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Original article

Differences in the validity of a visual estimation method for determining patients' meal intake between various meal types and supplied food items

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SUMMARY

Background & aims: The aim of this study was to examine differences in the validity of a visual estimation method for determining patients' meal intake between various meal types and supplied food items in hospitals and to find factors influencing the validity of a visual estimation method.
Methods: There are two procedures by which we obtained the information on dietary intake of the patients in these hospitals. These are both by visual assessment from the meal trays at the time of their clearing, by the attending nursing staff and by weighing conducted by researchers. The following criteria are set for the target trays: A) standard or therapeutic meals, which are monitored by a doctor, for energy and/or protein and/or sodium; B) regular, bite-sized, minced and pureed meal texture, and C) half-portion meals. Visual assessment results were tested for their validity by comparing with the corresponding results of weighing. Differences between these two methods indicated the estimated and absolute values of nutrient intake.
Results: A total of 255 (76.1%) trays were included in the analysis out of the 335 possible trays and the results indicated that the energy consumption estimates by visual or weighing procedures are not significantly different (412 ± 173 kcal, $p = 0.15$). However, the mean protein consumption was significantly different (16.3 ± 6.7 g/tray, $p < 0.01$) between the two procedures. Compared with standard meals (38 ± 45 kcal, 1.9 ± 2.5 g/tray), raters significantly misestimated the energy and protein intake of half-portion meals (78 ± 65 kcal, 2.8 ± 2.2 g/tray, $p = 0.01$) but accurately estimated the protein intake of protein controlled meals (0.5 ± 0.6 g/tray, $p = 0.03$). Trays adding supplied food items were significantly misestimated for energy intake (66 ± 58 kcal/tray) compared to trays with no additions (32 ± 39 kcal/tray, $p < 0.01$). Moreover, the results of multivariable analysis demonstrated that supplied food items were significantly associated with increased odds of a difference between the two methods (OR: 3.84; 95% confidence interval [CI]: 1.07–13.85).
Conclusions: There were high correlations between the visual estimation method and the weighing method measuring patients' dietary intake for various meal types and textures, except for meals with added supplied food items. Nursing staff need to be attentive to supplied food items.

1. Introduction

Accurately measuring patients' meal consumption can contribute to all phases of nutritional care, from admission to discharge [1,2]. Clinical staff use dietary intake charts to calculate nutrient consumption data [3]. The common way to assess dietary intake of the patients in many studies as well as in hospitals is by

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visual estimation [4–6], and this is accomplished simply by looking at the meal tray directly, for evaluating the leftover food so that meal intake can be assessed. On the other hand, the accuracy of this method is lower than the weighing method, where raters weigh the plate waste of each food item [7].

Despite the importance of evaluating patients' dietary intake, currently no method is available that is simple to use in clinic and reliable. Although many validation studies have reported high validity, these studies have several problems [7–16]. For example, the types of target trays were limited, and therefore the results of these previous studies cannot apply to all types of meals in the clinical setting. Little is known about the influence of patients' meal types and supplied food items on the validity [7]. In previous studies, most of the target trays have been standard meals, with approximately the same serving size, and generally served to patients who did not require additional nutritional care or where it was not necessary to distinguish between standard and therapeutic meals [7–16]. Therefore, it is unclear in these studies whether the visual estimation was valid, and whether when clinical staff checked therapeutic meals or portion controlled meals, such as half-portion meals. Therapeutic meals are nutrient controlled and served in many Japanese hospitals to patients with diabetes, hypertension, chronic kidney disease and cardiovascular disease, for example, to control nutrient values such as energy, protein and sodium, for effective treatment [17–19]. Half-portion meals are generally served to patients with poor appetites, and contain additional supplied food items on meal trays, such as high energy and/or protein drinks or jelly to counter the lack of nutrient content in many cases.

Additionally, factors influencing the validity of a visual estimation method were not clearly identified. We undertook a comprehensive and qualitative analysis in the present study to identify the relevant factors in the actual clinical setting, because many factors may influence the validity of visual estimation. We also highlighted the barriers to accurate measurement of patients' dietary intake in hospital when using the visual estimation method, such as scale types, meal types, and meal texture [20]. Although differences in the validity evaluations between tray division, scale types, meal texture, and consumption percentages have been reported in previous studies, few studies have analyzed these multiple factors in combination [8,10,16].

