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Yeast hydrolysate can reduce body weight and abdominal fat accumulation in obese adults

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ABSTRACT

Objective: The aim of this study was to examine the effect of yeast hydrolysate on the abdominal fat in obese humans.
Methods: We observed the effects of yeast hydrolysate that had a molecular weight below 10 kDa on the anti-abdominal fat accumulation in obese men and women ages 20 to 50 y for 10 wk. The abdominal fat mass was assessed by computed tomographic scans.
Results: By the sixth week, the reductions in energy intake in the yeast group (yeast hydrolysate 1 g/d) were significantly greater than those in the control group (placebo 1 g/d) ($P < 0.05$). The body weight and body mass index (BMI) were significantly reduced by week 10 compared with baseline in the yeast group, and these differences were significantly greater than those in the control group: body weight 0.83 kg versus −2.60 k g ($P < 0.001$), BMI 0.29 kg/m^2 versus −0.90 kg/m^2 ($P < 0.001$). Despite the increased loss of body weight in the yeast group, lean body mass did not significantly differ between the two groups. Body fat mass in the control group did not significantly change between baseline and week 10. However, the yeast group lost a significant amount of body fat mass after 10 wk of treatment ($P < 0.01$). The differences in abdominal fat thickness and abdominal circumference between the two groups were significant after 10 wk of treatment ($P < 0.001$). The total abdominal fat area in the yeast group was significantly lower than in the control group after 10 wk of treatment (−7.06 cm^2 versus −17.34 cm^2; $P < 0.01$).
Conclusions: Yeast hydrolysate can reduce body weight and the accumulation of abdominal fat without an adverse effect on lean body mass in obese adults, regardless of sex, via the reduction of energy intake.

Introduction

The metabolic risks associated with obesity are closely correlated with a central (abdominal), rather than a peripheral (gluteo-femoral) fat pattern [1]. Abdominal obesity, which is manifested by an increased waist circumference, abdominal subcutaneous fat, and visceral fat, is associated with a high risk for heart disease, hypertension, insulin resistance, and type 2 diabetes mellitus [2]. Abdominal fat is also a symptom of metabolic disorder and is an indicator used to predict the prevalence of the diseases [2,3]. Abdominal fat is now generally believed to be the deposit that conveys the largest health risk.

Recently, yeast hydrolysate, which is acquired from *Saccharomyces cerevisiae* via protein hydrolysis, has attracted significant attention as a useful anti-obesity supplement [4,5]. Yeast hydrolysate reportedly has significant body fat-suppressive effects in humans: Yeast hydrolysate increases the reduction of body fat in obese individuals compared with placebo, which supports the hypothesized abdominal fat-lowering effects of yeast hydrolysate [4,6].

However, most of these human trials were conducted either on a small scale (< 50) or over a short period (< 6 wk) or were age/sex-biased (just young women). Furthermore, the abdominal fat in individuals supplemented with yeast hydrolysate has

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Table 1
Baseline characteristics of participants

Characteristics	Control group (n = 27)		Yeast group (n = 27)	
	Men (n = 12)	Women (n = 15)	Men (n = 12)	Women (n = 15)
Age distribution				
20–29 y	3	5	4	5
30–39 y	4	4	4	4
40–49 y	4	3	4	3
50–59 y	1	3	0	3
Age (y)	35.50 ± 2.36	38.33 ± 3.07	34.75 ± 2.41	36.87 ± 2.75
	37.07 ± 1.99		35.93 ± 1.84	
Body weight (kg)	86.34 ± 5.16	63.41 ± 2.42	81.28 ± 2.47	67.70 ± 2.51
	73.60 ± 3.43		73.74 ± 2.19	
BMI (kg/m^2)	28.33 ± 1.23	24.51 ± 0.68	27.39 ± 0.72	26.24 ± 0.90
	26.21 ± 0.75		26.75 ± 0.59	
Body fat mass (kg)	26.76 ± 1.06	30.03 ± 0.76	26.57 ± 0.72	32.37 ± 0.82
	28.58 ± 0.70		29.79 ± 0.79	
Lean body mass (kg)	59.58 ± 4.39	33.38 ± 2.30	54.72 ± 2.58	35.33 ± 1.87
	45.0 ± 3.42		43.9 ± 2.42	
Abdominal fat thickness (mm)	34.45 ± 2.79	26.66 ± 1.38	34.93 ± 1.57	31.84 ± 1.78
	30.55 ± 1.65		33.39 ± 1.21	
Abdominal circumference (cm)	98.00 ± 3.29	82.8 ± 2.67	94.42 ± 1.76	84.61 ± 1.78
	89.60 ± 2.52		88.97 ± 1.56	
Total abdominal fat area (cm^2)	397.52 ± 39.11	306.24 ± 23.52	346.85 ± 19.10	324.29 ± 24.89
	346.81 ± 23.07		334.32 ± 16.09	
Subcutaneous abdominal fat area (cm^2)	239.27 ± 33.03	217.32 ± 16.55	233.01 ± 18.01	240.79 ± 18.34
	227.07 ± 17.08		237.33 ± 12.73	
Abdominal sagittal diameter (cm)	34.87 ± 0.97	31.57 ± 0.75	33.65 ± 0.61	31.79 ± 0.63
	33.04 ± 0.67		32.62 ± 0.47	

Data are mean ± SEM

never been estimated based on computed tomography (CT) measurements, which are known as the gold standard for measuring the amount of abdominal fat [7,8]. Therefore, we observed the effects of yeast hydrolysate on the accumulation of abdominal fat via CT measurements of obese men and women ages 20 to 50 y for 10 wk.

