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Research on Strategies for Promoting the "Early to Bed, Early to Rise, and Don't Forget Your Breakfast" Campaign: Applying a breakfast Tryptophan index to dietary education

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Abstract

Tryptophan content in breakfast is converted to serotonin in the morning, which is then converted to melatonin at night, which then acts as a sleep-promoting agent. We used an estimated Tryptophan intake index (Trp-Index) to investigate eating methods for effectively receiving Tryptophan in order to improve lifestyle rhythms. In July, 2008, self-assessment questionnaires were administered to children (aged 0-6 years) and their parents in 10 kindergartens located in Kochi Prefecture and 921 responses were received (response rate: 75.8%). The data from 816 children aged 2-5yrs (419 girls and 397 boys) were statistically analyzed using SPSS12.0 software. We analyzed the responses to questions on breakfast content to calculate the average Tryptophan and vitamin B6 intake in staple foods, main dishes, side dishes, miso soup, fruit, 100% juice and milk products. We then used these values to create a list of the average Tryptophan and vitamin B6 intake per breakfast for different eating patterns. The Morningness-Eveningness Questionnaire (Torsval & Åkerstedt, 1980) and a version for children were used to objectively measure diurnal preferences for the different groups of eating patterns. A total of 523 children aged 2-5 years (63.9%) ate a breakfast that consisted of a staple food, main dish and side dish. In contrast, only 2.1% of children had a breakfast that consisted of none of the above (for example, consisted of a beverage only). Children who ate a well-balanced breakfast that consisted of a staple food, main dish and side dish were estimated to receive over 3 times as much Tryptophan as those who did not (those who ate a smaller number of items). Furthermore, breakfast patterns with a high total average Tryptophan intake often had a higher total average protein intake (g) and vitamin B6 intake. A breakfast pattern that includes a staple food, main dish and milk product was shown to provide Tryptophan more effectively than patterns that did not include those items at all. Looking at the Morningness-Eveningness scores for the different breakfast combinations, children who ate a breakfast consisting of a staple food, main dish, side dish and milk product tended to have higher Tryptophan intake (total Tryptophan: Kruscal Wallis test: chi-square=231.7, df=7, $P<0.001$) and relatively higher M-E scores than those with the other breakfast combinations (M-E: Kruscal Wallis test: chi-square=17.52, df=7, $P=0.014$). Children who ate complete breakfasts consisting of a staple food, main dish and side dish were estimated to consume over 3 times as much Tryptophan and vitamin B6 as those who ate fewer food items.

A breakfast pattern that consists of a staple food, main dish, milk product and side dish and that include high amounts of protein which contain Tryptophan can be promoted through several educational methods. This recommendation may be an effective method for dietary education to help promote the "Early to Bed, Early to Rise, and Don't Forget Your Breakfast" campaign by making the diurnal rhythm morning-typed.

Key words: breakfast, children, circadian, education-typology, Tryptophan

Introduction

With the advance of 24 hour society, increasing eveningness is becoming a concern even for young children in the early stages of development. This eveningness can lead to disruptions in basic lifestyle habits and diversification of lifestyles which has been suggested as contributing to both a decline in motivation for learning and in physical and mental strength in children during their growth period.

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It is possible that living an extremely nocturnal lifestyle in one's early years when physiological functions based on the internal clock are still being established may have detrimental effects on the regular development of these functions. In addition, such a lifestyle may also have negative effects on mental health and development during the secondary sexual characteristic developmental stage centered on puberty.

There is concern that the high rate of skipping breakfast that is seen among young people, due to the disorder of lifestyle habits, may lead to future adult lifestyle diseases (Health and Nutrition Information and Research Group 2008, Kellogg Co. 2003). To combat this, a national "Early to Bed, Early to Rise, and Don't Forget Your Breakfast" campaign is being promoted in Japan to establish fundamental lifestyle habits starting in early childhood. This campaign indicates that breakfast can act as a zeitgeber for circadian rhythms, promoting regular lifestyle habits. However, there has been no mention of specific breakfast content.

