Dietary Minimum Days Estimation

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EPFL, May 31, 2024

Abstract

The aim of this work is to identify the minimum number of days generally required to achieve reliable estimates of the nutritional intake of a subject over a week. The accuracy of nutritional features estimations is assessed using two metrics: the mean intake over different days and the within-subject standard deviation (W-std) in intake between days. These metrics are computed for different number of days combinations (1, 2, 3, ..., 7), for each subject and nutritional features, and compared with a reference period (entire week, 7 days), using the Intraclass Correlation Coefficient (ICC), to evaluate the reliability depending on the number and combinations of days sampled. Additional methods including Principal Component Analysis (PCA), Bland-Altman, and the within, between subject variation coefficient ratio (CVw/CVb) analysis were performed to compare, confirm, and strengthen the results.

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1 Intorduction

Accurate assessment of an individual's typical nutritional intake is crucial for various fields, including nutrition research, public health policy, and clinical practice. However, dietary intake can vary considerably from day to day, making it challenging to obtain reliable estimates of usual intake. The key question that arises is: How many days of dietary assessment are necessary to achieve a reliable estimate of an individual's usual nutritional intake ?
This work aims to identify the minimum number of days generally required to achieve reliable estimates of the nutritional intake of a subject over a week. The accuracy of nutritional features estimations is assessed using two primary metrics: the mean intake over different days and the within-subject standard deviation (W-std) in intake between days.

To answer this question, several statistical methods were combined in ordeer to provide a robust analysis of dietary intake patterns:

- **Intraclass Correlation Coefficient (ICC) Analysis:** Evaluates the reliability of various day combinations in representing the entire week's nutritional intake. This method assesses how well shorter, specific periods can reflect the overall weekly dietary patterns.
- **Principal Component Analysis (PCA):** Examines the proportion of within-subject variance in nutritional intakes explained by different linear combinations of days. This technique helps identify key patterns and sources of variability in dietary habits.
- **Bland-Altman Analysis:** Assesses the agreement, in terms of mean intake, between different day combinations and the entire week.
- **Coefficient of Variation Ratio Analysis:** Determines the minimum number of days required for reliable assessment of dietary habits on the basis of the ratio of within-subject variance to between-subject variance.

The analysis was conducted on a dataset comprising 453 distinct subjects, each providing dietary intake data representing one complete consecutive week. The 37 nutritional features listed below were analyzed and categorized into different groups such as macronutrients, micronutrients, and food groups.

Demographic Feature	Category	Total	Percentage
Gender	female	238	52.5%
	male	215	47.4%
Age Group	35-49	180	39.7%
	18-34	171	37.7%
	50-64	87	19.2%
	65+	15	3.31%
BMI Category	Normal	312	68.8%
	Overweight	111	24.5%
	Obese	22	4.85%
	Underweight	8	1.76%

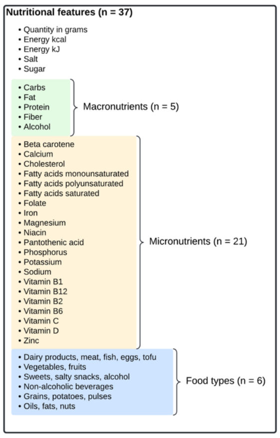


Figure 1: Demographic features distribution and nutritional features

2 Methods

2.1 Metric of Reliability: Intraclass Correlation Coefficient

The reliability is quantified using the ICC, which calculates the ratio of between-subject variance to total variance. A higher ICC value indicates that a smaller proportion of the total variance is due to within-subject variance, thereby indicating higher reliability.The minimum number of days required for a reliable intake estimation of a nutritional feature is determined by identifying the smallest number of day combinations obtaining an ICC score reaching the thresholds of 0.6 considered as good reliability and 0.8 for very good reliability[1]

Given the study's design where nutritional features for each subject are measured multiple times across different days using a consistent measurement method (but different subjects have different measurement method; each subject could introduce bias in the way they measure), a two-way mixed ICC model looking for absolute agreement seems to be the most appropriate method for this scenario and is given by the following formula[1]:

$$\text{Population ICC}_{3A} = \frac{\sigma_{bs}^2}{\sigma_{bs}^2 + \theta_m^2 + \sigma_r^2} \tag{1}$$

σ_{bs}^2 : variance between subjects.
θ_m^2 : variance between measurements.
σ_r^2 : residual error variance.

Corresponding to:

$$\text{Sample ICC(A,1)} = \frac{\text{MSBS} - \text{MSE}}{\text{MSBS} + (k-1)\text{MSE} + \left(\frac{k}{n}\right)(\text{MSBM} - \text{MSE})} \tag{2}$$

$MSBS$: mean square between subjects.
MSE : mean square error, representing the within-subject variability.
k : number of measurements per subject.
n : number of subjects.
$MSBM$: mean square between measurements.

2.2 Data Sampling Method

Only subjects who provided data for a full, consecutive week were included in the analysis. If participants had more than one full week of consecutive data, the average values of their nutritional features across these weeks were used to represent a single week. This approach was justified by a preliminary analysis using the Intraclass Correlation Coefficient (ICC), which demonstrated a good stability in the average food intake from one week to another. The ICC analysis revealed good reliability, (ICC > 0.7 for a large majority of the nutritional features) between consecutive weeks for subjects with multi-week data (63 subjects presented at least 2 full and consecutive weeks), supporting the use of averaged weekly data as representative of typical weekly intake patterns.

Furthermore, this approach standardizes the data, enhancing the reliability of comparisons between individuals. It also improves the understanding of variations related to different types of days (such as weekends versus weekdays), offering a more detailed and comprehensive analysis of food consumption patterns. This methodology helps minimize biases that could occur if certain types of days were disproportionately represented. Moreover, tracking consecutive in times days ensure a more accurate reflection of usual dietary habits.

To address issues related to missing data and to explore the impact of different specific days combinations, both consecutive (a standard week) and non-consecutive day combinations were analyzed. For the latter, all possible combinations from one to seven different days within the week were evaluated.

2.3 Data Analysis

2.3.1 Intra-class correlation coeficient analysis

First, a linear mixed model (LMM) is applied, with the subject as the only random variable and BMI, gender, age category, and day of the week as categorical fixed effects. This analysis identifies general trends in consumption throughout the week and daily variations in nutrient intake.

Next, for each subject, the mean and within-subject standard deviation (W-std) for each nutritional feature are calculated across all possible combinations of days, including the full week (7 days) as the reference period. For example, the protein intake for Subject 1 is analyzed for combinations like Monday-Tuesday-Saturday. This process is repeated for every subject, nutritional feature, and day combination from 1 to 7 days.

These metrics are then used to compute the ICC, which assesses how representative different day combinations are of the reference period in terms of mean intake and variability. An ICC score is calculated for each combination, providing insights into the reliability of these combinations compared to the full week.

The final step involves averaging the ICC scores for all possible combinations of each number of days, from two to six, to assess the general impact of missing data.

This analysis helps determine the minimum number of days, and specific combinations, required to reliably estimate weekly nutritional intake, focusing on accurate measures of average intake and variability.

2.3.2 Principal component analysis

To support the previous analysis, Principal Component Analysis (PCA) is employed to examine the proportion of within-subject variance in nutritional data explained by different linear combinations of days (PC1, PC2, PC3, etc.). In this analysis, each day of the week is treated as a distinct dimension, which allows for the capture of variations in subjects' nutritional intakes from day to day.

For each subject, the average nutritional intake for each nutritional feature over the entire week is calculated. The data are then centered by subtracting this daily average from each corresponding value (each day), in order to minimize variations between subjects and focus exclusively on the within-subject variance. In the context of this study, it is precisely this within-subject variance that is of interest, as it provides insight into the reliability of the measurements.

PCA is then applied to these centered data. The objective is to extract the principal components that reveal the axes of greatest variance. Each principal component is a linear combination of the days of the week, and the coefficients of this combination (the "loadings") indicate the relative importance of each day in the component. The variance ratios explained by each principal component are analyzed to determine how many components, composed of which days, are necessary to capture the majority of the within-subject variance.

2.3.3 Bland-Altmann analysis

Although the ICC is used to measure reliability, it does not guarantee agreement or the absence of systematic bias between measurements. Therefore, to further assess agreement between the different day combinations and the reference period (in terms of mean and W-std in intakes), a supplementary Bland-Altman analysis is conducted. This analysis calculates mean bias values (reference minus comparison) and 95% confidence intervals (CI 95% = $\pm 1.96 \times$ standard deviation), both in grams and as a percentage relative to the reference and present the results in table format. For each combination of "n" days, the analysis yields the range of minimum and maximum mean biases, as well as the ranges of the 95% CIs. For instance, for the combination of two days for a specific nutritional feature, the analysis identifies the range from the most negative to the most positive mean bias across all possible two days combinations. This approach facilitates the observation of bias evolution and agreement with the reference as the number of sampled days varies.

