0.162	0.688
AST (IU/L)	23.9	1.0	29.4	1.8	*F*=5.892	0.016
ALT (IU/L)	27.0	1.6	37.3	3.0	*F*=7.680	0.006
γ-GTP (IU/L)	42.0	4.0	62.7	7.4	*F*=2.447	0.120
T-Bil (mg/dL)	0.87	0.04	0.86	0.06	*F*=0.093	0.761
ChE (IU/mL)	7.7	0.12	8.0	0.22	*F*=1.004	0.318
TP (mg/dL)	7.3	0.03	7.3	0.06	*F*=0.396	0.530
Alb (mg/dL)	4.7	0.02	4.8	0.04	*F*=3.606	0.060
HbA1c (%)	5.2	0.07	5.2	0.12	*F*=0.048	0.826

Note. [a] n=109. [b] n=37. SBP=systolic blood pressure; DBP=diastolic blood pressure;T-C=total cholesterol; HDL-C=high-density-lipoprotein cholesterol; LDL-cholesterol=low-density lipoprotein-cholesterol; TG=triglyceride; AST=aspartate aminotransferase; ALT=alanine glutarate aminotransferase; γ-GTP=g-glutamyl transpeptidase; T-Bil=total bilirubin; ChE=cholinesterase; TP=total protein; Alb=albumin and HbA1c=glyco hemoglobin A1c. F-value from ANCOVA with BMI as covariance. Means and standard errors were adjusted for BMI. [c] The distributions of TG, LDL-C, AST, ALT, and γ-GTP levels were subjected to common logarithm transformation to reduce the skewness and kurtosis of the distribution prior to statistical parametric analysis.

history, and six adjusted measures (weight status, current dieting, experience of recent weight gain, regular meals, eating breakfast, eating snacks between meals) were entered into the regression model. Of the 25 logistic regression analyses for biological abnormalities and quartile categories (the fourth quartile or first quartile), only eight -2 log likelihood statistics were significant (TG fourth quartile categories, χ^2=17.89, p=0.013; AST abnormality, χ^2=24.79 p=0.001; AST fourth quartile categories, χ^2=19.87, p=0.006; ALT abnormality, χ^2=24.71, p=0.001; ALT fourth quartile categories, χ^2=28.94, p<0.001; γ-GTP abnormality, χ^2=18.04, p=0.012; γ-GTP fourth quartile categories, χ^2=20.39, p=0.005; ChE fourth quartile categories, χ^2=17.93, p=0.007, respectively). The results of the logistic regression are summarized in Table 4. Weight cycling history made significant independent contributions to the relative risk of three abnormal liver enzyme measures (AST, OR=5.46, 95%CI: 1.08–27.67, p=0.040; ALT, OR=3.31, 95%CI: 1.24–8.78, p=0.016; γ-GTP, OR=3.38, 95%CI: 1.07–10.67, p=0.038, respectively). Moreover, the adjusted odds ratio for the last quartile of TG was 3.68 (95%CI, 1.23 to 11.01), for those of AST it was 3.03 (95%CI, 1.08 to 8.50), for those of ALT it was 4.23 (95%CI, 1.45 to 12.30), for those of γ-GTP it was 3.72 (95%CI, 1.16 to 11.94), and for those of ChE it was 3.79 (95%CI, 1.46 to 9.83) among cyclers compared with non-cyclers.

Discussion

1) Distinctive features of the subjects

The Japanese National Nutrition Survey in 1998 showed that the percentage of obesity among Japanese males, ages 40–49 years, was 29.0%. This rate is similar to other age groups (i.e. 30-year-old age group: 30.6%, 50-year-old age group: 29.0%), while in the present study the percentage of obesity was 30.8%. The prevalence of obesity in the present study is consistent with the Japanese National Nutrition Survey[1)].

