

## Original Article

# A global overall dietary index: ODI-R revised to emphasize quality over quantity

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Incorporating the Healthy Eating Index concept, we have developed a global dietary quality index, the Overall Dietary Index (ODI). We have evaluated the relationships between ODI and chronic disease in a 1998 Taiwanese Health Screening program with over 46,000 members (51.2% females) aged 19-84. However, it could not predict health status adequately. Therefore, we revised this ODI which became ODI-R (Revised). The revision added a quality evaluation for staples (whole grains) and protein-rich foods (fish and soy) and reduced the impact of dietary fat quantity. ODI-R comprises nine items with a maximal score of 100. It has 5 food categories: dairy products, protein rich foods (eggs/legumes/fish/meats), vegetables, fruits and cereals; 2 dietary fat qualities (P/S ratio and cholesterol); and 2 descriptors: dietary moderation (alcohol, salt and sugar as one item) and dietary variety. The mean ODI-R was lower than ODI (64.4 vs. 68.1 in men and 65.5 vs. 69.0 in women) and the distribution. The correlations between macronutrients and ODI-R were weaker than for ODI, especially for fat (from -0.52 to -0.07) as well as for cholesterol and all fatty acid types by degree of saturation. For dietary fiber and micronutrients, the correlations became either less negative or more positive, signaling that the ODI-R reflects food quality more appropriately than ODI in regard to micronutrients. Empirically, a subtraction scoring approach for the overeating of protein rich foods, did not meaningfully decrease ODI-R in Taiwanese elderly or children. ODI-R provides an effective measure of dietary quality over quantity.

**Key Words:** Food Guides, Dietary Guidelines, Overall Dietary Index (ODI), Overall Dietary Index-Revised (ODI-R)

## INTRODUCTION

From a public health perspective, the operational definitions of "healthful diet" can be Nutrient Standards (e.g., RDA, RDNA, DRIs, etc), Dietary Guidelines and Food Guides (e.g., MyPyramid). Yet, variety, balance and moderation are the three most commonly used dimensions of a "Healthful Diet".<sup>1</sup> Kennedy has developed a 10-component, 100-point score, the Healthy Eating Index (HEI) to measure adherence to the 1995 Dietary Guidelines for Americans and the US Food Guide Pyramid.<sup>2</sup> Similar approaches, which incorporate the recommendations from Food Guides and Dietary Guidelines have become popular in designing diet quality tools.<sup>3,4</sup>

On the bases of the Taiwanese "Food Guides"<sup>5</sup> and "Dietary Guidelines"<sup>6</sup>, we have developed a global dietary quality index for Taiwanese. It is referred to as the Overall Dietary Index (ODI) incorporating the HEI concept (Table 1). With this index we have evaluated the relationships between dietary quality and chronic disease in a 1998 Health Screening program with over 46,000 members aged 19-84. However, ODI could not predict health status adequately.<sup>7</sup> There has been increasing criticism that the quality of fat rather than the total amount is the more important

contributor to the quality of diet. In addition, numerous studies have reported that fish and soy, which are sources of dietary fat and protein, have many healthy aspects.<sup>8-11</sup> We revised the ODI accordingly. The present paper provides the revision details and indicates how this revision impacts on diet quality.

## METHODS

### Study population

The MJ Health Screening Center is a membership-oriented private institute. It has four health check-up clinics around Taiwan, which provides periodic health examinations for its members. Each member completes a self-administered questionnaire, has anthropometric and blood pressure measurements, and laboratory investigations. The questionnaire includes sociodemographic characteristics, life-

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Manuscript received 9 September 2007. Accepted 3 December 2007.