Therefore, the aim of this study was to examine the differences in the validity for assessing dietary intake of patients by a visual estimation method between various meal types and supplied food items in hospitals and determine the factors influencing the validity of the visual estimation method.

2. Materials and methods

2.1. Data collection

In this study, the data collection method was based on our previously published study [10]. All data were collected during August 2016 and September 2016, from 3 hospitals in Tokyo, Japan. Two procedures were employed to obtain patients' dietary intake, on the basis of the meal tray at the time of its clearance, in the normal clinical settings: 1) visual assessment by nursing staff, and 2) researcher-conducted weighing. We also collected data on the evaluation method and characteristics of target trays, such as tray division as the evaluating unit, meal types, meal texture, and whether there were supplied food items. If nurses and nursing assistants consented, they responded to a questionnaire, which recorded their demographic characteristics, professional occupation and other relevant factors. It was estimated by power analysis that, a minimum of 27 trays need to be compared between the two methods for achieving an effect size of 0.5 (Cohen's 'medium') and power of 0.8 [21].

We have obtained ethical approvals for this study from the Ochanomizu University Research Ethics Board.

2.2. Meal trays

We chose a total of 13 non-consecutive research days: 5 days (hospital 1), 5 days (hospital 2) and 3 days (hospital 3), in each hospital. The number of available research days was more limited for Hospital 3 compared to the other 2 hospitals because we were given permission to conduct our investigation at Hospital 3 for only 3 days. The research days had similar lunch menus, allowing for more accurate comparable weighing. The inclusion criteria were as follows: 1) standard or therapeutic (controlled energy and/or protein and/or sodium intake, under a doctor's direction) meals; 2) regular, bite-sized, minced, and pureed meal textures; and 3) regular or half-portion meals.

A therapeutic meal could control for more than one nutrient at a time, for example, an energy and sodium-controlled meal. Specific patient meal types were assigned by the patient's doctor, although the same food items were served in standard and therapeutic meal menus. We could not include some meal types in each hospital because of variations in meal production. For example, in hospital 1, we could not include protein-controlled meals if main dish menus differed for standard meals (downsized dishes could be included). Therapeutic meals in target trays could not be included in hospital 3. In addition, meal types, where the number of servings was limited in number on each research day, could not be included from any of the selected hospitals. We defined half-portion meals as meals in which each food item was reduced by half compared to the basic menu, except for portion-controlled items, for example, dairy products, and jams.

Supplied food items were defined as food items not included in the basic menu of each meal type, such as high-nutrient jelly and drinks, which were generally served to patients lacking an appetite for the basic menu. These did not include foods that may have been sourced externally (e.g. lollies/chocolates/soft drinks from cafeterias and vending machines and those brought in by visitors.)

2.3. Visual estimation methods

The processes of visual estimation, such as using tray division as an evaluating unit and scale type, were selected based on the medical staff's routine work in each hospital. Taking tray divisions as an evaluating unit of measurement revealed differences between whole trays, grains/other food divisions, and particular food item assessment in each hospital. These are generally used in Japanese hospitals [3]. With respect to whole tray division, raters evaluated patients' meal consumption each time. In grains/other food divisions, raters first evaluated the patients' consumption ratio of grains and then evaluated other food items each time. In the actual clinical setting, some raters used grains/other food divisions to accurately measure energy intake because grains were the highest energy food item in most hospital meals. Raters used a whole tray division as the evaluating unit in hospital 2, whereas grains/other food divisions, which involved separately evaluating grains and other food items, were used for evaluation in hospital 1 and hospital 3. However, grains/other food divisions plus supplied food items were used if several types of supplied food items were also involved, which were set by each ward and added to target trays in hospital 1. Ten percent scales (0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%) were used in all hospitals. This scale is generally used in Japanese hospitals, and we have reported on the validity of the visual estimation method in assessing meal consumption and that the odds ratios per 10% consumption were significantly different in our previous study [10].

They routinely estimated and recorded patients' intake rates onto food intake lists near the carts as dishes were cleared in each ward during their work. The design of food intake lists was different between each hospital. The results from these lists and the names of raters who evaluated each tray were collected. The names of clinical staff and patients who were served target trays were exchanged and data anonymized using a unique ID number for our research after collating the questionnaire data.