2.3.4 Coefficient of variation ratio analysis

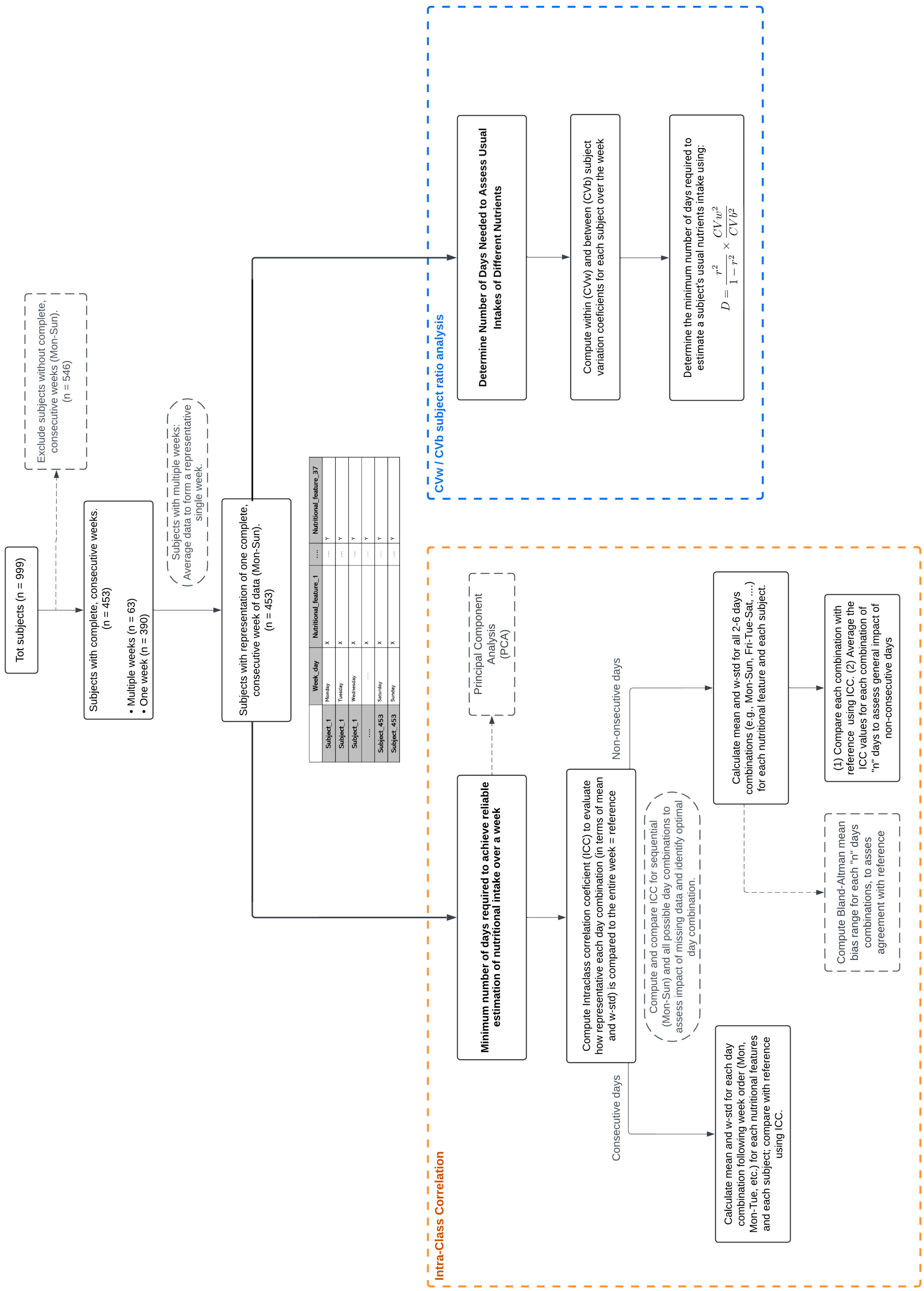
A final analysis, based on the ratio between intra-subject and inter-subject variance, is conducted to determine the minimal number of days of dietary assesment required to obtain a reliable estimate of usual nutritional intakes. This method differs from the one previously used with the ICC. Indeed, in previous analyses, an entire week was taken as a reference, focusing on the number of days needed to reliably meet this reference. The current approach is different: it does not rely on a reference but proceeds to an absolute estimation by analyzing the variances obtained from the nutritional data over the maximum number of days available (in this case, an entire week). The reliability of this approach thus depends on the precision with which the intra and inter-subject food variances can be estimated, which are naturally more precise as the study extends, thus increasing the number of days available per subject. In this case, the representation of a complete and consecutive week (7 days) per subject is available and will be considered as sufficiently representative of a person's eating habits to provide a reliable estimate of the true variance of usual dietary intakes between and within subjects.

For each nutritional feature, intra and inter-individual variations are calculated using a LMM. The average intra-individual variation is determined, and two coefficients of variation (CV) are calculated: $CV_w = \frac{\sqrt{intra-individualvariation)}}{mean} \times 100$, and $CV_b = \frac{\sqrt{inter-individualvariation)}}{mean} \times 100$. The ratio of intra to inter-individual variance (CV_w^2/CV_b^2) is then determined. The number of days (D) required to estimate the usual nutritional intake of the various nutritional features is then derived using the following formula[2]:

$$D = \frac{r^2}{1-r^2} \times \frac{CVw^2}{CVb^2}$$

This formula uses a hypothetical correlation coefficient (r) between the observed and the true intakes. As r increases, the proportion of individuals correctly classified increases. In the current work, different values of r are examined (0.8-0.85-0.9). D is influenced by the variance ratio, so that if the observed intra-individual variance is smaller than the inter-individual variance, less measures will be needed. D also depends on the selected r. Thus, depending on the hypothetical r selected, the number of days of dietary assessment required may increase or decrease, with an r closer to 1 increasing the number of days required.

2.4 Data Processing Workflow



3 Results

3.1 Definitions of Acronyms

- **ICC:** Intraclass Correlation Coefficient - A coefficient used to assess the reliability between days combination and the reference by calculating the proportion of total variance attributable to variability among subjects.
- **LMM:** Linear Mixed Model - A statistical model that incorporates both fixed and random effects to analyze data.
- **W-std:** Within(-subject) Standard Deviation - The standard variability of nutritional intake across the days within the same subject.
- **CV:** Coefficient of Variation - A relative measure of data dispersion around the mean.
- **CVw:** Within-subject Variation Coefficient - A coefficient measuring the variability of observations within the same subjects.
- **CVb:** Between-subject Variation Coefficient - A coefficient measuring the variability among different subjects.
- **PCA:** Principal Component Analysis - A dimensionality reduction technique that transforms original variables into a smaller number of independent variables while retaining the maximum variation.
- **std:** Standard Deviation - A measure of the dispersion or variability of data around the mean.

3.2 ICC analysis, consecutive days combinations

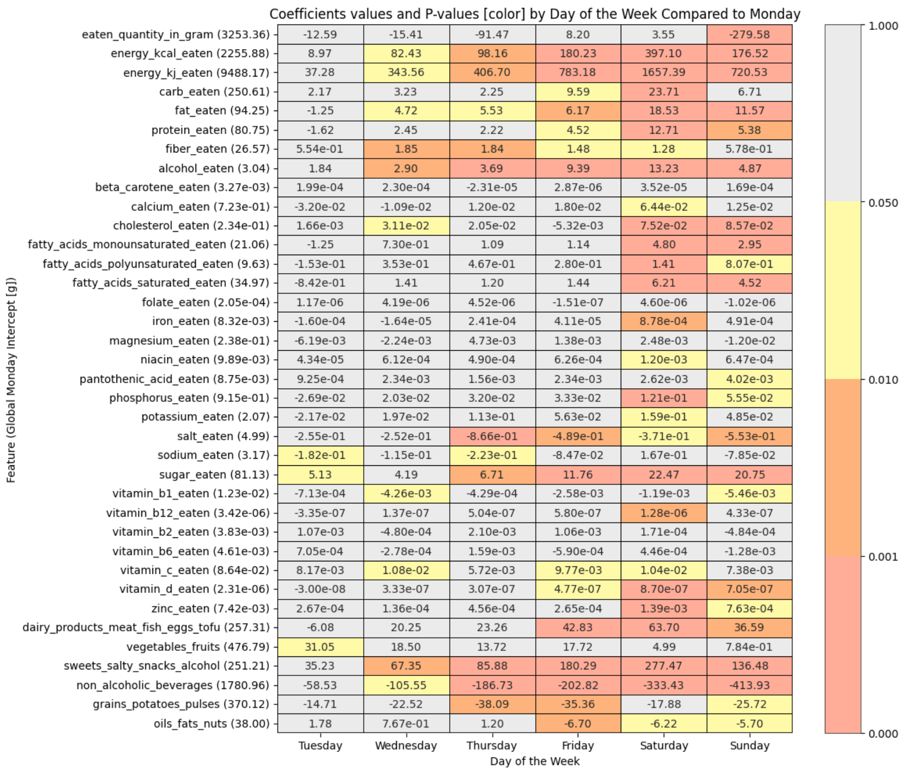


Figure 2: Linear mixed model, nutritional features trend across days.

Figure 2 presents the coefficients for each day of the week, treated as a categorical fixed effect in a LMM, for each nutritional feature. Additionally, it includes the p-value results that test the null hypothesis that the coefficients for each day are equal to zero. The LMM was fitted using the subjects as random effect and BMI, gender, age group, and day of the week as categorical fixed effects.

The values represent the change in the average quantity of the dietary component consumed each day compared to Monday, and can be compared to the intercept (value shown next to the feature label, indicating the average consumption of that feature on Monday). A cell is colored if the p-value is less than 0.05, indicating that the coefficient is statistically different from zero and thus significant. A white/grey cell indicates a p-value greater than 0.05, suggesting that the difference is not statistically significant, and the null hypothesis cannot be rejected.
It is observed that the days from Monday to Thursday show relatively similar trends for most features, while Friday to Sunday and particularly Saturday display different trends, with coefficients also indicating that they differ from one another.The coefficients for the week-end seems to indicate that this difference mainly comes from an increase in the consumption of festive foods such as alcohol, sweets, and snacks. This could reflect weekend behavior where diets are often less structured and more likely to include social meals and leisure activities that encourage more indulgent eating.

