*Table 6 Energy and nutrient intakes estimated by a self-administered diet history questionnaire (DHQ) by sex **

		Crude model				Density model		
		Men (n=116)	Women (n=119)	P-value **		Men (n=116)	Women (n=119)	P-value **
Energy	kcal /day	2709 ± 791	2209 ± 813	<0.001				
Protein	g/day	96.0 ± 30.0	84.9 ± 30.5	0.005	% energy	14.3 ± 2.4	15.5 ± 2.4	<0.001
Fat	g/day	76.0 ± 33.2	70.5 ± 37.1	0.236	% energy	24.9 ± 7.0	27.8 ± 6.0	0.001
Total fatty acid	g/day	66.8 ± 29.4	61.1 ± 33.2	0.163	% energy	21.9 ± 6.3	24.0 ± 5.5	0.010
Saturated fatty acid	g/day	20.9 ± 8.9	19.7 ± 10.0	0.320	% energy	6.9 ± 2.0	7.8 ± 1.7	<0.001
Monounsaturated fatty acid	g/day	27.6 ± 13.4	24.8 ± 14.7	0.132	% energy	9.0 ± 3.0	9.6 ± 2.8	0.091
Polyunsaturated fatty acid	g/day	18.0 ± 7.9	16.3 ± 9.1	0.134	% energy	5.9 ± 1.7	6.4 ± 1.7	0.025
Cholesterol	mg/day	429 ± 182	358 ± 174	0.003	mg/1000 kcal	158 ± 55	160 ± 53	0.736
Alcohol	g/day	32.5 ± 44.8	2.4 ± 5.8	<0.001	% energy	7.7 ± 9.5	0.7 ± 1.8	<0.001
Sodium	mg/day	5488 ± 1964	5459 ± 2326	0.917	mg/1000 kcal	2044 ± 526	2493 ± 630	<0.001
Potassium	mg/day	3318 ± 924	3235 ± 1228	0.556	mg/1000 kcal	1253 ± 258	1486 ± 305	<0.001
Calcium	mg/day	904 ± 260	943 ± 312	0.292	mg/1000 kcal	347 ± 104	442 ± 112	<0.001
Magnesium	mg/day	359 ± 99	331 ± 119	0.054	mg/1000 kcal	136 ± 28	152 ± 28	<0.001
Phosphorus	mg/day	1529 ± 430	1392 ± 479	0.022	mg/1000 kcal	574 ± 104	639 ± 103	<0.001
Iron	mg/day	8.8 ± 2.7	8.5 ± 3.5	0.436	mg/1000 kcal	3.3 ± 0.8	3.9 ± 0.9	<0.001
Zinc	mg/day	11.0 ± 3.3	9.4 ± 3.3	0.000	mg/1000 kcal	4.1 ± 0.6	4.3 ± 0.5	0.020
Copper	mg/day	1.4 ± 0.4	1.3 ± 0.5	0.023	mg/1000 kcal	0.5 ± 0.1	0.6 ± 0.1	<0.001
Retinol	μg/day	482 ± 549	368 ± 430	0.078	μg/1000 kcal	180 ± 193	159 ± 134	0.324
Carotene	μg/day	3009 ± 2001	3966 ± 2652	0.002	μg/1000 kcal	1129 ± 680	1823 ± 1070	<0.001
Vitamin D	μg/day	12.0 ± 6.8	11.1 ± 6.7	0.305	μg/1000 kcal	4.4 ± 2.1	5.0 ± 2.5	0.039
Thiamin	mg/day	1.2 ± 0.4	1.1 ± 0.5	0.012	mg/1000 kcal	0.4 ± 0.1	0.5 ± 0.1	0.075
Riboflavin	mg/day	2.1 ± 0.6	2.0 ± 0.7	0.119	mg/1000 kcal	0.8 ± 0.2	0.9 ± 0.2	<0.001
Niacin	mg/day	23.3 ± 9.4	18.6 ± 8.3	<0.001	mg/1000 kcal	8.6 ± 2.4	8.4 ± 2.1	0.490
Vitamin C	mg/day	117 ± 63	127 ± 88	0.311	mg/1000 kcal	45 ± 23	57 ± 31	<0.001
Soluble dietary fiber	g/day	3.5 ± 1.5	3.7 ± 1.8	0.269	g/1000 kcal	1.3 ± 0.5	1.7 ± 0.6	<0.001
Insoluble dietary fiber	g/day	10.5 ± 3.7	11.0 ± 4.9	0.316	g/1000 kcal	4.0 ± 1.2	5.1 ± 1.5	<0.001
Total dietary fiber	g/day	14.4 ± 5.1	15.5 ± 7.1	0.189	g/1000 kcal	5.5 ± 1.6	7.1 ± 2.2	<0.001

* Values are experessed as mean±standard deviation
** Significant difference between sexes (analysis of variance)

*Table 7 Energy and nutrient intakes estimated by a self-administered diet history questionnaire (DHQ) by BMI cateogries * (Crude model)*

		Men n=116				Women n=119			
		1 (n=29)	2 (n=29)	3 (n=29)	4 (n=29)	1 (n=29)	2 (n=30)	3 (n=30)	4 (n=30)
Energy	kcal /day	2522 ± 871	2791± 596	2653± 630	2870± 994	2494 ± 961	2170± 618	2242± 916	1941± 648**
Protein	g/day	90.4 ± 27.9	95.6 ± 24.3	93.6 ± 28.5	104.7 ± 37.3	94.4 ± 37.0	82.5 ± 22.0	85.1 ± 33.0	77.9 ± 27.1
Fat	g/day	69.4 ± 30.9	77.6 ± 24.4	72.4 ± 26.9	84.6 ± 45.9	80.5 ± 37.0	69.4 ± 29.2	72.5 ± 46.6	60.1 ± 31.9
Total fatty acid	g/day	61.3 ± 27.7	67.9 ± 21.4	63.7 ± 24.0	74.5 ± 40.6	69.5 ± 31.9	60.1 ± 26.0	62.8 ± 42.5	52.4 ± 29.3
Saturated fatty acid	g/day	19.8 ± 9.3	21.2 ± 6.7	19.9 ± 8.0	22.7 ± 11.1	22.3 ± 10.6	20.0 ± 9.9	20.5 ± 11.5	16.0 ± 6.9**
Monounsaturated fatty acid	g/day	25.1 ± 12.4	28.1 ± 9.5	25.9 ± 10.3	31.2 ± 18.9	28.4 ± 13.7	24.1 ± 11.4	25.5 ± 19.0	21.3 ± 13.4
Polyunsaturated fatty acid	g/day	16.1 ± 6.4	18.0 ± 5.8	17.6 ± 6.4	20.2 ± 11.4	18.5 ± 8.4	15.7 ± 6.1	16.5 ± 12.1	14.6 ± 8.7
Cholesterol	mg/day	395 ± 149	427 ± 154	444 ± 191	447 ± 228	401 ± 179	335 ± 147	371 ± 196	325 ± 169
Alcohol	g/day	26.7 ± 34.7	28.3 ± 33.1	33.4 ± 41.8	41.6 ± 63.7	5.3 ± 9.7	1.0 ± 3.0**	1.5 ± 3.7**	1.6 ± 3.7**
Sodium	mg/day	4856 ± 1591	5670 ± 1619	5175 ± 1659	6252 ± 2605	5733 ± 2220	5531 ± 1745	5585 ± 3109	4995 ± 2054
Potassium	mg/day	3121 ± 738	3263 ± 844	3294 ± 942	3594 ± 1114	3632 ± 1385	3173 ± 890	3220 ± 1601	2927 ± 816
Calcium	mg/day	894 ± 277	872 ± 231	925 ± 291	925 ± 245	1057 ± 364	923 ± 262	955 ± 376	841 ± 183**
Magnesium	mg/day	333 ± 76	355 ± 90	366 ± 109	381 ± 115	374 ± 142	327 ± 89	331 ± 146	294 ± 76**
Phosphorus	mg/day	1456 ± 410	1502 ± 371	1533 ± 418	1626 ± 513	1559 ± 565	1363 ± 366	1405 ± 562	1246 ± 352**
Iron	mg/day	8.0 ± 1.9	8.9 ± 2.2	9.0 ± 2.7	9.4 ± 3.5	9.5 ± 4.3	8.4 ± 2.5	8.6 ± 4.2	7.7 ± 2.4
Zinc	mg/day	10.5 ± 3.8	11.2 ± 2.6	10.9 ± 2.9	11.6 ± 3.9	10.5 ± 4.1	9.2 ± 2.2	9.5 ± 3.7	8.4 ± 2.6**
Copper	mg/day	1.3 ± 0.4	1.5 ± 0.4	1.4 ± 0.4	1.5 ± 0.5	1.4 ± 0.6	1.3 ± 0.3	1.3 ± 0.6	1.2 ± 0.4
Retinol	μg/day	549 ± 863	448 ± 353	507 ± 432	423 ± 416	360 ± 262	349 ± 282	470 ± 735	292 ± 216
Carotene	μg/day	2681 ± 1537	2815 ± 1568	3037 ± 2478	3505 ± 2253	4703 ± 2699	4166 ± 2476	3697 ± 3437	3323 ± 1600
Vitamin D	μg/day	10.9 ± 5.2	11.6 ± 6.6	11.2 ± 6.2	14.3 ± 8.7	12.4 ± 7.4	10.4 ± 5.2	11.2 ± 8.4	10.3 ± 5.7
Thiamin	mg/day	1.2 ± 0.4	1.1 ± 0.3	1.2 ± 0.4	1.4 ± 0.5	1.2 ± 0.6	1.1 ± 0.3	1.0 ± 0.5	0.9 ± 0.4
Riboflavin	mg/day	2.0 ± 0.5	2.1 ± 0.5	2.1 ± 0.5	2.3 ± 0.6	2.1 ± 0.8	2.0 ± 0.5	2.0 ± 0.8	1.8 ± 0.5
Niacin	mg/day	22.0 ± 7.8	22.4 ± 7.5	22.3 ± 8.5	26.4 ± 12.7	20.8 ± 9.1	18.7 ± 6.8	18.6 ± 9.5	16.5 ± 7.5
Vitamin C	mg/day	101 ± 44	112 ± 52	110 ± 61	146 ± 83 **	138 ± 96	127 ± 66	123 ± 105	122 ± 85
Soluble dietary fiber	g/day	3.2 ± 1.1	3.4 ± 1.2	3.5 ± 1.7	3.8 ± 1.7	4.2 ± 2.2	3.6 ± 1.3	3.8 ± 2.5	3.3 ± 1.0
Insoluble dietary fiber	g/day	9.8 ± 2.3	10.3 ± 3.2	10.6 ± 4.4	11.1 ± 4.4	12.4 ± 6.0	10.9 ± 3.3	11.3 ± 6.5	9.7 ± 2.8
Total dietary fiber	g/day	13.4 ± 3.5	14.2 ± 4.3	14.7 ± 6.1	15.5 ± 6.2	17.4 ± 8.2	15.2 ± 4.7	15.9 ± 9.8	13.5 ± 4.0

BMI; Body mass Index
* Values are experessed as mean±standard deviation
** Significant difference compared with the lowest BMI category between BMI categories (Dunnett's t-test) p<0.05
*** Significant difference between BMI categories (analysis of variance)

*Table 8 Energy and nutrient intakes estimated by a self-administered diet history questionnaire (DHQ) by BMI cateogries * (Density model)*