Currently, as a population approach to eating habits, the predominating advice on how to eat is based on the Japanese Food Guide (Japan Ministry of Health, Labor and Welfare and the Ministry of Agriculture, Forestry and Fisheries, 2005). In this approach, daily targets for amounts and types of food are portrayed straightforwardly using a spinning top (reverse pyramid) illustration. A typical Japanese style meal is recommended, centered on a staple food (rice) and including a good balance of main and side dishes. This illustrates the importance of eating a well-balanced meal consisting of a staple food and main and side dishes.

When it comes to breakfast, busy mornings have their own time constraints, and people often try to get by on only bread and juice or milk alone. Some people give the excuse that they feel energized enough after having just a staple food (often a sweet food) for breakfast or that they will be fine as long as they drink 100% vegetable juice. The "Early to Bed, Early to Rise, and Don't Forget Your Breakfast" campaign aims to combat these issues and establish regular lifestyle habits, and is therefore a movement to improve lifestyle rhythms.

As one method for correcting sleep habits that are the key to lifestyle rhythms, analytical support is possible for supporting previous research reporting that Tryptophan content in breakfast is converted to serotonin in the morning, which is then converted to melatonin at night, which acts as a sleep-promoting agent (Moore *et al*., 2000, Zheng *et al*., 2004). Previous survey results have already shown that Tryptophan intake from breakfast can increase morningness of sleep habits in infants to 8 year olds (in their second year of elementary school) (Harada *et al*., 2007). In addition, it was previously reported that protein intake from breakfast and exposure to sunlight are linked to better sleep health and morning-typed sleep-wake cycle in young children (Nakade *et al*., 2009). Serotonin, a chemical that is synthesized from Tryptophan, is the precursor that metabolizes to melatonin (Suzuki, 2002), functioning as a sleep trigger. Two enzymes assist in the metabolism of tryptophan into serotonin, and vitamin B6 is a coenzyme required for this process. Furthermore, synthesis of serotonin has been shown to be weak without exposure to sunlight (Rosenthal *et al*., 1997).

Tryptophan is an essential amino acid that can only be consumed through food. This study was conducted to evaluate a new estimated Tryptophan intake index (Trp-Index) and to propose new eating methods for effectively receiving Tryptophan in order to improve lifestyle rhythms.

1. Methods

In July, 2008, self-assessment questionnaires were administered to children (aged 0-6 years) and their parents in 10 kindergartens located in Kochi Prefecture and 921 responses were received (response rate: 75.8%). The data from 816 children aged 2-5yrs (419 girls and 397 boys) were statistically analyzed using SPSS12.0 software.

The study followed the guidelines established by the Journal, Chronobiology International for the conduct of research on human subjects (Touitou *et al*., 2004, Portaluppi *et al*., 2008). Before administering the questionnaires, each of the participants (parents or guardians) was given a written explanation that detailed the concepts and purposes of the study and stated that their answers would be used only for academic purposes. Having understood this, all parents gave full consent to the proposal. The study was also permitted by the kindergarten nurses' committees which carried out an ethical inspection of the contents of the questionnaire. As the children could not complete the questionnaires themselves, their parents or guardians completed them on their behalf.

Mean Tryptophan (Trp) intake per breakfast was used as the average way to eat breakfast. We analyzed the responses to questions on breakfast content to calculate the average Trp (and vitamin B6: Vi-B6) intake in staple foods, main dishes, side dishes, miso soup, fruit, 100% juice and milk products.

These values were used to create a list of the average Trp (Vi-B6) intake per breakfast for different

eating patterns. This eating pattern analysis only included the data from 624 children aged 3-5 who responded that they ate breakfast regularly every day or nearly every day.

1) *Questionnaire contents*

The questionnaire included three questions concerning breakfast habits. The questions were about regularity of breakfast timing, frequency of having a breakfast that consists of a staple food, a main dish and a side dish and the types of foods regularly eaten for breakfast (Table 1).

Table 1. Questions about breakfast content

Q. Circle all the types of foods that your child regularly eats for breakfast. For numbers (11) (13) (14) (22) (29), please write the type of foods often eaten (e.g. beef, mackerel, herring, banana).