**Table 1.** Components of the Overall Dietary Index (ODI) in accordance with the Taiwanese Dietary Recommendations and its comparison with Healthy Eating Index (HEI)

Taiwanese Recommendations	ODI (0-100) <sup>†</sup>	HEI (0-100)
<b>Food Guides</b>		
Dairy	Dairy (10) <sup>‡</sup>	Milk (10)
Eggs/soy/fish/meats	Eggs/soy/fish/meats (10)	Meat (10)
Vegetables	Vegetables (10)	Vegetables (10)
Fruit	Fruit (10)	Fruits (10)
Grains/starchy tubers	Grains/starchy tubers (10)	Grains (10)
<b>Dietary Guidelines</b>		
Less fat	Total fat en <sup>§</sup> % (10)	Total fat en% (10)
	Saturated fat en% (10)	Saturated fat en% (10)
	Dietary cholesterol (10)	Cholesterol (10)
Less salt	Salt (5)	Sodium (10)
Less sugar	Sugar (5)	
Wide selection of foods	Dietary variety (10)	Variety (10)

<sup>†</sup> Range of total score.

<sup>‡</sup> Scores for each item are shown in parenthesis.

<sup>§</sup> en: refers to energy value of the food macronutrients.

**Table 2.** Components and scoring criteria of Overall Dietary Index Revised (ODI-R)<sup>†</sup>

Components	Range (points)	Criteria for maximum score <sup>‡,§</sup>	Criteria for minimum score
1. Grains/ starchy tubers (svgs/d)	0-10	12-24	0
1) Whole grain (% of svgs/d)	0-5	50	0
2. Vegetables (svgs/d)	0-10	3	0
3. Fruits (svgs/d)	0-10	2	0
4. Eggs/soy/fish/meats (svgs/d)	0-10	4	0
1) Soybean (svgs/d)	0-2.5	0.5	0
2) Fish (svgs/d)	0-2.5	0.5	0
5. Dairy products (svgs/d)	0-10	1	0
6. P/S ratio	0-10	1	<0.5
7. Cholesterol (mg/d)	0-10	<400	>800
8. Dietary moderation			
1) Refined sugar (% total energy)	3	<3.5	
	2	3.5-7	
	1	7-10	
	0	>10	
2) Sodium (mg/d)	0-4	<2400	>4800
3) Alcohol (g/d)	3	5-30	
	1.5	<5	
	0	>30	
9. Dietary diversity	0-10	0.5 svgs from 10 food gp <sup>¶</sup>	None from 10 food gp <sup>¶</sup>

<sup>†</sup> In all cases, except refined sugar and alcohol, scores are derived on a proportionate basis.

<sup>‡</sup> Number of servings (svgs) was based on the Taiwanese Food Guides.

<sup>§</sup> Proportional scores were computed for intakes situated between the maximum and the minimum criteria.

<sup>¶</sup> The 10 food groups (gp) were whole grains (including starchy tubers), refined grains, dark-colored vegetables, light-colored vegetables, fruits, milk, eggs, meats, seafoods, and soybean products.

style characteristics including behaviors like food habits, cigarette smoking, alcohol consumption, physical activity, as well as a personal and family medical history. The Ethics Review Committee of the MJ Health Screening Center approved the protocol for this research on human subjects. During 1998, 46,238 members (51.2% females) aged 18-84 who have completed the Screening Center's food frequency questionnaire were eligible for this empirical study.

