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Original Article

Iodine-enriched egg reduced total body fat and visceral fat among normal individuals: A placebo-controlled, randomized, double-blind study

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Abstract

***Objectives*:** This study aimed to evaluate the effects of iodine-enriched egg (IE) on total body fat, visceral fat, body weight, body mass index (BMI), and safety parameters among normal individuals.
***Methods*:** This randomized, double-blind, placebo-controlled study recruited 56 normal individuals (28 men, 28 women; BMI: 25−30 kg/m^2), who were assigned to receive either boiled IE or ordinary egg (OE) each day for 12 weeks. Total body fat and visceral fat were measured at baseline and 12 weeks using abdominal computed tomography. Body weight, BMI, and blood samples were also evaluated at baseline and week 12.
***Results*:** Although both groups exhibited similar caloric intakes, the IE group exhibited significantly reduced visceral fat area at week 12, compared to the OE group. In addition, the IE group exhibited a significant reduction in total and visceral fat area, compared to the baseline value. There were no significant differences in the blood parameters between the IE and OE groups. No significant adverse effects were observed.
***Conclusion*:** These results suggest that IE ingestion may help reduce visceral fat.

***KEY WORDS*:** iodine-enriched egg, total body fat, visceral fat

Introduction

Body fat accumulation is regulated by energy intake and expenditure, and a serious imbalance between these two processes is a major risk factor for cardiovascular disease and lifestyle-related diseases, such as diabetes, hypertension, hyperlipidemia, and arteriosclerosis. In this context, metabolic syndrome is defined as a group of disorders that involve abdominal obesity with high blood glucose levels, dyslipidemia, and high blood pressure.

Several functional foods and substrates can be used to prevent the accumulation of excess total body fat and visceral fat, and these functional foods have been commonly incorporated into diets [1)]. Functional eggs are easily consumed every day, and previous studies have revealed that iodine-enriched eggs (IE) protect against diabetes and alter lipid metabolism [2-6)]. Furthermore, patients with diabetes who consumed IE for 3 months exhibited significantly lower blood glucose levels, compared to normal individuals [7)]. Moreover, chickens that received egg white from IE exhibited lower plasma glucose concentrations, compared to chickens that were fed egg white from ordinary eggs (OE) [8)]. However, to the best of our knowledge, no studies have evaluated the effects of IE and OE on body fat accumulation in humans. Therefore, the present study aimed to evaluate whether ingesting IE helped reduce total body fat and visceral fat in normal individuals.

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Methods

Ethical considerations

The present study complied with the ethical principles of the Declaration of Helsinki (the 2004 clarification by the World Medical Association General Assembly), Japan's Act on the Protection of Personal Information, the Ministry of Health, Labor, and Welfare's Ordinance regarding Good Clinical Practice (no. 28; March 27, 1997), and the Ethical Guidelines for Epidemiological Research (Ministry of Health, Labor, and Welfare; Ministry of Education, Culture, Sports, Science, and Technology). The study's design was approved by the Doshisha University Ethics Committee for Scientific Research Involving Human Subjects (##14082) and the clinical research ethics board of the Tokyo Synergy Clinic. All participants provided their informed consent after receiving a full explanation regarding the study.

Study design

This study used a randomized, double-blind, placebo-controlled design. Participants were recruited from individuals who were identified by the Department of Anti-Aging Medicine (Doshisha University, Faculty of Life and Medical Sciences). Individuals were considered eligible if they were ≥ 20 years old and did not fulfill any of the exclusion criteria: a food or drug allergy, pregnant or lactating, receiving treatment using medication or follow-up, diabetes mellitus diagnosis, pronounced cardiopulmonary function disorder, receiving medication for hypertension, a history of gastrointestinal surgery, or suspicion of infectious disease. Some individuals were also excluded from the study based on the investigator's discretion.

The included individuals were randomly allocated to receive one boiled IE (Yodoran Hikari®) or one OE each day for 12 weeks. The compositions of OE and IE were shown in ***Table 1***. During the study, the participants were required to make five clinic visits: a health screening, a baseline evaluation, after 4 weeks of ingestion, after 8 weeks of ingestion, and at week 12 (4 weeks after the ingestion period). A well-trained nurse recorded the participants' body weight, height, BMI, and subjective complaints at each visit, and collected blood samples for laboratory testing (collected during the morning after a 10-h fast). The blood test parameters included levels of triglycerides, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and other metabolites. Self-reported dietary caloric intakes for the 3 consecutive days before the baseline and week 12 visits were assessed, and the average daily caloric intake values were calculated for each participant.

Subcutaneous and visceral fat assessment

Computed tomography (CT) was performed at baseline and week 12 to measure the subcutaneous and visceral fat areas at the level of the umbilicus (L4–L5; Legato Duo CT; GE Yokogawa Medical Systems, Tokyo, Japan). The visceral fat area was used to evaluate visceral obesity. The CT data were analyzed using FatScan software.