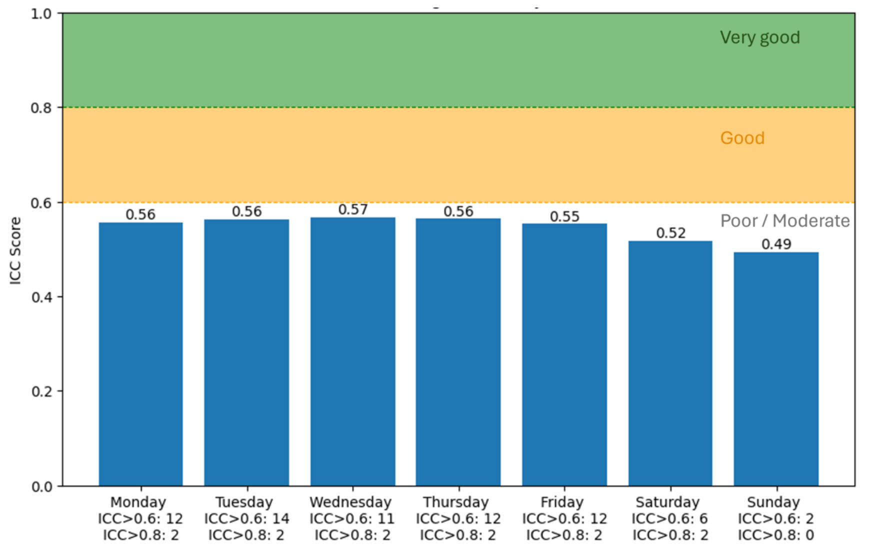


Figure 3: Average ICC score for single week day

Figure 3 displays the averaged ICC scores over all features for each individual days of the week (for exemple, $ICC_{Mon} = 1/n \times [ICC_{feat1_{Mon}} + ... + ICC_{featN_{Mon}}]$). It illustrates the reliability of each day in representing the average intake of various nutritional features throughout the complete week. It can be seen that, none of the days reaches an ICC value considered "good" (0.6) or "very good" (0.8). This visualization helps identify which days align closely or differ with the weekly average feature intake. This could only be done for the ICC in terms of mean intake as calculating the W-std for a single day is not possible.
From Monday to Friday, the ICC scores and the number of features meeting the reliability threshold are quite similar, suggesting a consistent dietary pattern during the weekdays. In contrast, Saturday and Sunday show lower ICC scores and fewer features reaching the reliability threshold, indicating less consistency with the weekly dietary trends, which is in line with the previous results.

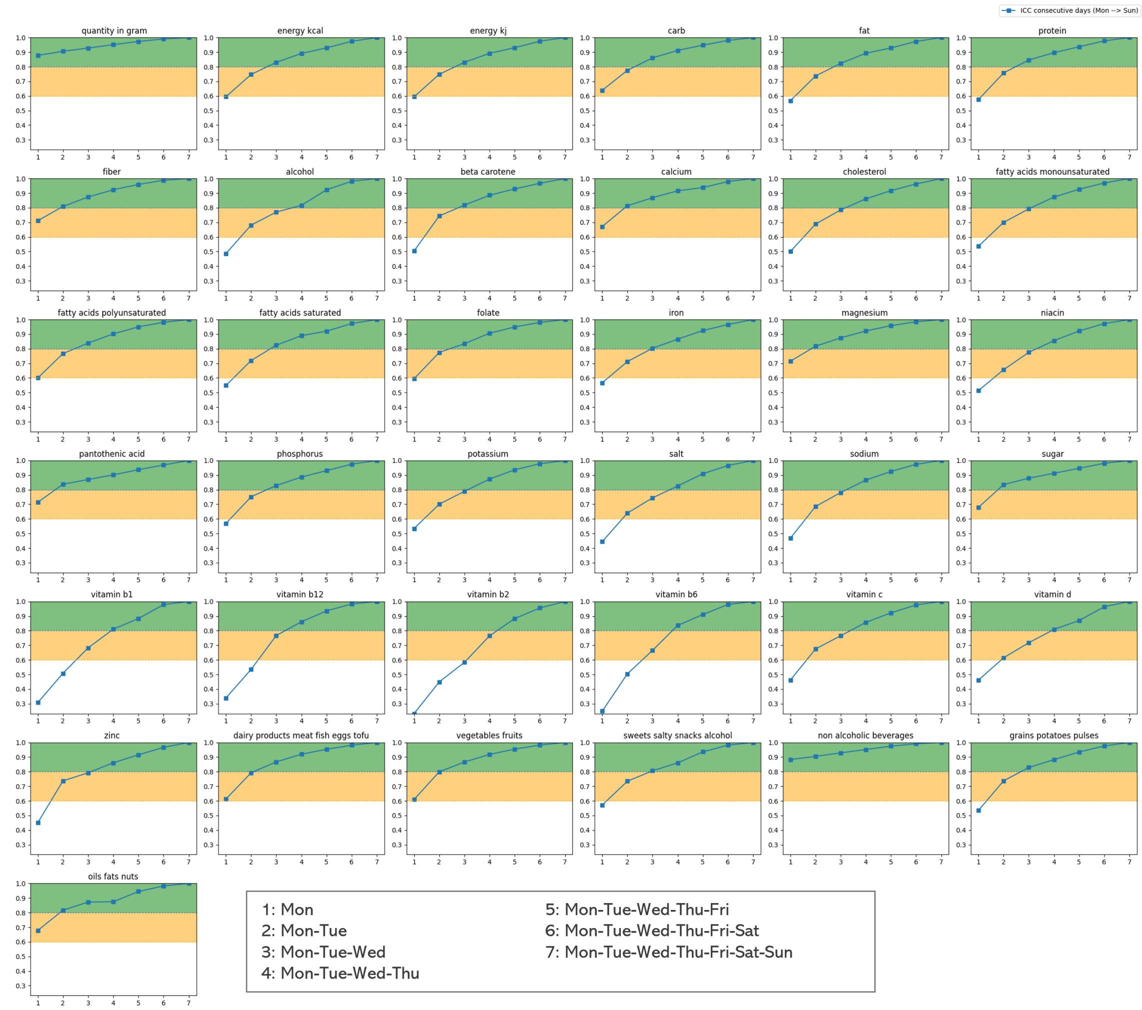


Figure 4: ICC score computed with the mean for combination of days following week order

Figure 4 presents the ICC scores calculated by comparing the mean intake over a combination of "n" consecutive days with the mean intake over the reference period (whole week), for each nutritional feature. The ICC scores generaly smothely improve as the week progresses, indicating a progressive increase in the reliability in approximating typical weekly mean intakes. More particulary, for macronutrients and food groups, aggregating data from just Monday to Wednesday typically results in 'very good' reliability scores, surpassing the 0.8 ICC threshold. Meaning that knowing the intake of macronutrients or food group from Monday to Wednesday is enough to represent reliably the average intake throughout the complete week.
However, for micronutrients, especially vitamins, achieving similar reliability levels requires incorporating data from up to Thursday.
The graph indicates that nearly all nutritional features reach 'very good' reliability by Thursday, except for vitamin B2.

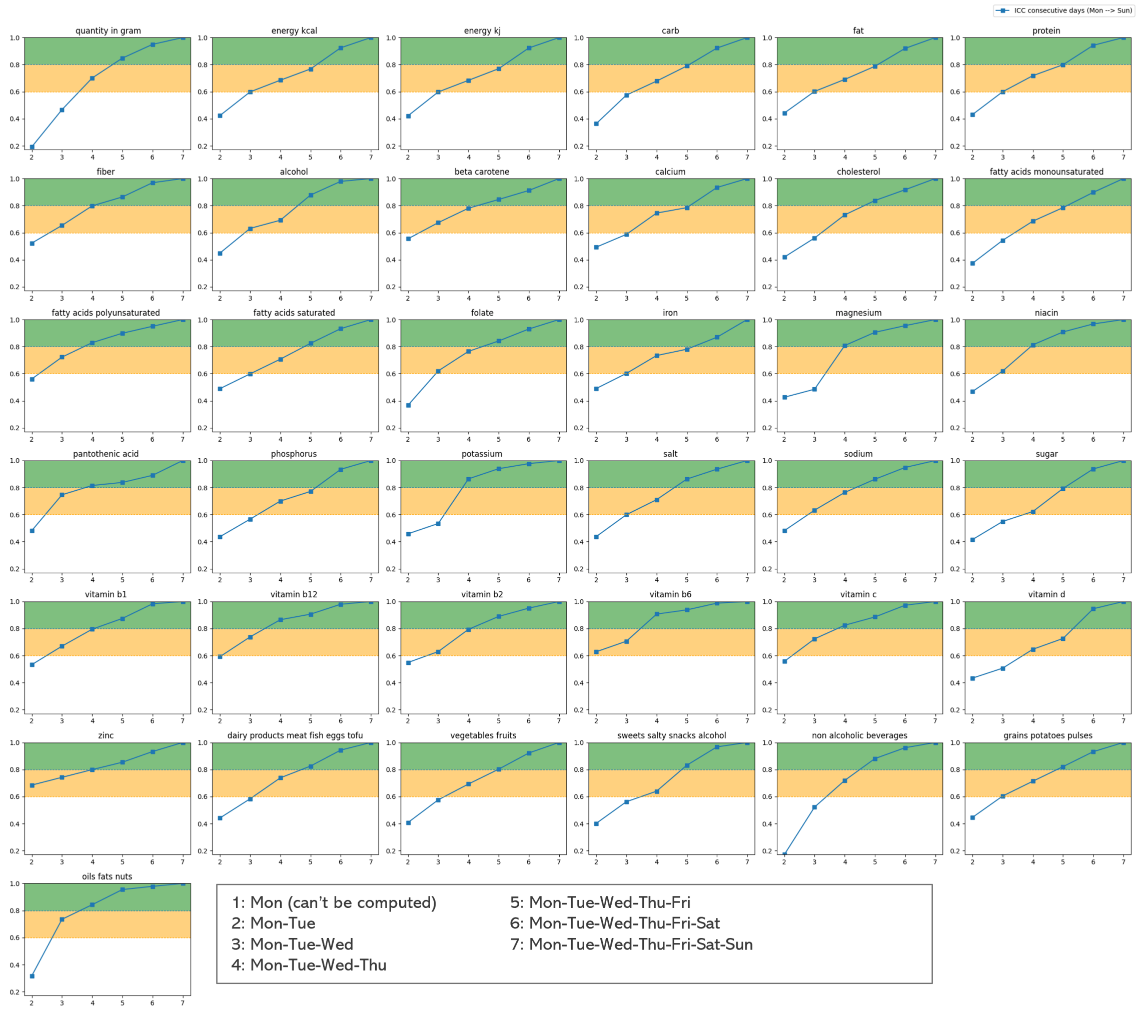


Figure 5: ICC score computed with the W-std for combination of days following week order

Figure 5 presents the ICC scores, calculated by comparing the W-std in intake over a combination of "n" consecutive days with the W-std in intake over the reference period (whole week), for each nutritional feature. The ICC scores generally improve as the week progresses, indicating a progressive increase in the reliability in approximating typical weekly intakes variation within-subject. Macronutrients and food group tend to demonstrate quicker stabilization in ICC scores, often achieving very good reliability after the 5 first days of the week. In contrast, micronutrients typically require an extra day to reach comparable levels of reliability, with substantial improvement often not observed until data from Thursday or the full week are included. Notably, it can be observed that once the weekend days are reached (represented by 5,6,7 on the x-axis) the slope of the ICC curve tends to get steeper (clearly seen for alcohol, sweet-salty snack or sugar for exemple).This indicates that weekends contribute strongly to the total within-subject variance of the whole week. On the other hand, the fact that the scores generaly start at a low value and remain relatively low on the first 3 days indicates that these days together contribute only slightly to the within-subject variance and therefore show similar trends in the nutritional intakes.

