Application of Food Exchange List Program for Elderly Dietary Planning

A. Dholvitayakhun, T. Kaewwongkhieo, and J. Kluabwang, *Member, IAENG*

Abstract—This paper presents a computer program to evaluate nutritional status especially for the elderly in order to help to solve optimal dietary planning problem by food exchange list method. The proposed computer program was coded by PHP language. Computational test for 10 elderly cases and also an implementation has been done. Each case was successfully solved by the proposed program for 20 independent trials. The computational results showed that among these cases, the highest and the lowest of the average searching iterations were 98.6 and 12.3 iterations, respectively. The average searching time was between 2.47 and 10.07 seconds.

***Index Terms*—Food exchange list, dietary planning problem, body mass index (BMI), local search technique**

I. Introduction

THAILAND has been expected to become aging population, accounting for 20 percent of the population by 2021 [1]. Interestingly, there was a research team studying Thai elderly health survey in 2013 [2], they reported that only 5 percent of Thai elderly are healthy, but the rest and the most of them (95 percent) got sick. The biggest two numbers of diseases found were high blood pressure disease and diabetes. Both diseases may be treated and prevented by focusing on nutrition control. To be a partial part concerning this coming public problem of Thailand, authors would like to propose a computer program for elderly or whoever wants to do easily meal planning. There are some related works referred to [3]-[5].

This article contains four topics, introduction, methodology, result, and conclusion. Additionally, two tables of all computational results including searching time and iteration are also appended at the last section in order to further reads.

Manuscript received January 08, 2019. This work was supported in part by Rajamangala University of Technology Lanna Tak, Thailand 63000.

A. Dholvitayakhun is with Agricultural and Food Technology Department, Rajamangala University of Technology, Tak 63000 Thailand, (corresponding author: 66-555-15900; fax: 66-555-11833; e-mail: achara2518@yahoo.co.th).

T. Kaewwongkhieo is with Northern College, Tak 63000 Thailand, (e-mail: kaewwongkhieo@gmail.com).

J. Kluabwang is with the Electrical Engineering Department, Rajamangala University of Technology Lanna, Tak, 63000 Thailand, (e-mail: kluabwang.j@ieee.org).

II. Methodology

This study consists of two main parts, the first part is on computational work including a proposed program and the second part is an implementation of a selected result. Computations used in this study are listed as follows

1) Body Mass Index (BMI)

$$BMI = \frac{Weigh(kg)}{Height(cm)} \tag{1}$$

2) Waist to Hip Ratio (WHR) [6]

$$WHR = \frac{Waist(cm)}{Hip(cm)} \tag{2}$$

3) Ideal Body Weight (IBW)

$$\begin{aligned} IBW &= Height(cm) - 100 \quad for\ male \\ &= [Height(cm) - 100] \times 0.9 \quad for\ female \end{aligned} \tag{3}$$

4) Required Energy (*RE*)

$$RE = Demand \times IBW \tag{4}$$

5) To convert *RE* to acceptable macronutrient distribution ranges (*AMDRs*) in kilocalorie unit for elderly may require mapping ratio 55:20:25 of carbohydrate, protein and fat, respectively from [7].

6) To convert *AMDRs* in kilocalorie to weight in gram unit, we use the knowledge that a gram of fat is equivalent to energy 9 kilocalories and carbohydrate or protein can provide energy 4 kilocalorie per gram as well.

7) To generate ingredient list per day, food exchange list is very useful and widely used to provide essential information to set proper meals according to the obtained *RE* in step 5) and also the *AMDRs* in step 6). However, a mismatch between theory (step 5 to 6) and practices may occur, but this study is acceptable if the error tolerances of energy and the quantity are no more than 30 kilocalories and 3 grams, respectively.

A conventional method for step 7, generating ingredient list, with human force can cause a large mismatch and tend to spend more time in trial and error until requirement found.

For this reason, an efficient iterative procedure was proposed to solve the tedious work from the human force. The iterative procedure operates when the main program invokes

ISBN: 978-988-14048-5-5
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

and it will stop looping until one of the termination criterion, solution quality, and time limit is met. This procedure and main program have been coded in PHP language and also have been evaluated performance detailed in the next section.