(1) rice (2) bread (3) noodles
(4) potatoes (5) cereal (6) eggs
(7) fermented soybeans ('natto') (8) tofu
(9) soymilk (10) miso soup
(11) meat ( )
(12) processed meat (e.g. ham, bacon)
(13) fish ( )
(14) dried fish ( )
(15) seaweed (16) milk
(17) milk products (e.g. yogurt, cheese)
(18) lactic acid drink
(19) brightly colored vegetables
(20) other vegetables
(21) 100% vegetable juice
(22) fruit ( )
(23) 100% fruit juice
(24) 100% vegetable and fruit juice
(25) coffee (26) black tea (27) green tea
(28) other juice
(29) nutritional supplements ( )

2) *Morningness-Eveningness Questionnaire:*

The Morningness-Eveningness Questionnaire (Torsvall & Åkerstedt, 1980) and a version for children were used to objectively measure diurnal preferences. This section consisted of seven questions; three pertaining to bed times, three to wake times, and one to peak timing of activity. Each question allows for choice (scored from 1 to 4) and the Morningness-Eveningness (M-E) score was the sum of the 7 answers. Scores ranged from 7 to 28, with lower scores representing evening-types and higher scores representing morning-types.

The sleep habits section consisted of questions on bed times and wake times during weekdays and weekends and questions about the quality of sleep such as mood when falling asleep and waking up.

3) *Method for calculation of the estimated tryptophan intake*

The following method was used for children who had breakfast nearly every day (not including those who ate irregularly and often skipped breakfast).

(1) Amount of Tryptophan or vitamin B6 (based on amino-acid constituent tables) contained in 100 g food × recommended amount (g) of each food source/100g at breakfast (based on the dietary intake standards for 1-2 year old, 3-5 year old and 6-8 year old Japanese children.) = (a)
(2) Using the value (a) for each food item, a general estimate of mean consumption amount was calculated based on the top 10 most popular breakfast menus using all food items chosen in this questionnaire for Japanese children in general=(b)
(3) (b) × correction value (ranged from 0 to 1) based on the frequency (per week) of having a breakfast that consists of a staple food, a main dish and a side dish = (c)
(4) The value for (c) will be referred to below as simply 'Trp (Vi-B6) intake'. A corrected mean value was used to account for the frequency (per week) of having a breakfast that consists of a staple food, a main dish and a side dish. This value was calculated by reducing the mean by 1/4 as the number of times when breakfast was consumed per week decreased. In other words, every day = mean value, 4-5 times per week = 3/4 mean value, 2-3 times per week = 1/2 mean value and 0-1 time(s) per week = 1/4 mean value.

2. Results

Table 2 shows combinations of staple food, main dish and side dish for breakfast for all respondents (2-5 yr olds). A total of 523 children (63.9%) ate a breakfast that consisted of a staple food, main dish and side dish. In contrast, only 2.1% of children had a breakfast that consisted of none of the above (for example, consisted of a beverage only).

Table 2. Combinations of staple food, main dish and side dish (children aged 2-5)

Staple food (yn)	Main dish (yn)	Side dish (yn)	n	(%)
no	no	no	17	(2.1)
no	no	yes	0	(0.0)
yes	no	no	108	(13.2)
yes	no	yes	34	(4.2)
yes	yes	no	136	(16.6)
yes	yes	yes	523	(63.9)

Table 3. Typical breakfast (3-5 yrs) and average Tryptophan (Trp) intake per breakfast