Statistical analyses

All data were reported as mean ± standard error. The paired t-test was used to evaluate intra- and inter-group differences. A *P*-value of <0.05 was used to identify statistically significant differences.

Results and Discussion

Among the 64 individuals who were randomized to the treatment groups, 5 individuals dropped out because of personal reasons that were unrelated to the IE or OE. Fifty-nine individuals completed the study, although 3 individuals were excluded during the analysis because of poor compliance (1 individual did not follow the ingestion protocol) or unreliable CT data (n = 2). Thus, the final analyses evaluate data from 56 individuals (28 men, 28 women, age: 50.4 ± 6.5 years, body mass index [BMI]: 27.12 ± 1.33 kg/m^2). The IE and OE groups exhibited similar baseline demographic and anthropometric characteristics (***Table 2***).

The FatScan analyses of the CT data revealed that the IE group exhibited significantly lower week-12 values for total body fat and visceral fat, compared to the OE group ($p = 0.037$ and $p = 0.001$, respectively). However, both groups exhibited similar week-12 values for BMI, triglyceride levels, low-density lipoprotein cholesterol levels, and high-density lipoprotein cholesterol levels (***Table 3***). Most blood test parameters did not exhibit time-related intra-group changes (e.g., the IE group exhibited similar baseline and week-12 values for free triiodothyronine and thyroxine). However, the IE group did exhibit a significant 12-week increase in urinary iodine levels.

Our previous study revealed that the treatment of 3T3-L adipocytes using yolk from IE reduced their fat accumulation and inhibited adipocyte differentiation [9]. Another study also revealed altered lipid metabolism in rats after they ingested IE, such as higher tissue lipoprotein lipase activity [3]. The present study showed that the pituitary-thyroid axis was not changed by ingestion of IE. The iodide related components as iodide peptide of IE responsible for fat accumulation in adipocytes are present in egg yolk. These findings suggest that the iodide peptide in IE may help directly reduce fat accumulation in normal individuals, without changing their thyroid hormone secretions.

Conclusion

The present study revealed three main findings. First, the IE group exhibited significantly lower total body fat and visceral fat, compared to the OE group. Second, both groups exhibited similar values for body weight, BMI, and blood parameters (e.g., total cholesterol and low-density lipoprotein cholesterol). Third, none of the participants reported problematic adverse effects.

Conflicts of interest

The authors have no financial relationship with the organization that sponsored this study. The sponsor played no part in the research, data collection, data analysis, writing of the manuscript, or decision to publish.

Table 1. The composition of OE and IE

		IE	OE
Crude protein	g	12.3	12.3
Crude fat	g	9.1	10.3
Crude Carbohydrate	g	0.8	0.3
Energy	kcal	134	151
Iodine	μg	1300	17
Iodide peptide	μg	361	ND

IE, iodine-enriched egg; OE, ordinary egg; ND, Not detected All compositions were shown per 100 grams of edible egg.

Table 2. The participants' baseline characteristics

		IE (n = 28)	OE (n = 28)	Total (n = 56)
Age	years	49.86 ± 6.65	50.93 ± 6.47	50.39 ± 6.53
Height	cm	163.90 ± 7.80	164.10 ± 9.80	164.00 ± 8.80
Body weight	kg	73.50 ± 7.44	72.61 ± 8.74	73.06 ± 8.06
Body mass index	kg/m^2	27.31 ± 1.25	26.93 ± 1.41	27.12 ± 1.33
Total fat area	cm^2	365.02 ± 62.89	352.13 ± 53.60	358.57 ± 58.26
Subcutaneous fat area	cm^2	234.45 ± 57.74	233.75 ± 66.91	234.10 ± 61.92
Visceral fat area	cm^2	130.56 ± 38.68	118.38 ± 41.26	124.47 ± 40.10
White blood cells	/μL	5,789.30 ± 1,385.20	5,635.70 ± 1,237.40	5,712.50 ± 1,303.70
Red blood cells	$10^4/μL$	472.10 ± 38.70	480.70 ± 37.10	476.40 ± 37.80
Hemaglobin	g/dL	14.26 ± 1.45	14.24 ± 1.87	14.25 ± 1.66
Hematocrit	%	42.55 ± 3.66	42.58 ± 4.37	42.57 ± 3.99
Triglycerides	mg/dL	128.80 ± 58.10	122.90 ± 51.60	125.90 ± 54.50
LDL	mg/dL	157.20 ± 37.00	150.60 ± 38.00	153.90 ± 37.30
HDL	mg/dL	58.30 ± 11.40	61.10 ± 13.50	59.70 ± 12.50
Free T4	ng/dL	1.15 ± 0.15	1.22 ± 0.15	1.18 ± 0.16
Free T3	pg/mL	3.28 ± 0.26	3.34 ± 0.28	3.31 ± 0.27
Urinary iodine	μg/L	453.20 ± 498.00	351.70 ± 312.10	402.50 ± 414.90
Urinary iodine corrected for creatinine	μg/g Cre	391.10 ± 758.30	224.00 ± 171.10	307.50 ± 551.20
Total free iodine	μg/day	530.20 ± 1,144.90	278.80 ± 202.90	404.50 ± 824.50

Data are expressed as mean ± standard error.
IE, iodine-enriched egg; OE, ordinary egg; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; T3, triiodothyronine; T4, thyroxine.

