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Validation of a Digital Dietary Survey Tool (Food Survey) Adapted to Elite Chadian Athletes

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Abstract

To ensure effective nutritional surveillance of athletes on a national scale, it is essential to collect reliable and representative data on dietary intakes. This requires the design and validation of standardised tools that are regularly updated to reflect recent changes in the composition of food products and the nutritional habits of the population. The aim of this study was to create and validate a digital tool designed to assess the dietary profiles of elite Chadian martial arts practitioners. A total of 63 elite Chadian martial artists (33 men and 31 women) with an average age of 18.58 ± 2.36 years participated in this study. Anthropometric parameters, including height, body weight and body mass index (BMI) were measured. To validate the Food Survey software package, energy, macro- and micronutrient intakes were assessed using a 24-hour food intake recall (reference method) and compared with the same data collated from Food Survey (tested method) in order to analyse reconciliation agreements between the results of the two methods. The comparison of energy and nutrient intakes for women and men revealed similar results for most nutrients, indicating overall consistency. Analyses of the various Bland-Altman distribution curves indicate that the majority of the parameters from the two methods studied show good agreement: the biases (y = absolute bias) are, for the most part, perfect, with most of their values close to 0. The limits of agreement (y = absolute bias ± 1.96 × standard deviation) are also narrow for all the data analysed, with the exception of phosphorus (−371.299; 250.113). This IT tool represents an innovative alternative for assessing food choices, particularly in contexts where dietary behaviour is measured only once. Unlike 24-hour dietary recalls or food frequency questionnaires, which require repeated administrations to provide a more comprehensive assessment of dietary habits, this tool stands out for its ability to be effective in studies with limited time and budget. It is a practical solution for rapidly collecting reliable data on food choices in constrained research environments.

Keywords

Digital Tool, Validation, Nutritional Intake, Dietary Survey, Combat Sport

1. Introduction

Nutrition plays a crucial role in sports performance, directly influencing physical capacity, recovery and endurance. For elite athletes, a balanced diet adapted to the specific requirements of their discipline is essential to optimise their performance [1]-[4]. Accurate assessment of dietary intake is therefore essential to help athletes make informed decisions about dietary recommendations for athletes.

Several methods are used to assess diets, each with its own advantages and limitations. Commonly used tools include 24-hour dietary recalls, food frequency questionnaires (FFQs), food diaries and direct observations [5]-[7]. These methods make it possible to obtain qualitative and quantitative data on people's eating habits. For example, food recalls provide a snapshot of food consumption, but are highly dependent on the memory and sincerity of the respondent. FFQs, on the other hand, provide an overall view of dietary trends over an extended period, although they are often biased by reporting errors.

In recent years, however, a number of food survey tools have been designed and validated using computer software, the Internet and the Web, thanks to the work of leading researchers. These tools are now used worldwide [8]-[11]. Although these technological innovations do not guarantee greater dietary accuracy than traditional dietary assessment methods, they offer interesting prospects for minimising dietary reporting bias [8].

The majority of researchers working on new dietary survey technologies validate them by relying on traditional reference tools and methods, such as the 24-hour dietary recall or the food frequency questionnaire, combined with statistical analyses [8] [12]. These tools also seem unsuitable for certain countries, due to the wide range of environmental factors that determine dietary behaviour [13].

In the Chadian context, assessing the diets of elite athletes faces several challenges. Limited resources, restricted access to country-specific dietary databases, and cultural and regional variations in dietary habits complicate the application of standard methods. In addition, Chadian sportsmen and women live in an environment where sports facilities and nutritional resources are often inadequate, making understanding their needs even more critical.

This problem highlights the importance of choosing assessment tools that are adapted to the local context. The integration of modern technologies, such as mobile applications for dietary monitoring, could offer a promising solution for collecting accurate data while overcoming some of the limitations of traditional methods. It is also essential to train athletes and their coaches in the basics of sports nutrition so that they can better understand the impact of their dietary choices on their performance. The aim of this project was to create and validate a digital tool designed to assess the dietary habits of elite martial arts practitioners in Chad. This new tool will also be validated using more sophisticated methods such as isotopes and accelerometers.