Staple food (yn)		Main dish (yn)		Sidedish (yn)		Miso soup (yn)		Fruits (yn)		100% fruit and vegetable/fruit juice(yn)		Milk and milk products (yn)		Trp(total)		referrence
yn	average intake	yn	average intake	yn	average intake	yn	average intake	yn	average intake	yn	average intake	yn	average intake	average intake	ranking	protein (g) (total)
no	0	no	0	no	0	no	0	no	0	no	0	yes	28.03	28.03	60	2.23
	0		0		0		0	yes	1.05	no	0	yes	28.03	29.08	59	2.38
yes	35.24	no	0	no	0	no	0	no	0	no	0	no	0	35.24	58	4.15
	35.24		0		0		0		0		0	yes	28.03	63.27	46	6.37
	35.24		0		0		0	no	0	yes	0.10	no	0	35.34	57	4.35
	35.24		0		0		0		0		0.10	yes	28.03	63.37	45	6.58
	35.24		0		0	no	0	yes	1.05	no	0	no	0	36.29	56	4.30
	35.24		0		0		0		1.05		0	yes	28.03	64.32	44	6.53
	35.24		0		0		0		1.05	yes	0.10	no	0	36.39	55	4.51
	35.24		0		0		0		1.05		0.10	yes	28.03	64.42	43	6.74
	35.24		0		0	yes	7.88	no	0	no	0	no	0	43.11	54	4.88
	35.24		0		0		7.88		0		0	yes	28.03	71.15	42	7.11
	35.24		0		0		7.88	yes	0	yes	0.10	yes	28.03	71.25	41	7.31
	35.24		0		0		7.88		1.05	no	0	no	0	44.16	53	5.04
	35.24		0		0		7.88	yes	1.05		0	yes	28.03	72.19	40	7.26
	35.24		0		0		7.88		1.05	yes	0.10	no	0	44.26	52	5.24
	35.24		0	yes	9.35	no	0	no	0	no	0	no	0	44.59	51	4.97
	35.24		0		9.35		0		0		0	yes	28.03	72.62	39	7.19
	35.24		0		9.35		0	no	0	yes	0.10	yes	28.03	72.72	38	7.40
	35.24		0		9.35		0		1.05	no	0	no	0	45.63	50	5.12
	35.24		0		9.35		0	yes	1.05		0	yes	28.03	73.67	35	7.35
	35.24		0		9.35		0		1.05	yes	0.10	yes	28.03	73.77	34	7.56
	35.24		0		9.35	yes	7.88	no	0	no	0	no	0	52.46	49	5.70
	35.24		0		9.35		7.88		0		0	yes	28.03	80.49	31	7.92
	35.24		0		9.35		7.88	no	0	yes	0.10	no	0	52.56	48	5.90
	35.24		0		9.35		7.88		0		0.10	yes	28.03	80.60	30	8.13
	35.24		0		9.35		7.88	yes	1.05	no	0	yes	28.03	81.54	27	8.08
	35.24		0		9.35		7.88		1.05	yes	0.10	no	0	53.61	47	6.06
	35.24	yes	37.58	no	0	no	0	no	0	no	0	no	0	72.82	37	7.76
	35.24		37.58		0		0		0		0	yes	28.03	100.85	16	9.99
	35.24		37.58		0		0	no	0	yes	0.10	no	0	72.92	36	7.97
	35.24		37.58		0		0		0		0.10	yes	28.03	100.95	15	10.20
	35.24		37.58		0		0	yes	1.05	no	0	no	0	73.87	33	7.92
	35.24		37.58		0		0		1.05		0	yes	28.03	101.90	14	10.15
	35.24		37.58		0		0		1.05	yes	0.10	no	0	73.97	32	8.13
	35.24		37.58		0		0		1.05		0.10	yes	28.03	102.00	13	10.36
	35.24		37.58		0	yes	7.88	no	0	no	0	no	0	80.69	29	8.50
	35.24		37.58		0		7.88		0		0	yes	28.03	108.72	12	10.72
	35.24		37.58		0		7.88	no	0	yes	0.10	no	0	80.80	28	8.70
	35.24		37.58		0		7.88		0		0.10	yes	28.03	108.83	11	10.93
	35.24		37.58		0		7.88	yes	1.05	no	0	no	0	81.74	26	8.65
	35.24		37.58		0		7.88		1.05		0	yes	28.03	109.77	10	10.88
	35.24		37.58		0		7.88		1.05	yes	0.10	no	0	81.84	25	8.86
	35.24		37.58		0		7.88		1.05		0.10	yes	28.03	109.88	9	11.09
	35.24		37.58	yes	9.35	no	0	no	0	no	0	no	0	82.16	24	8.58
	35.24		37.58		9.35		0		0		0	yes	28.03	110.20	8	10.81
	35.24		37.58		9.35		0	no	0	yes	0.10	no	0	82.27	23	8.79
	35.24		37.58		9.35		0		0		0.10	yes	28.03	110.30	7	11.02
	35.24		37.58		9.35		0	yes	1.05	no	0	no	0	83.21	22	8.74
	35.24		37.58		9.35		0		1.05		0	yes	28.03	111.25	6	10.97
	35.24		37.58		9.35		0		1.05	yes	0.10	no	0	83.32	21	8.95
	35.24		37.58		9.35		0		1.05		0.10	yes	28.03	111.35	5	11.18
	35.24		37.58	yes	9.35	yes	7.88	no	0	no	0	no	0	90.04	20	9.31
	35.24		37.58		9.35		7.88		0		0	yes	28.03	118.07	4	11.54
	35.24		37.58		9.35		7.88	no	0	yes	0.10	no	0	90.14	19	9.52
	35.24		37.58		9.35		7.88		0		0.10	yes	28.03	118.18	3	11.75
	35.24		37.58		9.35		7.88	yes	1.05	no	0	no	0	91.09	18	9.47
	35.24		37.58		9.35		7.88		1.05		0	yes	28.03	119.12	2	11.70
	35.24		37.58		9.35		7.88		1.05	yes	0.10	no	0	91.19	17	9.68
	35.24		37.58		9.35		7.88		1.05		0.10	yes	28.03	119.22	1	11.91