3.3 ICC analysis, non-conecutive days combinations

Combinations	Count Feature ICC > 0,8	Count Feature ICC > 0,6	Average ICC All Features
Mon	2	12	0,5568
Mon_Tue	8	33	0,7247
Mon_Tue_Wed	23	36	0,811
Mon_Tue_Wed_Thu	36	37	0,879
Mon_Tue_Wed_Thu_Fri	37	37	0,9315
Mon_Tue_Wed_Thu_Fri_Sat	37	37	0,9762
Mon_Tue_Wed_Thu_Fri_Sat_Sun	37	37	1

Combinations	Count Feature ICC > 0,8	Count Feature ICC > 0,6	Average ICC All Features
Mon	0	2	0,5959
Mon_Tue	1	5	0,7519
Mon_Tue_Wed	4	5	0,8349
Mon_Tue_Wed_Thu	5	5	0,888
Mon_Tue_Wed_Thu_Fri	5	5	0,9392
Mon_Tue_Wed_Thu_Fri_Sat	5	5	0,9801
Mon_Tue_Wed_Thu_Fri_Sat_Sun	5	5	1

Combinations	Count Feature ICC > 0,8	Count Feature ICC > 0,6	Average ICC All Features
Mon	1	4	0,6485
Mon_Tue	2	6	0,7976
Mon_Tue_Wed	6	6	0,8615
Mon_Tue_Wed_Thu	6	6	0,9011
Mon_Tue_Wed_Thu_Fri	6	6	0,9496
Mon_Tue_Wed_Thu_Fri_Sat	6	6	0,9825
Mon_Tue_Wed_Thu_Fri_Sat_Sun	6	6	1

Combinations	Count Feature ICC > 0,8	Count Feature ICC > 0,6	Average ICC All Features
Mon	0	4	0,5019
Mon_Tue	3	17	0,6853
Mon_Tue_Wed	9	20	0,7835
Mon_Tue_Wed_Thu	20	21	0,8668
Mon_Tue_Wed_Thu_Fri	21	21	0,9229
Mon_Tue_Wed_Thu_Fri_Sat	21	21	0,9732
Mon_Tue_Wed_Thu_Fri_Sat_Sun	21	21	1

All nutritional features

Food group

Macronutrients

Micronutrients

Figure 6: ICC scores computed with the mean, consecutive days.

Days	Combination	Average ICC All Features	Days	Combination	Count Feature ICC > 0,8	Count Feature ICC > 0,6
2	Wed_Sat	0,7524	2	Wed_Fri	11	34
2	Wed_Fri	0,7507	2	Mon_Fri	10	33
2	Thu_Sat	0,7497	2	Tue_Thu	10	34
2	Fri_Sun	0,7119	2	Wed_Thu	6	34
2	Fri_Sat	0,7096	2	Fri_Sun	5	32
2	Sat_Sun	0,6778	2	Sat_Sun	1	31
3	Tue_Thu_Sat	0,8559	3	Tue_Wed_Sat	32	36
3	Wed_Thu_Sat	0,8518	3	Wed_Fri_Sun	32	35
3	Mon_Thu_Sat	0,8514	3	Mon_Wed_Fri	32	36
3	Tue_Wed_Thu	0,822	3	Mon_Fri_Sat	27	37
3	Mon_Sat_Sun	0,8176	3	Tue_Wed_Thu	26	37
3	Fri_Sat_Sun	0,7936	3	Fri_Sat_Sun	24	34
4	Mon_Tue_Thu_Sat	0,9108	4	Mon_Tue_Thu_Fri	37	37
4	Tue_Thu_Fri_Sat	0,9102	4	Mon_Thu_Fri_Sat	36	37
4	Mon_Wed_Thu_Sat	0,9097	4	Mon_Tue_Thu_Sat	36	37
4	Thu_Fri_Sat_Sun	0,8869	4	Thu_Fri_Sat_Sun	34	37
4	Mon_Tue_Wed_Fri	0,8864	4	Mon_Fri_Sat_Sun	33	37
4	Mon_Fri_Sat_Sun	0,8808	4	Mon_Tue_Wed_Sun	33	37
5	Mon_Tue_Thu_Fri_Sat	0,95	5	Mon_Tue_Wed_Thu_Sat	37	37
5	Mon_Tue_Thu_Sat_Sun	0,949	5	Mon_Wed_Thu_Fri_Sat	37	37
5	Mon_Wed_Thu_Fri_Sat	0,9488	5	Tue_Thu_Fri_Sat_Sun	37	37
5	Mon_Tue_Wed_Fri_Sun	0,9366	5	Wed_Thu_Fri_Sat_Sun	37	37
5	Mon_Tue_Fri_Sat_Sun	0,9365	5	Mon_Wed_Fri_Sat_Sun	35	37
5	Mon_Tue_Wed_Thu_Sun	0,9333	5	Tue_Wed_Fri_Sat_Sun	35	37
6	Mon_Tue_Thu_Fri_Sat_Sun	0,9781	6	Mon_Tue_Wed_Thu_Fri_Sun	37	37
6	Mon_Wed_Thu_Fri_Sat_Sun	0,9765	6	Mon_Tue_Wed_Thu_Sat_Sun	37	37
6	Mon_Tue_Wed_Thu_Sat_Sun	0,9763	6	Mon_Tue_Wed_Fri_Sat_Sun	37	37
6	Tue_Wed_Thu_Fri_Sat_Sun	0,9759	6	Mon_Tue_Thu_Fri_Sat_Sun	37	37
6	Mon_Tue_Wed_Fri_Sat_Sun	0,9707	6	Mon_Wed_Thu_Fri_Sat_Sun	37	37
6	Mon_Tue_Wed_Thu_Fri_Sun	0,9698	6	Tue_Wed_Thu_Fri_Sat_Sun	37	37

Days	Combination	Average ICC All Features	Days	Combination	Count Feature ICC > 0,8	Count Feature ICC > 0,6
2	Thu_Sat	0,7869	2	Mon_Sat	2	5
2	Thu_Fri	0,7854	2	Mon_Sun	2	5
2	Wed_Sat	0,78	2	Tue_Thu	2	5
2	Tue_Wed	0,7575	2	Tue_Wed	1	5
2	Sat_Sun	0,7463	2	Mon_Fri	1	5
2	Fri_Sat	0,7426	2	Sat_Sun	1	5
3	Mon_Thu_Sat	0,879	3	Tue_Wed_Sun	5	5
3	Tue_Thu_Sat	0,8784	3	Wed_Thu_Sat	5	5
3	Wed_Thu_Sat	0,8768	3	Tue_Thu_Sat	5	5
3	Mon_Tue_Thu	0,8454	3	Mon_Thu_Sun	4	5
3	Tue_Wed_Thu	0,8435	3	Mon_Wed_Thu	4	5
3	Mon_Wed_Thu	0,8423	3	Mon_Tue_Thu	4	5
4	Tue_Thu_Fri_Sat	0,9261	4	Mon_Tue_Wed_Fri	5	5
4	Tue_Wed_Thu_Sat	0,926	4	Tue_Thu_Fri_Sat	5	5
4	Mon_Wed_Thu_Sat	0,9259	4	Tue_Wed_Thu_Fri	5	5
4	Mon_Tue_Wed_Sun	0,902	4	Mon_Tue_Thu_Fri	5	5
4	Mon_Wed_Thu_Sun	0,9009	4	Mon_Tue_Wed_Sun	5	5
4	Mon_Tue_Thu_Sun	0,9	4	Thu_Fri_Sat_Sun	5	5
5	Tue_Wed_Fri_Sat_Sun	0,9592	5	Mon_Tue_Wed_Thu_Sat	5	5
5	Tue_Wed_Thu_Fri_Sat	0,959	5	Mon_Tue_Wed_Thu_Sun	5	5
5	Mon_Tue_Thu_Fri_Sat	0,9587	5	Tue_Thu_Fri_Sat_Sun	5	5
5	Mon_Tue_Wed_Fri_Sun	0,9493	5	Mon_Tue_Wed_Fri_Sun	5	5
5	Mon_Wed_Thu_Fri_Sun	0,9487	5	Mon_Tue_Wed_Fri_Sat	5	5
5	Mon_Tue_Wed_Thu_Sun	0,9315	5	Wed_Thu_Fri_Sat_Sun	5	5
6	Tue_Wed_Thu_Fri_Sat_Sun	0,9845	6	Mon_Tue_Wed_Thu_Fri_Sun	5	5
6	Mon_Wed_Thu_Fri_Sat_Sun	0,9831	6	Mon_Tue_Wed_Thu_Sat_Sun	5	5
6	Mon_Tue_Thu_Fri_Sat_Sun	0,9823	6	Mon_Tue_Wed_Fri_Sat_Sun	5	5
6	Mon_Tue_Wed_Fri_Sat_Sun	0,9817	6	Mon_Tue_Thu_Fri_Sat_Sun	5	5
6	Mon_Tue_Wed_Thu_Sat_Sun	0,9782	6	Mon_Wed_Thu_Fri_Sat_Sun	5	5
6	Mon_Tue_Wed_Thu_Fri_Sun	0,9698	6	Tue_Wed_Thu_Fri_Sat_Sun	5	5