Table 3. The characteristics of participants who ingested iodine-enriched egg and ordinary egg for 12 weeks

				Baseline	week 12	P-values		
						1	2	3
Age	years	IE	28	49.86 ± 6.65	– ± –	–	–	–
		OE	28	50.93 ± 6.47	– ± –	–		
Height	cm	IE	28	163.90 ± 7.80	– ± –	–	–	–
		OE	28	164.10 ± 9.80	– ± –	–		
Body weight	kg	IE	28	73.50 ± 7.44	73.73 ± 7.68	0.41	0.17	0.21
		OE	28	72.61 ± 8.74	72.36 ± 8.44	0.25		
Body mass index	kg/m^2	IE	28	27.31 ± 1.25	27.40 ± 1.46	0.40	0.16	0.17
		OE	28	26.93 ± 1.41	26.83 ± 1.45	0.24		
Total fat area	cm^2	IE	28	365.02 ± 62.89	355.02 ± 57.24	0.04	0.36	0.53
		OE	28	352.13 ± 53.60	347.77 ± 59.38	0.30		
Subcutaneous fat area	cm^2	IE	28	234.45 ± 57.74	235.62 ± 57.19	0.76	0.44	0.30
		OE	28	233.75 ± 66.91	231.41 ± 68.80	0.35		
Visceral fat area	cm^2	IE	28	130.56 ± 38.68	119.40 ± 37.66	0.00	0.05	0.03
		OE	28	118.38 ± 41.26	116.36 ± 41.69	0.55		
White blood cells	/μL	IE	28	5,789.30 ± 1,385.20	5,725.00 ± 1,523.80	0.77	0.89	0.76
		OE	28	5,635.70 ± 1,237.40	5,614.30 ± 1,331.00	0.93		
Red blood cells	10^4/μL	IE	28	472.10 ± 38.70	469.60 ± 34.00	0.58	0.70	0.79
		OE	28	480.70 ± 37.10	480.50 ± 38.50	0.95		
Hemaglobin	g/dL	IE	28	14.26 ± 1.45	14.06 ± 1.57	0.17	0.80	0.80
		OE	28	14.24 ± 1.87	14.09 ± 1.92	0.21		
Hematocrit	%	IE	28	42.55 ± 3.66	42.55 ± 3.89	0.99	0.94	0.88
		OE	28	42.58 ± 4.37	42.54 ± 4.62	0.89		
Total cholesterol	mg/dL	IE	28	232.20 ± 40.20	235.30 ± 38.10	0.55	0.60	0.60
		OE	28	227.50 ± 41.50	227.00 ± 38.50	0.91		
Triglycerides	mg/dL	IE	28	128.80 ± 58.10	146.10 ± 128.30	0.50	0.55	0.46
		OE	28	122.90 ± 51.60	123.30 ± 70.40	0.98		
LDL	mg/dL	IE	28	157.20 ± 37.00	155.40 ± 37.90	0.76	0.51	0.49
		OE	28	150.60 ± 38.00	144.10 ± 34.90	0.13		
HDL	mg/dL	IE	28	58.30 ± 11.40	57.60 ± 11.40	0.65	0.15	0.18
		OE	28	61.10 ± 13.50	63.50 ± 14.90	0.13		
Free T4	ng/dL	IE	28	1.15 ± 0.15	1.19 ± 0.17	0.12	0.59	0.58
		OE	28	1.22 ± 0.15	1.23 ± 0.17	0.56		
Free T3	pg/mL	IE	28	3.28 ± 0.26	3.29 ± 0.35	0.84	0.37	0.43
		OE	28	3.34 ± 0.28	3.28 ± 0.28	0.29		
Urinary iodine	μg/L	IE	28	453.20 ± 498.00	971.40 ± 1,351.20	0.05	0.15	0.01
		OE	28	351.70 ± 312.10	448.20 ± 686.00	0.46		
Urinary iodine corrected for creatinine	μg/g Cre	IE	28	391.10 ± 758.30	698.20 ± 882.70	0.20	0.30	0.01
		OE	28	224.00 ± 171.10	278.30 ± 419.00	0.43		
Total urinary idoine	μg/day	IE	28	530.20 ± 1,144.90	899.30 ± 1,328.20	0.30	0.41	0.01
		OE	28	278.80 ± 202.90	349.60 ± 500.3	0.41		

Data are expressed as mean ± standard error.
[1] P-values for comparing baseline and week 12 values in the IE and OE groups.
[2] P-values for comparing the 12-week overall change between the IE and OE groups.
[3] P-values for comparing the 12-week percent change between the IE and OE groups.
IE, iodine-enriched egg; OE, ordinary egg; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; T3, triiodothyronine; T4, thyroxine.

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