2.4. Reference method

In order to determine the reference food weight, one exactly identical extra serving was prepared by the kitchen staff for each food item and this was weighed by the researchers. However, for portion-controlled items, the relevant information was obtained directly from the supplier. Also, the serving portions and the leftovers were weighed by the researchers, employing regular kitchen digital scales.

Leftovers on the target meal trays for each food item were weighed for calculating patients' dietary intake by five trained researchers, working in shifts. In cases where there was no leftover on the meal tray, a 100% consumption was assessed by the researchers. Also, consumption of certain type of food items such as dairy items etc., that can be kept in a refrigerator by the patients' bedside or in other locations, and thus not found on the trays, was evaluated after consulting with the patients.

2.5. Analysis

There were a total of 335 possible trays from which meal intake data were to be collected by the visual estimation and weighing methods. Out of these, 255 trays (76.1%) were included in the study, on the basis of the following exclusion criteria: a) all the leftover food items on the trays could not be weighed, b) if any special type of foods that do not match basic menu replaced the regular food items.

We employed the Statistical Package for Social Science (SPSS) for Windows (version 20, SPSS Inc.) for performing all the statistical analyses reported in this study. We converted visually estimated intake into energy and protein because the results of nursing staff's visual estimation generally involves calculating nutrient intake, such as energy and protein, since clinical staff working alongside physicians, nurses and dietitians are trained to use various treatment and nutrition therapies, including assessing energy and protein levels, in hospitals [3]. Patients' protein and energy consumptions were calculated by using the formula described in our earlier study [10], and from the information in the Standard Tables of Food Composition in Japan 2010 and the suppliers' instructions.

In order to evaluate the validity of the visual estimation, the patients' dietary intake by this method was compared to that from the weighing approach. We also compared the obtained results in different categories including, meal tray division as the evaluating unit, types and textures of meals, and the presence of any supplied food items. Results on the patients' protein and energy intake, and differences between the methods of visual assessment and weighing, were presented as mean ± standard deviation (S.D.). The differences in the meal intakes as assessed by the two methods were determined as actual accounts and absolute values from the following equation: difference = visual estimation − weighing. As the analyzed samples were not normally distributed using the Shapiro–Wilk test ($p < 0.05$), we performed non-parametric analysis. Nutrient intakes assessed by the visual estimation and weighing methods were compared separately by the Wilcoxon signed-rank test and Spearman's correlation coefficient analysis. We also used a Mann–Whitney U test and a Kruskal–Wallis test to compare the validity of the visual estimation method when considering factors such as tray division as the evaluating unit, meal types, meal texture, and whether there were supplied food items. On this occasion, we converted consumption ratio target trays per 10% into per 50%. We also used univariable and multivariable logistic regression models (the stepwise method) for comparing these factors, as these showed a lower validity criterion. Trays without leftovers were excluded from the logistic regression analyses, as the raters were unable to assess the tray characteristics during visual evaluation, as they were empty due to 100% consumption. The following standards were set: using the absolute values, different groups of energy intake with large/small differences were calculated, and dichotomized by the median. The cut-off point for the median of the different groups was 32.4 kcal. Besides this, meal types and texture, and the presence of supplied food items were also included as independent variables. Calculations using logistic regression analysis were adjusted for the raters' occupation categories, as well as hospitals and wards. Tray division, as the evaluating unit, was not included in this analysis because it was a structured routine for each hospital or ward. Energy, protein and sodium controlled meals were grouped together as a category: nutrient controlled meals, because most of the protein and sodium controlled meals were also controlled energy meals. We modified the percentage consumption data by dividing by 10 for analysis (based on the 10 percent scale), and the differences were considered statistically significant if $P < 0.05$.