		Men n=116				Women n=119			
		1 (n=29)	2 (n=29)	3 (n=29)	4 (n=29)	1 (n=29)	2 (n=30)	3 (n=30)	4 (n=30)
Energy									
Protein	% energy	14.6 ± 2.4	13.7 ± 2.1	14.2 ± 2.5	14.7 ± 2.5	15.2 ± 2.7	15.3 ± 1.6	15.5 ± 3.0	16.1 ± 2.3
Fat	% energy	25.0 ± 8.6	24.8 ± 5.5	24.6 ± 7.0	25.4 ± 7.0	28.5 ± 6.9	28.0 ± 5.0	27.7 ± 6.1	26.8 ± 6.0
Total fatty acid	% energy	22.1 ± 7.8	21.7 ± 5.0	21.6 ± 6.2	22.3 ± 6.3	24.7 ± 6.3	24.3 ± 4.7	23.7 ± 5.7	23.3 ± 5.5
Saturated fatty acid	% energy	7.1 ± 1.9	6.8 ± 1.6	6.8 ± 2.5	7.0 ± 2.1	7.9 ± 1.9	8.0 ± 1.8	8.0 ± 1.7	7.4 ± 1.5
Monounsaturated fatty acid	% energy	9.0 ± 3.9	9.0 ± 2.4	8.8 ± 2.6	9.2 ± 3.0	10.1 ± 3.1	9.7 ± 2.4	9.5 ± 2.9	9.3 ± 2.8
Polyunsaturated fatty acid	% energy	5.9 ± 2.3	5.8 ± 1.3	6.0 ± 1.5	6.0 ± 1.8	6.6 ± 1.9	6.5 ± 1.5	6.2 ± 1.7	6.4 ± 1.8
Cholesterol	mg/1000 kcal	161 ± 60	152 ± 46	168 ± 61	151 ± 54	161 ± 45	152 ± 51	164 ± 55	165 ± 60
Alcohol	% energy	7.2 ± 8.4	7.2 ± 8.7	8.4 ± 10.1	8.1 ± 10.9	1.5 ± 2.9	0.3 ± 0.9**	0.5 ± 1.0	0.7 ± 1.4
Sodium	mg/1000 kcal	2010 ± 677	2038 ± 423	1942 ± 422	2187 ± 537	2305 ± 432	2581 ± 624	2505 ± 861	2575 ± 505
Potassium	mg/1000 kcal	1295 ± 293	1172 ± 210	1264 ± 308	1282 ± 199	1475 ± 343	1478 ± 242	1437 ± 354	1554 ± 271
Calcium	mg/1000 kcal	371 ± 108	315 ± 73	363 ± 136	340 ± 84	434 ± 115	433 ± 89	441 ± 123	460 ± 121
Magnesium	mg/1000 kcal	139 ± 33	128 ± 21	140 ± 34	136 ± 23	152 ± 29	152 ± 26	149 ± 34	156 ± 25
Phosphorus	mg/1000 kcal	594 ± 114	539 ± 82	587 ± 123	576 ± 90	630 ± 107	633 ± 73	637 ± 133	657 ± 92
Iron	mg/1000 kcal	3.4 ± 0.9	3.2 ± 0.5	3.4 ± 0.8	3.3 ± 0.8	3.8 ± 0.9	3.9 ± 0.8	3.9 ± 1.1	4.0 ± 0.7
Zinc	mg/1000 kcal	4.2 ± 0.6	4.0 ± 0.4	4.2 ± 0.6	4.1 ± 0.8	4.2 ± 0.6	4.3 ± 0.4	4.3 ± 0.6	4.4 ± 0.5
Copper	mg/1000 kcal	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	0.6 ± 0.1
Retinol	μg/1000 kcal	205 ± 250	158 ± 118	211 ± 228	147 ± 144	139 ± 66	154 ± 106	192 ± 214	150 ± 98
Carotene	μg/1000 kcal	1162 ± 725	979 ± 478	1148 ± 865	1227 ± 602	1872 ± 936	1992 ± 1172	1619 ± 1249	1810 ± 897
Vitamin D	μg/1000 kcal	4.5 ± 2.3	4.1 ± 2.2	4.2 ± 1.8	4.7 ± 2.0	5.0 ± 2.2	4.7 ± 1.9	5.0 ± 3.7	5.3 ± 2.0
Thiamin	mg/1000 kcal	0.5 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	0.5 ± 0.1
Riboflavin	mg/1000 kcal	0.8 ± 0.2	0.8 ± 0.2	0.8 ± 0.2	0.8 ± 0.2	0.9 ± 0.2	0.9 ± 0.2	0.9 ± 0.2	1.0 ± 0.2
Niacin	mg/1000 kcal	9.0 ± 2.8	8.0 ± 2.0	8.3 ± 2.1	9.1 ± 2.4	8.5 ± 2.5	8.6 ± 1.9	8.1 ± 2.1	8.4 ± 2.0
Vitamin C	mg/1000 kcal	43 ± 20	41 ± 19	43 ± 25	52 ± 27	53 ± 22	59 ± 26	53 ± 28	65 ± 42
Soluble dietary fiber	g/1000 kcal	1.4 ± 0.6	1.2 ± 0.4	1.3 ± 0.6	1.3 ± 0.5	1.7 ± 0.5	1.7 ± 0.5	1.7 ± 0.8	1.8 ± 0.4
Insoluble dietary fiber	g/1000 kcal	4.2 ± 1.4	3.7 ± 0.8	4.0 ± 1.4	4.0 ± 1.0	4.9 ± 1.4	5.1 ± 1.4	5.1 ± 2.0	5.1 ± 1.1
Total dietary fiber	g/1000 kcal	5.7 ± 2.0	5.1 ± 1.1	5.5 ± 1.9	5.5 ± 1.5	6.9 ± 2.0	7.2 ± 1.9	7.2 ± 3.0	7.2 ± 1.7

BMI; Body mass Index
* Values are experessed as mean±standard deviation
** Significant difference compared with the lowest BMI category between BMI categories (Dunnett's t-test) $p<0.05$
*** Significant difference between BMI categories (analysis of variance)

*Table 9 Food group intakes estimated by a self-administered diet history questionnaire (DHQ) by group **

	Density model (g/1000kcal)			Density model (g/1000kcal)		
	Intervention group (n=59)	Control group (n=57)	P-value **	Intervention group (n=60)	Control group (n=59)	P-value **
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Cereals	227.5 ± 55.7	220.3 ± 70.2	0.541	197.1 ± 57.9	208.5 ± 61.4	0.300
Nuts	1.0 ± 1.2	1.3 ± 1.6	0.307	1.1 ± 1.6	1.8 ± 4.2	0.279
Potatoes	10.6 ± 8.5	11.8 ± 8.3	0.444	14.5 ± 15.0	16.3 ± 11.7	0.465
Sugars	4.9 ± 3.0	5.5 ± 3.5	0.339	5.8 ± 2.9	5.9 ± 2.5	0.829
Confectionaries	20.5 ± 15.0	24.7 ± 15.1	0.134	43.7 ± 23.4	37.9 ± 25.2	0.192
Animal fat	0.2 ± 0.4	0.2 ± 0.3	0.601	0.2 ± 0.4	0.3 ± 0.7	0.600
Vegetable oil	9.8 ± 4.3	11.3 ± 8.1	0.225	13.6 ± 8.9	11.2 ± 6.7	0.094
Pulses	22.7 ± 15.2	24.5 ± 12.4	0.472	25.5 ± 14.4	32.0 ± 20.4	0.048
Fruits	45.9 ± 69.7	33.9 ± 27.3	0.225	51.6 ± 43.2	71.4 ± 102.3	0.174
Green and yellow vegetables	42.1 ± 34.3	41.9 ± 25.3	0.967	57.1 ± 36.1	64.5 ± 35.9	0.263
Other vegetables	62.3 ± 37.3	64.0 ± 32.0	0.788	81.9 ± 46.6	91.7 ± 42.0	0.232
Mushrooms	4.7 ± 4.4	4.3 ± 4.0	0.627	7.6 ± 6.1	8.4 ± 6.9	0.516
Seaweeds	4.5 ± 4.7	5.0 ± 3.6	0.534	7.8 ± 7.1	10.6 ± 7.7	0.040
Seasonings	7.5 ± 3.7	7.6 ± 4.0	0.886	9.6 ± 7.8	11.4 ± 8.5	0.244
Alcoholic beverages	92.8 ± 101.4	130.3 ± 147.4	0.115	19.5 ± 57.0	29.6 ± 68.6	0.381
Nonalcoholic beverages	369.0 ± 214.8	402.9 ± 290.7	0.477	399.1 ± 222.3	469.7 ± 286.5	0.136
Fish and shellfish	39.8 ± 18.3	43.5 ± 22.4	0.333	43.4 ± 20.8	45.1 ± 22.7	0.671
Meats	28.7 ± 13.7	30.0 ± 19.6	0.665	22.9 ± 15.1	22.7 ± 12.8	0.924
Eggs	17.2 ± 11.9	15.0 ± 10.7	0.292	15.1 ± 10.2	15.1 ± 10.7	0.981
Dairy products	203.1 ± 61.2	112.0 ± 71.2	<0.001	237.6 ± 72.7	157.1 ± 69.4	<0.001
Water	168.0 ± 167.7	193.8 ± 238.3	0.503	209.8 ± 222.0	241.3 ± 279.3	0.497

* Values are experessed as mean±standard deviation
** Significant difference between randomized groups (analysis of variance)

observed in both crude and density models. Similar differences between the two groups were observed when men and women analyzed separately.

Food intake by randomized group. In crude models, only dairy product intake was higher in the intervention than in the control groups, while energy-adjusted intake of dairy product was higher and that of pulses and seaweeds was lower in the intervention than in the control groups ($p<0.05$). Apparently similar differences between the two groups were observed when men and women analyzed separately (*Table 9*).

Discussion

The importance of health counseling aimed at lifestyle modification has long been emphasized for preventing and/or treating lifestyle-related diseases. Several lifestyle intervention methods have therefore been developed and used in Japan to promote healthier lifestyles. However, few intervention methods have been examined their effectiveness by using appropriate study designs. We therefore planed a moderate-intensity weight-control intervention program, and examined their effectiveness.

We evaluated the baseline dietary characteristics by validated self-administered DHQ.[1-3] In a validation study, mean energy intake estimated from DHQ was comparable with that estimated from 3-day dietary records in 47 normal-weight women (1752 vs 1739 kcal/day).[1] Because our mean estimate of energy intake in overweight men and women (2709 and 2209 kcal/day, respectively) was higher than that estimated from 16-day weighed dietary records (2366 and 1864 kcal/day, respectively) in normal weight men and women (n = 92 and 91, respectively),[4] mean energy intake obtained in the present study seems to be generally reasonable. However, given that underreporting of energy intake by subjects with higher BMI is quite common even in Japanese people when using self-reported dietary assessment methods.[4,5] and BMI-dependent dietary underreporting seems to be canceled by using energy-adjusted values[6], energy-adjusted rather than crude values of nutrient and food intakes may be somewhat reliable.

In conclusion, mean dietary intake level of energy, nutrients, and foods at baseline was similar between the intervention and the control groups although small significant difference was observed for a few dietary variables. These results suggest the success of randomization in the present study at least regarding dietary intake.

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Original Article

Nutritional Education and Exercise Treatment Based on Cognitive Behavioral Treatment in the Saku Control Obesity Program (SCOP)

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Abstract

BACKGROUND: Long-term weight loss is difficult to maintain, but recently cognitive behavioral therapy has been shown to be effective for long-term weight loss and maintenance.

METHODS: The 119 participants, who had been assigned to program to lose weight, were interviewed by dieticians regarding their motivation for weight loss and psychological status and self-corrected problems with their eating activities and exercises, following recognition of problems, discussing solutions, and devising personal dietary plans and exercise plan to loose weight at 1.0-2.0 kg per month.

RESULTS: In women, the prevalence of motivation to resolve the situation (n = 44, 84.6%) was significantly higher than that of men (n = 33, 67.3%; $p < 0.05$). In men, awareness of the need to keep healthy by oneself was significantly associated with the motivation to resolve the situation ($p = 0.002$) and the availability of support from others ($p = 0.004$). Thirty problems and 29 dietary goals were set by participants. The percentages of intake of alcohol ($p < 0.05$) and intake of sweets ($p < 0.01$) as the problems and decrease of intake in specified foods ($p < 0.01$) and snacks ($p = 0.05$) as dietary goals were significantly different between men and women. Women with BMI over 31 kg/m^2 set fewer additional steps as exercise goals than those with BMI under 29 kg/m^2 ($p < 0.05$).

CONCLUSIONS: The characters of subjects such as psychological status and the problems and the target recognized by participants were different between gender and the degree of obesity.

KEY WORDS: cognitive behavioral treatment, health education, obesity, baseline data

Introduction

Obesity is increasing in prevalence in Japan, and it represents a major risk not only for metabolic syndromes, such as type 2 diabetes, ischemic heart disease, hypertension, gout, and dyslipidemias, but also some cancers.[1] Loss of 10% of starting weight is thought to be associated with amelioration of risk factors such as hypertension, hypercholesterolemia, and hyperglycemia.[2] Traditional dietary treatment of obesity consists of an energy-reduced diet prescribed by dietitians to achieve weight loss in a short period.[3] Long term evaluations of obesity interventions indicate that weight loss accomplished through changes in diet and physical activity is rarely maintained.[4]

Since Stuart first applied behavior therapy to weight loss in the obese,[5] more than 100 papers have been published in the field. The goal of behavioral treatment is for participants themselves to choose to reduce caloric intake and increase energy expenditures based on alternatives provided by professionals, such as the dietitians.

Recently, cognitive behavioral treatment has been applied to weight loss in the obese. Cognitive behavioral treatment (therapy) is a methodology for systematically modifying eating and activity habits, other behaviors, or negative thoughts that appear to contribute to obesity using a combination of self-monitoring, goal setting, stimulus control, cognitive restructuring, stress management, and social support. The cognitive behavioral treatment can be applied in an individual or group setting to achieve a long-term change in eating and physical activity behaviors. Studies suggest that frequent contact between professionals and patients is necessary to achieve the weight loss. Several studies in a group setting showed that the treatments, typically delivered in 15–26 weekly 30- to 60-min group sessions consisting of fewer than 10 patients, produced a mean post-treatment weight loss of approximately 8.5 kg a 1 year.[4-6,10] However, long-term evaluations of interventions indicated that maintenance of weight loss is difficult.[11-13] The U.S. Institute of Medicine defined success as a weight loss of 5% of body weight maintained for 1 or more years.[13] These results suggested that intensive intervention (weekly group sessions) is successful for weight loss up to 1 year, but long-term adherence to the weight-loss plan cannot be facilitated by these programs. Perri and Corsica evaluated several specific maintenance strategies to achieve better long-term outcomes, including a problem-solving model, relapse prevention training, motivation, and extended behavioral therapy.[14] However, a truly effective intervention treatment for obesity has not yet been established. Renjilian reported the benefits of group treatment as cost-effectiveness and greater weight loss in patients at the end of the program.[15] In the case of intensive intervention, such as weekly sessions for 6 months, individual treatment is more expensive than the group approach.