In the present study, approximately one half of the subjects reported intending to lose weight, and 32.2% of the subjects reported that they were currently dieting to lose weight. In contrast to previous research done in the USA, the prevalence of current

Table 4 The Relations between Weight Cycling History for Biological Factors while Controlling for the Effects of Weight Status, Weight Gain, Current Dieting and Health Behavioral Factors

Dependent variables[c]	Non-cyclers[a]		Cyclers[b]		$\chi^{2\,d}$	OR	Wald	95% CI	p
	(%)	n	(%)	n					
BP									
abnormality	(20.2)	22/109	(24.3)	9/37	13.26	1.67	0.82	(0.55–5.04)	0.364
SBP: Quartile 4 (138–194 mmHg)	(26.6)	29/109	(27.0)	10/37	15.08	1.32	0.25	(0.45–3.90)	0.618
DBP: Quartile 4 (86–120 mmHg)	(15.6)	17/109	(35.1)	13/37	13.83	3.44	5.00	(1.16–10.16)	0.025
T-C									
abnormality	(50.5)	55/109	(59.5)	22/37	1.85	1.35	0.41	(0.53–3.43)	0.523
Quartile 4 (221–329 mg/dL)	(20.2)	22/109	(35.1)	13/37	6.55	3.13	4.30	(1.06–9.21)	0.038
HDL-C									
abnormality	(10.1)	11/109	(10.8)	4/37	7.45	1.43	0.22	(0.31–6.55)	0.641
Quartile 1 (30–46 mg/dL)	(23.9)	26/109	(29.7)	11/37	11.00	1.16	0.07	(0.41–3.27)	0.785
LDL-C									
abnormality	(44.0)	48/109	(62.2)	23/37	1.74	1.94	1.74	(0.72–5.21)	0.187
Quartile 4 (141–227 mg/dL)	(23.9)	26/109	(27.0)	10/37	3.70	1.19	0.10	(0.41–3.45)	0.754
TG									
abnormality	(31.2)	34/109	(45.9)	17/37	12.43	1.63	0.50	(0.42–6.29)	0.478
Quartile 4 (181–597 mg/dL)	(19.3)	21/109	(40.5)	15/37	17.89*	3.68	5.45	(1.23–11.01)	0.020
AST									
abnormality	(2.8)	3/109	(21.6)	8/37	24.79***	5.46	4.20	(1.08–27.67)	0.040
Quartile 4 (27–86 IU/L)	(19.3)	21/109	(45.9)	17/37	19.87**	3.03	4.43	(1.08–8.50)	0.035
ALT									
abnormality	(24.8)	27/109	(62.2)	23/37	24.71***	3.31	5.76	(1.24–8.78)	0.016
Quartile 4 (35–155 IU/L)	(15.6)	17/109	(51.4)	19/37	28.94***	4.23	7.01	(1.45–12.30)	0.008
γ-GTP									
abnormality	(19.3)	21/109	(32.4)	12/37	18.04*	3.38	4.33	(1.07–10.67)	0.038
Quartile 4 (58–287 IU/L)	(21.1)	23/109	(35.1)	13/37	20.39**	3.72	4.86	(1.16–11.94)	0.027
T-Bil									
abnormality	(3.7)	4/109	(5.4)	2/37	6.15	2.24	0.94	(0.44–11.40)	0.332
Quartile 4 (1.1–2.8 mg/dL)	(22.9)	25/109	(16.2)	6/37	7.38	0.57	0.89	(0.17–1.85)	0.346
ChE									
abnormality	(3.7)	4/109	(8.1)	3/37	9.30	0.59	0.23	(0.07–4.96)	0.631
Quartile 4 (8.47–12.57 IU/mL)	(16.5)	18/109	(51.4)	19/37	17.93**	3.79	7.47	(1.46–9.83)	0.006
TP									
abnormality	(0.0)	0/109	(2.7)	1/37					–
Quartile 4 (7.5–8.3 mg/dL)	(24.8)	27/109	(37.8)	14/37	9.53	2.11	2.12	(0.77–5.74)	0.146
Alb									
abnormality	(0.0)	0/109	(0.0)	0/37					–
Quartile 4 (4.9–5.3 mg/dL)	(21.1)	23/109	(29.7)	11/37	6.38	1.73	1.00	(0.59–5.04)	0.318
HbA1c									
abnormality	(3.7)	4/109	(8.1)	3/37	0.36	2.25	0.74	(0.35–14.29)	0.391
Quartile 4 (5.4–9.7%)	(21.1)	23/109	(29.7)	11/37	5.34	1.35	0.31	(0.47–3.89)	0.575