3. Results

3.1. Raters and meals

We enrolled 47 nursing staffs as raters, who evaluated patients' dietary intake during each research day. We collected demographic data from 42 staffs (89.4%) of the raters by questionnaire. They were 22 nurses and 19 nursing assistants (1 was not recorded her occupation) and almost all female ($n = 41$, 97.6%). Their years of experiences averaged 10.0 ± 8.8. The characteristics of the target trays are shown in Table 1. The number of target trays included in analysis for each hospital was 95 (37.5%), 108 (42.4%) and 52 (20.4%), respectively. Approximately half of target trays were evaluated by the grains/other food division (141 trays, 55.3%) and comprised standard meals (142 trays, 55.7%). About 70% of trays were regular texture (174 trays, 68.2%). Twenty-four trays (9.4%) had added supplied food items. Mean nutrient value and the percentage of nutrient contents of supplied food items were 205 ± 145 kcal and 6.6 ± 5.7 g/tray, 33.9 ± 18.8% (energy) and 28.5 ± 21.8% (protein), respectively. No leftovers trays (100% consumption) accounted for 23.9% (61 trays) of the total. Nurses evaluated 87 trays (34.1%) and nursing assistants evaluated 133 trays (52.2%).

3.2. Relationship between the visual assessment and weighing methods of meal intake

Table 2 presents the mean values of nutrient consumption and the correlations and the differences between the methods of visual assessment and weighing for determining nutrient intake of the patients. We found that there was no significant difference in the mean energy consumption of target trays using the visual estimation and the weighing method (412 ± 173 kcal/tray, $p = 0.15$), even though there was significant difference in protein consumption (16.3 ± 6.7 g/tray, $p < 0.01$). Spearman correlation coefficients for

Table 1
Characteristics of the target trays by hospitals.

	Total		Hospital 1		Hospital 2		Hospital 3	
	n	%	n	%	n	%	n	%
Total	255	100.0	95	100.0	108	100.0	52	100.0
Tray division as evaluating unit								
Whole tray[a]	108	42.4	0	0.0	108	100.0	0	0.0
Grains/other[b]	141	55.3	89	93.7	0	0.0	52	100.0
Grains/other + supplied food items[c]	6	2.4	6	6.3	0	0.0	0	0.0
Meal types[d]								
Standard	142	55.7	15	15.8	75	69.4	52	100.0
Energy	97	38.0	64	68.4	33	30.6	0	0.0
Protein	16	6.3	16	16.8	0	0.0	0	0.0
Sodium	71	27.8	63	66.3	8	7.4	0	0.0
Half-portion	12	4.7	12	12.6	0	0.0	0	0.0
Texture								
Regular	174	68.2	86	90.5	42	38.9	46	88.5
Bite-sized	17	6.7	5	5.3	12	11.1	0	0.0
Minced	55	21.6	4	4.2	45	41.7	6	11.5
Pureed	9	3.5	0	0.0	9	8.3	0	0.0
Supplied food items								
None	231	90.6	72	75.8	107	99.1	52	100.0
Additional food items	24	9.4	23	24.2	1	0.9	0	0.0
Percent consumption (%)[e]								
<50	33	12.9	13	13.7	18	16.7	2	3.8
50 ≦ % < 100	161	63.1	60	63.2	67	62.0	34	65.4
100	61	23.9	22	23.2	23	21.3	16	30.8
Rater occupations								
Nurses	87	34.1	14	14.7	65	60.2	8	15.4
Nursing assistants	133	52.2	80	84.2	28	25.9	25	48.1
Data missing[f]	35	13.7	1	1.1	15	13.9	19	36.5

[a] Raters measured intake based on proportions of whole portions.
[b] Raters measured intake based on grain (rice, bread, others) and other food items individually (supplied food items are included in "other").
[c] Raters measured intake based on grain/other food items without supplied food items.
[d] Therapeutic meal could control for more than one nutrient at a time, such as an energy and sodium-controlled meal.
[e] Percentage consumption was calculated based on energy intake.
[f] We could not confirm who evaluated patients' dietary intake using the visual estimation method.

both methods were high for the intakes of energy ($\rho = 0.95$, $p < 0.01$) and protein ($\rho = 0.84$, $p < 0.01$). According to Spearman's analysis for tray division as the evaluating unit, meal types, meal texture, and whether there were supplied food items, high correlations were indicated in almost all categories of target trays for energy ($\rho = 0.87$–1.00, $p < 0.01$) and protein ($\rho = 0.75$–1.00, $p < 0.01$) intake, except where the tray division as the evaluating unit was for grains/other food divisions plus supplied food items (energy: $\rho = 0.37$, protein: $\rho = 0.37$, $p > 0.05$) and where percentage consumption was below 50% (energy: $\rho = 0.58$, protein: $\rho = 0.58$, $p < 0.01$).