In this baseline survey, we clarified the characteristics of the psychological status of subjects and the problems and dietary goals that the subjects had realized and set at the first meeting in Saku Control Obesity Program (SCOP), because there were few reports about the problems and targets that the participants made, so far.

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Methods

The study is a randomized controlled trial comparing the effect of 1-year behavioral treatment and exercise versus a control group conducted at the Saku General Hospital Human Dock Center. Details of the aim and design of the study are described in other paper written by Watanabe et al.[16,17]

Participants

235 participants (116 males, 119 females) out of 976 people, who had received the regular medical checkup, were finally recruited through the Saku General Hospital Human Dock Center. Inclusion criteria were age 40–64 years, at body mass index (BMI) over 28.3kg/m^2 within top fifth percentile, stated with desire to lose weight, and no serious medical condition. A total of 119 participants (59 men, 60 women) attended the first group session, and 116 participants (57 men, 59 women) were placed on a waiting list control group for a second session. All participants provided written informed consent, and the ethical committees of the National Institute of Health and Nutrition and the Saku General Hospital approved the study.

Interventions

Dieticians interviewed participants about their motivation for losing weight and to assess psychological status by considering the following: benefits to losing weight, probability of losing weight, level of motivation to resolve the situation, availability of support from others, level of awareness of the need to keep healthy by oneself, obstacles to executing the plans, and the amount of stress felt.

Using a behavioral management treatment, teams of health professionals, including doctors, registered dietitians, and physical activity instructors, conducted a weight-loss intervention that focused on self-management of diet, exercise, and individually set behavior goals. Participants had a brief interview with doctors followed by an individual session for 30–45 min with dieticians and a group session with physical activity instructors; if necessary, participants also received individual instruction in physical activity.

Various strategies were used to modify participants' behaviors, including self-monitoring, problem solving, goal setting, cognitive restructuring, stress management, stimulus control, and social support. Following recognition of the specific dietary problems, participants were expected to self-correct problems with their eating activity and exercise, choose a solution, implement a plan, and evaluate the outcome. During the individual sessions with dieticians every 3 months, participants evaluate their ability to self-monitor weight, physical activity (number of steps per day), accomplishment of the dietary and exercise plan, and daily diet activity. The dietitians provide positive feedback to participants for their progress in weight loss and engaged participants in problem solving to deal with obstacles. Then the dieticians help participant to recognize any dietary problems and to make plans for the following month. Between these face-to-face sessions, participants report their progress for the previous month and their new plans for the following month by mailing records to the dieticians in the months when they have no meeting with dieticians. When the reports are sent from the participants, dieticians and physical activity instructors send back their comments to the participants within 1 week.

The goal of weight loss was set at 1.0–2.0 kg per month, with a final goal of 10 kg lost by the end of the program. Nutritional education focused on individual dietary behaviors as clarified by monitoring participants' dietary records, especially fat intake, amount of grains, cooking methods, snacking, eating out, skipping meals, and alcohol intake. Each month, participants are also required to make their exercise plans with 1,000 more steps per day into the actual steps last month, with aim at the final goal of 10,000 steps per day by the end of the program.

Data Analysis

Data were analyzed using the Statistical Package for Social Sciences® (SPSS/PC, version 12.0, SPSS Inc., Japan). Differences between men and women with regard to psychological status, problem-solving strategies, and goal setting were analyzed using chi-square tests. Analysis of variance was used to examine differences between initial goals for exercise with regard to BMI.

Results

In this baseline survey, the data collected from 119 participants in first intervention group were analyzed for psychological characteristics and the data from 117 participants except 2 dropout participants were analyzed for problems and dietary and exercise goals.

The prevalence of motivation to resolve the situation in women was significantly higher than that of men ($p < 0.05$; *Table 1*). Compared to women, more men expected support from others ($p < 0.05$), particularly their wives. More women were aware of obstacles to executing their weight-loss plans, although the prevalence of seeing benefits to losing weight, probability of losing weight, awareness of the need to keep healthy by oneself, and stress were not different between men and women.

Table 1 Sample characteristics of psychological status

Variables	levels	Men		Women		
		n	%	n	%	p value *
Benefits to lose weight	High	46	85.2	51	91.1	0.34
	Low	8	14.8	5	8.9	
Probability to lose weight	High	32	61.5	28	53.8	0.43
	Low	20	38.5	24	46.2	
Motivation to resolve the situation	High	33	67.3	44	84.6	0.04
	Low	16	32.7	8	15.4	
Availability of support from others	High	32	66.7	22	45.8	0.04
	Low	16	33.3	26	54.2	
Awareness of necessity to keep healthy by oneself	High	37	84.1	39	76.5	0.35
	Low	7	15.9	12	23.5	
Obstacles to executing plans	Yes	20	45.5	30	66.7	0.06
	No	22	50.0	15	33.3	
Feel stress	Yes	31	77.5	35	71.4	0.52
	No	9	16.7	14	28.6	

* Results of chi-square tests to examine the distribution of psychological status with men and women.

Table 2 Association of awareness of necessity to keep healthy by oneself and other psychological variables

Variables		Awareness of necessity to keep healthy by oneself: Men					Women				
		High		Low			High		Low		
		n	%	n	%	p value *	n	%	n	%	p value *
Benefits to lose weight	High	32	72.7	6	13.6	0.96	39	76.5	7	13.7	<0.001
	Low	5	11.4	1	2.3		0	0.0	5	9.8	
Probability to lose weight	High	22	50.0	3	6.8	0.60	24	50.0	2	4.2	<0.01
	Low	15	34.1	4	9.1		12	25.0	10	20.8	
Motivation to resolve the situation	High	27	62.8	1	2.3	<0.01	35	72.9	6	12.5	<0.01
	Low	9	20.9	6	14.0		2	4.2	5	10.4	
Availability of support from others	High	26	60.5	1	2.3	<0.01	18	40.9	2	4.5	0.12
	Low	10	23.3	6	14.0		17	38.6	7	15.9	
Obstacles to executing plans	Yes	18	47.4	2	5.3	0.54	7	17.1	6	14.6	0.03
	No	15	39.5	3	7.9		24	58.5	4	9.8	
Feel stress	Yes	7	20.0	0	0.0	0.23	8	18.6	2	4.7	0.64
	No	23	65.7	5	14.3		24	55.8	9	20.9	

* Results of chi-square tests to examine the distribution of psychological status

Table 3 Recognition of problems related to diet

Classification	Contents	Men n	Men %	Women n	Women %
Behaviors for diet					
Behavior as a cause of eating too much	Eat fast	24	40.7	28	47.5
	Eat much at supper	7	11.9	4	6.8
	Eat much	9	15.3	9	15.3
	Can not leave food	2	3.4	7	11.9
	Eat continuously for long time	0	0.0	1	1.7
	Eat meal served in large plate	1	1.7	1	1.7
	Eat until feel full	1	1.7	1	1.7
Time of eating	Eat late supper	4	6.8	4	6.8
	Skip meal	3	5.1	4	6.8
Behavior related eating	Lay down immediately after eating meal	2	3.4	4	6.8
	Eat at any time when the others eat	0	0.0	1	1.7
	Eat something when I feel stress	1	1.7	0	0.0
	Can not refuse when the others offer	0	0.0	1	1.7
	Eat snacks surrounded myself	0	0.0	2	3.4
	Buy too much	0	0.0	1	1.7
	Eat often outside	1	1.7	1	1.7
Snacks	Eat sweet snacks too much	5	8.5	15	25.0
	Eat snacks after supper	6	10.2	5	8.5
Meal contents					
Eat specified foods too much	Eat too few vegetables	14	23.7	10	16.9
	Take much fat or fatty food	18	30.5	16	27.1
	Take much salt or salty food	7	11.9	7	12.1
	Eat grains too much	7	11.9	6	10.3
	Eat noodles too much	5	8.5	0	0.0
	Eat the main dish too much	4	6.8	2	3.4
	Eat meat too much	4	6.8	0	0.0
Alcohol	Drink alcohol too much	13	22.0	3	5.1
Sweets	Drink sweet beverage too much	3	5.1	5	8.5
	Eat fruits too much	1	1.7	3	5.2
	Eat sweets too much	6	10.2	18	30.5
Dietary balance	Eat unbalanced meal	2	3.4	0	0.0

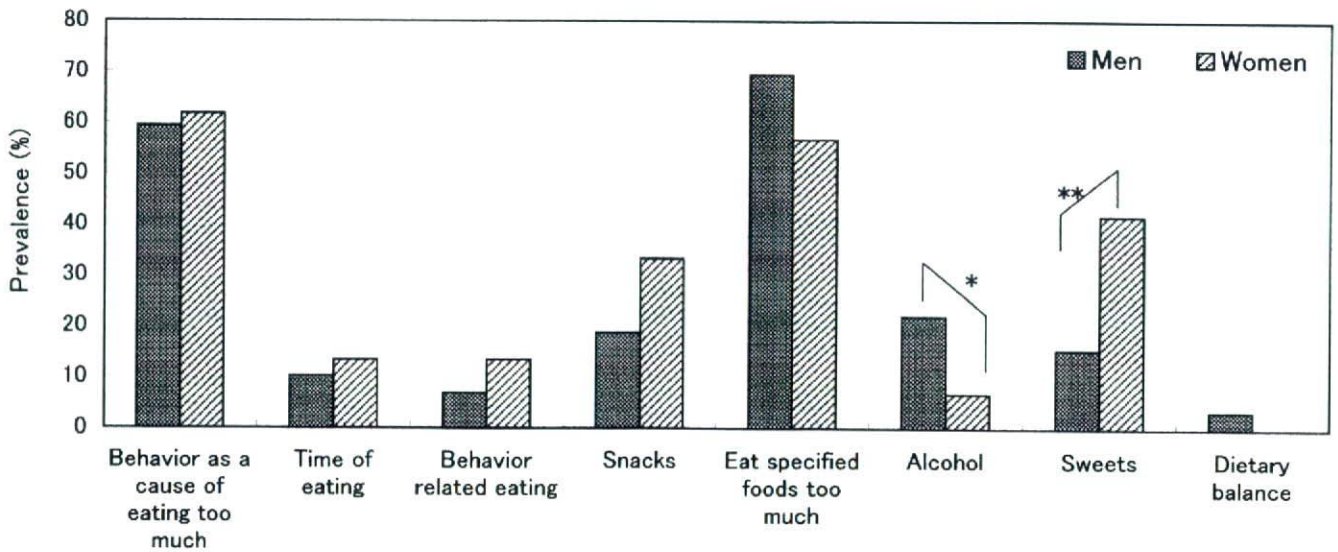

Fig. 1. Prevalence of dietary problems in men and women. The complete list of dietary problems is shown in *Table 3*. $*p < 0.05$, $**p < 0.01$

Table 2 shows the relationships between the awareness of the need to keep healthy by oneself and the other six psychological variables. In men, this awareness was significantly associated with level of motivation to resolve the situation ($p = 0.002$) and the availability of support from others ($p = 0.004$). In women, however, the awareness of the need to keep healthy by oneself was significantly associated with seeing the benefits of weight loss ($p < 0.001$), probability of losing weight ($p = 0.003$), motivation to resolve the situation ($p = 0.001$), and obstacle to executing the plans ($p = 0.027$).

Following the advice of dietitians, participants were asked to define the problems with their dietary habits and behaviors while setting personal goals for the following month. 30 recognized problems were classified into 8 categories and into two final categories of dietary behaviors and meal contents (***Table 3***). More than 40% of men and women recognized eating fast as a problem, and about 15% of men and women recognized eating too much as a problem. Insufficient intake of vegetables and excess intake of fat or fatty foods were recognized by both men and women. ***Figure 1*** shows the differences between men and women across the categories. With regard to meal contents, 41.7% of women reported eating too many sweets as a problem, whereas only 15.3% of men listed this as a problem ($p < 0.01$). In contrast, 22.0% of men reported drinking too much alcohol as a problem, whereas only 6.7% of women listed this as a problem ($p < 0.05$). The problems of behaviors as a cause of eating too much and eating specified food too mush were major common problems to men and women.

At their first meeting, dieticians and participants discussed which problems could be solved easily and which were the most important to solve. Following these evaluations, participants set and declared their personal dietary goals. Twenty-nine dietary goals were set and fell into the categories of dietary behavior and meal contents and were classified into seven categories (***Table 4***). The most prevalent goal of both men (31%) and women (39%) was chewing well during meal time. More women than men set goals of decreasing their snacking after supper and not eating snacks between meals. Similar percentages of men and women set the goals of eating more vegetables and decreasing their intake of fat or fatty foods. 23.7% of men set the goal of consuming less alcohol, whereas only 3.4% of women set this goal. Compared to men, more women set the goals of decreasing salt intake and replacing high-calorie snacks with low-calorie foods.