All nutritional features

Food group

Macronutrients

Micronutrients

Days	Combination	Average ICC All Features	Days	Combination	Count Feature ICC > 0,8	Count Feature ICC > 0,6
2	Wed_Fri	0,8349	2	Wed_Sun	4	6
2	Wed_Sat	0,8281	2	Mon_Wed	3	6
2	Thu_Fri	0,8256	2	Wed_Fri	3	6
2	Fri_Sun	0,7386	2	Mon_Sat	1	6
2	Fri_Sat	0,72	2	Fri_Sun	1	5
2	Sat_Sun	0,6919	2	Sat_Sun	0	5
3	Mon_Thu_Sat	0,9011	3	Mon_Tue_Thu	6	6
3	Tue_Thu_Sat	0,9001	3	Tue_Wed_Sat	6	6
3	Tue_Thu_Fri	0,8992	3	Thu_Sat_Sun	6	6
3	Mon_Fri_Sat	0,8585	3	Mon_Fri_Sun	5	6
3	Mon_Sat_Sun	0,8573	3	Mon_Sat_Sun	5	6
3	Fri_Sat_Sun	0,7881	3	Fri_Sat_Sun	4	5
4	Tue_Wed_Fri_Sun	0,9404	4	Mon_Tue_Wed_Fri	6	6
4	Tue_Thu_Fri_Sun	0,94	4	Mon_Thu_Fri_Sun	6	6
4	Wed_Thu_Fri_Sat	0,9383	4	Wed_Fri_Sat_Sun	6	6
4	Thu_Fri_Sat_Sun	0,9073	4	Thu_Fri_Sat_Sun	6	6
4	Tue_Fri_Sat_Sun	0,8975	4	Mon_Fri_Sat_Sun	5	6
4	Mon_Fri_Sat_Sun	0,8938	4	Tue_Fri_Sat_Sun	5	6
5	Mon_Wed_Thu_Fri_Sat	0,9671	5	Mon_Tue_Wed_Thu_Sat	6	6
5	Mon_Tue_Thu_Sat_Sun	0,9667	5	Mon_Tue_Wed_Thu_Sun	6	6
5	Mon_Tue_Thu_Fri_Sun	0,9662	5	Tue_Thu_Fri_Sat_Sun	6	6
5	Mon_Tue_Wed_Thu_Sat	0,9568	5	Mon_Tue_Wed_Fri_Sun	6	6
5	Mon_Tue_Wed_Thu_Sun	0,9499	5	Mon_Tue_Wed_Fri_Sat	6	6
5	Mon_Tue_Fri_Sat_Sun	0,9463	5	Wed_Thu_Fri_Sat_Sun	6	6
6	Mon_Wed_Thu_Fri_Sat_Sun	0,9856	6	Mon_Tue_Wed_Thu_Fri_Sun	6	6
6	Tue_Wed_Thu_Fri_Sat_Sun	0,9847	6	Mon_Tue_Wed_Thu_Sat_Sun	6	6
6	Mon_Tue_Thu_Fri_Sat_Sun	0,9833	6	Mon_Tue_Wed_Fri_Sat_Sun	6	6
6	Mon_Tue_Wed_Thu_Sat_Sun	0,9832	6	Mon_Tue_Thu_Fri_Sat_Sun	6	6
6	Mon_Tue_Wed_Fri_Sat_Sun	0,9827	6	Mon_Wed_Thu_Fri_Sat_Sun	6	6
6	Mon_Tue_Wed_Thu_Fri_Sun	0,9801	6	Tue_Wed_Thu_Fri_Sat_Sun	6	6

Days	Combination	Average ICC All Features	Days	Combination	Count Feature ICC > 0,8	Count Feature ICC > 0,6
2	Wed_Fri	0,7153	2	Tue_Fri	5	18
2	Wed_Sat	0,7131	2	Mon_Fri	5	17
2	Tue_Sat	0,7126	2	Wed_Fri	4	18
2	Tue_Wed	0,684	2	Wed_Thu	1	18
2	Fri_Sun	0,6826	2	Thu_Sun	1	18
2	Sat_Sun	0,6484	2	Sat_Sun	0	16
3	Tue_Thu_Sat	0,8324	3	Wed_Thu_Sat	17	21
3	Wed_Thu_Sat	0,8273	3	Wed_Thu_Fri	17	21
3	Mon_Thu_Sat	0,8233	3	Tue_Thu_Sat	17	21
3	Wed_Sat_Sun	0,7948	3	Tue_Wed_Sun	12	20
3	Mon_Sat_Sun	0,7865	3	Tue_Wed_Thu	12	21
3	Fri_Sat_Sun	0,7746	3	Fri_Sat_Sun	11	19
4	Mon_Tue_Thu_Sat	0,8968	4	Mon_Tue_Thu_Fri	21	21
4	Tue_Thu_Fri_Sat	0,8953	4	Mon_Thu_Fri_Sat	20	21
4	Mon_Wed_Thu_Sat	0,8945	4	Mon_Tue_Thu_Sat	20	21
4	Mon_Tue_Wed_Sun	0,8671	4	Mon_Tue_Fri_Sun	18	21
4	Mon_Tue_Wed_Fri	0,8659	4	Thu_Fri_Sat_Sun	18	21
4	Mon_Fri_Sat_Sun	0,8617	4	Mon_Tue_Wed_Sun	17	21
5	Mon_Tue_Thu_Fri_Sat	0,942	5	Mon_Tue_Wed_Thu_Sat	21	21
5	Mon_Tue_Thu_Sat_Sun	0,9409	5	Mon_Wed_Thu_Fri_Sat	21	21
5	Mon_Wed_Thu_Fri_Sat	0,9395	5	Tue_Thu_Fri_Sat_Sun	21	21
5	Tue_Wed_Fri_Sat_Sun	0,9238	5	Wed_Thu_Fri_Sat_Sun	21	21
5	Mon_Wed_Fri_Sat_Sun	0,9226	5	Mon_Wed_Fri_Sat_Sun	19	21
5	Mon_Tue_Wed_Fri_Sun	0,9222	5	Tue_Wed_Fri_Sat_Sun	19	21
6	Mon_Tue_Thu_Fri_Sat_Sun	0,9748	6	Mon_Tue_Wed_Thu_Fri_Sun	21	21
6	Mon_Tue_Wed_Thu_Sat_Sun	0,973	6	Mon_Tue_Wed_Thu_Sat_Sun	21	21
6	Mon_Wed_Thu_Fri_Sat_Sun	0,9709	6	Mon_Tue_Wed_Fri_Sat_Sun	21	21
6	Tue_Wed_Thu_Fri_Sat_Sun	0,9697	6	Mon_Tue_Thu_Fri_Sat_Sun	21	21
6	Mon_Tue_Wed_Thu_Fri_Sun	0,9659	6	Mon_Wed_Thu_Fri_Sat_Sun	21	21
6	Mon_Tue_Wed_Fri_Sat_Sun	0,9615	6	Tue_Wed_Thu_Fri_Sat_Sun	21	21

Figure 7: ICC scores computed with the mean, non-consecutive days.

Figure 7 showcases the ICC scores computed by comparing the mean intake over various non-consecutive day combinations (ranging from 2-6 days) compared to the reference period (whole week). The values displayed are the averages ICC scores over all the nutritional features, as well as the number of nutritional features meeting the different reliability thresholds (ICC of 0.6 and 0.8) for the three best combinations (coloured green) and the three worst (coloured red). This analysis makes it easier to identify the number and type of days that are most effective in accurately estimating the average weekly intake of macronutrients, micronutrients and food type.
Comparative analysis between Figures 7 and 6 (which presents the data for consecutive day combinations) reveals significant insights; globaly, for all type of nutritional features, the non-consecutive day combinations approach consistently outperform consecutive day combinations in terms of ICC score and level of reliability achieved. Overall, for all type of nutritional feature, the consecutive day approach often mirrors the performance of the least effective non-consecutive days combinations. Moreover it is observable that the best combination of 2,3,4,5 almost systematicaly iclude a weekend day (more particulary Saturday). This inclusion of weekend days in the optimal combinations suggests that variability in diet associated with weekends plays a crucial role in capturing the full spectrum of nutritional mean intake over a week.

To address the research question, the results show that a consecutive data collection approach requires four days (Monday to Thursday) to reliably represent ($ICC \geq 0.8$) the average macronutrient intake over an entire week. For micronutrients, five days (Monday to Friday) are needed,

while for food types, three days (Monday to Wednesday) suffice.
Alternatively, using a non-consecutive approach, three days (Tuesday, Wednesday, Sunday) are adequate for macronutrients, four days (Monday, Tuesday, Thursday, Friday) for micronutrients, and three days (Tuesday, Wednesday, Saturday) for types of food.