In energy intake, the mean differences between both methods, as calculated by actual accounts, were significantly different for the different meal types and whether supplied food items were added and for the percentage consumption. In protein intake, data showed the same tendency as energy intake, except for supplied food items. Compared with standard meals (8 ± 58 kcal, 0.8 ± 3.0 g/tray), raters significantly underestimated the energy intake of half-portion meals (−67 ± 78 kcal/tray, $p < 0.01$) and the protein intake of energy (0.3 ± 2.1 g/trays, $p = 0.27$), and protein (−0.4 ± 0.6 g/tray, $p < 0.01$), and sodium (0.1 ± 2.1 g/tray, $p = 0.02$) controlled meals. Trays adding supplied food items were significantly underestimated for energy intake (−34 ± 82 kcal/tray, $p < 0.01$) compared with trays with nothing added (7 ± 49 kcal/tray). Trays with substantial leftovers (<50% consumption) were significantly underestimated for energy intake (−25 ± 72 kcal/tray, $p < 0.01$) and small leftovers trays (50% < consumption < 100%) were significantly overestimated for energy (10 ± 59 kcal/tray, $p = 0.02$) and protein (0.8 ± 3.1 g/tray, $p < 0.01$) intake, compared with trays with no leftovers (0 ± 0 kcal, 0 ± 0 g/tray).

Along with the actual accounts, the mean differences between the two methods, as calculated by absolute values, were significantly different according to meal types, supplied food items and meal consumption. Compared with standard meals (38 ± 45 kcal, 1.9 ± 2.5 g/tray), raters significantly misestimated the energy and protein intake of half-portion meals (78 ± 65 kcal, 2.8 ± 2.2 g/tray, $p = 0.01$), but accurately estimated the protein intake of protein controlled meals (0.5 ± 0.6 g/tray, $p = 0.03$). Trays adding supplied food items were significantly misestimated for energy intake (66 ± 58 kcal/tray, $p < 0.01$) compared with trays with nothing added (32 ± 39 kcal/tray). Trays with leftovers were significantly misestimated for energy and protein intake (<50% consumption: 57 ± 50 kcal, 2.4 ± 2.3 g/tray, $p < 0.01$, 50% < consumption <100%: 44 ± 40 kcal, 2.2 ± 2.2 g/tray, $p < 0.01$), compared with trays with no leftovers (0 ± 0 kcal, 0 ± 0 g/tray). No significant difference was found using tray division as the evaluating unit and using texture.

3.3. *Characteristics associated in the validity of the visual estimation method*

The odds ratios (OR) of differences between the two methods of meal intake assessment, i.e., visual estimation and weighing methods were given in Table 3. These OR were given for meal types, meal texture and if the trays contained supplied food items, and were analyzed by absolute values on the basis of energy consumed. For these calculations, we assumed that the large and small difference groups for visual estimation and weighing methods to be dependent variables. Thus, the relation between various factors including meal types, meal texture, presence of supplied food items and percent food consumption, were analyzed along with the validity of visual

Table 2
Mean nutrient consumption, the Spearman's correlations (ρ) and differences between visual estimation methods for determining patient's nutrient intake by tray characteristics.