Note. [a] n=109. [b] n=37. [c] BP=blood pressure; SBP=systolic blood pressure; DBP=diastolic blood pressure; T-C=total cholesterol; HDL-C=high-density-lipoprotein cholesterol; LDL-cholesterol=low-density lipoprotein-cholesterol; TG=triglyceride; AST=aspartate aminotransferase; ALT=alanine glutarate aminotransferase; γ-GTP=γ-glutamyl transpeptidase; T-Bil=total bilirubin; ChE=cholinesterase; TP=total protein; Alb=albumin and HbA1c=glyco hemoglobin A1c. Abnormality was defined on the basis of the following criteria; 1) Blood pressure: SBP≥140 mmHg or DBP≥90 mmHg (according to the Guidelines Subcommittee 1999 World Health Organization-International Society of Hypertension Guidelines for the Management of Hypertension, 1999), 2) T-C≥200 mg/dL, 3) HDL-C<40 mg/dL, 4) LDL≥120 mg/dL, 5) TG≥150 mg/dL (according to the guidelines set out by the Japan Atherosclerosis Society, 1997), 6) ALT>33 IU/L, 7) AST>40 IU/L, 8) γ-GTP>70 IU/L, 9)T-Bil>1.5 mg/dL, 10) ChE>10.00 IU/mL, 11) TP>8.3 g/dL, 12) Alb>5.5 g/dL (according to the criterias set out by the Association for Preventive Medicine of Japan, 1996), 13) HbA1c≥6.5% (according to the guidelines set out by the Japan Diabetic Society, 1999).
[d] χ^2: Model fit was assessed by the 2-log likelihood statistic. * $p<0.05$; ** $p<0.01$; *** $p<0.001$. OR: odds ratio, reference categories are non-cyclers. 95% CI: 95% confidence interval. Weight Cycling (0=non-cycler, 1=cycler). Odds ratios are adjusted for weight status (0=BMI<25 kg/m^2, 1=BMI≥25 kg/m^2); recent weight gain (0=none or <2 kg, 1=≥2 kg); dieting (0=non-dieting, 1=dieting), eating breakfast (0=sometimes or not, 1=everyday); meal (irregularly=0, regulary=1), eating snacks between meals (once or more per day=0, not eating between meals every day=1). p-value from Wald statistic.

dieting and the intention to lose weight in this study was higher. According to a review of the consequences of dieting to lose weight[22], approximately 23–25% of adult males and 41–44% of adult females reported currently trying to lose weight, and 6–13% of adult males reported currently dieting to lose weight. This difference might suggest that many of the subjects in the present study considered weight management was important for their health, since recent estimates of the prevalence of obesity in Japanese adult males were higher than those reported in earlier surveys, suggesting an upward trend.

2) Relations between weight cycling history and weight/dieting related factors

In general, weight cycling history as a result of intentional weight loss is associated with relative weight in obese or young women[12,20,22,27]. In addition, dieting is more prevalent among those with higher body weight[12]. The effect of weight cycling and dieting on body weight is not fully known; however, it was suggested that both weight cycling and dieting might be risk factors for further weight gain or weight variability.