III. Experiments and Results

There are two experiments, one in the computational test for 10 cases in 20 independent runs for each and the other in the implementation of a selected computational result. Table I shows informative input of the cases which can be divided into two groups of male and females equally.

TABLE I
Input Data for Each Cases

Cases	Sex/Age(year)	Weight (kg)/ Height (cm)	Waist (cm)/ Hip (cm)	Daily Activity
1	Male / 61	55 / 168	78 / 88	Heavy
2	Male / 62	68 / 162	93 / 95	Light
3	Male / 74	51 / 165	76 / 96	Heavy
4	Male / 81	58 / 150	64 / 71	Heavy
5	Male / 80	52 / 160	82 / 86	Medium
6	Female / 69	50 / 155	68 / 80	Heavy
7	Female / 75	49 / 155	72 / 90	Heavy
8	Female / 60	55 / 151	68 / 80	Heavy
9	Female / 67	68 / 158	88 / 98	Medium
10	Female / 73	58 / 155	93 / 99	Medium

TABLE II
Computational Results from 20 Trials per Case

Cases	Iterations				Searching time (milliseconds)			
	Min	Mean	Max	SD	Min	Mean	Max	SD
1	17	47.65	122	26.12	1.71	2.47	3.28	0.43
2	5	69.50	107	17.40	2.76	10.07	14.27	3.10
3	3	38.90	138	37.26	1.98	2.83	4.48	0.58
4	2	12.30	32	8.61	2.20	3.29	5.72	0.81
5	5	22.70	66	16.14	2.40	3.71	5.92	0.88
6	2	29.3	63	17.82	2.27	3.04	4.68	0.65
7	2	21.40	69	21.08	2.36	3.07	4.23	0.60
8	80	98.60	141	22.03	2.74	4.92	9.57	2.09
9	3	34.25	132	34.61	2.19	3.81	6.54	1.13
10	4	70.40	170	58.01	2.98	4.73	9.30	1.92

Source: [8].

Table II summarized computational results from 20 runs of all cases. Middle columns show details of used iterations in minimum, mean, maximum and standard deviation. The left columns are of the searching time as well. Consider searching times, their units are in milliseconds and the maximum time among all of them is 14.27 milliseconds. It is very shorter than of time spent by the human. That means, the nutritionist can help more elderly patients. Fig.1 illustrates the entry form of the proposed program after calling it either through the installed computer or internet website (http://www.northern.ac.th/kcal).