	n	Energy					Protein				
		Visual[a] Mean ± S.D.[b] kcal	Weighed Mean ± S.D. kcal	ρ[c]	Difference[d] − Actual count Mean ± S.D. kcal	Difference[d] − Absolute value Mean ± S.D. kcal	Visual[a] Mean ± S.D. g	Weighed Mean ± S.D. g	ρ[c]	Difference[d] − Actual count Mean ± S.D. g	Difference[d] − Absolute value Mean ± S.D. g
Total	255	412 ± 173	409 ± 159	0.95^{**}	3 ± 54	35 ± 42	$16.3 \pm 6.7^{**}$	15.0 ± 5.9	0.84^{**}	1.3 ± 3.4	2.8 ± 3.1
Tray division as the evaluating unit											
Whole tray	108	362 ± 139	355 ± 127	0.94^{**}	7 ± 49	30 ± 39	$15.8 \pm 5.7^{*}$	15.0 ± 5.5	0.86^{**}	0.8 ± 3.0	1.9 ± 2.4
Grains/other	141	446 ± 187	444 ± 169	0.96^{**}	2 ± 58	38 ± 44	$16.7 \pm 7.5^{*}$	16.3 ± 7.1	0.94^{**}	0.4 ± 2.5	1.6 ± 2.0
Grains/other + supplied food items	6	511 ± 166	546 ± 137	0.37	−35 ± 57	42 ± 51	17.5 ± 4.5	17.9 ± 3.3	0.37	−0.4 ± 2.6	2.1 ± 1.4
Meal types											
Standard	142	434 ± 197	426 ± 181	0.96^{**}	8 ± 58^{e}	38 ± 45^{e}	$17.7 \pm 7.1^{**}$	16.8 ± 6.7	0.92^{**}	0.8 ± 3.0^{efg}	1.9 ± 2.5^{ef}
Energy	97	390 ± 133	384 ± 124	0.93^{**}	6 ± 39	26 ± 29	14.7 ± 5.9	14.5 ± 6.0	0.94^{**}	0.3 ± 2.1^{e}	1.4 ± 1.6
Protein	16	388 ± 123	369 ± 124	0.95^{**}	18 ± 41	29 ± 34	$8.6 \pm 2.0^{*}$	9.0 ± 2.1	0.95^{**}	-0.4 ± 0.6^{f}	0.5 ± 0.6^{e}
Sodium	71	399 ± 131	392 ± 122	0.93^{**}	7 ± 42	29 ± 31	14.4 ± 6.1	14.3 ± 6.1	0.94^{**}	0.1 ± 2.1^{g}	1.4 ± 1.5
Half-portion	12	$317 \pm 144^{*}$	384 ± 147	0.87^{**}	-67 ± 78^{e}	78 ± 65^{e}	11.9 ± 5.2	13.1 ± 5.3	0.75^{**}	−1.2 ± 3.5	2.8 ± 2.2^{f}
Texture											
Regular	174	453 ± 170	451 ± 154	0.95^{**}	2 ± 54	34 ± 42	$17.2 \pm 6.6^{*}$	16.7 ± 6.5	0.94^{**}	0.5 ± 2.5	1.6 ± 2.0
Bite-sized	17	359 ± 166	354 ± 154	0.97^{**}	4 ± 38	26 ± 27	13.5 ± 6.9	12.9 ± 5.9	0.94^{**}	0.6 ± 2.9	1.9 ± 2.2
Minced	55	312 ± 152	302 ± 129	0.90^{**}	10 ± 64	45 ± 47	14.3 ± 6.9	13.6 ± 6.4	0.85^{**}	0.7 ± 3.5	2.3 ± 2.6
Pureed	9	338 ± 45	342 ± 42	0.97^{**}	−4 ± 15	12 ± 10	17.0 ± 2.0	16.8 ± 2.5	0.97^{**}	0.2 ± 1.4	0.7 ± 1.2
Supplied food items											
None	231	$415 \pm 171^{*}$	408 ± 157	0.96^{**}	7 ± 49^{e}	32 ± 39^{e}	$16.6 \pm 6.7^{*}$	15.9 ± 6.3	0.93^{**}	0.6 ± 2.5	1.6 ± 2.0
Added	24	$387 \pm 199^{*}$	421 ± 185	0.87^{**}	-34 ± 82^{e}	66 ± 58^{e}	14.1 ± 6.9	14.5 ± 7.7	0.84^{**}	−0.5 ± 4.2	2.8 ± 3.2
Percentage consumption (%)											
<50	33	$130 \pm 82^{*}$	155 ± 54	0.58^{**}	-25 ± 72^{e}	57 ± 50^{e}	5.5 ± 3.8	5.6 ± 2.8	0.58^{**}	0.1 ± 3.3	2.4 ± 2.3^{e}
50 ≦ % < 100	161	425 ± 139	414 ± 126	0.90^{**}	10 ± 59^{ef}	44 ± 40^{f}	$17.2 \pm 5.5^{*}$	16.4 ± 5.2	0.86^{**}	0.8 ± 3.1^{e}	2.2 ± 2.2^{f}
100	61	531 ± 114	531 ± 114	1.00^{**}	0 ± 0^{f}	0 ± 0^{ef}	19.8 ± 5.0	19.8 ± 5.0	1.00^{**}	0 ± 0^{e}	0 ± 0^{ef}