There is no standardized definition for weight cycling. Although most constructs provide some continuous measure such as the number of diets or weight cycles, others are based on a classification, such as "*Are you a yo-yo dieter?*"[19]. Even among variables that appear to be identical (e.g. lifetime weight loss), the methods used to define this measure vary considerably. That is, the strategy to assess self-reported weight cycling history varies widely depending on the frequency, magnitude and time frame. Lifetime weight loss and regain of at least approximately 10 lb. (4.5 kg) or 10% of weight were also the most common magnitude in the general population[26,29–32]. Foster suggested that the amount of weight loss necessary to be recognized by others is defined as approximately 10% of body weight[19].

Weight cycling history in the current study was assessed, taking previously published findings into consideration, and it was found that weight cycling history was associated with not only current weight status but also the intention to lose weight and current dieting practices. In persons who had a weight cycling history, approximately 65% were obese and 90% reported intending to lose weight. In addition, about half of the weight cyclers reported to be currently dieting and had recent weight gain experience. These results suggest that weight cycling is strongly associated with not only weight status or actual weight gain but also with dieting related psycho-behavioral factors (e.g. intention to lose weight and dieting practices). Since significant relations were observed after adjusting for weight status, the present results also suggest that, independent of relative body weight, weight cycling is strongly associated with recent weight gain, intention to lose weight and current dieting practices. These results support the previous evidence in young women that weight cycling had a stronger relation to weight status, whereas not all obese persons that had experienced weight cycling were dieting to lose weight[21,25–27].

3) Relations between weight cycling history and health behavior factors

In the present study, the strongest and most consistent associations between the weight cycling groups in habitual health behaviors were seen in the eating habit measures. Cyclers reported having significantly fewer regular meals and eating breakfast less regularly when compared with non-cyclers. Not eating snacks between meals every day was also less frequent in cyclers compared with non-cyclers. Moreover, weight cyclers showed significantly less desirable health behaviors as measured by HPI than non-cyclers. Thus, the present results from the study of average Japanese adult males suggest that weight cycling history is associated with undesirable habitual health behavior patterns. These results were also consistent with previous studies using measures that reflect habitual eating related psycho-behavioral patterns.

The results of four studies in a clinical sample[38–41]—which used non-habitual measures such as food frequency questionnaires, food records, or 24-hour recalls to examine nutritional differences—were inconsistent. Only two studies supported the hypothesis. Weight cycling, however, is consistently associated with clinically significant reductions in eating self-efficacy and weak but consistent increases in binge eating severity in young women and obese women[19,24,42]. In several previous studies of young females, weight cycling was also associated with increased habitual unhealthy dieting behaviors or abnormal weight/eating concerns[19–22,24–26,43]. One of the reasons for these inconsistencies by different measures is that, persons who are dieting or intending to lose weight—many are likely to have a weight cycling history—have a trend of underestimating their actual amount of calorie intake, whereas they have more undesirable eating related psycho-behavioral patterns.

4) Relation between weight cycling history and biological factors

In the present study, lipid measures such as T-C and LDL-C, as well as liver enzyme measures such as ALT and AST were significantly higher in weight cyclers than in non-cyclers after controlling for BMI. These results show that weight cycling history is associated with undesirable lipid and liver enzyme profiles after controlling for BMI. In the logistic regression analyses in the present study, weight cycling history made significant independent contributions after controlling for weight status, current dieting, recent weight gain and health behaviors to three abnormal liver enzyme measures (AST, ALT, and γ-GTP), and the last quartiles of TG, AST, ALT, γ-GTP and ChE. Thus, after adjusting for available factors, we found no significant association between weight cycling history and lipid measures except TG. It has been suggested that weight cycling might affect cardiovascular risk factors[14–18]; however, the biological health effects of weight cycling in human studies is controversial[23,44,45]. Two cross-sectional studies using weight cycling measures that referred to the individual's assessment of the actual number of times weight had been lost and regained did not support the hypothesis. For example, Jeffery et al.[38] reported that weight cycling history was not directly associated with increased health risk factors such as blood pressure, lipid measures, fasting and 2-h glucose values in 111 obese males and females. Rebuffe-Scrive, et al.[39] also reported that weight cycling history was not associated with blood pressure and lipid profiles in 28 females with and without weight cycling history, who matched for weight and age. Consistent with the above two studies, the present findings did not support the apparent association between weight cycling and cardiovascular risk factors such as lipid profiles, glucose and hypertension after controlling for the effects of current dieting, lifestyle factors and weight status.