Compared to men, more women (30.5% vs. 50.0%) set a goal of decreasing the intake of snacks ($p < 0.05$). In contrast, more men (72.9%) set a goal of decreasing the intake of a specified food compared to women (48.3%; $p < 0.01$; ***Figure 2***). There were no differences between the genders with regard to the other five goal categories.

Table 4 ***The dietary goal-setting at first meeting***

Classification	Contents	Men n	Men %	Women n	Women %
Behaviors for diet					
Decrease intake of snacks	Eat less snacks after supper	4	5.8	9	15.0
	Do not eat anything 2 hours before sleep	2	3.4	2	3.4
	Eat fruits on the time decided	2	3.4	3	5.1
	Quit a snack or eat less	9	15.3	19	32.2
	Do not eat nuts	2	3.4	0	0.0
Decrease the amount of meal	Eat with chewing food well	18	30.5	23	39.0
	Leave food when finish meal	0	0.0	5	8.5
	Do not eat once full	1	1.7	2	3.4
	Do not eat continuing for long time	0	0.0	1	1.7
	Serve a meal individually	3	5.1	2	3.4
	Record the energy displayed on foods	2	3.4	0	0.0
Eat regularly	Do not skip meals	3	5.1	2	3.4
Order of certain foods	Eat vegetables first	5	8.5	6	10.0
	Take some drinks or soup first	0	0.0	2	3.4
Meal contents					
Decrease intake of specified foods	Decrease intake of grains	10	16.9	7	11.9
	Decrease intake of main meal	1	1.7	2	3.4
	Decrease intake of meals	5	8.5	4	6.8
	Decrease side dish with alcohol	2	3.4	0	0.0
	Decrease intake of alcohol	14	23.7	2	3.4
	Decrease intake of salt or salty food	1	1.7	6	10.0
	Decrease intake of fat or fatty food	15	25.4	14	23.7
	Decrease amount of supper meals	2	3.4	0	0.0
Increase the amount of specified food	Increase intake of vegetables	16	27.1	14	23.7
Replace with low-calories from high-calories	Replace a main dish with other low-calories	5	8.5	1	1.7
	Replace with other kinds of grains	1	1.7	0	0.0
	Replace snacks with other low-calories	2	3.4	9	15.0
	Replace drinks with other low-calories	4	6.8	4	6.8
	Replace alcohol with other low-calories	0	0.0	1	1.7

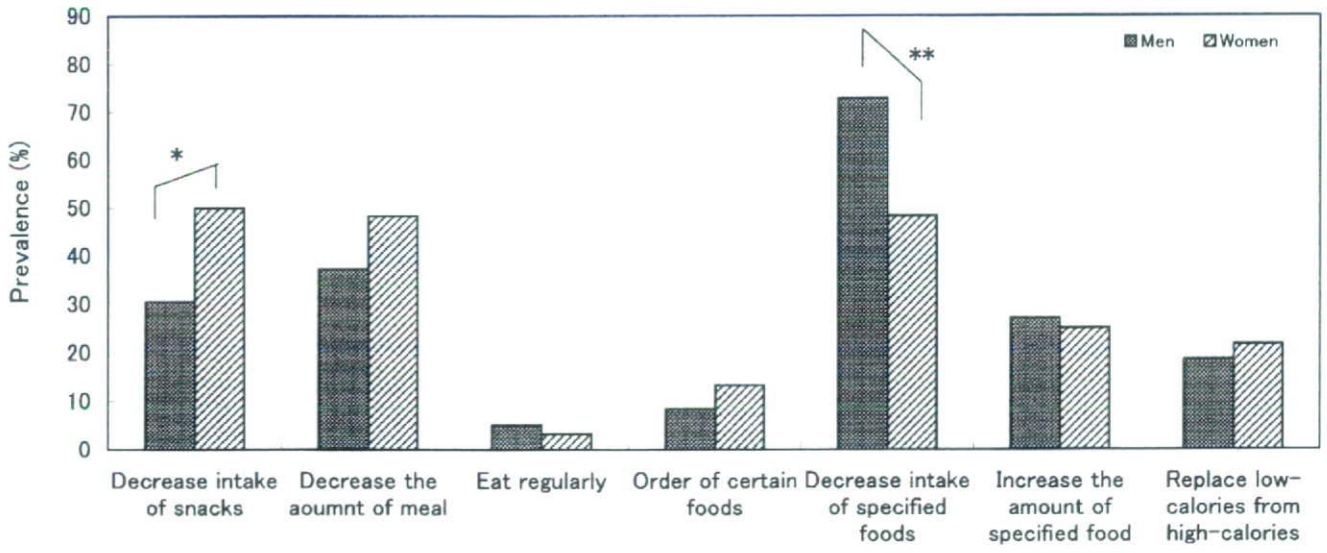

Fig. 2. Prevalence of dietary goals in men and women. The complete list of dietary goals is shown in *Table 4*. $*p < 0.05$, $**p < 0.01$

The final exercise goal was basically set at 10,000 walking steps per day. At the beginning of the program, 21 participants already walked over 10,000 steps per day on average, and their exercise goal was to maintain this level of exercise. The remaining participants walked fewer than 10,000 steps, and their goal was to walk an additional 1,000 steps per day every month, except those participants who had knee or lower back pain. For those participants who were walking fewer than 10,000 steps per day, the average walking steps per day at the beginning of the program were 6314.6 ± 1915.7 (SD) steps in men and 6780.6 ± 1582.4 steps in women, the additional walking steps first goals were 1232.8 ± 789.4 steps in men and 928.1 ± 597.1 steps in women, and the target exercise goals per day were 7581.6 ± 1934.7 steps in men and 7662.8 ± 1470.8 steps in women; there were no significant differences between genders.

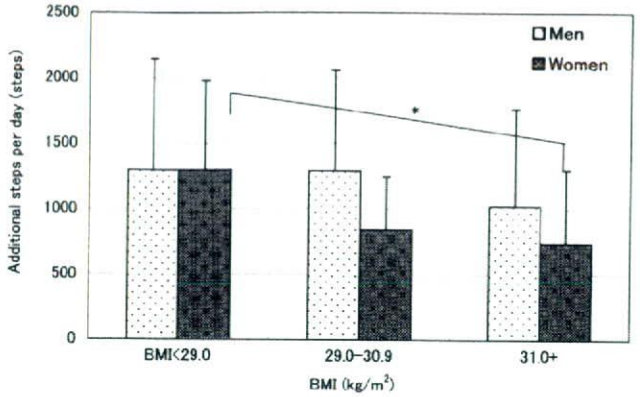

Fig. 3. The additional steps as an exercise goal among body mass index (BMI) tertiles in men and women.
Data represent subgroup mean ± SD. * $p < 0.05$

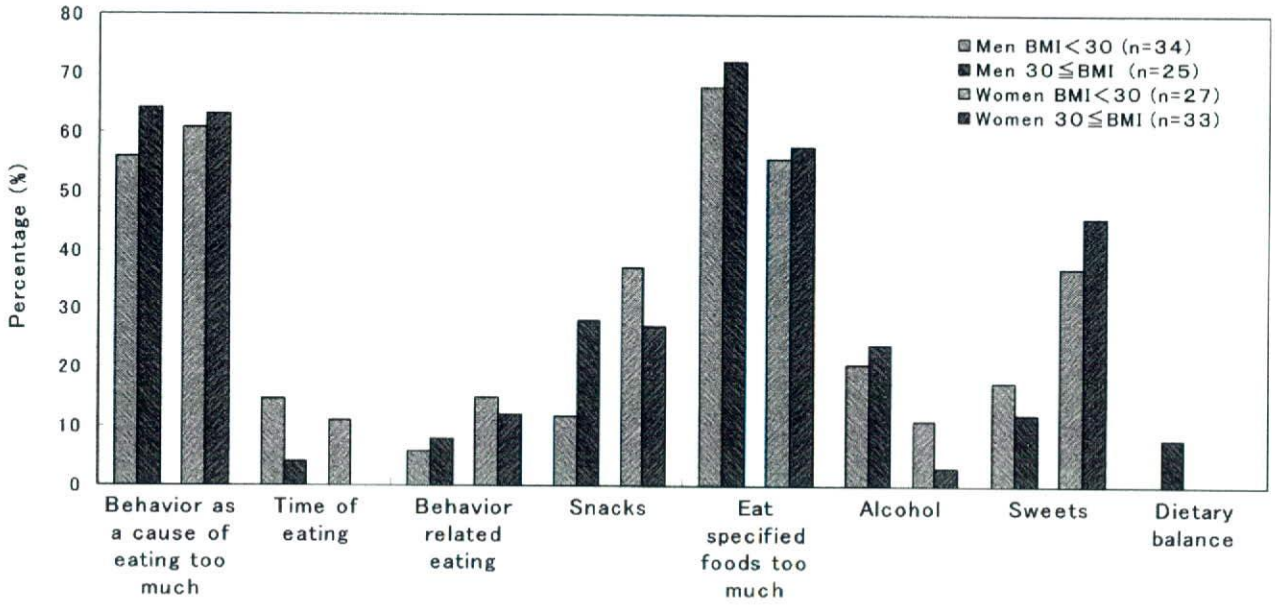

Fig. 4. Prevalence of the diet problems between body mass index (BMI) levels over or under 30 kg/m² in men and women.

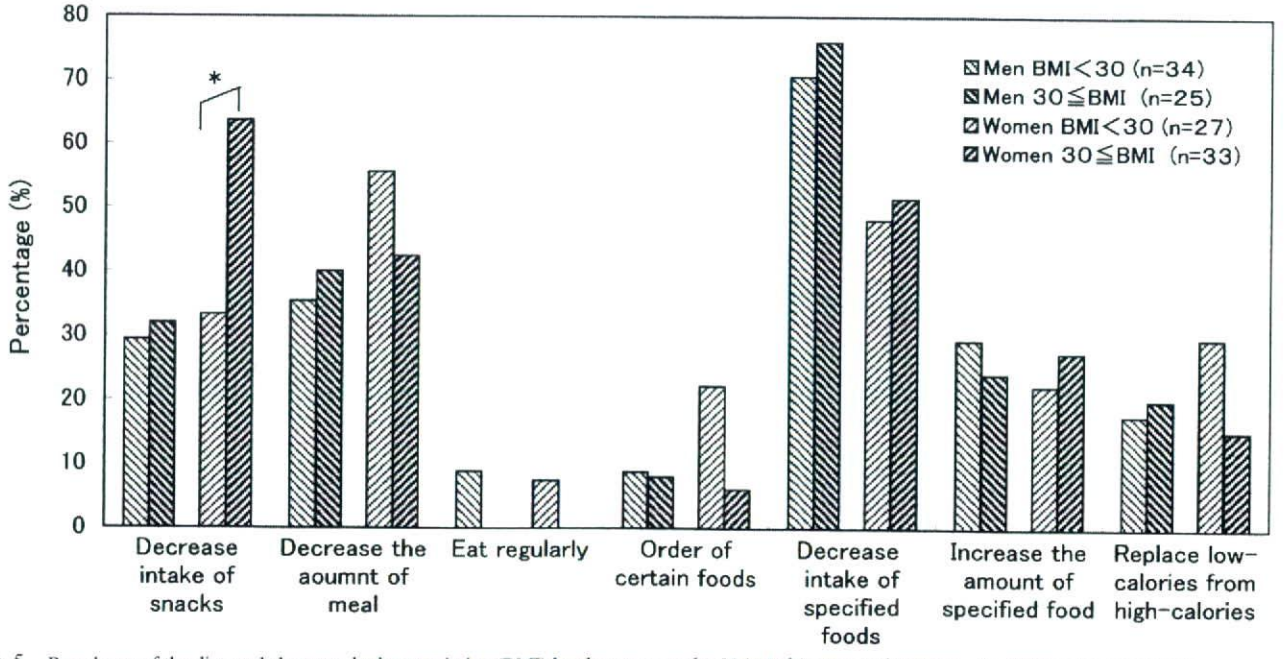

Fig. 5. Prevalence of the diet goals between body mass index (BMI) levels over or under 30 kg/m² in men and women. *$p < 0.05$; chi-square tests

Among those participants who set exercise goals, the relationship between BMI and the number of additional steps in the goal was analyzed by BMI tertiles. At baseline, there were no differences among BMI tertiles with regard to level of exercise. Those participants with BMI ≥ 31 set goals of significantly fewer additional steps compared to those with BMI < 29 ($p < 0.05$; *Figure 3*).

The mean BMI was 30.5 kg/m^2 and the median was 29.8s kg/m^2. We divided two groups over and under 30 kg/m^2 BMI, in order to clarify relationships between BMI and the dietary problems and dietary goals. There were not significant differences of the percentage of dietary problems between the BMI levels over and under 30 kg/m^2 in women and men. (*Figure. 4*). Among the dietary goals, the percentage of the decreasing intake of snack was different between the BMI levels over and under 30 kg/m^2 in women ($p < 0.05$; *Figure 5*).