All nutritional features

Combinations	Count Feature ICC > 0,8	Count Feature ICC > 0,6	Average ICC All Features
Mon_Tue	0	2	0.453
Mon_Tue_Wed	0	18	0.6126
Mon_Tue_Wed_Thu	9	37	0.7486
Mon_Tue_Wed_Thu_Fri	26	37	0.8424
Mon_Tue_Wed_Thu_Fri_Sat	37	37	0.9426
Mon_Tue_Wed_Thu_Fri_Sat_Sun	37	37	1

Macronutrients

Combinations	Count Feature ICC > 0,8	Count Feature ICC > 0,6	Average ICC All Features
Mon_Tue	0	0	0,4416
Mon_Tue_Wed	0	3	0,6122
Mon_Tue_Wed_Thu	0	5	0,7153
Mon_Tue_Wed_Thu_Fri	2	5	0,8237
Mon_Tue_Wed_Thu_Fri_Sat	5	5	0,9467
Mon_Tue_Wed_Thu_Fri_Sat_Sun	5	5	1

Food group

Combinations	Count Feature ICC > 0,8	Count Feature ICC > 0,6	Average ICC All Features
Mon_Tue	0	0	0,3646
Mon_Tue_Wed	0	2	0,5973
Mon_Tue_Wed_Thu	1	6	0,7246
Mon_Tue_Wed_Thu_Fri	6	6	0,8528
Mon_Tue_Wed_Thu_Fri_Sat	6	6	0,9509
Mon_Tue_Wed_Thu_Fri_Sat_Sun	6	6	1

Micronutrients

Combinations	Count Feature ICC > 0,8	Count Feature ICC > 0,6	Average ICC All Features
Mon_Tue	0	2	0,4989
Mon_Tue_Wed	0	13	0,629
Mon_Tue_Wed_Thu	8	21	0,7796
Mon_Tue_Wed_Thu_Fri	16	21	0,8522
Mon_Tue_Wed_Thu_Fri_Sat	21	21	0,9413
Mon_Tue_Wed_Thu_Fri_Sat_Sun	21	21	1

All nutritional features
Food group
Macronutrients
Micronutrients

Figure 8: ICC scores computed with the W-std, consecutive days.

All nutritional features

Days	Combination	Average ICC All Features	Days	Combination	Count Feature ICC > 0,8	Count Feature ICC > 0,6
2	Thu_Sat	0,5535	2	Wed_Sun	3	7
2	Tue_Sat	0,5439	2	Mon_Fri	2	7
2	Mon_Sat	0,5317	2	Mon_Sat	2	10
2	Fri_Sat	0,4793	2	Tue_Wed	0	2
2	Mon_Wed	0,4602	2	Mon_Sun	0	5
2	Tue_Wed	0,4574	2	Sat_Sun	0	5
3	Tue_Thu_Sat	0,721	3	Mon_Thu_Sat	6	36
3	Mon_Thu_Sat	0,7156	3	Wed_Fri_Sat	5	31
3	Wed_Thu_Sat	0,709	3	Tue_Thu_Sun	5	34
3	Mon_Wed_Fri	0,6488	3	Mon_Tue_Thu	2	26
3	Tue_Wed_Fri	0,6481	3	Tue_Wed_Thu	1	25
3	Tue_Wed_Thu	0,6474	3	Mon_Wed_Thu	1	24
4	Tue_Thu_Sat_Sun	0,8219	4	Tue_Thu_Sat_Sun	24	37
4	Tue_Thu_Fri_Sat	0,8215	4	Wed_Thu_Fri_Sat	23	37
4	Mon_Tue_Thu_Sat	0,8185	4	Mon_Thu_Sat_Sun	22	37
4	Mon_Tue_Wed_Sun	0,7671	4	Tue_Wed_Thu_Fri	12	37
4	Mon_Wed_Thu_Fri	0,7663	4	Mon_Tue_Wed_Sun	9	36
4	Mon_Tue_Wed_Fri	0,7495	4	Mon_Tue_Wed_Fri	8	37
5	Tue_Thu_Fri_Sat_Sun	0,9001	5	Mon_Tue_Wed_Thu_Sat	37	37
5	Mon_Tue_Thu_Sat_Sun	0,896	5	Mon_Tue_Thu_Fri_Sat	37	37
5	Mon_Tue_Thu_Fri_Sat	0,8934	5	Mon_Tue_Thu_Sat_Sun	37	37
5	Mon_Tue_Wed_Fri_Sat	0,8647	5	Mon_Wed_Fri_Sat_Sun	32	37
5	Mon_Tue_Wed_Thu_Sun	0,8603	5	Mon_Tue_Wed_Fri_Sun	32	37
5	Mon_Tue_Wed_Fri_Sun	0,8495	5	Tue_Wed_Fri_Sat_Sun	32	36
6	Mon_Tue_Thu_Fri_Sat_Sun	0,9584	6	Mon_Tue_Wed_Thu_Fri_Sun	37	37
6	Tue_Wed_Thu_Fri_Sat_Sun	0,9547	6	Mon_Tue_Wed_Thu_Sat_Sun	37	37
6	Mon_Wed_Thu_Fri_Sat_Sun	0,9515	6	Mon_Tue_Thu_Fri_Sat_Sun	37	37
6	Mon_Tue_Wed_Thu_Sat_Sun	0,9481	6	Mon_Wed_Thu_Fri_Sat_Sun	37	37
6	Mon_Tue_Wed_Fri_Sat_Sun	0,9317	6	Tue_Wed_Thu_Fri_Sat_Sun	37	37
6	Mon_Tue_Wed_Thu_Fri_Sun	0,927	6	Mon_Tue_Wed_Fri_Sat_Sun	35	37

Macronutrients

Days	Combination	Average ICC All Features	Days	Combination	Count Feature ICC > 0,8	Count Feature ICC > 0,6
2	Tue_Sat	0,515	2	Mon_Wed	0	0
2	Wed_Sat	0,502	2	Mon_Thu	0	0
2	Mon_Sat	0,5009	2	Fri_Sun	0	1
2	Wed_Thu	0,4374	2	Mon_Sat	0	1
2	Mon_Thu	0,4023	2	Mon_Fri	0	1
2	Mon_Sun	0,3963	2	Sat_Sun	0	1
3	Tue_Fri_Sat	0,6929	3	Tue_Fri_Sat	1	5
3	Tue_Thu_Sat	0,6901	3	Thu_Fri_Sat	1	5
3	Thu_Fri_Sat	0,6866	3	Wed_Fri_Sat	1	4
3	Mon_Tue_Thu	0,5996	3	Mon_Tue_Sun	0	4
3	Mon_Wed_Thu	0,5927	3	Mon_Tue_Sat	0	5
3	Mon_Thu_Sun	0,5835	3	Fri_Sat_Sun	0	5
4	Tue_Thu_Fri_Sat	0,8165	4	Wed_Thu_Fri_Sat	3	5
4	Tue_Fri_Sat_Sun	0,8052	4	Tue_Thu_Sat_Sun	3	5
4	Thu_Fri_Sat_Sun	0,8046	4	Tue_Thu_Fri_Sat	3	5
4	Mon_Tue_Wed_Sun	0,7249	4	Mon_Tue_Thu_Sun	0	5
4	Mon_Tue_Thu_Sun	0,7172	4	Mon_Wed_Thu_Sun	0	5
4	Mon_Wed_Thu_Sun	0,7155	4	Mon_Tue_Wed_Sun	0	5
5	Tue_Wed_Thu_Fri_Sat	0,8971	5	Mon_Tue_Wed_Thu_Sat	5	5
5	Tue_Thu_Fri_Sat_Sun	0,8963	5	Mon_Wed_Thu_Fri_Sat	5	5
5	Wed_Thu_Fri_Sat_Sun	0,8941	5	Tue_Thu_Fri_Sat_Sun	5	5
5	Mon_Tue_Wed_Fri_Sun	0,8274	5	Mon_Wed_Fri_Sat_Sun	4	5
5	Mon_Wed_Thu_Fri_Sun	0,8249	5	Mon_Tue_Wed_Fri_Sun	4	5
5	Mon_Tue_Wed_Thu_Sun	0,8059	5	Mon_Wed_Thu_Fri_Sun	3	5
6	Tue_Wed_Thu_Fri_Sat_Sun	0,9629	6	Mon_Tue_Wed_Thu_Fri_Sun	5	5
6	Mon_Wed_Thu_Fri_Sat_Sun	0,9476	6	Mon_Tue_Wed_Thu_Sat_Sun	5	5
6	Mon_Tue_Thu_Fri_Sat_Sun	0,9473	6	Mon_Tue_Wed_Fri_Sat_Sun	5	5
6	Mon_Tue_Wed_Fri_Sat_Sun	0,9443	6	Mon_Tue_Thu_Fri_Sat_Sun	5	5
6	Mon_Tue_Wed_Thu_Sat_Sun	0,9376	6	Mon_Wed_Thu_Fri_Sat_Sun	5	5
6	Mon_Tue_Wed_Thu_Fri_Sun	0,8952	6	Tue_Wed_Thu_Fri_Sat_Sun	5	5