Materials and methods

Yeast hydrolysate

Saccharomyces cerevisiae IFO 2346 was incubated in a medium containing 2% molasses, 0.6% $(NH_4)_2SO_4$, 0.1% $MgSO_4 \cdot 7H_2O$, 0.2% KH_2PO_4, 0.03% K_2HPO_4, and 0.1% NaCl for 3 d at 30°C. After incubation, the culture was centrifuged at 10,000*g* for 20 min. The cells were suspended in 20 mM phosphate buffer (pH 7.0) and hydrolyzed with 1000 units of bromelain at 30°C for 4 h. The hydrolysate was subsequently centrifuged at 10,000*g* for 20 min. The supernatant was then passed through a 10 kDa molecular-weight cutoff membrane (Sartocon cassette, Sartorius AG, Goettingen, Germany) and lyophilized. The yeast hydrolysate had a molecular weight < 10 kDa and was composed of water (5.4%), crude fat (0.8%), crude protein (64.9%, 14% glutamic acid), carbohydrates (26.9%), ash (0.9%), and cyclo-His-Pro (CHP, 680 μg/g).

Participants

Men and women ages 20 to 50 y with body mass indices (BMI) of ≥ 25 kg/m^2, which is used as a cutoff point for obesity in the Asia-Pacific region [9], were

Table 2
Changes of energy intake during 10 wk treatment

Energy intake (kcal/d)		Control group (n = 27)		Yeast group (n = 27)	
		Men (n = 12)	Women (n = 15)	Men (n = 12)	Women (n = 15)
Baseline	0 wk	1853.61 ± 82.59	1431.18 ± 88.78	1705.63 ± 145.31	1424.49 ± 73.71
△ Change	2 wk	126.14 ± 71.57	67.89 ± 72.70	82.95 ± 76.86	13.70 ± 67.90
	4 wk	31.87 ± 80.67	67.07 ± 88.91	−94.81 ± 89.93	−197.81 ± 76.04
	6 wk	30.05 ± 81.23	−46.74 ± 88.49	−225.82 ± 98.45	−215.30 ± 90.50
	8 wk	−39.18 ± 80.38	−154.46 ± 89.77	−359.49 ± 164.73	−373.88 ± 106.21
	10 wk	−70.60 ± 78.45	125.81 ± 81.52	−76.18 ± 125.04†	−405.34 ± 97.97*,†††
Baseline	0 wk	1618.93 ± 73.04		1549.44 ± 79.67	
△ Change	2 wk	93.78 ± 50.76		44.48 ± 50.36	
	4 wk	−23.10 ± 60.68		−152.03 ± 57.89	
	6 wk	−12.61 ± 60.33		−219.98 ± 65.37†	
	8 wk	−103.22 ± 61.25		−367.48 ± 92.08**,†	
	10 wk	−101.27 ± 56.34		−392.38 ± 76.28***,††	

Data are mean ± standard error of the mean (SEM). Significant differences were indicated by daggers ($^{\dagger}P < 0.05$, $^{\dagger\dagger}P < 0.01$, $^{\dagger\dagger\dagger}P < 0.001$) between 2 groups (control group versus yeast group) by *t*-test at each week. Asterisk indicates a significant difference ($^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$) between baseline and at each week by a repeated measure ANOVA followed by Bonferroni-adjusted pairwise comparisons within groups