$^{*}p < 0.05$, $^{**}p < 0.01$.
Letters (e, f, g) represent significant statistical differences between each factor by Mann–Whitney test or Kruskal–Wallis test ($p < 0.05$).
[a] Mean-value analysis between visual estimation and weighing method by Wilcoxon signed-rank test.
[b] S.D., standard deviation.
[c] Spearman's correlation coefficient.
[d] Difference = visual estimation − weighed.

Table 3
Odds ratios of differences between the visual estimation and weighing methods according to meal types, texture, supplied food items and percentage consumption (absolute value).[a]

	n[b]	Univariable		Multivariable	
		OR[d]	95%CI[e]	OR	95%CI
Meal types					
Standard	108	ref		–	
Therapeutic	75	0.57	0.24–1.31	–	
Half-portion	11	3.74	0.58–24.06	–	
Texture					
Regular	125	ref		–	
Bite-sized	13	1.14	0.29–4.39	–	
Minced	49	1.14	0.45–2.90	–	
Pureed	7	–		–	
Supplied food items					
None	173	ref		ref	
Add	21	5.00	1.44–17.43	3.84	1.07–13.85
Percent consumption[c]					
per 10%	194	0.996	0.995–0.998	0.997	0.995–0.999

[a] Logistic regression models conducted for each covariate (independent variable) and the difference (dependent variable) were employed for the univariable analyses. The multivariable model, on the other hand, used one logistic regression (stepwise analysis) that included all the covariates. Necessary adjustments were made for the occupations of the examiners (nurses or nursing assistants), and also the involved hospitals and wards in both the univariable and the multivariable analyses.
[b] Trays lacking leftovers were excluded.
[c] Percentage consumption was calculated based on energy intake.
[d] OR, Odds ratio.
[e] 95%CI, 95% Confidence Interval.

estimation. We used univariable and multivariable analyses for adjusting hospital and ward target trays. We found that the supplied food items were significantly associated with differences between the two assessment methods in the univariable analysis.

Besides, results from the multivariable analysis suggested that there was significant association of the supplied food items with increased odds of a difference between the two meal intake assessment methods (OR: 3.84; 95% confidence interval [CI]: 1.07–13.85). Despite the significant association of the percentage consumption with decreased odds of a difference between the two methods, the calculated OR was ~1.00 (OR: 0.997; 95% CI: 0.995–0.999). And, no noticeable difference was found for other categories, such as meal types and texture.

4. Discussion

In this study, we examined differences in the validity of the visual estimation method for determining patients' meal intake between various meal types, and whether supplied food items were considered in target trays in Japanese hospitals, through using nurses and nursing assistants' routine entries in food intake lists. We found that there were high correlations between the visual estimation method and the weighing method in measuring patients' dietary intake for various meal types and textures, except for meals with added supplied food items.

Our data firstly indicated visual estimation validity for therapeutic meals evaluated by the nursing staff. These results are likely to assist clinical staff, who may have questioned the visual estimation method, since few studies have examined nutrient controlled meals, despite the need for clinical staff to take more notice of patients who are served therapeutic and half-portion meals than standard meals because of nutritional care needs [3,20]. Correlations were high and mean differences by absolute value were small. These results concerning therapeutic meals are consistent with previous research results relating to standard meals [10]. The same degree of correlations and mean differences have been reported in several research studies concerning standard meals with an evaluated food items division where raters measured each food item individually [7–9,11–16]. Moreover, we also reported in our previous studies that correlations and mean differences of visual estimation using a whole tray division as the evaluating unit were also of the same degree [10]. However, as with these previous studies, our data's standard deviations of mean difference were wide. Some of the possible causes of these wider standard deviations may have been due to adding supplied food items and varying inter-rater reliability of visual estimation between nursing staff, although this study considered the influence of supplied food items in the validity of the visual estimation method. Nursing staff need to take care with supplied food items.