To our knowledge, this is the first study where the relation of weight cycling history to liver function has been examined. Elevated aminotransferases and cholinesterase are markers for abnormal liver function and suggest a possible increase in visceral and hepatic fat[46,47]. The incidence of obese patients with fatty liver has recently increased in Japan, as well as in the USA and Europe[48]. Gradual weight loss in morbidly obese persons is accompanied by improvement in fat distribution and the return of liver function tests to the normal range; however, the progression of fatty liver disease after a jejunoileal bypass to portal fibrosis has been attributed in part to rapid weight loss associated with malabsorption and complex nutritional deficiencies[46]. In a cross-sectional study of out-patients with anorexia or bulimia—many of whom usually experienced a considerable weight fluctuation as a result of severe calorie restriction, unbalanced nutritional intake, and binge eating—, there were strong associations between ALT and low weight[49]. Mickley, et al.[49] screened a large sample of outpatients with anorexia or bulimia for liver enzyme abnormalities, examining their frequency and their clinical correlates. Consequently, ALT was the most frequent enzyme abnormality and was correlated with lower current and past weights and BMI. They concluded that low weight alone can cause liver damage, yet elevated liver chemistries in patients with anorexia and especially bulimia are often not due to their eating disorder. To summarize, several clinical findings have shown the possibilities that major weight loss experience, severe calorie restrictions, or weight regain are associated with increased hepatic fat or liver damage, although subjects in these studies were not representative of the general population. The cause and effect relation between weight cycling and unhealthy behavior such as severe calorie restriction or unbalanced nutrition intake is unclear. However, prospective studies in non-clinical male samples are needed to examine the effects of weight cycling on liver function and lipid metabolism in the liver.

6) Limitations and implications of this study

Limitations of the present study involve the methodological issues regarding the use of self-reported measures, the small sample size and the cross-sectional design. Health behaviors were assessed by a self-administrated short questionnaire; therefore, details of behavioral patterns are unknown. Since weight loss practices are complex and appear to be related to a wide range of psycho-behavioral patterns and lifestyle choices, future studies should use validated measures across a range of various psycho-behavioral variables including binge eating, depression, eating self-efficacy, and dietary restraint. Another limitation of this study was using non-validated weight-related measures including weight cycling history and dieting. However, this limitation is in concordance with many previous studies, because there are no standardized assessments of weight cycling and dieting.

Despite the limitations, the strength of the current study is that we have obtained information on weight cycling history as a result of intentional weight loss, as well as several weight/dieting related measures. Moreover, various health behavior measures and information about weight/dieting related factors allowed us to evaluate the independent relation of weight cycling to biological health hazards.

Conclusion

In conclusion, this study brought forth new information on self-reported weight cycling history showing that, independent of current weight status, this factor was associated with current dieting, undesirable health behaviors, LDL-C, T-C, AST, and ALT. Moreover, weight cycling history was associated with adverse liver function profiles after controlling for the effect of weight status and lifestyle factors. Thus, the findings of the present study suggest the importance of examining self-reported weight cycling history and dieting in Japanese adult males and their causal relationship to bio-behavioral factors.

Acknowledgements

This study was partly supported by the 20th research grant of the Descente and Ishimoto Memorial Foundation for the Promotion of Sports Science, Tokyo, Japan, 1998.

The authors gratefully thank Professor Toshihito Katsumura, Dr. Ayumi Sakamoto, Dr. Takafumi Hamaoka, Dr. Yoshikazu Takanami, and Yuko Kurosawa, Department of Preventive Medicine & Public Health, Tokyo Medical University for helpful advice and assistance in the preparation of this manuscript.

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