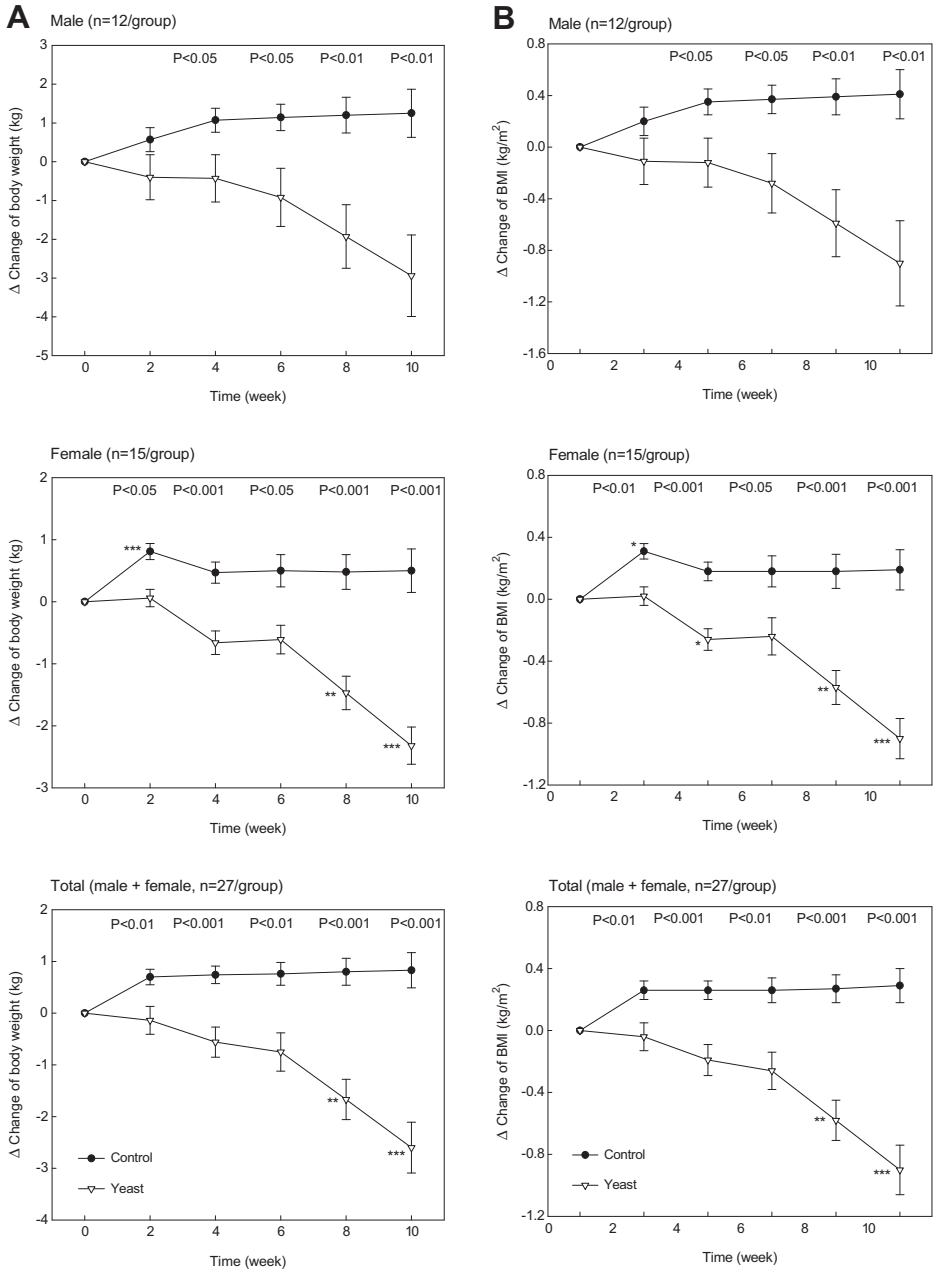

Fig. 1. Changes in body weight (A) and body mass index (BMI) (B) during 10 wk of treatment. The data are the mean ± SEM. *P*-value indicates a statistical analysis between two groups (control group versus yeast group) by *t* test at each week. The asterisk indicates a significant difference (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$) between baseline and at each week by a repeated measure ANOVA followed by Bonferroni-adjusted pairwise comparisons within groups.

recruited. Potential participants attended a medical screening, which included physical assessments (height, weight, vital signs, and physical examination) and clinical assessments (liver function, serum electrolytes, and hematology). Individuals were excluded if they had diabetes; liver, gastrointestinal, or cardiovascular diseases; took lipid-lowering or anti-obesity medications; had a known hypersensitivity or allergy to yeast; were on a weight-reduction program, a medically supervised diet, or had lost more than 5 kg within the month before the study; or were participating in any other study in the 3 mo before commencement of the study. The study was approved by the Ethical Committee for Human Experimentation of the Korea University and was conducted in accordance with its rules and regulations. The conditions and procedures of the investigation were reviewed with all individuals before they provided written informed consent.

Study protocol

This randomized, placebo-controlled study was carried out in Seoul between March and May 2011 for 10 wk. Participants were randomly assigned to the control or yeast group. The yeast group was asked to consume a pouch (yeast hydrolysate/pouch of 0.5 g) with water twice a day 30 min before breakfast and dinner. The total daily dose of yeast hydrolysate was 1 g. This dosage was selected based on preliminary studies [4,10]. The control group received only the vehicle (100% dextrin), which was given at the same amount and was the same color as the yeast hydrolysate. To ensure compliance, participants were asked to record the number of pouches taken at the end of each week and to return any unused pouches at the completion of the study. All participants were instructed to continue their regular diet and exercise patterns. They received instructions to