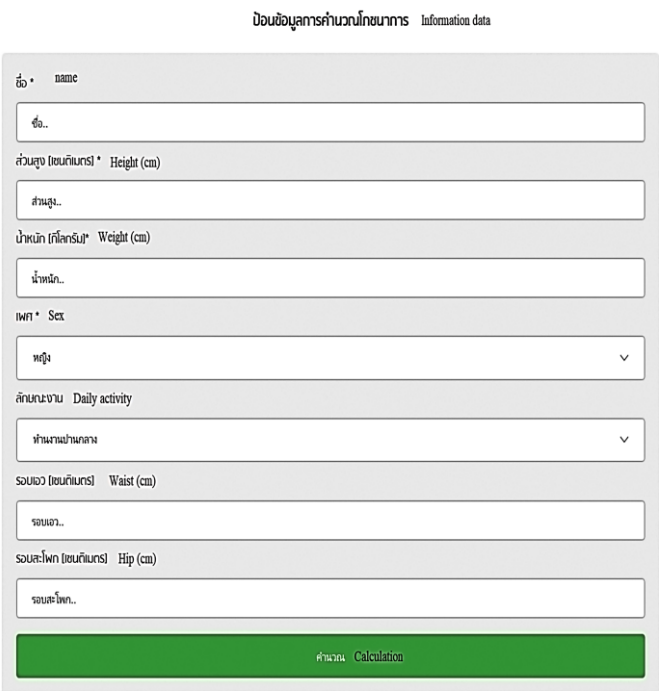
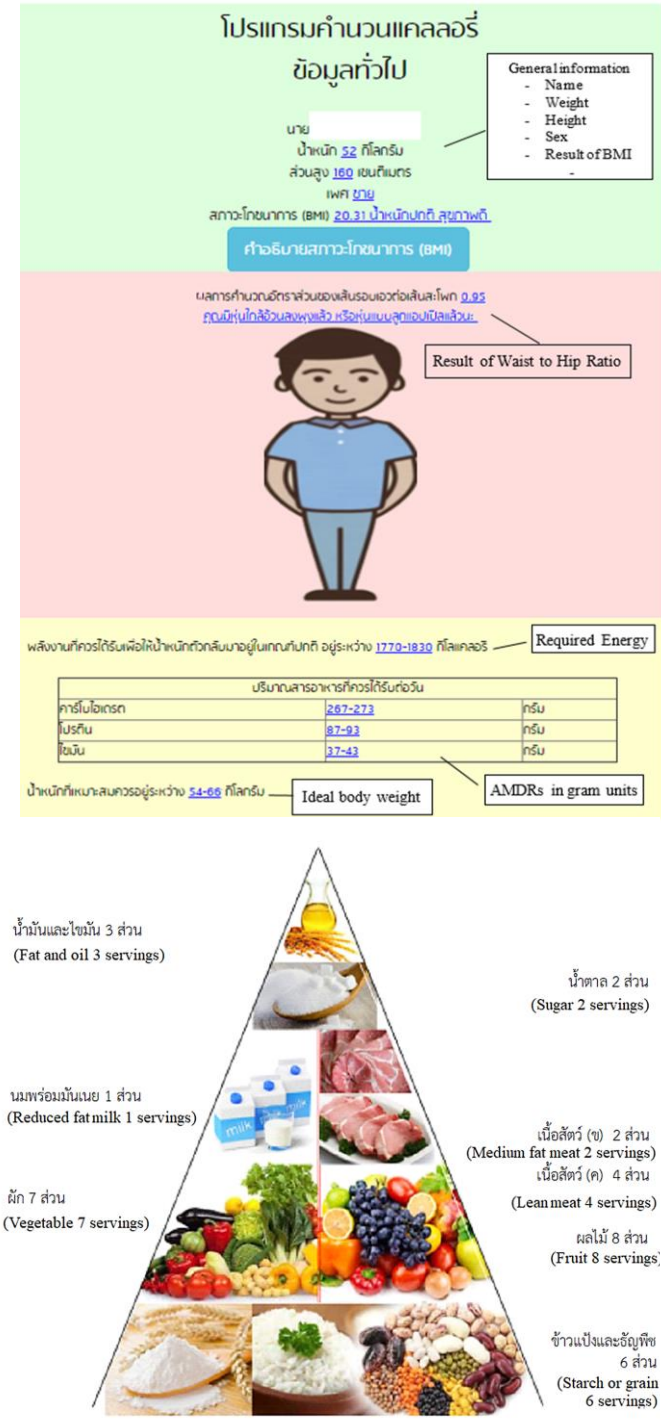


Fig. 1. The caption of entry form of the proposed nutritional program which everyone can freely access and try at www.northern.ac.th/kcal. Reproduced from [8].

All entries for users inserting their own personal information are arranged in the top-down format with name, height in centimeter, weight in kilogram, sex, daily activity categorized into 4 levels from heavy on the top to light on the bottom, waist, and hip in centimeter, respectively. Among 10 cases of a computational experiment, one of them was selected to go on implementation. The one is case 5th, a man with 80 years, 52 kilograms weigh and 160 centimeters height. Fig. 2 showed its details, computation executed very fast by 34 iterations and about 4 milliseconds in time spent. At the beginning of the report, the man was classified into good health group with his BMI at 20.31 but waist/hip ratio at 0.95 indicated that he is looked like an apple-shape. It suggests that his proper weight should be between 54 and 66 kg. He may need slightly more food. The food pyramid summarized the number of servings per day for each nutritional portion as follows, fats:3, reduced fat milk:1, vegetable:7, sugar:2, medium fat meat:2, lean meat:4, fruit:8 and starch or grain:6. These volumes can convert into energy about 1,825 kilocalories, carbohydrate 269 grams, protein 91 grams, and fat 40 grams.

Food exchange list plays an important role to convert the obtained portion to practical quantity. Each portion of fat, reduced fat milk, vegetable, sugar, medium meat, lean meat, fruit and starch are equivalent to 1 teaspoons of rice bran oil, 164 grams of skimmed yogurt with natural flavor, 100 grams of asparagus or kale, 5 grams of sugar, 40 grams of chicken as a medium-fat meat, 30 grams of canned salt tuna as a lean meat, 120 milliliters of apple or orange juice, and 55 grams of cooked rice or 90 grams of cooked noodles, respectively.