Discussion

Most studies of traditional obesity treatment, including dietary restriction, nutritional education, and an increase in exercise, have demonstrated limited success. Other methods that have been used as an adjunct to dietary restriction in the treatment of obesity include lifestyle modification, drugs, therapeutic starvation, very low calorie diets, and surgical treatment. Long-term weight loss and maintenance requires management strategies including a combination of nutritional education and physical activity as well as behavioral interventions.[18]

In the SCOP study, we constructed a strategy for obesity treatment that mainly included cognitive behavioral treatment for nutritional education and physical activity. The dietitians interviewed participants about their levels of social support, stress, motivation, and self-efficacy. More men expected support from others, such as their wives and family than women (*Table 1*). In addition, in men, the awareness of the need to keep healthy by oneself was significantly associated with the motivation to resolve the situation and the availability of support from others (*Table 2*). Studies have shown that social support is an important aid in weight maintenance,[19,20] although the effect of family involvement on weight control is unclear. Wing et al. reported better weight maintenance when participants, especially women, were treated together with their spouses.[21] In contrast, Black and Lantz reported weight maintenance to be better when participants were treated alone, particularly men.[22] In the present study, however, men expected the support from others even though they were aware of the need to keep healthy by themselves in order to succeed in their weight loss.

The motivation to resolve the situation was significantly more prevalent in women than in men ($p < 0.05$; *Table 1*). In women, the awareness of the need to keep healthy by oneself was also significantly associated with recognition of the benefits and probability of losing weight, the motivation to resolve the situation, and realizing the obstacles to success. Many studies have reported that a higher motivation for weight reduction was related to greater weight loss.[23] However, the Weight Loss Readiness Test (WLRT), which was developed to access weight loss readiness[24] and motivation, failed to predict weight loss.[23,25]

In the SCOP study, the dietary goals were well matched with problems, as participants were first asked to list potential problems and then set goals based on these. More than 40% of men and women recognized eating too fast as a problem and about 15% saw eating too much as an issue (*Table 3*). Likewise, both men and women recognized as problems eating too few vegetables, too much fat or fatty foods, and high salt intake. More women listed eating sweet snacks as a problem, whereas more men saw alcohol intake as an issue (*Figure 1*).

Compared to men, significantly more women set the goal of decreasing the intake of snacks, whereas more men aimed to decrease the intake of specified foods, including drinking alcohol, revealing that the favorite foods and the problem eating behaviors were different between men and women (*Table 4 and Figure 2*). The dietary goal of "Decrease intake of fat or fatty food" was set mainly in the category of "Decrease intake of specified foods" in both men and women. In women, more participants over 30 kg/m^2 BMI focused about decreasing intake of snacks including 5 goals related snacks than that under 30 kg/m^2 BMI, even though the percentage of snacks in the problems was not different between BMI levels. The goals set by participants were in line with sound dietary advice, as studies have shown that weight loss and maintenance is associated with reduced frequency of snacks,[26] less dietary fat,[26-30] and increased intake of vegetables and fruits.[26]

The dieticians usually proposed setting an exercise goal of an additional 1,000 steps per day to the actual steps last month. Although there was no difference among BMI tertiles with regard to the mean number of walking steps at the beginning of the intervention, women in the highest tertile (BMI = 31+) set significantly fewer additional steps as an exercise goal (*Figure 3*), suggesting that women in this tertile hesitate to walk. In women, there was a significant difference in the percentage of decreasing intake of snacks as a dietary goal between BMI levels over and under 30 kg/m^2 (*Figure 5*). This result may show that the participants in SCOP could set the successful dietary goal to lose weight by themselves with the guidance of the dieticians, as reported in previous study.[26]

Self-monitoring of body weight and food intake were reported as important factors in weight loss as well as weight maintenance.[27,31,32] In this study, the participants self-monitored and recorded items such as weight, daily food intake, and daily evaluations of their personal dietary and exercise goals and reported to dieticians the results of their efforts at the end of each month.

Obesity is recognized as a complex disorder involving appetite regulation and energy metabolism, and it is associated with a variety of comorbid conditions. Many studies have shown that traditional obesity treatment has been effective over the short term, but long-term outcomes do not mirror those satisfactory results. Lang and Froelicher concluded that the combination of a low-calorie diet, an increase of physical activity, and behavioral therapy should be incorporated in obesity treatments.[18] They also found that interventions involving frequent behavioral therapy, such as weekly sessions, seemed to improve the participants' adherence to changes in eating and exercise patterns and produced better outcomes. Elfhag and Rossner reviewed a variety of potential factors and concluded that weight maintenance was associated with an internal motivation to lose weight, social support, better coping strategies, a better ability to handle life stress, self-efficacy, autonomy, assuming responsibility in life, and greater overall psychological strength and stability.[33]

This survey baseline data revealed that the psychological characters were different in gender and the problems and dietary and exercise targets were also different in gender and BMI.

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Original Article

Association of Personality (NEO-Five Factor Inventory) with Eating Behaviors and Physical Activity Levels in Obese Subjects in the Saku Control Obesity Program (SCOP)

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Abstract

BACKGROUND: Obesity is one of the most common risks for lifestyle-related diseases, but the personality of individuals in relation to obesity has not been well studied. We investigated the association of personality traits with physical activity levels and eating behaviors in obese subjects.

METHOD: The subjects were 116 males and 119 females in the Saku Control Obesity Program SCOP study. The influence of personality on obesity was analyzed using a questionnaire from the NEO-FFI. We analyzed the association of physical activity level (measured with an accelerometer) and eating behavior (assessed by a questionnaire) among the three classes (low, average, high) of scores within five personality domains.

RESULTS: Scores in the Neuroticism and Agreeableness domains of females were significantly higher than those of males. There were significant differences among the three classes of Neuroticism and Agreeableness with regard to physical activity levels. Eating behavior was associated with the Neuroticism and Openness domains. The scales of bad eating behavior related to obesity were positively correlated with scores in the Neuroticism domain in both males and females. In males the scale of all categories of eating behavior increased as scores in the Openness domain rose; in females the scale of "perception of constitution and weight" decreased as Openness scores rose.

CONCLUSION: Personality determined by NEO-FFI was related to physical activity level and eating behavior. In particular, the Neuroticism domain had great effects on these parameters.

KEY WORDS: obesity, personality, NEO-FFI, eating behavior, physical activities

Introduction

Obesity appears to be closely correlated with personality, and recent studies have shown that obese people are at increased risk of depression and Neuroticism.[1,2] A study using the NEO-Five Factor Inventory (NEO-FFI) reported that obese females had more neurotic tendencies compared with females who were not obese.[3] In addition, Yoshida et al reported that the effectiveness of treatment for obesity was influenced by differences in personality.[4]

To further investigate the effects of personality traits on obesity, we performed a psychological behavior analysis (NEO-FFI) of obese participants in a weight-loss intervention program. The present NEO-FFI [5] is a shortened version of the Revised NEO Personality Inventory (NEO PI-R). Yoshimura et al translated this version into Japanese, and its reliability and validity have been confirmed.[6] NEO-FFI is a questionnaire that measures personality traits within five domains, and it has been most widely used in the United States. The NEO-FFI has proven useful for the study of health consciousness and behavior in both young and elderly subjects.[7,8]

Although a wide array of research has shown a positive effect of weight loss in the prevention of lifestyle-related diseases, methods to achieve changes in physical activity and eating behaviors in obese individuals have not been well developed. In addition, no studies have examined how personality traits are related to the process of losing weight in obesity education programs. Therefore, we conducted a multifactorial study of the physical activity levels and eating behaviors among obese subjects using the NEO-FFI questionnaire. We also tried to clarify whether individual personality assessment can serve as a valuable tool in such individualized education programs.

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Method

The subjects and methods of this study were described in detail elsewhere in this supplement.[9] Subjects were 235 obese people (116 males and 119 females; 40–64 years) with BMI > 28.3 kg/m^2 at their last medical check-up at the Saku Central Hospital. The participants gave written informed consent prior to being enrolled in the SCOP study.

The NEO-FFI consists of 60 questions, 12 for each of five personality domains. For each question, subjects express agreement or disagreement on a five-point Likert scale: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, (5) strongly agree. The NEO-FFI is used to measure the five major domains of individual personalities (Neuroticism, Extroversion, Openness, Agreeableness, and Conscientiousness), which allow for a comprehensive assessment of normal adult personality. Raw scores of Neuroticism, Extroversion, Openness, Agreeableness, and Conscientiousness were converted into *T*-scores, and each domain was grouped into three classes: high (T = 56 and higher), average (T = 45-55), and low (T = 44 and lower).[10] *T*-scores have a mean of 50 and a standard deviation of 10 and allow for comparison of individuals across the population.

Physical activity levels were measured using an accelerometer (Suzuken, Nagoya, Japan); the details of how these levels were assessed is described elsewhere.[11] The device can monitor the number of steps as well as exercise intensity with the acceleration sensor, allowing calculation of the caloric expenditure through physical activity. Each subject received the device 2 weeks before the baseline health check-up. Participants were unable to view the data so that they would not consequently alter their normal routines of physical activity.

Participants'eating behavior was analyzed by a questionnaire in the Manual of Obesity 2006 written by the Japan Society for the Study of Obesity (see Appendix 1).[12,13] The questionnaire's 55 statements are based on the statements given by obese people in a clinical survey, and subjects were asked to agree or disagree on a four-point Likert scale: (1) disagree, (2) sometimes, (3) having a trend, (4) agree. The questionnaire is assessed by categorizing 51 items into the following eight categories: (1) perception of constitution and weight, (2) motivation for eating, (3) unhealthful eating, (4) feeling of fullness and hunger, (5) bad eating habits, (6) contents of diet, (7) unsteady eating pattern, and (8) total of all of them. One is a dummy question. The higher score in this questionnaire indicated worse in eating behavior. Based on each participant's answers; his or her eating behaviors were plotted along these eight axes and used for further analysis. Because we slightly modified the eating behavior questionnaire, the validity of the eight categories was analyzed using principal component analysis.

The associations between personality, physical activity levels, and eating behaviors were analyzed using SPSS® version 14.0 (SPSS Inc., Tokyo). Associations among the mean physical activity levels, eating behavior categories, and NEO-FFI classes were analyzed by ANOVA, Bonferroni test, and Games-Howell multiple comparison. Analysis was administrated according to each subject's sex because selecting the different question from 55 question to assess each category by sex. The database was processed using Excel®2003 (Microsoft, Redmond, WA, USA) and converted to SPSS.

Results

The mean and standard deviation of NEO-FFI raw scores of the subjects and the distribution of *T*-scores among the low, average, and high classes for each personality domain are shown in *Table 1* and *Figure 1*. The raw scores for both males and females coincided well, except for significantly higher scores in females in the domains of Neuroticism and Agreeableness. Within each sex, there was no significant difference in the distribution of *T*-scores across all domains. Correlation coefficients among the raw scores of the NEO-FFI are shown in *Table 2*. Significant negative associations were found between Neuroticism and Extroversion and between Neuroticism and Agreeableness in males. In females, however, significantly negative associations existed between Neuroticism and Extroversion, Neuroticism and Agreeableness, and Neuroticism and Conscientiousness, but significantly positive associations were found between Extroversion and Agreeableness, Extroversion and Conscientiousness, and Agreeableness and Conscientiousness.

Table 1 The raw score of NEO-Five Factor Inventory

	male (n = 116)	female (n = 119)	total (n = 235)
Neuroticism	22.8 ± 5.6	25.5 ± 6.8 *	24.2 ± 6.4
Extraversion	25.3 ± 5.6	26.7 ± 6.1	26.0 ± 5.9
Openness	28.2 ± 5.1	28.6 ± 4.5	28.4 ± 4.8
Agreeableness	29.7 ± 4.4	32.2 ± 4.3 *	31.0 ± 4.5
Conscientiousness	28.1 ± 5.2	28.5 ± 5.9	28.3 ± 5.5

Value present the mean ±SD
* Significantly diffelent between sex (P<0.05)

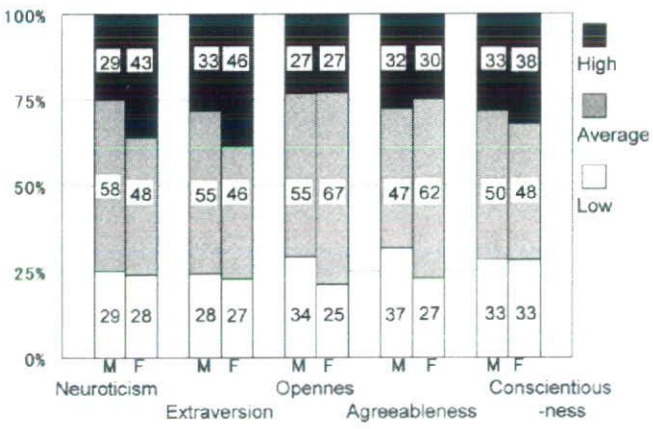


Fig. 1. The distribution of *T*-scores among the low class (T = 44 and lower), average class (T = 45–55), and high class (T = 56 and higher) in each personality domain of the NEO-FFI by sex. The values indicate the number of subjects (males, M, n = 116; females, F, n = 119)

· Relationship between NEO-FFI Scores and Physical Activity

Although the absolute number of daily step counts was greater in females (8015 ± 3126) than in males (7601 ± 3300), there was no significant difference between these values. METs h (exercise intensity × time) was similar in males and females: 3.0 ± 1.4 and 3.1 ± 1.3, respectively.