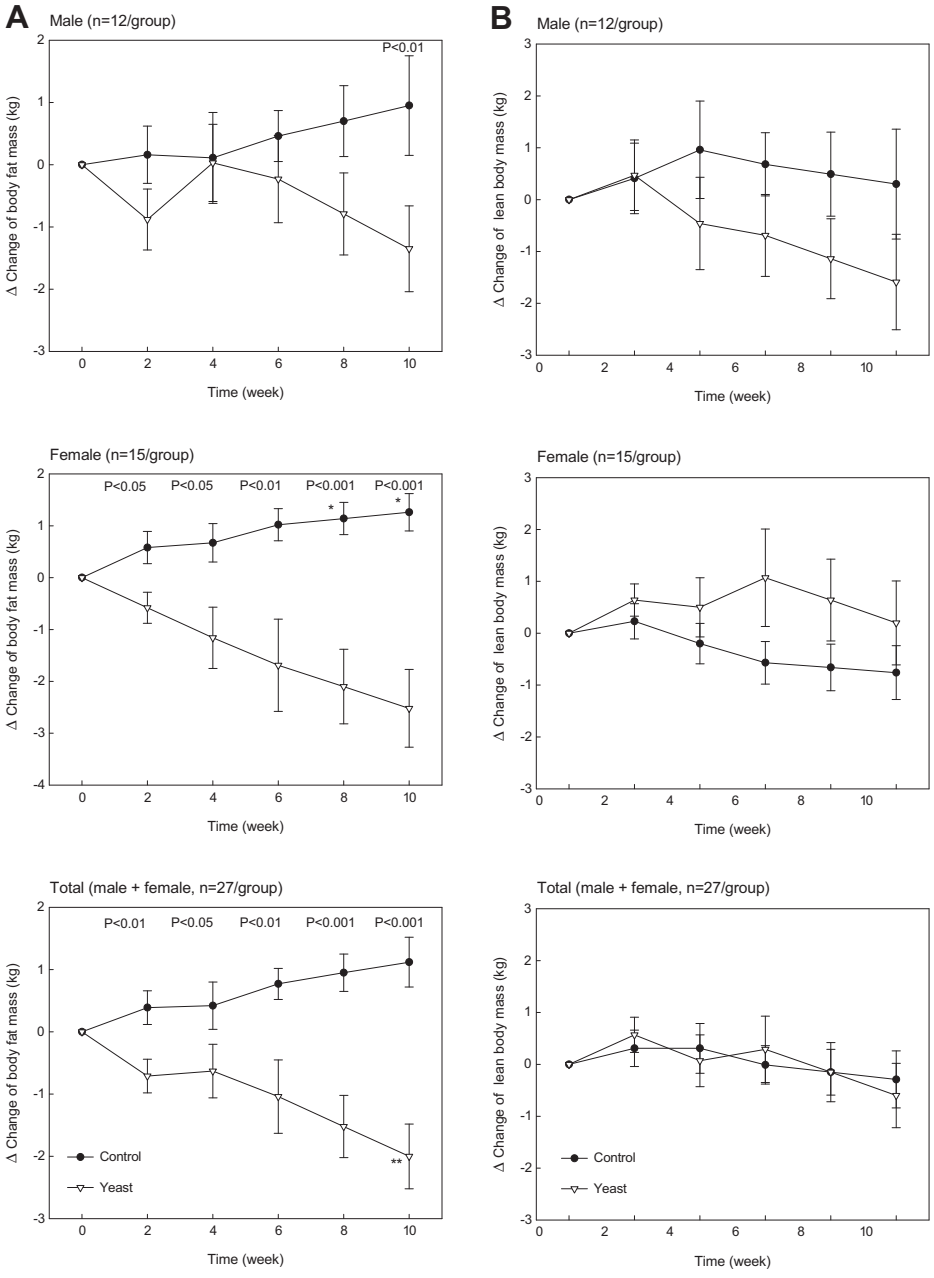

Fig. 2. Changes in body fat mass (A) and lean body mass (B) during 10 wk of treatment. The data are the mean ± SEM. *P*-value indicates a statistical analysis between the two groups (control group versus yeast group) by *t* test at each week. An asterisk indicates a significant difference ($^{*}P < 0.05$, $^{**}P < 0.01$) between baseline and at each week by a repeated measure ANOVA followed by Bonferroni-adjusted pairwise comparisons within groups.

record food intake. They maintained records of the foods they had eaten three times a week (twice on weekdays and once on the weekend). Food intake records were analyzed by Can-Pro (Korean Nutrition Society, Seoul, Korea). All participants also completed the side-effect questionnaire weekly.

Clinical assessments

Standard clinical laboratory analyses were performed at the screening visit (baseline) and subsequently at weeks 5 and 10. These measurements included liver function, serum electrolytes, and hematology. Fasting blood (10–12 h overnight) was obtained by direct venipuncture of a forearm vein. The resting blood pressure and heart rate were measured using a FT- 700R apparatus (Jawon medical Co., Seoul, Korea).

Anthropometric measurement

The height was measured barefoot to the nearest 0.1 cm with an extensometer (DS-102, Jenix Co., Seoul, Korea). The body weight was measured to the nearest 0.1 kg with a standard balance beam scale (Giant-150N, Hana Co., Seoul, Korea). BMI was calculated by dividing the weight by the height squared (kg/m^2). The body fat mass and lean body mass (LBM) were measured with a body impedance assessment (In Body 3.0, Biospace Co., Seoul, Korea).

Abdominal fat

The abdominal fat thickness was measured to the nearest 0.1 mm with a Skinfold caliper (Skyndex I Electronic fat calipers, Caldwell, Justiss & Co., AR, USA), and the abdominal circumference was measured to the nearest 0.1 cm with

a plastic tape measure. The abdominal fat was also scanned with a 4-detector CT scanner (Somatom volume zoom; Siemens medical solutions, Forchheim, Germany). A single 5-mm-thick slice through the umbilicus level was obtained at 120 kVp and an automatic tube current dose modulation system over 0.5 sec. The amount of abdominal fat was calculated at this slice using the offline workstation (Aquarius software, version 3.6.3.0; TeraRecon Inc., CA, USA) with attenuation values for the region of interest from −190 to −30 Hounsfield units.

Statistical analysis

All statistical analyses were performed using the Statistical Package for Social Sciences ver. 12.0 (SPSS Inc., IL, USA). The differences between two groups (control versus yeast) were statistically evaluated by a *t* test. A repeated measure analysis of variance, followed by Bonferroni-adjusted pairwise comparisons, were used to assess the differences of the change from baseline to each week within groups. All data were two-sided at the 5% significance level and were reported as the mean ± SEM.

Results

Baseline characteristics

The baseline characteristics of the participants are listed in Table 1. Fifty-six individuals were selected for participation in this study. Of these individuals, 2 were withdrawn from the trial (1 failed to complete the study, and 1 was noncompliant) leaving 54 participants who completed the study requirements. Each group ultimately consisted of 27 participants (men n = 12, women n = 15). The control group and the yeast group had mean body weights of 73.60 kg and 73.74 kg, BMI values of 26.21 kg/m^2 and 26.75 kg/m^2, and body fat masses of 28.58 kg and 29.79 kg, respectively. Furthermore, the control group and the yeast group had a mean abdominal fat thickness of 30.55 mm and 33.39 mm, abdominal circumference of 89.60 cm and 88.97 cm, and total abdominal fat areas of 346.81 cm^2 and 334.32 cm^2, respectively. The initial values of any variable did not significantly differ between the two groups.