ISBN: 978-988-14048-5-5
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)



ปริมาณสารอาหารที่คำนวณได้ต่อวัน (nutrients for calculated per day)		
แคลอรี (Energy)	1825	กิโลแคลอรี (Kilocalories)
คาร์โบไฮเดรต (Carbohydrate)	269	กรัม (grams)
โปรตีน (Protein)	91	กรัม (grams)
ไขมัน (Fat)	40	กรัม (grams)

จำนวนครั้งที่ประมวลผล 34 รอบ (number of iterations 34 runs)
เวลาที่ใช้ในการประมวลผล 0.0040009021759033 วินาที
(Searching times 0.0040009021759033 seconds)

Fig. 2. A reporting result of case 5 at run no. 5th. Reproduced from [8].

From the obtained food pyramid and food exchange list mentioned above to the real world food, meal planning or meal program is also very important due to less of more eating may cause reduction of human performance during work, eg. hungry or sleepy as well. To deliver energy into a body smoothly for a day, this study was divided into four meals as shown in Table III. Implementation for all menus has been done very well and shown in Fig. 3.

TABLE III
THE SELECTED MENUS FOR 4 MEALS A DAY OF 1,825 KCALS

Meals	Menu
Breakfast	1.Tuna Fried Rice
	2.Mushroom Soup
	3.Juice
Morning break	1.Pineapple Yogurt Smoothie
	2.Mix Fruits
Lunch	1.Fried Noodle in Soy Sauce
	2.Apple Juice
Dinner	1.Cooked Rice
	2.Fried Asparagus with Shrimp
	3.Chicken Tom Yum
	4.Orange Juice
	5.Guava and Apple

Fig. 3. A picture of completely prepared 4 meals a day, breakfast (left), morning break (bottom center), lunch (top center) and dinner (right). Source: [8].

IV. CONCLUSION

This article proposed a computer program for nutritionist and anyone in monitoring health situation based on body mass index and also in planning proper meals for a day. The program was code in PHP language because of its familiarity with internet system where has been expected to support users in various platforms. A target of this program was focused on the nutrition of the elderly who will be the most people in the

ISBN: 978-988-14048-5-5
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

world. An experiment has chosen ten samples, male and female equally to be case studies for the proposed program. The computational results from randomly 20 runs for each case have shown that no more than fifteen milliseconds were spent to reach the satisfied result. We can say that the proposed program can search very fast with respect to human work which may need more than fifteen minutes. An obtained result from computation was selected to realize through the food exchange list step. For this case, Tuna fried rice, fried noodle in soy sauce and cooked rice with fried asparagus played an important role in the main course of breakfast, lunch, and dinner, respectively. In the near future, authors want to continue developing a convenient and efficient app on mobile for the elderly to take care of themselves.

TABLE IV
COMPUTATIONAL RESULTS OF 20 RUNS FOR CASE 1 TO 5

Run/ Case	Iterations 1	2	3	4	5	Searching time (milliseconds) 1	2	3	4	5
1	65	78	27	9	38	2.19	8.02	2.53	2.25	4.17
2	47	70	101	16	24	2.61	10.66	1.98	3.69	4.88
3	122	70	12	17	12	2.91	11.72	2.01	3.05	4.04
4	27	70	28	16	43	2.65	10.83	2.85	2.20	2.90
5	29	70	23	2	34	1.71	10.46	3.20	3.30	3.54
6	39	70	73	9	48	2.82	10.50	4.48	2.58	2.99
7	21	5	43	3	66	2.53	2.76	2.75	3.80	4.02
8	50	80	23	27	20	1.78	3.52	2.68	2.81	2.40
9	22	107	9	18	7	2.09	3.99	2.44	4.23	3.43
10	26	70	18	3	8	1.77	14.27	3.22	2.70	4.50
11	39	70	8	3	19	2.41	11.26	2.53	2.82	2.82
12	46	70	10	8	5	2.65	11.99	2.23	3.14	3.72
13	42	70	10	20	31	2.83	11.16	3.24	4.03	3.00
14	31	70	64	7	16	2.46	10.83	3.57	3.93	3.98
15	64	70	3	11	17	2.91	10.91	2.33	3.45	4.15
16	17	70	19	2	7	2.43	12.71	3.09	3.20	2.54
17	82	70	99	17	10	1.95	11.39	3.16	5.72	3.24
18	37	70	43	20	17	2.91	12.32	2.94	3.48	3.06
19	84	70	138	6	22	2.44	11.10	2.51	2.83	5.92
20	63	70	27	32	10	3.28	11.08	2.84	2.64	4.39