We then created combination patterns with details on the staple food, main dish and side dish to examine more closely how Trp intake differed by breakfast pattern. The average Trp intake values obtained in these calculations are shown in Table 3. According to estimates from this table, children who eat breakfast consisting of a staple food, main dish and side dish (63.9% of children; Table 2) receive over 3 times as much Trp as children who ate a fewer number of items (36.1% of children). Furthermore, breakfast patterns with a high total average Trp intake often had a higher total average protein intake (g) (Table 3).

Table 4 shows differences in Trp intake with breakfasts consisting of various combinations of staple food, main dish and milk product and numbers of side dishes (including juice and 100% vegetable juice) based on Table 2.

A breakfast consisting of a milk product and neither staple food nor main dish provided 28.0 mg of Trp, while a breakfast consisting of a milk product and some kind of side dish provided almost 30 mg of Tr on average. In contrast, a breakfast that included a staple food, main dish, milk product and some kind of side dish provided more than 100 mg. This suggests that a breakfast consisting of a staple food, main dish and milk product can provide Trp more effectively.

Table 5 shows the M-E scores for children eating different combinations of breakfast. M-E scores range from 7-28 with lower scores reflecting evening types and higher scores reflecting morning types. Children who ate a breakfast consisting of a staple food, main dish, side dish and milk product tended to have higher Trp intake (total Trp: Kruscal Wallis test: chi-square=231.7, df=7, P<0.001) and relatively higher M-E scores (more morning-typed) compared to children who ate fewer food items for breakfast (M-E: Kruscal Wallis test: chi-square=17.52, df=7, P=0.014).

Discussion

This study attempts to evaluate the efficiency of a revised version of the estimated Tryptophan intake index with the hope of leading to effective consumption of Tryptophan with breakfast as one method for correcting sleep habits that are a key factor in lifestyle rhythms. The results showed that children who ate complete breakfasts

Table 4. Differences in Tryptophan (Trp) intake at breakfast consisting of various combinations of staple food, main dish & milk product and numbers of side dishes

Staple food (yn)	Main dish (yn)	Milk and milk products (yn)	Number of side dish	Total of Trp intake(average)	Minimum values	Maximum values
no	no	yes	0	28.0	-	-
no	no	yes	1-4	29.1	-	-
yes	no	no	0	35.2	-	-
yes	no	no	1-4	44.4	35.3	53.6
yes	no	yes	0	63.3	-	-
yes	no	yes	1-4	72.5	63.4	81.5
yes	yes	no	0	72.8	-	-
yes	yes	no	1-4	82.6	72.9	91.2
yes	yes	yes	0	100.9	-	-
yes	yes	yes	1-4	110.6	101.0	119.2

Table 5. Variation in M-E scores among several types of combinations of dishes at breakfast