Tables 3 and 4 lists the number of steps and physical activity levels according to *T*-score class among the NEO-FFI domains. In females, daily step counts and METs·h were low in those with low Neuroticism scores, and physical activity was significantly higher in the average class than in the low class of Neuroticism.

Table 2 Correlation coefficients in the scales of the five domain of NEO-Five Factor Inventory

	male : n = 116				female : n = 119			
	Extraversion	Openness	Agreeableness	Conscientiousness	Extraversion	Openness	Agreeableness	Conscientiousness
Neuroticism	-0.30 *	0.08	-0.23 *	-0.12	-0.43 *	0.01	-0.24 *	-0.32 *
Extraversion		0.06	0.11	0.18		-0.02	0.32 *	0.47 *
Openness			0.18	0.16			0.15	0.01
Agreeableness				-0.15				0.25 *

* p<0.05

Table 3 The association between the daily step counts and NEO-Five Factor Inventory.class in each domain

		Low class			Average class			High class	
		mean ± SD	(n)		mean ± SD	(n)		mean ± SD	(n)
Neuroticism	male	7178 ± 3284	(26)	male	7479 ± 3424	(57)	male	8242 ± 3069	(28)
	female	6741 ± 2422	(28)	female	8692 ± 3467	(48)	female	8090 ± 2937	(43) * a
Extraversion	male	7945 ± 2118	(27)	male	7512 ± 3848	(52)	male	7455 ± 3222	(32)
	female	7435 ± 3036	(27)	female	7918 ± 2980	(46)	female	8454 ± 3319	(46)
Openness	male	7926 ± 3301	(34)	male	7254 ± 2967	(51)	male	7856 ± 3932	(26)
	female	8303 ± 3371	(25)	female	7789 ± 2632	(67)	female	8310 ± 3999	(27)
Agreeableness	male	8659 ± 3950	(34)	male	6703 ± 2542	(46)	male	7773 ± 3244	(31) * a
	female	8825 ± 3366	(27)	female	7898 ± 2830	(62)	female	7529 ± 3448	(30)
Conscientiousness	male	7428 ± 3180	(32)	male	7364 ± 2624	(50)	male	8200 ± 4361	(29)
	female	7102 ± 2696	(33)	female	8055 ± 3080	(48)	female	8696 ± 3425	(38)

* Significant between groups by ANOVA (P<0.05)
a : Significantly different between Low class and Average class (P<0.05)
Low class : *T*-scores = 44 and lower
Average class : *T*-scores = 45 - 53
High class : *T*-scores = 56 and higher

Table 4 The association between METs · h and NEO-Five Factor Inventory class in each domain

		Low class			Average class			High class	
		mean ± SD	(n)		mean ± SD	(n)		mean ± SD	(n)
Neuroticism	male	2.8 ± 1.3	(26)	male	3.0 ± 1.5	(57)	male	3.3 ± 1.3	(28)
	female	2.6 ± 1.0	(28)	female	3.4 ± 1.5	(48)	female	3.2 ± 1.2	(43) * a
Extraversion	male	3.2 ± 0.9	(27)	male	3.0 ± 1.7	(52)	male	3.0 ± 1.3	(32)
	female	2.9 ± 1.3	(27)	female	3.1 ± 1.3	(46)	female	3.3 ± 1.4	(46)
Openness	male	3.1 ± 1.4	(34)	male	2.9 ± 1.3	(51)	male	3.1 ± 1.7	(26)
	female	3.2 ± 1.5	(25)	female	3.0 ± 1.1	(67)	female	3.3 ± 1.7	(27)
Agreeableness	male	3.5 ± 1.8	(34)	male	2.6 ± 1.1	(46)	male	3.1 ± 1.3	(31) * a
	female	3.5 ± 1.5	(27)	female	3.1 ± 1.2	(62)	female	2.9 ± 1.5	(30)
Conscientiousness	male	3.0 ± 1.4	(32)	male	2.9 ± 1.2	(50)	male	3.3 ± 1.9	(29)
	female	2.8 ± 1.1	(34)	female	3.2 ± 1.4	(47)	female	3.4 ± 1.5	(38)

* Significant between groups by ANOVA (P<0.05)
a : Significantly different between Low class and Average class (P<0.05)
Low class : *T*-scores = 44 and lower
Average class : *T*-scores = 45 - 53
High class : *T*-scores = 56 and higher

In males, there were no significant differences in daily step counts and METs·h among the Neuroticism classes. With regard to Agreeableness scores, in males both physical activity measures were lower in the average class than in the low and high classes. In females there was an increase in daily step counts and METs·h as Conscientiousness scores rose, but no significant difference existed among the classes according to ANOVA.

· Association between Eating Behavior and NEO-FFI Scores

The results of the principal component analysis with a varimax rotation for eating behavior are shown by sex in *Table 5*. According to the principal component analysis, 16 factors had eigenvalues > 1.0. For each sex, we chose the five highest factors, where the cumulative percentage for attribution was no less than 40%. In males, these factors were: (1) eat between meals; (2) fast eating·gluttony; (3) uncertainty of hunger; (4) promiscuous eating habits·dining out; and (5) supper conscious. In females the top factors were: (1) comfort eating·Western food; (2) uncertainty of hunger; (3) fast eating; (4) dining out; and (5) promiscuous eating habits. We examined the relationship between principal component scores of these factors and the raw scores in the five personality domains; although some associations were significant, the coefficients were all less than 0.265 (data not shown).

Stronger correlations were found between the eight eating behavior categories within the Manual of Obesity 2006

Table 5-1 Rotated factor loading based on rank correlations of eating behaiver

Male	Factor 1 Eat between meals	2 Fast eating· Gluttony	3 Uncertainty of hunger	4 Promiscuous eating habits· Dining out	5 Supper-conscious
I often eat between meals.	0.817	0.073	0.019	0.142	0.025
I often eat snacks.	0.778	0.061	-0.013	-0.016	0.073
I tend to eat anything when I have nothing to do.	0.671	0.115	0.181	0.089	-0.044
I often eat sweet rolls.	0.585	-0.082	0.048	0.064	0.089
I always keep food around.	0.550	0.124	0.158	0.311	0.030
I often have a midnight snack.	0.543	0.043	-0.021	0.247	0.064
I don't have a sense of hunger and fullness.	0.403	0.214	0.323	0.195	0.106
I eat a meal fast.	0.094	0.825	-0.069	0.107	-0.059
I don't chew well.	0.051	0.811	0.119	0.105	0.074
I eat as putting food into my mouse one after another.	0.043	0.759	0.236	0.010	0.042
I stuff food into my month.	-0.019	0.632	0.140	0.125	0.058
I'm told I eat a lot.	0.390	0.515	0.241	0.024	0.129
I don't satisfied unless I eat my fill.	0.340	0.440	0.033	0.156	0.159
I tend to order more than I can eat at eating out.	0.085	0.414	0.112	0.063	0.191
Just a meal, I can eat my favorite foods a meal	0.336	0.390	0.206	0.001	0.134
I cannot help cooking more than enough.	-0.008	0.198	0.757	0.074	-0.022
I eat a lot at dinner compared with other meals.	0.062	0.283	0.724	0.076	0.212
I'm uncomfortable unless I keep enough food let in a refrigerator.	0.191	0.017	0.625	0.165	0.071
When I find something good at the grocery store, I buy it even if it is not planed.	0.192	0.053	0.483	0.006	0.424
I eat well even if I have a cold.	0.029	0.267	0.399	0.046	-0.093
I have dinner late.	0.012	0.103	0.039	0.768	0.158
I don't have a regular meal rhythm.	0.233	0.183	0.103	0.649	-0.048
I don't have enough time to eat meal.	0.324	0.324	0.176	0.643	-0.012
I am a night person	0.098	-0.039	-0.199	0.554	0.157
I often eat out and have food delivered.	0.007	-0.061	0.274	0.545	0.308
I often buy at the convenience stores.	0.288	0.070	0.071	0.379	0.262
I have much occasions to attend dinner at drinking parties.	0.068	0.016	-0.060	0.145	0.781
I have many social occasions to eat.	0.101	0.219	0.066	0.203	0.681
I drink beer often.	-0.152	-0.009	0.155	0.010	0.572
I am not satisfied when a very few-food items are served at dinner.	0.174	-0.025	0.398	-0.057	0.535
I can't sleep when I feel hungry.	0.045	0.137	0.183	0.107	0.417

Principal components analysis with varimax rotation
Figure in front of each question is the number of each items of questionnaire (see Appendix)

Table 5-2 Rotated factor loading based on rank correlations of eating behaiver

Female	Factor 1 Comfort eating, Western food	2 Uncertainty of hunger	3 Fast eating	4 Dining out	5 Promiscuous eating habits
I tend to eat fruits and sweets when I see them.	0.772	0.275	0.080	0.134	0.064
Just a meal, I can eat my favorite foods a meal	0.711	-0.014	0.253	-0.116	0.383
I tend to eat anything when I have nothing to do.	0.637	0.180	-0.020	0.257	-0.079
I tend to eat when I see others eating.	0.633	0.336	0.030	0.156	-0.150
I love sweets.	0.611	0.132	0.123	0.073	0.227
I always gain weight whenever I take long holidays.	0.603	-0.016	0.006	0.210	-0.133
I regret after I eat a lot.	0.575	0.282	0.218	0.087	-0.003
I often eat between meals.	0.574	0.124	0.068	0.003	0.237
I don't satisfied unless I eat my fill.	0.565	0.200	0.324	-0.076	0.153
I tend to eat when I am irritated or stressed.	0.554	0.138	-0.044	0.077	0.276
I believe that I gain weight because I like sweets	0.504	0.108	-0.054	0.081	0.048
I'm told I eat a lot.	0.502	0.203	0.250	0.094	-0.086
I eat more western food than Japanese food.	0.468	-0.275	0.118	0.445	0.050
I like greasy food.	0.420	-0.009	0.208	0.233	-0.022
I eat a lot at dinner compared with other meals.	0.136	0.785	0.022	-0.108	0.113
I cannot help cooking more than enough.	0.154	0.750	0.157	-0.215	0.052
I'm uncomfortable unless I keep enough food let in a refrigerator.	0.220	0.687	0.062	0.025	-0.165
I tend to order more than I can eat at eating out.	0.104	0.568	0.063	0.289	0.222
When I find something good at the grocery store, I buy it even if it is not planed.	0.340	0.471	0.166	0.120	0.172
I always keep food around.	0.326	0.403	0.153	0.274	0.152
I eat a meal fast.	0.047	0.053	0.818	0.162	-0.045
I don't chew well.	0.133	0.123	0.776	0.081	0.109
I eat as putting food into my mouse one after another.	0.238	0.159	0.632	0.121	0.126
I often buy at the convenience stores.	0.171	-0.078	0.148	0.755	0.194
I often eat fast food like hamburgers.	0.187	-0.010	0.025	0.718	-0.134
I eat meal a lot.	0.263	-0.145	0.207	0.525	0.090
I often eat out and have food delivered.	-0.059	0.194	0.196	0.507	0.314
I don't have a regular meal rhythm.	0.069	0.124	-0.039	0.040	0.765
I have dinner late.	0.154	-0.004	0.147	0.124	0.717
I often have a midnight snack.	0.250	0.230	0.197	0.010	0.485

Principal components analysis with varimax rotation
Figure in front of each question is the number of each items of questionnaire (see Appendix)

questionnaire and the raw scores in each of the personality domains *(Table 6)*. In females, scores in the eight categories had negative associations with the domains of Extroversion, Openness, Agreeableness, and conscientiousness. In both males and females, however, the associations with Neuroticism were positive. Extroversion scores had significant positive associations with eating behavior scores only in males, whereas Agreeableness and Extroversion scores had significant negative associations with these scores only in females.

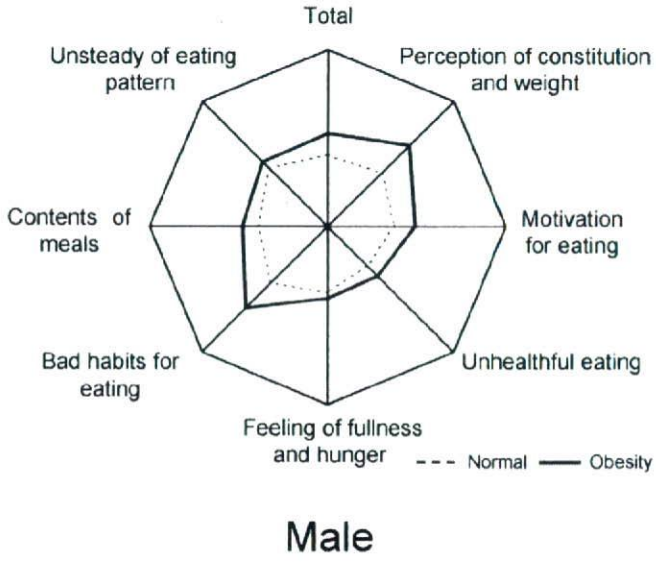
We compared the mean score of the eight eating behavior categories by sex with those from a previous study on normal-weight subjects *(Fig. 2)*.[12] In both males and females, the scales of "perception of physical constitution and weight" and "bad habits for eating" in our subjects were much higher than those of the normal-weight subjects.