#### Overall Dietary Index-Revised (ODI-R)

Both ODI and ODI-R scores were calculated for the

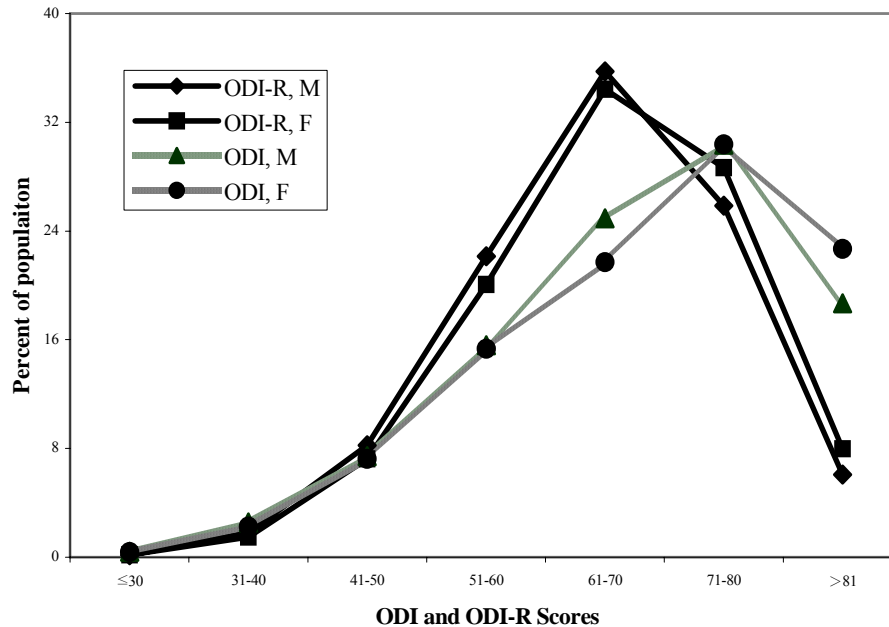
members by using dietary information provided from a semi-quantitative food frequency questionnaire. ODI-R scores were obtained from the following 9 components and summed to a maximum of 100 points: 1) amount (number of servings) (10 points) and quality (5 points) of grains and starchy tubers, 2) amount of vegetables (10 points), 3) amount of fruits (10 points), 4) amount (10 points) and quality (soy and fish) (5 points) of protein-rich foods (eggs/soy/fish/meats), 5) amount of dairy products (10 points), 6) P/S ratio (10 points), 7) amount of dietary cholesterol (10 points), 8) dietary moderation: amounts of refined sugar (3 points), salt (4 points), and

alcohol (3 points), and 9) food diversity (10 points). Specifically, we have added a quality evaluation for certain staple foods (grain/starchy tubers) and protein-rich foods (fish and soy) and reduced the impact of dietary fat from 30%-20% of the total score, regardless of total fat intake. For grains/starchy tuber, 5 extra points were added if more than 50% were from whole grains or intact starchy tubers. In the protein-rich foods group, half servings of soy products or fish per day, attracted extra 2.5 points. For fat, the ODI-R uses P/S ratio instead of total fat and

saturated fat as in ODI. Therefore, the total contribution of fat related components was reduced from 30 points to 20 points of the total 100 points. Table 2 lists the details of the scoring criteria. In all cases, except refined sugar and alcohol, scores were derived on a proportionate manner.

#### Subtraction approach to food excess

In order to evaluate the effect of subtraction on the score for those who overeat protein-rich foods, we set the upper



**Figure 1.** Gender-specific distributions of Overall Dietary Index (ODI) and Overall Dietary Index (ODI-R) in a Taiwanese health screening population (1998, n=46,238).

**Table 3.** Spearman rank correlation coefficients between Overall Dietary Index (ODI), Overall Dietary Index Revised (ODI-R) and nutrient intakes<sup>†</sup> of 1998 M-J Health Screening members (n=46,238)

	DRIs <sup>‡</sup>	ODI-R					$\rho^{\S}$	ODI, $\rho^{\S}$
		Q1 n=9,269	Q2 n=9,249	Q3 n=9,246	Q4 n=9,248	Q5 n=9,226		
ODI-R <sup>†</sup>		50.4	59.8	65.8	71.2	78.3		
Protein (g)		69.2	66.2	63.4	61.7	60.0	-0.07	-0.39
Fat (g)		60.0	59.8	58.1	57.2	56.3	-0.07	-0.52
Carbohydrates (g)		207	214	219	220	221	0.11	0.42
Dietary fiber (g)		14.3	17.9	19.6	20.6	21.8	0.51	0.40
Calcium (mg)	1000	363	439	478	514	572	0.52	0.31
Magnesium (mg)	360	206	230	240	248	263	0.37	0.10
Iron (mg)	10	14.1	13.8	13.2	12.6	12.2	-0.08	-0.42
Vit A (RE)	600	237	354	430	473	522	0.37	0.36
Vit E (IU)	12	6.92	8.00	8.47	8.79	9.42	0.32	-0.05
Vit B1 (mg)	1.0	1.01	1.01	0.99	0.98	0.99	0.01*	-0.32
Vit B2 (mg)	1.1	2.12	1.88	1.71	1.56	1.45	-0.11	-0.37
Niacin (mg)	13	17.1	15.8	14.8	13.9	13.0	-0.12	-0.43
Vit B6 (mg)	1.6	.843	.869	.863	.866	.871	0.07	-0.28
Vit C (mg)	100	117	151	166	173	180	0.40	0.28
Folic acid (mg)	400	270	312	323	325	331	0.22	-0.04
SFA (g)		20.6	19.2	18.1	17.5	16.9	-0.17	-0.51
MFA (g)		22.5	21.7	20.6	20.0	19.1	-0.16	-0.50
PUFA (g)		15.6	17.1	17.3	17.5	17.9	0.16	-0.29
Cholesterol (mg)		850	685	574	485	389	-0.32	-0.59
Alcohol (g)		29.1	19.2	15.2	11.3	7.53	-0.29	-0.13