Staple food (yn)	Main dish (yn)	Milk and milk products (yn)	Number of side dish	Total of trp intake(average)	Minimum values	Maximum values	M-E (average)
no	no	yes	0-1	28.6	-	-	16.0
yes	no	no	0	35.2	-	-	17.0
yes	no	no	1-4	46.6	35.3	53.6	18.2
yes	no	yes	0	63.3	-	-	19.8
yes	no	yes	1-3	73.0	63.4	81.5	20.0
yes	yes	no	0	72.8	-	-	21.0
yes	yes	no	1-4	84.3	72.9	91.2	20.0
yes	yes	yes	0	100.9	-	-	20.5
yes	yes	yes	1-4	112.3	101	119.2	20.8
Kruscal-Wallis test							
				Total of Trp: $\chi 2=231.7$, df=7, p<0.001		M-E: $\chi 2=17.52$, df=7, p=0.014	

consisting of a staple food, main dish and side dish consumed over 3 times as much Tryptophan and vitamin B6 as those who did not (those who ate fewer food items). Tryptophan is one of the essential amino acids that make up protein. Thus, it is no surprise that meals which provide a higher total average Tryptophan intake also provide a higher average protein intake (g).

Furthermore, Tryptophan intake differs by nearly 100 mg between meal combinations. The combinations range from a nutritionally poor meal, for example, staple food or main dish only, or only milk products or milk products with a side dish to the perfect meal that consists of a staple food, main dish, milk product and a side dish. A similar difference was seen in M-E score.

In previous research, children with higher estimated Trp intake at breakfast tended to be more morning typed (Harada *et al*., 2007, Nakade *et al*., 2009). The current analysis adopting food combinations showed similar results. These results support previous research that showed that Tryptophan contained in breakfast has a positive effect on sleep after being converted to serotonin in the morning and the sleep-inducing agent, melatonin, at night (Moore *et al*, 2000, Zheng *et al*, 2004).

Tryptophan is an essential amino acid that can only be consumed through food. In addition, the amount of Tryptophan contained in food is minimal even among essential amino acids. Consequently it is important to make a conscious effort to consume sufficient amounts of Tryptophan. Ordinary food items that are particularly high in Tryptophan include dried fish such as bonito flakes, fermented soybeans (natto), fish, meat and eggs (Gomyo, 1993). Fermented soybeans have been proposed as a particularly effective way to absorb high amounts of Tryptophan (Harada, unpublished) as 98% or more of the protein contained is absorbed into blood after being broken down into amino acids.

Vitamin B6 is a coenzyme required for the synthesis of serotonin metabolizing protein and is found in higher quantities among in beef, pork or chicken liver, lean fish and nuts and seeds. Fruits and bananas also contain higher amounts. As many foods contain higher amounts of both Tryptophan and vitamin B6, children with higher estimated Tryptophan intake are also likely to consume more vitamin B6.

The results of this study supported the hypotheses that vitamin B6 consumption could support serotonin synthesis as a co-enzyme and that exposure to sunlight after the consumption of Tryptophan and vitamin B6 was critical for serotonin synthesis. Such clear results even in a questionnaire study may be due to high levels of serotonin in body fluids surrounding the brain and also a high concentration of plasma melatonin in children that is three or five times higher than that in adults (Waldhauser, 1988). For children in the early stages of development who are acquiring fundamental lifestyle habits, regular consumption of breakfast that includes adequate amounts of Tryptophan and vitamin B6 and exposure to sunlight may be necessary for promoting secretion of melatonin at night and maintaining healthy sleep and regular circadian rhythms.

Thanks to the national "Early to Bed, Early to Rise, and Don't Forget Your Breakfast" campaign, the percentage of children having breakfast was reported to increase (National Agency for the Advancement of Sports and Health, 2009). However, Naoi (2007) suggested that breakfast content may not yet have been mentioned in many cases. In this study, young children who had nutritionally rich breakfast consisting of carbohydrates, protein, vitamins and minerals were estimated to consume more than three times as much Tryptophan and vitamin B6 as children who did not. It is recommended that breakfast for children aged 3-5 years include 7-8 g of protein, one third the total recommended daily amount of protein.

The recommended and detailed breakfast menus shown in this study consist of a staple food, main dish, milk product and side dish. These menus also include high amounts of protein. This recommendation may be an effective aid for dietary education to help promote the "Early to Bed, Early to Rise, and Don't Forget Your Breakfast" campaign to improve daily rhythms.

Further research is needed to test the effect of these recommendations. For example, would eating patterns change when the detailed sample menus are recommended in lectures to young parents with small children? In addition, if the ideas are implemented in a childhood education center, the results could be used to help develop dietary education as a part of general education for parents and as part of the school curriculum for children.

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