TABLE V
COMPUTATIONAL RESULTS OF 20 RUNS FOR CASE 6 TO 10

Run/ Case	Iterations 6	7	8	9	10	Searching time (milliseconds) 6	7	8	9	10
1	42	8	83	24	24	2.27	2.60	5.37	2.79	5.29
2	21	14	80	12	4	2.64	2.74	4.08	3.56	3.19
3	12	15	141	77	50	4.68	2.36	2.93	6.54	4.58
4	42	2	83	30	89	4.68	2.55	7.09	3.56	8.35
5	26	6	114	65	12	3.69	2.38	3.54	3.79	2.99
6	51	27	83	132	170	2.90	3.02	6.04	3.00	3.63
7	18	44	102	22	50	2.88	2.53	4.33	5.86	3.80
8	24	37	80	17	89	3.56	4.23	4.41	2.66	8.04
9	44	65	141	18	12	4.48	4.23	2.76	5.07	4.05
10	10	7	83	9	170	3.06	2.99	7.86	2.76	3.59
11	26	69	114	103	50	3.11	2.62	2.85	4.23	4.44
12	61	2	102	12	89	2.94	3.30	3.24	2.85	7.42
13	31	20	83	31	12	3.36	3.47	6.76	2.82	4.16
14	63	7	80	5	170	2.66	2.87	3.72	3.24	3.29
15	25	12	141	28	50	2.59	2.70	3.07	4.38	4.06
16	13	6	83	49	89	2.46	4.06	9.57	4.51	9.30
17	30	8	114	24	12	2.70	3.69	3.37	4.00	3.96
18	2	55	102	3	170	2.44	2.57	2.75	2.19	3.20
19	43	12	83	7	46	2.89	3.27	7.14	3.57	3.45
20	2	12	80	17	50	2.28	3.24	7.63	7.84	3.72

Source: [8].

APPENDIX

In an appendix, there are two tables (TABLE IV and V) shown searching performances of the proposed program in time and iteration for 20 runs.

ACKNOWLEDGMENT

Authors would like to thank both valuable educational institutes, firstly, Rajamangala University of Technology Lanna Tak for partial financial support in this publication and, secondly, Northern College for supporting facilities to this work.

REFERENCES

[1] K. Khumsuwan, "Older persons meaning in a regime of truth: debates on therapy and social philosophy," *Thai Population Journal*, vol. 5, no.1, pp. 23-52, Mar. 2017.

[2] S. Doungthipsirikul et. al, *Thai Elderly Healthy Survey 2013*. Wacharin pp printing, 2013, ch 1.

[3] A. Dholvitayakhun and J. Kluabwang, "Application of local search for optimal assignment of food exchange list problem," *International Journal of Computer Theory and Engineering*, vol. 6, no.2, pp. 189-191, Apr. 2014.

[4] A. Dholvitayakhun and J. Kluabwang, "Design of food exchange list for obesity using modified local search" in *2016 IEEE ECTI-CON Conf.*, pp.1-5.

[5] A. Dholvitayakhun and J. Kluabwang, "Design of food exchange list for diabetes mellitus by using modified local search techniques," *RMUTK Research Journal*, vol. 11, no.1, pp. 1-7, Jan.-Jun. 2017. (in Thai)

[6] E.D. Schlenker and S. L. Roth, *Williams' Essentials of Nutrition and Diet Therapy*. Elsevier, USA, 2010.

[7] M. Bernstein and A. S. Luggen, *Nutrition for The Older Adult*. Jones and Barlett Publisher LLC, USA, 2010

[8] A. Dholvitayakhun and J. Kluabwang. "Computer program of nutrition assessment for elderly dietary planning by using food exchange list," in *Research report*. Rajamangala University of Technology Lanna, pp. 1-101, 2018.