<sup>†</sup> Energy-adjusted mean

<sup>‡</sup> Dietary Reference Intakes of Taiwan<sup>12</sup>

<sup>§</sup>  $p$  value for Spearman rank correlation coefficients ( $\rho$ ) of energy-adjusted nutrients,  $p < 0.0001$ , unless otherwise noted \*  $p < 0.05$ .

<sup>†</sup> Median

limit of acceptable intake of these foods to less than 8 servings/day. Above that, and up to 16 servings per day, the ODI-R was penalized proportionately through subtraction. We then compared ODI-Rs with and without subtraction using two nationally representative data sets, referred to as NAHSIT (Nutrition and Health Survey in Taiwan) for children<sup>13</sup> and the elderly.<sup>14</sup>

### Statistical Analysis

Spearman rank correlation coefficients were used to describe the relationship between dietary quality scores and nutrient intakes.

### RESULTS

The figure is the gender-specific distributions of dietary quality scores among the 46,238 MJ Screening members, aged 18-84. The distributions for ODI-R are moved towards the left and more normal than those for ODI. The range of ODI-R (21.2-95.0) is narrower than (19.5-99.4) ODI. The mean ODI-R is smaller than ODI (64.4 vs. 68.1 in men and 65.5 vs. 69.0 in women). These differences demonstrate the impact of the greater emphasis on quality evaluation than quantity in the ODI-R score relative to ODI.

Table 3 shows the distributions of individual nutrients across quintiles of ODI-R. Dietary References Intakes (DRIs) are listed for reference. The Spearman correlation coefficients ( $\rho$ ) indicate that the quantity of the macronutrients protein, fat and carbohydrate are minimally associated with ODI-R and much less so than with ODI. For fat,  $\rho$  changes from  $-0.52$  with ODI to  $-0.07$  with ODI-R. The same applies to fatty acid types by saturation and to cholesterol intakes. For dietary fiber and micronutrients, the correlations become either less negative or more positive, signaling that the ODI-R reflects food quality more appropriately than ODI in regard to micronutrients.

With ODI-R, the quintile range from Q1 to Q5 is flat for the macronutrients, fatty acid types and cholesterol, but with a biologically meaningful gradient for dietary fiber and micronutrients. This reflects the revision in ODI-R which adds a quality evaluation for staples (whole grains) and protein-rich foods (fish and soy) and reduces the impact of dietary fat quantity.

Table 4 is an evaluation of the subtraction approach to deal with the problem that higher intakes of protein-rich foods may increase the ODI-R score and encourage over-

eating. However, as shown in Table 3, the  $\rho$  is small in ODI-R but not in ODI. Table 4 confirms the finding about ODI-R. When points are subtracted from ODI-R on the basis of protein-rich foods intake with servings eight or over a day, there is no apparent change in the ODI-R in children or the elderly.