We should standardize the process of evaluating supplied food items using visual estimation, regardless of meal types when clinical staff use whole tray or grains/other food divisions. Although we reported in our previous study that using a whole tray division or food items as the evaluating unit was equally useful for raters in evaluating standard meals, the validity of visual estimation using whole tray or grains/other food divisions was low when clinical staff evaluated meal trays with supplied food items in this study [10]. In some previous studies, the nutrient intake of these supplied food items, which are important for the nutritional care of patients with poor appetite, were not calculated or were not included in the meal evaluation but considered as snacks [7–16]. In Japanese hospitals, supplied food items are generally served together with meals and are present on breakfast, lunch and dinner trays. To accurately measure patients' dietary intake when we use the whole tray and grains/other foods division, raters should be aware of high energy and protein food items. Adding supplied food items to patients' meal trays leads to a substantial change in the percentage of nutrient contents by food items for a meal. Although good validity of snacks evaluation has been reported using the food items division [11], oversight and clerical error are issues in clinical settings because supplied food items are not added for all patients and clinical staff are required to evaluate a lot of food items in the food items division [8,15]. To evaluate supplied food items separating by basic meals, grains/other food divisions plus a supplied food items division is one possible solution to this problem. However, we could not confirm the validity of this approach because the number of target trays was too small in our study, and it is the subject of future investigation.

In contrast to our previous study, meal texture and percentage consumption were not associated with the validity of visual estimation in this study [10]. Specifically, as the results of the multivariable logistic regression using the stepwise method showed, meal texture did not feature in the regression formula. This difference may be due to characteristics of the target trays rather than meal types. In our previous study, the percent consumption of dairy produce, which comprised high-energy food items on the target trays, was associated with the validity of visual estimation by nursing assistants. In this study, the number of dairy products on the menus on research days was small and we could not weigh some daily products, due to particular work practices at some hospitals. Additionally, modified texture meals were almost always included in the target trays of hospital 2. Although it was necessary to adjust for the hospital and ward, the influence of meal texture in the validity of visual estimation in therapeutic meals was still remains unclear in our analysis.

This study has several limitations. First, the nursing staff performing the visual estimation were aware of the research purpose and were also informed that the leftovers would be weighed by the researchers for reference. This could have influenced some raters to more carefully evaluate the patients' dietary intake using the visual estimation method than what they would have done usually. Second, the methodology of the visual estimation method, such as tray divisions, was different between hospitals. Although we needed to examine the difference in the validity between tray division, we could not conclude that the validity of the visual estimation method was not significantly different between the different tray divisions in this study. Third, the number of target trays was also different between each hospital because the number of research days was not equal. Finally, the types of therapeutic meals were limited. In Japanese hospitals, a variety of meal types is not on offer, only energy, protein, and sodium controlled meals and half-portion meals, such as fat controlled meals, potassium controlled meals and low residue diets. We could not evaluate all types of therapeutic meals because the number of trays for these therapeutic meals was too limited. However, we could evaluate energy, protein and sodium controlled meals, which comprised a large proportion of therapeutic meals and we obtained a positive result. Therefore, we described the possibility that many meal types could be evaluated using the visual estimation method.

Despite these limitations, the strength of this study is that this is the first to examine the validity of the visual estimation method for patients' dietary intake in respect of several types of therapeutic meals. Furthermore, we calculated an OR, adjusting for meal types, meal texture, percent consumption and whether there were supplied food items, based on our previous qualitative study [10]. We expect that our findings will assist and promote further validation studies of the visual estimation method from diversified standpoints. Further research is needed to examine the differences in the validity of visual estimation, using factors such as raters' knowledge, attitudes towards nutritional care and level of training, to help evaluate the effects of nutrition education.

5. Conclusions

The results of this study showed that there were high correlations between the visual estimation method and the weighing method measuring patients' dietary intake for various meal types and textures, except for meals in which supplied food items were added. Although the evaluation validity of half-portion meal intakes was not high, it was influenced by the addition of supplied food items, which were harder to determine. The nursing staff need to take care with supplied food items.

Statement of authorship

The project was designed by YK, YT, RA, MAS and KF. The data collection was carried out by YK, YT and ST. Data analysis and the manuscript drafting was conducted by YK. The final manuscript was critically appraised and approved by all the authors.

Conflicts of interest

All the authors have declared no conflict of interest for this study.

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