Food group

Days	Combination	Average ICC All Features	Days	Combination	Count Feature ICC > 0,8	Count Feature ICC > 0,6
2	Thu_Sat	0,604	2	Mon_Fri	1	3
2	Wed_Sat	0,602	2	Mon_Sat	1	3
2	Mon_Sat	0,5953	2	Fri_Sun	1	1
2	Tue_Wed	0,4608	2	Tue_Wed	0	1
2	Fri_Sat	0,4576	2	Mon_Sun	0	2
2	Wed_Thu	0,4104	2	Sat_Sun	0	1
3	Mon_Thu_Sat	0,7644	3	Tue_Wed_Sun	2	6
3	Wed_Sat_Sun	0,7564	3	Wed_Fri_Sun	2	6
3	Wed_Fri_Sat	0,7491	3	Tue_Thu_Sun	2	5
3	Mon_Tue_Thu	0,6548	3	Fri_Sat_Sun	1	5
3	Mon_Wed_Thu	0,6427	3	Tue_Wed_Thu	0	3
3	Tue_Wed_Thu	0,6185	3	Mon_Wed_Thu	0	4
4	Wed_Fri_Sat_Sun	0,8519	4	Wed_Fri_Sat_Sun	5	6
4	Mon_Thu_Sat_Sun	0,8489	4	Mon_Thu_Sat_Sun	4	6
4	Wed_Thu_Sat_Sun	0,8481	4	Tue_Thu_Sat_Sun	4	6
4	Mon_Wed_Thu_Fri	0,7939	4	Mon_Tue_Thu_Fri	2	6
4	Mon_Tue_Wed_Fri	0,7905	4	Mon_Tue_Wed_Sun	2	6
4	Tue_Wed_Thu_Fri	0,7759	4	Mon_Tue_Wed_Fri	2	6
5	Mon_Wed_Thu_Sat_Sun	0,917	5	Mon_Tue_Wed_Thu_Sat	6	6
5	Mon_Wed_Fri_Sat_Sun	0,9135	5	Mon_Wed_Thu_Sat_Sun	6	6
5	Mon_Thu_Fri_Sat_Sun	0,913	5	Tue_Thu_Fri_Sat_Sun	6	6
5	Mon_Tue_Wed_Fri_Sun	0,8927	5	Mon_Tue_Wed_Fri_Sat	6	6
5	Tue_Wed_Thu_Fri_Sun	0,8877	5	Wed_Thu_Fri_Sat_Sun	6	6
5	Mon_Tue_Wed_Thu_Sun	0,8694	5	Mon_Tue_Wed_Thu_Sun	5	6
6	Mon_Wed_Thu_Fri_Sat_Sun	0,9653	6	Mon_Tue_Wed_Thu_Fri_Sun	6	6
6	Mon_Tue_Thu_Fri_Sat_Sun	0,9622	6	Mon_Tue_Wed_Thu_Sat_Sun	6	6
6	Tue_Wed_Thu_Fri_Sat_Sun	0,9582	6	Mon_Tue_Wed_Fri_Sat_Sun	6	6
6	Mon_Tue_Wed_Fri_Sat_Sun	0,9571	6	Mon_Tue_Thu_Fri_Sat_Sun	6	6
6	Mon_Tue_Wed_Thu_Sat_Sun	0,9568	6	Mon_Wed_Thu_Fri_Sat_Sun	6	6
6	Mon_Tue_Wed_Thu_Fri_Sun	0,941	6	Tue_Wed_Thu_Fri_Sat_Sun	6	6

Micronutrients

Days	Combination	Average ICC All Features	Days	Combination	Count Feature ICC > 0,8	Count Feature ICC > 0,6
2	Thu_Sat	0,5614	2	Wed_Sun	1	4
2	Tue_Thu	0,5434	2	Mon_Wed	0	4
2	Thu_Sun	0,5413	2	Mon_Thu	0	6
2	Wed_Fri	0,4716	2	Mon_Sat	0	5
2	Fri_Sun	0,4706	2	Mon_Fri	0	2
2	Tue_Wed	0,458	2	Sat_Sun	0	2
3	Tue_Thu_Sat	0,7303	3	Mon_Thu_Sat	3	20
3	Mon_Thu_Sat	0,7177	3	Tue_Thu_Sat	2	20
3	Wed_Thu_Sat	0,7159	3	Tue_Thu_Sun	2	20
3	Fri_Sat_Sun	0,6375	3	Mon_Thu_Fri	0	17
3	Mon_Wed_Fri	0,636	3	Mon_Wed_Fri	0	14
3	Tue_Wed_Fri	0,6293	3	Thu_Fri_Sat	0	20
4	Tue_Thu_Sat_Sun	0,8273	4	Tue_Thu_Sat_Sun	16	21
4	Mon_Tue_Thu_Sat	0,8261	4	Mon_Thu_Sat_Sun	15	21
4	Tue_Thu_Fri_Sat	0,8199	4	Tue_Wed_Thu_Sat	15	21
4	Mon_Wed_Fri_Sun	0,759	4	Tue_Wed_Fri_Sun	6	19
4	Tue_Wed_Fri_Sun	0,7445	4	Mon_Tue_Wed_Sun	6	20
4	Mon_Tue_Wed_Fri	0,7374	4	Mon_Tue_Wed_Fri	4	21
5	Mon_Tue_Thu_Sat_Sun	0,9048	5	Mon_Tue_Wed_Thu_Sat	21	21
5	Tue_Thu_Fri_Sat_Sun	0,8981	5	Mon_Tue_Thu_Fri_Sat	21	21
5	Tue_Wed_Thu_Sat_Sun	0,895	5	Mon_Tue_Thu_Sat_Sun	21	21
5	Tue_Wed_Fri_Sat_Sun	0,8471	5	Mon_Tue_Wed_Fri_Sun	17	21
5	Mon_Tue_Wed_Fri_Sat	0,8454	5	Mon_Tue_Wed_Fri_Sat	17	21
5	Mon_Tue_Wed_Fri_Sun	0,8348	5	Tue_Wed_Fri_Sat_Sun	16	20
6	Mon_Tue_Thu_Fri_Sat_Sun	0,961	6	Mon_Tue_Wed_Thu_Fri_Sun	21	21
6	Mon_Tue_Wed_Thu_Sat_Sun	0,9526	6	Mon_Tue_Wed_Thu_Sat_Sun	21	21
6	Tue_Wed_Thu_Fri_Sat_Sun	0,9503	6	Mon_Tue_Thu_Fri_Sat_Sun	21	21
6	Mon_Wed_Thu_Fri_Sat_Sun	0,9476	6	Mon_Wed_Thu_Fri_Sat_Sun	21	21
6	Mon_Tue_Wed_Thu_Fri_Sun	0,9312	6	Tue_Wed_Thu_Fri_Sat_Sun	21	21
6	Mon_Tue_Wed_Fri_Sat_Sun	0,9146	6	Mon_Tue_Wed_Fri_Sat_Sun	19	21

All nutritional features
Food group
Macronutrients
Micronutrients

Figure 9: ICC scores computed with the W-std, non-consecutive days.

Figures 8 and 9 continue the analytical approach established in Figures 6 and 7, but focus on the ICC scores calculated using the W-std for various non-consecutive day combinations, compared to the reference period (whole week). These figures demonstrate that generally, optimal non-consecutive day combinations outperform the consecutive day approach for all types of nutritional features. Specifically, these optimal non-consecutive combinations consistently achieve higher average ICC scores and reach the reliability thresholds more rapidly. Notably, these combinations systematically include at least one weekend day (mainly Saturday), highlighting the importance of weekends in capturing the full spectrum of an individual's dietary variability.

To address the research question, the analysis indicates that with a consecutive data collection approach, six days of data (Monday to Saturday) are required to reliably represent ($ICC \geq 0.8$) the within-subject standard deviation (W-std) in macronutrient and micronutrient intake over the entire week. For the type of food, five days (Monday to Friday) are necessary.
In contrast, for the non-consecutive approach, five days (Monday, Tuesday, Wednesday, Thursday, Saturday) are sufficient to achieve a reliable representation for both macronutrients and micronutrients, as this combination shows the same optimal configuration. For the type of food, four days (Wednesday, Friday, Saturday, Sunday) are adequate.

Figure 10: Average ICC score, in terms of mean and W-std, for non-consecutive days combination (red curve), compared to consecutive combination (blue curve).

Figure 10 illustrates the ICC values in terms of mean (left) and W-std (right), in function of the number of day combined, obtained by averaging the ICC scores for each possible combination of n (non-consecutive) days for each nutritional feature. Specifically, the red curves represent these averaged ICC scores for non-consecutive day combinations; for example, the ICC score of an element on a two-day combination is the average ICC score of all possible non-consecutive two-day combinations of this element. The blue curves, which are identical to those in Figure 4 and 5, depict the evolution of the ICC as consecutive days are added. The aim of this figure is to illustrate the general impact of non-consecutive days of dietary assessment and to compare it with the consecutive day assessment approach. It also provides an insight into the general effect of missing data in a survey protocol intended to collect data over an entire week. For example, it explores how missing 1, 2, or 3 days of data in the studied population might globaly affect the expected results, which represent the mean and w-std of intake over a week. This could offer valuable insights for similar cohort studies.

Upon comparing the two approaches (consecutive and non-consecutive), it is observable that for the ICC, in terms of the mean, there is no significant difference between the two curves regarding the speed at which they reach reliability thresholds. This suggests that despite the advantage observed in previous results, where specific non-consecutive day combinations outperformed consecutive day combinations, the average ICC score across all possible combinations balances out to that achieved by adding consecutive days. However, this observation is less true for features showing distinct trends between weekends and weekdays (such as alcohol or sweet and savory snack consumption), where the non-consecutive approach generally performs better than the consecutive approach. This is because combinations of 2, 3, 4, 5 days including weekend days are already factored into the non-consecutive combinations.
In terms of W-std, the non-consecutive approach (red curve) slightly outperforms the consecutive one (blue curve). It is also noted that the red curve is smoother than the blue curve, which generally shows a steep increase in slope from the fifth day, marking the addition of weekend days. This increase is not observed in the red curve, as it is moderated by the fact that some combinations of 2, 3, 4, 5 days contributing to the average ICC value already include representations of weekend days. These results further emphasize the importance of weekends in capturing the full spectrum of an individual's dietary variability.

3.4 PCA analysis

Open Principal components analysis in another page.

The PCA results reveal insights into the W-std of dietary habits. For the vast majority of nutritional features (encompassing macronutrients, micronutrients, and food groups) the first two principal components (PC1 and PC2) are largely explained by weekend days, with Saturday particularly standing out as the most significant contributor. This observation indicates that weekends are the primary source of W-std in weekly food consumption patterns. Furthermore, the analysis shows that, on average, five principal components are required to explain over 80% of the W-std of the whole week. These findings underscore the importance of accounting for weekend consumption variations to capture the full specturm of weekly dietary habit, while also recognizing that multiple dimensions are necessary to capture the majority of W-std in food intake throughout the week.

3.5 Bland-Altmann analysis

Open Bland-Altmann in another page.

Bland-Altman results indicate the greatest agreement (both in terms of mean and W-std across the combined days) for all nutritional features is found in any 6-day combinations versus the 7-day reference period. Generally speaking, the addition of days increases agreement with the reference period. These complementary results to the ICC ensure not only the reliability of measurements but also their agreement with the reference period ensuring that the ICC is not influenced by systematic biases in food intake.