Clinical assessments

No participant was removed from the study protocol for treatment-related adverse effects. Measures of liver function, serum electrolytes, and hematology remained within healthy ranges throughout the intervention, indicating a lack of adverse effects due to treatment. The resting blood pressure and heart rate were also unaffected by yeast hydrolysate treatment (data not shown).

Calorie intake

Table 2 compares the effect of yeast hydrolysate treatment on the calorie intake of the two groups. The energy intake at baseline was 1618.93 kcal/d and 1549.44 kcal/d in the control and yeast groups, respectively. The calorie intake did not significantly differ at baseline between the two groups. During the 10 wk of treatment, both groups reduced their calorie intake. By week 6, the reduction in calorie intake in the yeast group was significantly greater than in the control group: week 6: 12.61 kcal/d versus −219.98 kcal/d ($P < 0.05$); wk 8: 103.22 kcal/d versus −367.48 kcal/d ($P < 0.05$); wk 10: −101.27 kcal/d versus −392.38 kcal/d ($P < 0.01$). Participants' physical activity did not significantly differ during treatment compared with baseline in either group (data not shown).

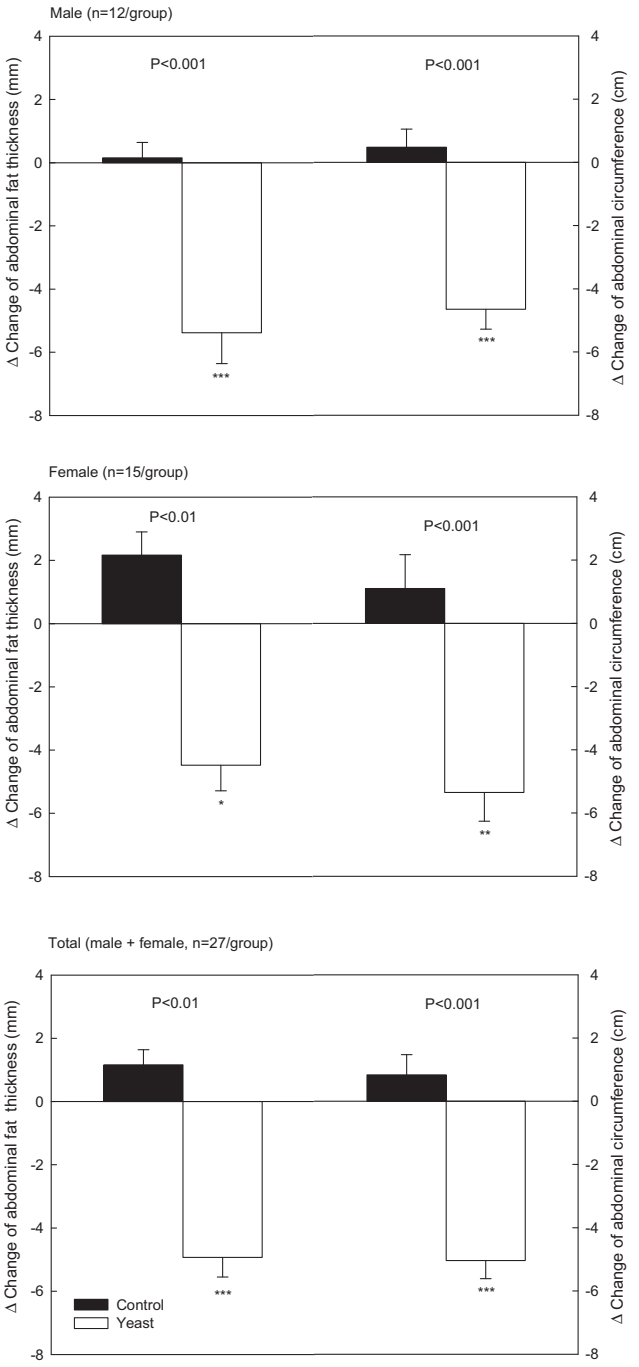

Fig. 3. Changes in abdominal fat thickness and abdominal circumference after 10 wk of treatment. The data are the mean ± SEM. *P*-value indicates a statistical analysis between the two groups (control group versus yeast group) by *t* test at each week. An asterisk indicates a significant difference (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$) between baseline and at each week by a repeated measure ANOVA followed by Bonferroni-adjusted pairwise comparisons within groups.