Diagrams of the eight eating behavior categories by three classes (low, average, high) of Neuroticism and Openness are shown in *Figure 3* (no other domains showed significant associations). Significant differences among the three classes of Neuroticism scores were seen in the categories "unhealthful eating" and "feeling of fullness and hunger" in males. In all categories, the higher the Neuroticism class, the higher the eating behavior score. Females showed a similar trend, except "total points," "unsteady eating pattern," and "contents of meals" also showed significant difference between Neuroticism classes. Among the three classes of Openness scores, there were significant differences in the eating behavior categories of "total points," "motivation for eating," "unhealthful eating," and "unsteady eating pattern" in males. In females, "contents of meals," and "perception of constitution and weight" showed a significant difference among Openness classes.

Table 6 Correlation coefficients between NEO-Five Factor Inventory scale and principal component score by eating behavior questionnaire

		Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness
Male	Total point	0.221 *	0.204 *	0.272 *	0.007	-0.015
	Conception of body constitution and weight	0.090	0.120	0.084 *	-0.142	0.123
	Motivation for eating	0.112	0.204 *	0.273	0.079	0.030
	Unhealthful eating	0.338 *	0.022	0.278 *	-0.082	0.099
	Feeling of fullnes and hunger	0.313 *	0.141	0.155	-0.023	0.070
	Bad habits for eating	0.212 *	0.197 *	0.174	0.058	-0.056
	Contents of meals	0.015	0.192 *	0.111	0.009	-0.136
	Unsteady of eating pattern	0.224 *	0.114	0.316 *	0.051	-0.111
Female	Total point	0.277 *	-0.055	-0.085	-0.133	-0.211 *
	Conception of body constitution and weight	0.143	-0.046	-0.271 *	-0.176	-0.225 *
	Motivation for eating	0.161	0.087	0.012	0.052	-0.106
	Unhealthful eating	0.353 *	-0.136	-0.024	-0.112	-0.090
	Feeling of fullnes and hunger	0.238 *	-0.114	-0.042	-0.168	-0.140
	Bad habits for eating	0.148	-0.003	-0.082	-0.103	-0.114
	Contents of meals	0.240 *	-0.098	-0.208 *	-0.207 *	-0.240 *
	Unsteady of eating pattern	0.203 *	-0.070	0.095	-0.081	-0.192 *

* $p<0.05$



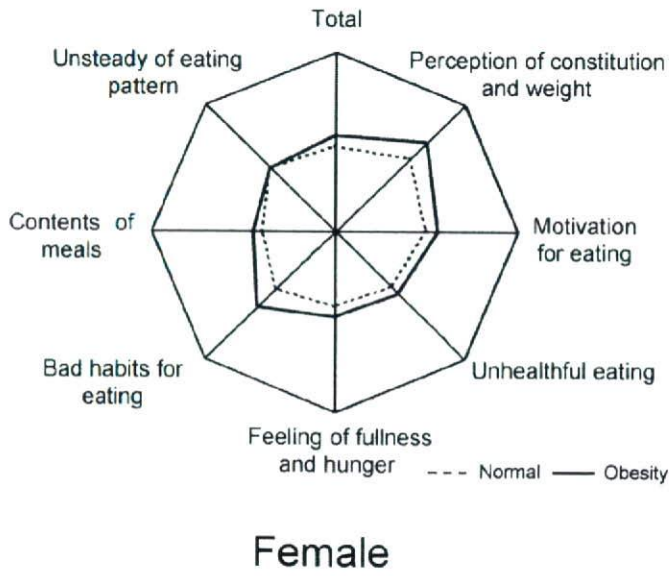


Fig. 2. Comparison between the eating behaviors of obese subjects in this study and normal-weight subjects in a previous study.[12] Displayed are the scores of obese subjects (solid line) and normal-weight subjects (dash line) by sex.

*Fig. 3*a

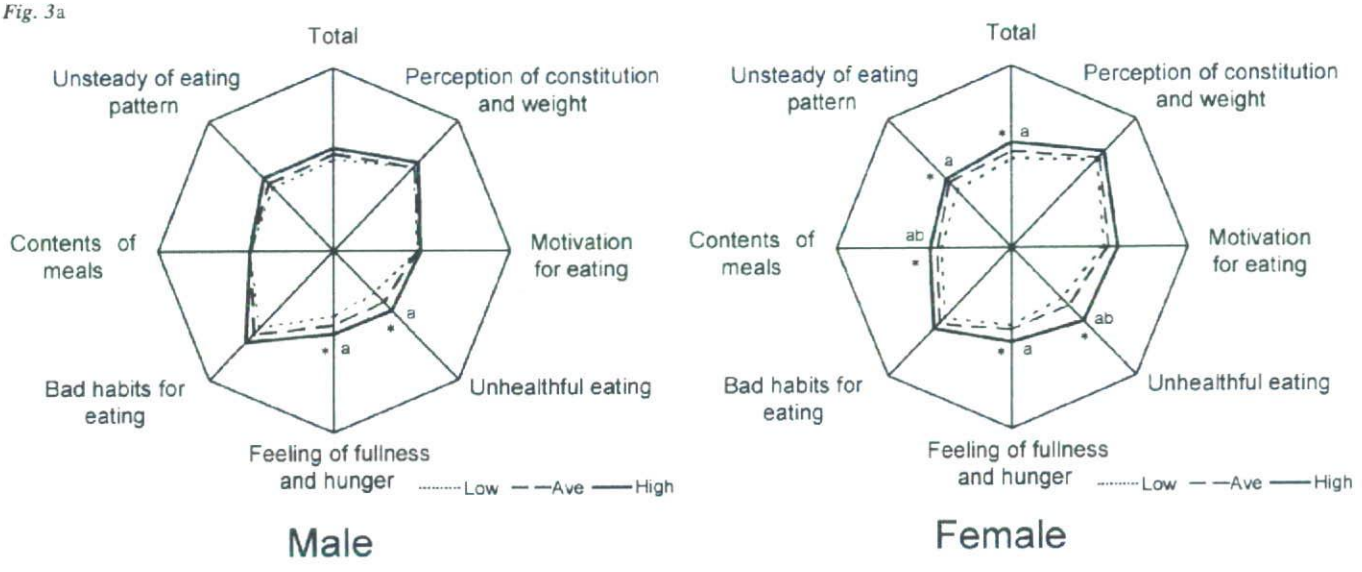


*Fig. 3*b

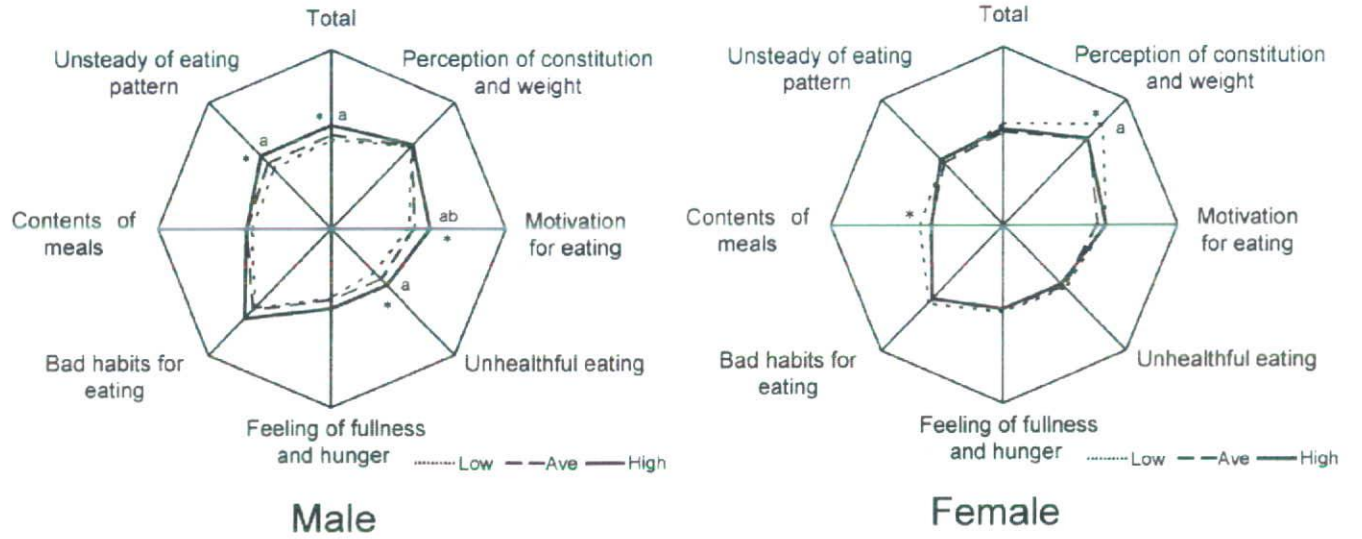


Fig. 3. Comparison of the eating behaviors among subjects in the low, average, and high classes of Neuroticism (a) and Openness (b), separated by sex (males, left; females, right). Asterisks indicate significant difference among the three classes (ANOVA, *p < 0.05). Each superscript indicates significant difference between High vs Low (a: P<0.05), significant between High vs Ave in (b:P<0.05), significant between Ave vs Low (c: P<0.05) by multiple comparison.

Discussion

Basic personality is considered to be static throughout a person's life unless a significant incident occurs.[14] Therefore, personality is an important element that affects an individual's lifestyle, including eating behavior and physical activities. However, the relationship between lifestyle and the personality traits of obese people has not been studied in detail.

According to Costa and McCrae, the five-factor model of personality should not be used to judge the value (i.e., good vs. bad) of particular personality traits;[14] rather it allows for a comprehensive assessment of normal adult personality. Consistency was reported between the five personality domains of the NEO-FFI as rated by the subjects themselves and by close family and friends. This consistency suggests that the questionnaire in the NEO-FFI can be successfully translated into different languages without losing efficacy.

Considering the distribution of NEO-FFI personality domains among the subjects in this study, in females there was a tendency to *T*-score higher in Neuroticism and Extroversion, although there were no significant differences among the low, average, and high classes in these domains. The mean *T*-score and the standard deviation of the subjects in this study were 56 and 28, whereas those in the normative population were 50 and 10 for each domain. Thus, compared with the subjects who are representative samples of other area examined in previous studies [6,15] our subjects tended to be somewhat more neurotic and extroverted. It is expected that these differences were influenced from obesity. However, they might are influenced from regional difference. An American national survey[16] showed that the distribution of NEO-FFI was not effected by the differences of age, race and sex. Thus, it is necessary to compare the subjects in same region for more reliable results.

Costa and Mcrae said that an individual with high scores of Neuroticism tends to be nervous, uneasy, and very sensitive to stress, whereas a person with low scores of Neuroticism tends to be relaxed and stable.[14] A study by Gidi showed a positive

correlation between BMI and Neuroticism scores in both obese and the non-obese females.[3] In addition, previous studies showed that Neuroticism is positively correlated with levels of Eating Disorder and bad eating behavior.[17,18] In this study, females in the high class for Neuroticism showed high scores for eating behaviors. Thus, it is suggested that a person with high scores of Neuroticism may have some problems related to eating behavior. Also, females in the high class for Neuroticism had high daily step counts and high METs·h. Considering the result, people with a low Neuroticism score, who tend to be relaxed, secure, and confident, may not overeat but may also engage in little physical activity.

In males, the scores of all categories of eating behavior increased as Openness scores rose. People with a high degree of Openness tend to be very curious and quick to take positive actions,[10] and their curiosity and activities might cause somewhat of a rise in appetite. In contrast, we found no positive association between Openness scores and eating behaviors among females. Thus, it appears that the effects of Openness on eating behavior differ between males and females.

With regard to Agreeableness, the average class of males showed low values for daily step counts and METs·h, whereas those in the low and high classes had higher physical activity. Meta analysis studying the correlates of personality and physical activities did not show the association between Agreeableness and physical activities until 2006.[19] Subjects of the studies which use NEO-FFI including this meta-analysis were selected from students, cancer survivors, elderly people; were not middle-aged people such as our study. It isn't still clear that there was the association between Agreeableness and physical activities. It is necessary to clearly the association of NEO-FFI and physical activities in greater number of samples with and without obesity in general population including middle-aged people.

According to our analysis based on the NEO-FFI, different personality trait distributions were found between obese people and the general population, so further study regarding personality traits is necessary for the obese population. For instance, among the five personality domains, there was a significant difference in eating behaviors among the three classes of Neuroticism in both males and females, with the scores of nearly all categories of eating behavior increasing as Neuroticism scores rose. The associations between eating behaviors, physical activity levels, and personality traits defined by the NEO-FFI showed that personality analysis can serve as a useful tool in health education. As seen in *Figure 2*, obese people showed a broader range of scores for the eight categories of eating behavior compared to the general adult population.[12] Using this eating behavior questionnaire, we were able to identify which categories caused more problems for each subject, which can then be used to improve an individual's eating behavior through nutritional education.