3.6 Coefficient of variation ratio analysis

Nutritional Feature	Mean ± Std	Median	CVw (%)	CVb (%)	Variance Ratio	Days (r=0.8)	Days (r=0.85)	Days (r=0.9)
eaten_quantity_in_gram	3225.63 ± 1491.44	3063	25,6035	38,5028	0,4422	**1**	**2**	**2**
energy_kcal_eaten	2544.42 ± 661.79	2425,025	21,72	11,6012	3,5052	**7**	**10**	**15**
energy_kj_eaten	10712.70 ± 2776.97	10249,6096	21,5851	11,6096	3,4568	**7**	**10**	**15**
salt_eaten	5.19 ± 3.06	4,655	53,8284	23,4325	5,277	**10**	**14**	**23**
sugar_eaten	91.14 ± 44.45	85,2937	37,4444	29,8928	1,5691	**3**	**5**	**7**
carb_eaten	263.34 ± 80.52	254,15	24,4739	16,5022	2,1995	**4**	**6**	**10**
fat_eaten	109.52 ± 38.93	103,468	30,3149	16,4893	3,3799	**7**	**9**	**15**
protein_eaten	93.47 ± 33.05	88,663	29,7196	16,5309	3,2322	**6**	**9**	**14**
fiber_eaten	28.32 ± 12.83	26,2505	34,2865	29,0175	1,3961	**3**	**4**	**6**
alcohol_eaten	10.06 ± 17.95	0	148,7938	86,4837	2,9601	**6**	**8**	**13**
beta_carotene_eaten	3.31e-03 ± 3.84e-03	0,0019	101,4457	55,0512	3,3957	**7**	**9**	**15**
calcium_eaten	8.03e-01 ± 5.13e-01	0,6963	51,9455	36,5667	2,018	**4**	**6**	**9**
cholesterol_eaten	2.97e-01 ± 2.33e-01	0,2339	69,4821	33,4483	4,3152	**8**	**12**	**19**
fatty_acids_monounsaturated_eaten	25.01 ± 13.06	22,924	45,4998	23,6145	3,7125	**7**	**10**	**16**
fatty_acids_polyunsaturated_eaten	10.97 ± 7.31	9,275	54,512	37,4079	2,1235	**4**	**6**	**10**
fatty_acids_saturated_eaten	40.83 ± 18.20	38,042	38,6834	19,9215	3,7706	**7**	**10**	**17**
folate_eaten	2.12e-04 ± 1.12e-04	0,0002	43,1487	29,7654	2,1014	**4**	**6**	**9**
iron_eaten	9.08e-03 ± 4.98e-03	0,0082	47,6244	26,6533	3,1927	**6**	**9**	**14**
magnesium_eaten	2.54e-01 ± 1.38e-01	0,2307	42,3156	33,5611	1,5898	**3**	**5**	**7**
niacin_eaten	1.19e-02 ± 8.02e-03	0,01	60,4616	28,6135	4,465	**8**	**12**	**20**
pantothenic_acid_eaten	1.08e-02 ± 3.56e-02	0,0038	250,743	211,6929	1,403	**3**	**4**	**6**
phosphorus_eaten	1.06 ± 4.72e-01	1,0012	38,0822	21,6481	3,0946	**6**	**9**	**14**
potassium_eaten	2.27 ± 1.10	2,137	42,6492	21,4975	3,9359	**8**	**11**	**17**
sodium_eaten	3.35 ± 1.48	3,1473	38,9297	18,5715	4,3941	**8**	**12**	**19**
vitamin_b1_eaten	1.07e-02 ± 3.36e-02	0,0009	299,0129	97,7763	9,3522	**17**	**25**	**40**
vitamin_b12_eaten	4.58e-06 ± 7.93e-06	0	152,5074	79,7377	3,6581	**7**	**10**	**16**
vitamin_b2_eaten	4.74e-03 ± 1.99e-02	0,001	415,9487	82,1951	25,6087	**45**	**66**	**108**
vitamin_b6_eaten	4.91e-03 ± 1.71e-02	0,0014	341,0752	65,3518	27,2386	**49**	**72**	**117**
vitamin_c_eaten	9.22e-02 ± 8.13e-02	0,0708	78,0623	40,1721	3,776	**7**	**10**	**17**
vitamin_d_eaten	3.05e-06 ± 3.47e-06	0	105,9042	39,841	7,0659	**13**	**19**	**31**
zinc_eaten	8.79e-03 ± 5.50e-03	0,0078	55,9173	26,6198	4,4125	**8**	**12**	**19**
dairy_products_meat_fish_eggs_tofu	336.70 ± 221.95	306	53,6116	35,0785	2,3358	**5**	**7**	**10**
vegetables_fruits	474.21 ± 288.59	439	47,7073	36,5684	1,702	**4**	**5**	**8**
sweets_salty_snacks_alcohol	372.40 ± 387.52	259	84,9345	51,4234	2,728	**5**	**8**	**12**
non_alcoholic_beverages	1547.18 ± 1375.89	1400	46,7922	75,1993	0,3872	**1**	**2**	**2**
grains_potatoes_pulses	366.45 ± 210.95	340	48,7895	29,1138	2,8084	**6**	**8**	**12**
oils_fats_nuts	37.06 ± 45.29	30	101,5772	66,8229	2,3107	**5**	**7**	**10**

Figure 11: Mean, SD, median, coefficients of variation, within-to-between individual variance ratios and number of days to reach $r \geq 0.8, 0.85, 0.9$ for all nutritional features.

Figure 11 presents the median, mean intakes and the std for all features across the whole week. CV_w and CV_b are also presented. Overall, CV_b was smaller than CV_w, resulting in a variance ratio (CV_w^2/CV_b^2)of more than 1. The number of days of dietary assessment required, resulting from the formula: $D = \frac{r^2}{1-r^2} \times \frac{CV_w^2}{CV_b^2}$ are presented in the figure 11

4 Discussion

The various results obtained highlight a significant difference in dietary habits between weekdays (Monday to Thursday) and weekends (Friday to Sunday). Indeed, the first four days of the week show relatively stable and similar eating trends, while the weekends, especially Saturday, exhibit significant variations. These variations seem to be mainly attributable to typical weekend behaviors, where diets are often less structured and include social meals as well as leisure activities that promote more liberal and indulgent consumption.

The results demonstrate that this variability in nutritional intake related to the type of day (weekday vs. weekend) is a crucial factor in capturing the full spectrum of average consumption and intra-subject weekly variance. For exemple, figure 3 underscores the potential of weekdays, particularly one from Monday to Thursday, to serve as reliable indicators (the day as itself) of weekly dietary patterns. Since four out of the seven days share similar trends, it could be inferred that this explains why one of these days is more representative of the entire week in terms of average characteristics compared to weekend days.

Interestingly, when examining combinations of more than one day, for example two days, the best combinations consistently include a weekday and a weekend day, usually Saturday. This approach of combining non-consecutive days performs significantly better than the consecutive day approach in reliably capturing the average intakes and weekly dietary variance, as demonstrated in figures 6, 7, 8, and 9. The weekday would serve to capture the habits of the first 4 days which are little differentiated from each other and can be represented as the dietary baseline of the subject (4 days out of 7 present similar habits) and the weekend day, which as seen previously, is the main source of dietary variance among subjects (notably in the PCA analysis, LMM results and deducted from the ICC analysis), serves to capture the deviation that the weekend brings to this baseline.

The ideal approach, therefore, seems to be to combine a day where dietary habits deviate with one or more days where habits are more stable, which, in the studied population, is characterized by a Saturday and a Monday, for example.
For the ideal combinations depending on the food features, refer to the figures 7 and 9.

This observation could be important for the design of nutrition studies, where flexibility in data collection planning can significantly improve the accuracy of nutritional estimates. An ideal protocol might require customization based on precise dietary assessments, adapted to individual variations. For instance, categorizing certain people according to their specific dietary habits (party-loving students, athletes, religious practices influencing alcohol consumption, etc.) could anticipate the weekdays including the most variance and lead to a personalized protocol.
Furthermore, figure 11 illustrates the general effect of missing data in a survey protocol designed to collect data over an entire week. This analysis could offer valuable insights for similar cohort studies, exploring how the absence of 1, 2, or 3 days of data might globally affect the expected outcomes, representing the standard mean and deviation of intake over a week.

5 Conclusion

This work has provided insights for nutritional research and dietary assessment protocols regarding the estimation of minimum days required for accurate weekly food intake estimation. The findings emphasize the significance of weekend days, especially Saturday, in capturing a comprehensive understanding of weekly dietary habits due to the significant contribution they make to within-subject variance. Non-consecutive day combinations tend to outperform consecutive day approaches in reliably estimating weekly nutritional intake, indicating that strategic sampling can enhance estimation accuracy.

For macronutrients, a dietary assessment of 3-4 days is typically sufficient for a very reliable estimation of mean intake, whereas 5-6 days are needed to estimate the within-subject standard deviation. Micronutrients generally require 4-5 days to obtain a very reliable mean intake estimation and 5-6 days to assess within-subject standard deviation, owing to their greater variability. Food type categories can often be very reliably estimated with just 3-4 days of data.

These results underscore the importance of designing optimal dietary assessment protocols that include both stable consumption days and days with expected deviations to accurately represent weekly patterns. By categorizing individuals into typical profile groups (e.g., party-going students, athletes, individuals with specific dietary restrictions), researchers can anticipate sources of variation and build up assessment protocols, accordingly, resulting in improved efficiency and accuracy of data collection while reducing participant burden.

These findings have implications for the design of more efficient nutrition studies, potentially reducing participant burden while maintaining data quality. Moreover, they provide valuable insights into the potential impact of missing data in weekly food surveys, which can guide researchers in handling incomplete datasets.

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