Body weight and BMI

Figure 1 shows the changes in body weight and BMI from baseline to end point. The initial values of the body weight and BMI did not significantly differ between the two groups (Table 1). The body weight and BMI showed a significant time × group interaction. The reductions in body weight and BMI between the

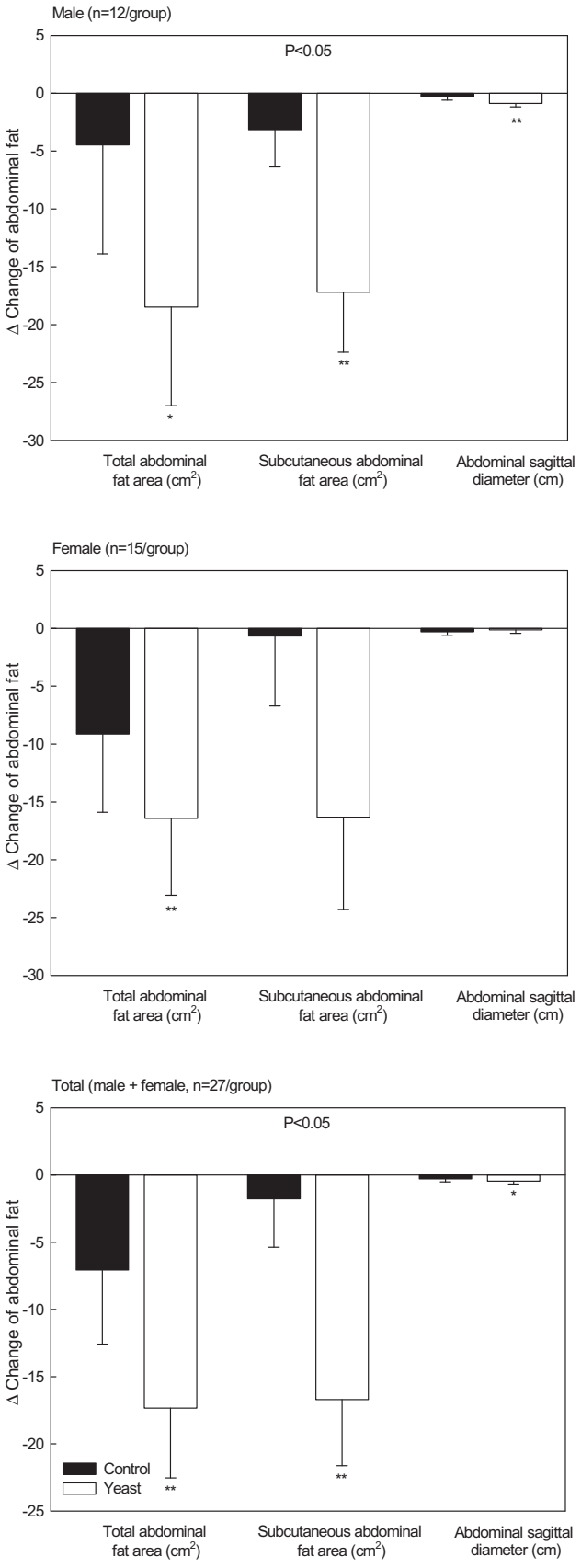

Fig. 4. Changes in abdominal fat area measured by computed tomography (CT) after 10 wk of treatment. The data are the mean ± SEM. *P*-value indicates a statistical analysis between the two groups (control group versus yeast group) by *t* test at each week. An asterisk indicates a significant difference (*$P < 0.05$, **$P < 0.01$) between baseline and at each week by a repeated measure ANOVA followed by Bonferroni-adjusted pairwise comparisons within groups.

baseline and week 10 in the yeast group were significantly greater than those in the control group: body weight 0.83 kg versus −2.60 kg ($P < 0.001$); BMI 0.29 kg/m^2 versus −0.90 kg/m^2 ($P < 0.001$). Body weight and BMI did not significantly differ between the baseline and week 10 in the control group. However, participants in the yeast group lost a significant amount of body weight and reduced their BMI after 10 wk of treatment ($P < 0.001$). Notably, men in the control group gained 1.25 kg of body weight and increased their BMI by 0.41 kg/m^2, whereas the men in the yeast group lost 2.94 kg of body weight and reduced their BMI by 0.90 kg/m^2 after 10 wk of treatment. Similarly, the women in the yeast group lost 2.42 kg of body weight and reduced their BMI by 0.91 after 10 wk of treatment.

Body composition

The changes in the body fat mass and LBM during the 10 wk of treatment are shown in Figure 2. The reduction in the body fat mass between baseline and week 10 was significantly greater in the yeast group than in the control group (1.12 kg versus −2.00 kg; $P < 0.001$). The body fat mass in the control group was not significantly different between baseline and week 10, whereas yeast group participants lost a significant amount of body fat mass after 10 wk of treatment ($P < 0.01$). Notably, women in the control group gained approximately 1.26 kg of body fat mass, whereas women in the yeast group lost 2.52 kg of body fat mass after 10 wk of treatment. Changes in body fat mass in the men were not as dramatic as those of the women participants, but they were significant.

As shown in Figure 2B, both groups lost a small amount of LBM (< 0.7 kg) after 10 wk of treatment. However, neither group experienced a significant change from the baseline in LBM. Furthermore, LBM did not significantly differ between the control (−0.29 kg) and the yeast groups (−0.6 kg) despite the increased loss in body weight in the yeast group.

Abdominal fat

Figure 3 shows the changes in the abdominal fat thickness and abdominal circumference after 10 wk of treatment. Regardless of gender, the yeast group showed a significant reduction in the abdominal fat thickness after 10 wk of treatment (men −5.38 mm, women −4.48 mm) ($P < 0.001$); whereas the control group showed a slightly increased abdominal fat thickness (men 0.15 mm, women 2.17 mm). The difference in the abdominal fat thickness between the control group (1.16 mm) and the yeast group (−4.93 mm) was significant after 10 wk of treatment ($P < 0.001$). In the yeast group, the reduction in the abdominal circumference (men −4.65 cm, women −5.35 cm) was significant between the baseline and the week 10 ($P < 0.001$). These changes also were significantly different ($P < 0.001$) between the control group (0.83 cm) and yeast group (−5.04 cm).