Although personality has long been considered to be unchangeable throughout an individual's life, Adil et al. recently reported that the personality scales have changed in a short period of time.[20] Another study reported that the NEO-FFI scales differ between elderly people and college students.[21] Thus, if personality can change over the course of a person's life, these baseline data should help us to elucidate which pre-intervention traits allow for more successful behavior modification with regard to eating behavior and physical activity.

Questionaire of eating behavior

	Question	Question number from Mannual of Obesity
1	I often have a midnight snack.	4
2	I am a night person	18
3	I don't have a regular meal rhythm.	27
4	I often eat between meals.	21
5	I don't have enough time to eat meal.	47
6	I have dinner late.	37
7	I don't eat breakfast.	48
8	I'm often told I eat a lot.	8
9	Just a meal, I can eat my favorite foods a meal	13
10	I don't satisfied unless I eat my fill.	15
11	I regret after I eat a lot.	32
12	I can't sleep when I feel hungry.	39
13	I think about next meal just after a meal.	45
14	I often eat snacks.	11
15	I like strong seasoning.	14
16	I often eat fast food like hamburgers.	30
17	I like greasy food.	43
18	I like noodles.	19
19	I often eat sweet rolls.	40
20	I love sweets.	52
21	I tend to eat left-over food because I don't want to waste.	12
22	I tend to eat when I am irritated or stressed.	16
23	I always keep food around.	23
24	I tend to eat when I see others eating.	24
25	I tend to eat fruits and sweets when I see them.	34
26	I always gain weight whenever I take long holidays.	20
27	I tend to eat anything when I have nothing to do.	31
28	I believe myself to gain weight more easily than others.	42
29	I believe myself to gain weight even by drinking water.	22
30	I eat a meal fast.	1
31	I eat as putting food into my mouse one after another.	55
32	I don't chew well.	25
33	I stuff food into my month.	41
34	I tend to order more than I can eat at eating out.	28
35	I cannot help buying more food than necessary.	33
36	I cannot help cooking more than enough.	38
37	I believe that I gain weight because I like sweets	2
38	I often buy at the convenience stores.	3
39	I eat a lot at dinner compared with other meals.	35
40	I gain weight because I have not sufficient physical activity.	36
41	I'm uncomfortable unless I keep enough food let in a refrigerator.	5
42	When I find something good at the grocery store, I buy it even if it is not planed.	44
43	I drink beer often.	46
44	I am not satisfied when a very few-food items are served at dinner.	17
45	I don't have a sense of hunger and fullness.	49
46	I have many social occasions to eat.	50
47	I don't loose weight although I don't so much.	51
48	I tend not to be hungry before meals.	53
49	I eat meal a lot.	54
50	I gain weight because I lie down soon after I finish meal.	6
51	I have much occasions to attend dinner at drinking parties.	7
52	I get irritated when I'm hungry.	9
53	I eat well even if I have a cold.	10
54	I eat more western food than Japanese food.	29
55	I often eat out and have food delivered.	26

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Original Article

The Use of a Uniaxial Accelerometer to Assess Physical-activity-related Energy Expenditure in Obese Men and Women: Saku Control Obesity Program (SCOP)

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Abstract

INTRODUCTION: Energy expenditure (EE) associated with physical activity is negatively correlated with prevalence of obesity and related diseases, and exercise plays a major role in prevention and treatment of these diseases. We determined baseline daily step-count and physical activity-related energy expenditure (PAEE) in 230 obese subjects (40–64 years old) participating in the Saku Control Obesity Program. The secondary purpose of this study was to determine the association between abdominal fat and amount of physical activity.

METHODS: Daily step-count and PAEE were measured using a uniaxial accelerometer. The subjects wore the uniaxial accelerometer on their belt from the time they woke up until going to bed for 2 weeks. Adjusted PAEE (METs·h/day) was calculated based on daily PAEE and body weight.

RESULTS AND CONCLUSIONS: Daily step-count, PAEE, and adjusted PAEE were 7,815±3,211 (mean±SD) steps/day, 258±115 kcal/day, and 3.09±1.38 METs·h/day, respectively. There were no significant differences in daily step-count or adjusted PAEE between men and women. Daily step-count and adjusted PAEE were somewhat lower than the reference values for the quantity of physical activity for health promotion (8,000-10,000 steps/day and 3.3 METs·h/day) established by the Ministry of Health, Labour, and Welfare of Japan. BMI, visceral fat area, and abdominal circumference were negatively and weakly correlated with daily step-count and adjusted PAEE ($r=-0.13$ to -0.19, $P<0.05$ to 0.01). These results suggest that the amount of physical activity assessed by uniaxial accelerometry is partially associated with not only systemic obesity but also abdominal obesity.

KEY WORDS: accelerometer, energy expenditure, daily step-count, obesity, physical activity

Introduction

The energy expenditure (EE) associated with physical activity is negatively correlated with the prevalence of obesity and related diseases, such as diabetes, hypertension, and cardiovascular disease, and exercise has been shown to play a major role in the prevention and treatment of these diseases.[1-3] When developing treatment strategies for these diseases, including nutritional education, quantitative information related to physical activity is required to provide more effective goals. Thus, to prevent and treat these diseases more effectively, information regarding physical activity is useful, not only for researchers and healthcare workers but also for the general public.

Activity monitoring based on an accelerometry sensor is a useful method for obtaining objective information on physical activity patterns and for estimating the related EE,[4,5] because this type of sensor (Lifecorder; Suzuken Co. Ltd., Nagoya, Japan) can continuously measure the intensity, duration, and frequency of activity. The device has a unique algorithm for assessment of PAEE, especially unstructured activities. In addition, several studies indicated that the EE during running and walking estimated using this device correspond to the EE measured by indirect calorimetry, and the device was also more effective for measuring EE in free-living conditions as compared with a metabolic chamber.[6,7]

Increasing physical activity and decreasing caloric intake are indispensable for the improvement of excess weight and obesity. The Saku Control Obesity Program (SCOP) is a randomized control crossover study that aims to reduce visceral fat in overweight and obese subjects by interventions of physical activity and diet. Our systematic review suggested that an increase in adjusted PAEE at 10 METs·h/week (1.38 METs·h/day) is necessary to reduce visceral fat area in overweight and obese subjects.[8] The increase in adjusted PAEE corresponds to an increase of nearly 3,000 steps/day. Thus, all SCOP subjects receive physical activity modification education so that their daily step-count increase gradually by 3,000 steps/day. As each subject's target for modification of physical activity depends on the baseline level, accurate baseline measurements of physical activity are needed. The first purpose of the present study was to accurately determine the baseline status of physical activity using a uniaxial accelerometer. Furthermore, there have been few studies of the relationship between abdominal obesity and physical activity. Therefore, the second purpose of this study was to determine the association between visceral fat area measured by CT scan and amount of physical activity estimated by accelerometry.

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Methods

Each year about 7,000 examinees came to in Saku Health Doc Center for health checkups. Including all visits, the Saku Health Doc Center database contains approximately 197,000 records. We used the database to select initial examination records, and about 45,000 examinees were identified. For this study, the inclusion criteria were age 40–64 years and a body mass index (BMI:kg/m^2) within the upper quintile (28.3). Exclusion criteria were psychiatric conditions or physical conditions (i.e., significant hepatic or renal dysfunction and significant cardiovascular disease such as heart failure, stroke, and transient ischemic attacks) that would preclude full participation in the study; current treatment for obesity; current treatments known to affect eating or weight (e.g., medications). A total of 917 people whose BMI was more than 28.3 (upper quintile) were identified in the health checkup database, and 235 participants were enrolled in the Saku Control Obesity Program (SCOP).[9]

Five subjects who did not wear the accelerometer for 7 days or more were excluded from the study. Of the remaining 230 subjects, 111 were male and 119 were female. All research procedures of SCOP were performed according to the Helsinki Declaration. All subjects gave their written informed consent to participation in the study, and all procedures were reviewed and approved by the Ethical Review Board of the National Institute of Health and Nutrition.

To determine the baseline values of physical activity, each subject wore a uniaxial accelerometer on his or her belt from the time of waking to going to bed for 2 weeks. Measurements were as follows: daily step-count; PAEE; adjusted PAEE for body weight; and time spent in light, moderate, and vigorous physical activity. As the daily physical activities varied across the measurement period, daily mean values were calculated.

The activity monitor measures acceleration in the vertical direction. According to technical details provided by the manufacturer (Suzuken Co.,Ltd.), it samples the acceleration at 32 Hz and assesses values ranging from 0.06 to 1.94 g (where 1.00 g is equal to the acceleration of free fall). The acceleration signal is filtered by an analog band-pass filter and digitized. The frequency of acceleration signals is used to determine the step frequencies. Studies have shown that during walking the step frequencies measured by the accelerometer are within ±3% of the actual number of steps.[10] A maximum pulse over 4 s is taken as the acceleration value, and the activities are categorized into 11 activity levels based on the pattern of the accelerometer signal. The activity levels are subsequently converted by an algorithm to calculate EE (kcal) based on the following principle: when the sensor detects or more three acceleration pulses for 4 consecutive seconds, the activities are recognized as physical activity and are categorized into one of 9 activity levels (levels 1.0–9.0). The activity levels are calculated and counted every 4 s. The activity levels for ranges from 1.0 to 9.0 in steps of one unit corresponded to 1.465, 2.075, 2.808, 3.601, 4.537, 5.737, 7.324, 9.460, and 10.661 cal/kg/4 s, respectively.[7] There was a strong correlation between the activity levels and the measured EE while walking (r^2=0.93; P<0.001).[7] The daily PAEE (kcal) was calculated by summing the EE corresponding with activity levels every 4 s (cal/kg/4 s) and the product of the body weight (kg) of each subject.

If an acceleration pulse due to physical activity (*i.e.*, corresponding to activity levels 1.0–9.0) is not followed immediately by another acceleration pulse, it is not counted as 0.0 but level 0.5 is arbitrarily assigned for 3 min. It is assumed that the subject is standing up (or sitting down) and remaining in that state. These postures involve a higher EE than the resting supine position. Briefly, isolated spurts of acceleration are assumed to be due to acute changes in posture (lying down, sitting, and standing), because walking and moving around are typically rhythmic activities. EE due to very small trunk movements and posture effects (*e.g.*, changing from sitting to standing position, light deskwork) were not included in the PAEE. Thus, the PAEE measured by the accelerometer was systematically underestimated during a 24-h period, and the accelerometer assessed energy expenditure well during both the exercise period and the non-structured activities.[7]

As the PAEE is associated with body weight, PAEE adjusted for body weight (adjusted PAEE) was calculated as follows: adjusted PAEE (METs·h)=PAEE (kcal)/[W (kg) × 1.05].[11] The various activity levels are categorized as light (<3.0 METs), moderate (3.0–6.0 METs), and vigorous (>6.0 METs), and the time spent in each activity category per total time of physical activity (%) was calculated. In addition, the time spent in sedentary activity (sitting at a desk, visiting friends, reading, or watching television) was obtained from subjects' answers to the International Physical Activity Questionnaire (IPAQ).[12]

Anthropometric measurements (height, weight, and abdominal circumference) were determined in the standing position after the subjects removed their clothes, shoes, and socks. Abdominal circumference as a surrogate measurement of abdominal obesity was measured at the level of the umbilicus during expiration. Abdominal fat distribution was determined with subjects in the supine position using CT according to the procedure described previously.[13] Visceral fat areas were measured on one cross-sectional scan obtained at the umbilicus.

All statistical analyses were performed using SPSS® software (version 14.0; SPSS Inc., Chicago, IL, USA). All data are shown as means ± standard deviation. The differences between groups were analyzed by unpaired *t*-test. Linear regressions and Pearson's correlation coefficients were calculated. In addition, stepwise regression analysis was performed. Statistical significance was set at P<0.05.

Results

The subjects' characteristics are listed in *Table 1*. Although there were no significant differences in age or BMI between men and women, height, body weight, and abdominal circumference in men were significantly greater than those in women. Using the Japanese diagnostic criteria, the prevalence of metabolic syndrome was 62.9% in men and 51.3% in women. These values

Table 1 Subject characteristics at baseline

Variables	Total (n = 235)	Men (n = 116)	Women (n = 119)
Age (years)	53.9 ± 6.6	53.4 ± 6.6	54.5 ± 6.4
Height (cm)	161.8 ± 8.6	168.4 ± 5.8	155.4 ± 5.5*
Weight (kg)	80.7 ± 12.1	86.4 ± 11.8	75.2 ± 9.5*
BMI (kg/m^2)	30.8 ± 3.4	30.4 ± 3.5	31.1 ± 3.1
Abdominal circumference (cm)	106 ± 9	105 ± 9	107 ± 8
SBP (mmHg)	138 ± 19	136 ± 17	140 ± 20
DBP (mmHg)	85 ± 14	84 ± 14	86 ± 13
FPG (mg/dL)	112 ± 26	112 ± 25	112 ± 27
TG (mg/dL)	158 ± 84	167 ± 89	148 ± 78
HDL cholesterol (mg/dL)	53 ± 11	50 ± 10	56 ± 12*
Visceral fat area (cm^2)	144 ± 53	159 ± 54	130 ± 47*

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose; TG, triglyceride; HDL, high density lipoprotein
*: p < 0.05 vs. men