### DISCUSSION

Free living people's eating behavior is complex and multi-dimensional. A single-food or single-nutrient approach cannot completely capture the actual relationship between the entire diet and the risk of disease.<sup>15-17</sup> As a consequence, conclusions about a single nutrient, food or dietary constituent on health outcome may not be valid. There is now more study of patterns of nutrients, foods and food-group to take account over dietary quality.<sup>4</sup>

We have adapted the concept of HEI and developed a global dietary index, ODI, for Taiwanese. Though the respondents in the highest ODI quintile had lower glyce-mic status, uric acid, and more satisfactory lipids, ODI could not predict blood pressure or incidence of hypertension.<sup>7</sup> McCullough also found that the HEI was associated with only a small reduction in major chronic disease risk in the Nurses Health Study and the Health Professional follow-up Study.<sup>18, 19</sup>

With the growing knowledge about the place of soy, fish and whole grains in protection against the major chronic diseases,<sup>8-11, 20</sup> we revised the ODI accordingly to the ODI-R. The changes in distributions and the central location of the ODI-R indicated that the revision has been consequential. In other words, a 3 point difference between the two indices, after revision, makes it possible to recognize consumers of health relevant quantities of foods like soy, fish and whole grain.

By definition and by its design, the ODI was strongly correlated with macronutrient and type of fatty acid. However, the correlations between ODI with vitamins and minerals, the current core value of a healthful diet, were unacceptably low or in the wrong direction. After revision, based on the correlation coefficients, the scenario changed substantially to one which is consistent with the emerging consensus about what constitutes an optimal diet. It implies that ODI-R provides more sensitivity to recognize the nutritional quality potential of a diet.

In the Elderly NAHSIT study, for men and women

**Table 4.** Mean Overall Dietary Index Revised (ODI-R) without and with a subtraction scoring approach for NAHSIT Elderly, 1999-2000 and NAHSIT Children, 2001-2002

	NAHSIT Elderly, 1999-2000		NAHSIT Children, 2001-2002		
	Men	Women	1 <sup>st</sup> -2 <sup>nd</sup> Graders	3 <sup>rd</sup> -4 <sup>th</sup> Graders	5 <sup>th</sup> -6 <sup>th</sup> Graders
Without subtraction †					
ODI-R	62.0	62.2	62.2	64.4	65.6
Eggs/soy/fish/meats	6.9	6.7	7.1	7.5	7.9
With subtraction ‡					
ODI-R	61.8	62.0	62.2	64.4	65.6
Eggs/soy/fish/meats	6.7	6.5	7.1	7.5	7.9

† Scores were proportionate to the daily servings of Eggs/soy/fish/meats if they were < 4. 10 points were given if 4 servings.

‡ Scores were proportionate to the daily servings of Eggs/soy/fish/meats if they were < 4. 10 points were given if 4 servings but < 8 servings. Scores were inversely proportionate to the servings if 8-16. Zero points were given if servings > 16.

combined, we have found a lower mean ODI-R score in those with a high BMI. There was also a significant negative association between ODI-R and the risk of being obese in contrast to being underweight. Compared to the lowest ODI-R quintile, subjects with the highest 20 percent of scores had a more than 70 percent lower risk of obesity.<sup>21</sup> These findings suggest that overall dietary patterns, embracing quality, may contribute to weight management.

Current Food Guides usually have no upper limits on amounts of basic food commodities. There is a question about the scoring of indices based on Food Guides "Eat more (servings) get more (diet quality score) or eat more get less?" In the present paper, by an empirical approach, we have demonstrated that, for Taiwanese children or the elderly, number of servings of protein-rich foods needs no upper limit to ensure diet quality in an apparently healthy population.

The merit of an entire diet approach to measurement of food intake quality must take account of contemporary nutrition evidence and be responsive to future findings.<sup>22</sup>

#### ACKNOWLEDGEMENTS

This study was supported by grants (DOH92-TD-1097 and DOH95-TD-F-113-034) from the Department of Health, Taiwan. Data used in this paper were provided by MJ Health Screening Center from its members and Center for Survey Research, Academia Sinica from the research project "Nutrition and Health Survey in Taiwan (NAHSIT)" sponsored by the Department of Health in Taiwan (DOH-88-FS, DOH89-88shu717, DOH90-FS-5-4, DOH91-FS-5-4).

#### AUTHOR DISCLOSURES

Meei-Shyuan Lee, Chen-Ju Lai, Feng-Yu Yang, Hsing-Hwei Su, Hsiao-Li Yu, Mark L Wahlqvist, no conflicts of interest.

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