Figures 4 and 5 represent the abdominal fat area measured by CT before and after 10 wk of treatment. The total abdominal fat area in the yeast group was significantly lower than that of the control group after 10 wk of treatment (control versus yeast,

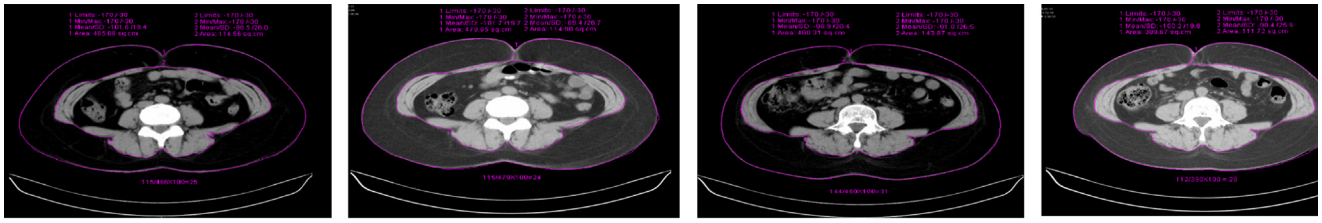

Fig. 5. Abdominal fat measured by computed tomography (CT) before and after 10 wk of treatment.

-7.06 cm^2 versus -17.34 cm^2; $P < 0.01$). A significant difference in the subcutaneous abdominal fat also was observed between the two groups after 10 wk of treatment (control, -1.77 cm^2 versus yeast, -16.71 cm^2; $P < 0.01$). At week 10, the change in the abdominal sagittal diameter was significantly lower in the yeast group (-0.46 cm) compared with the control group (-0.29 cm) ($P < 0.05$).

Discussion

In the present study, we evaluated the anti-obesity effects of yeast hydrolysate in obese men and women. The results demonstrated that yeast hydrolysate supplementation significantly decreased body weight and body fat. These results coincide with the results from previous studies, which showed that yeast hydrolysate supplementation reduced body weight and body fat in high-fat diet-induced obese rats [4,5]. In another study [11], rats administered yeast hydrolysate showed dose-dependent decreases in body weight and body fat. These changes were not observed in the control rats. After 28 consecutive d of oral yeast hydrolysate treatment at 1 g/kg, yeast hydrolysate induced a significant reduction in body weight in rats [12]. In clinical trials, obese individuals who received yeast hydrolysate also showed greater reductions in body weight and body fat compared with placebo [4,6].

The reduction in the calorie intake in the yeast group was significantly greater than in the control group. Efforts have been made to elucidate the mechanisms by which yeast hydrolysate reduces body weight and body fat. A distribution of neurotransmitters was observed in the hypothalamus of yeast hydrolysate-administered rats by using histochemical methods [12,13]. Based on this study, yeast hydrolysate might suppress the appetite by altering appetite-related neurotransmitters in the central nervous system (CNS). Furthermore, yeast hydrolysate contains high levels of CHP, which plays an important role in the regulation of leptin [5]. CHP is related to presynaptic dopaminergic mechanisms and a leptin-like function in the CNS [14]. CHP significantly reduces body weight in obese animals via the reduction of food intake [5,15,16]. In the context of appetite control, certain neuropeptides, such as neuropeptide Y (NPY), cocaine, and amphetamine-regulated transcript (CART), have drawn significant attention over the years. NPY is a known orexigenic neuropeptide that is the most potent among the peptides of the hypothalamus [17]. The most noticeable effect of NPY on biological functions was the stimulation of feeding in an experiment using animal models [18]. CART has been known to induce a powerful anorexic signal in mammals [19]. CART is widely expressed in the body, but is primarily concentrated in the hypothalamus. A particular CART peptide (55–102) appears to have an important regulatory function in energy homeostasis [19].

Although the exact mechanisms underlying the anti-obesity effects of yeast hydrolysate have not been defined, yeast hydrolysate might induce body weight loss via appetite control in the CNS.

In this study, yeast hydrolysate supplementation significantly decreased the thickness, circumference, area, and sagittal diameter of abdominal fat without reducing LBM. Recently, hepatic glucose-6-phosphate dehydrogenase and malic enzyme activities, which provide the reduced nicotinamide adenine dinucleotide phosphate required for fatty acid synthesis, have been reportedly inhibited by yeast hydrolysate supplementation in high-fat diet-induced obese mice [20]. Yeast hydrolysate might also suppress abdominal fat accumulation by modulating lipogenesis via the activities of hepatic lipid-regulating enzymes.

Large volumes of subcutaneous abdominal fat did not reportedly influence metabolic symptoms [21] because non-subcutaneous fat masses, such as visceral fat, are responsible for the metabolic benefits. Although we did not assess the reduction in visceral fat, the amount of fat was likely uniformly reduced throughout the body. Furthermore, the subcutaneous fat mass, which is solid and uniform, is easier to measure than the visceral fat mass, which is irregular in shape, with a radiographical image analysis [22,23]. Waist circumference and BMI strongly correlate with the total and visceral fat mass among women [24].

In conclusion, yeast hydrolysate can induce a reduction in body weight and abdominal fat accumulation without adverse effects on LBM in obese adults, regardless of sex, via the reduction of calorie intake. These results suggest that yeast hydrolysate can possibly be used to prevent and reduce abdominal fat accumulation.

References

[1] Ferreira I, Snijder M, Twis JWR, Van Mechelen W, Kemper HCG, Seidell JC, et al. Central fat mass versus peripheral fat and lean mass: opposite (adverse versus favorable) associations with arterial stiffness? The Amsterdam Growth and Health Longitudinal Study. J Clin Endocrinol Metab 2004;89:2632–9.
[2] Janssen I, Heymsfield SB, Allison DB, Kotler DP, Ross R. Body mass index and waist circumference independently contribute to the prediction of non-abdominal, abdominal subcutaneous, and visceral fat. Am J Clin Nutr 2002;75:683–8.
[3] Palacios C, Bertran JJ, Rios RE, Soltero S. No effects of low and high consumption of dairy products and calcium supplements on body composition and serum lipids in Puerto Rican obese adults. Nutrition 2011;27:520–5.
[4] Jung EY, Kim SY, Bae SH, Chang UJ, Choi J, Suh HJ. Weight reduction effects of yeast hydrolysate below 10 kDa on obese young women. J Food Biochem 2011;35:337–50.
[5] Jung EY, Lee HS, Choi JW, Ra KS, Kim MR, Suh HJ. Glucose tolerance and antioxidant activity of spent brewer's yeast hydrolysate with a high content of Cyclo-His-Pro (CHP). J Food Sci 2011;76:C272–8.
[6] Suh HJ. The weight reduction effect of yeast hydrolysate-SR101 on female college students. J Food Sci Nutr 2009;14:123–8.
[7] Singh JP, Steward MJ, Booth TC, Mukhtar H, Murray D. Evolution of imaging for abdominal perforation. Ann R Coll Surg Engl 2010;92:182–8.

[8] Yoshizumi T, Nakamura T. [Measurement of visceral fat by CT scan or MRI]. Nihon Rinsho 2011;69(Suppl 1):460–5.
[9] Waxman A. WHO global strategy on diet, physical activity and health. Food Nutr Bull 2004;25:292.
[10] Jung EY, Park SS, Kim JH, Chang UJ, Bae SH, Choi JW, et al. Safety study of yeast hydrolysate with below 10 kDa molecular weight in animal models. JJ Health Sci 2011;57:532–9.
[11] Kim JH, Jung EY, Hong YH, Bae SH, Kim JM, Noh DO, et al. Short communication: Pet foods with yeast hydrolysate can reduce body weight and increase girth in beagle dogs. Can J Anim Sci 2012;92:1–4.
[12] Jung E, Suh H, Kim S, Hong Y, Kim M, Chang U. Appetite suppressive effects of yeast hydrolysate on nitric oxide synthase (NOS) expression and vasoactive intestinal peptide (VIP) immunoreactivity in hypothalamus. Phytother Res 2008;22:1417–22.
[13] Jung EY, Kang DH, Suh HJ, Chang UJ. Effects of yeast hydrolysate on neuropeptide Y (NPY) and tryptophan hydroxylase (TPH) immunoreactivity in rats. Phytother Res 2009;23:619–23.
[14] Minelli A, Bellezza I, Grottelli S, Galli F. Focus on cyclo (His-Pro): history and perspectives as antioxidant peptide. J Amino Acids 2008;35:283–9.
[15] Song M, Rosenthal M, Song A, Uyemura K, Yang H, Ament M, et al. Body weight reduction in rats by oral treatment with zinc plus cyclo-(His-Pro). Br J Pharmacol 2009;158:442–50.
[16] Song MK, Rosenthal MJ, Song AM, Yang H, Ao Y, Yamaguchi DT. Raw vegetable food containing high cyclo (his-pro) improved insulin sensitivity and body weight control. Metabolism 2005;54:1480–9.
[17] Kalra SP, Kalra PS. NPY and cohorts in regulating appetite, obesity and metabolic syndrome: beneficial effects of gene therapy. Neuropeptides 2004;38:201–11.
[18] Inui A. Transgenic approach to the study of body weight regulation. Pharmacol Rev 2000;52:35–61.
[19] Murphy KG. Dissecting the role of cocaine- and amphetamine-regulated transcript (CART) in the control of appetite. Brief Funct Genomic Proteomic 2005;4:95–111.
[20] Jung EY, Hong YH, Kim JH, Park Y, Bae SH, Chang UJ, et al. Effects of yeast hydrolysate on hepatic lipid metabolism in high-fat-diet-induced obese mice: yeast hydrolysate suppresses body fat accumulation by attenuating fatty acid synthesis. Ann Nutr Metab 2012;61:89–94.
[21] Kuranuki S, Arai C, Terada S, Aoyama T, Nakamura T. Possible regulatory factors for intra-abdominal fat mass in a rat model of Parkinson's disease. Nutrition 2011;27:239–43.
[22] Bauer J, Thornton J, Heymsfield S, Kelly K, Ramirez A, Gidwani S, et al. Dual-energy x-ray absorptiometry prediction of adipose tissue depots in children and adolescents. Pediatr Res 2012;72:420–5.
[23] Wald D, Teucher B, Dinkel J, Kaaks R, Delorme S, Boeing H, et al. Automatic quantification of subcutaneous and visceral adipose tissue from whole-body magnetic resonance images suitable for large cohort studies. J Magn Reson Imaging 2012;36:1421–34.
[24] Weerarathna TP, Lekamwasam S, Rodrigo M. Prediction of total and visceral fat contents using anthropometric measures of adiposity in women. Ceylon Med J 2008;53:128–32.