2. Material and Methods

2.1. how Food Survey was Developed

Preliminary investigations using the Food Frequency Questionnaire (FFQ), carried out in accordance with international and scientific database standards, enabled us to draw up a booklet of food portions. To this end, 10 food groups (cereals; tubers; legumes; vegetables; fruit; meat; fish and eggs; dairy; oils and fats; beverages and other foods) comprising 190 foods were identified. Units of measurement were also listed: kitchen utensils (ladle, soup and coffee spoon, piece of carved calabash, glass…) and others (coins and banknotes, pinch of fingers, wrist of hand, palm of hand…). An electronic dietary scale with a capacity of 5 kg, brand Téfal, and model: copper 5 and accuracy 1 g, test tubes, beakers etc. and a camera were used for this purpose. The raw foods were weighed by Nutritionists assisted by students from the National Institute of Younth and Sports of N'Djamena and photographed by a professional photographer directly with women market vendors, in food stores or in households in the study area (3, 6, 7, and 9th Arrondissement of N'Djamena Commune). A portion of food corresponds to the standard unit of measurement or its equivalent (coin) customary in Chad for each foodstuff. For cooked foods, the research team weighed and photographed some purchased from vendors, informal traders and restaurateurs, and others prepared in the households selected for the occasion. In the case of multi-ingredient dishes, for example, the "bouillie composée": a Chadian dish whose gross weight is measured and estimated at 700 g of its portion, containing the standard unit of measurement commonly known as a "gobelet". The net weight of the main ingredient, grain rice, is estimated at 66g. Added to this is water, calculated and estimated at 517 g, cow's curd (57 g), peanut paste (20 g) and sugar (40 g). Portions of main and accessory ingredients are quantified using the Dop method [8]. Measurements are carried out a minimum of three times in different locations for the same foods, in order to retain the average values, which are recorded in the "Food Survey".

2.2. How Food Survey Works

The Food Survey application facilitates the assessment of dietary intakes in four main stages, illustrated by the figures shown.

Figure 1. Home page.

Figure 2. File/Edition menu.

Figure 3. File sub-menu.

Figure 4. Registration of sud-menus.

Figure 5. Menu edition.

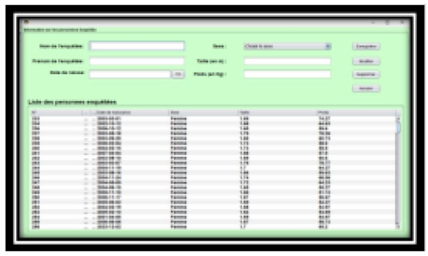


Figure 6. Registration of respondents.

Figure 7. Entering a food.

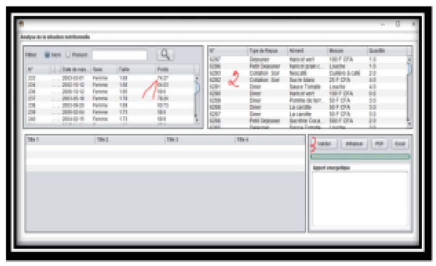


Figure 8. Parameter analysis.

Double-click on the Food Survey icon to open the main screen (Figure 1). Then click on the File/Edit menu (Figure 2).

1) Managing sub-menus in the File menu

Selecting the File menu gives you access to various sub-menus (Figure 3) such as the unit of measurement, meal types or the food composition table. To save a data item (for example, a unit of measurement), enter the necessary information, add an image if you wish, then click on Add to confirm (Figure 4).

2) Accessing the Edit menu

Click on Edit to display the sub-menus (Figure 5), such as Entering respondent information and Dishes served. Before any analysis, identify the respondents by filling in their information in the corresponding sub-menu (Figure 6).

3) Entering meals and analysing data

For each food consumed, enter the respondent, the meal (breakfast, lunch, dinner, etc.), the quantity and click Save (Figure 7). Finally, to calculate the energy and nutrient intakes, go to Data analysis, select the dishes served, and validate to obtain the cumulative results in energy, macronutrients (proteins, lipids, carbohydrates) and micronutrients (Calcium, Iron, vitamins, etc.) as shown in figure

8.2.2.

Indeed, the algorithms are based on the data contained in the food booklet, *i.e.* the food portion and its ingredients, the unit of measurement and the weight of each ingredient, combined with a food conversion sheet for macro and micronutrients per 100g of edible food. From this food portion, the rule of three is applied according to the quantity of food ingested by the subject, and recorded to determine the lipid, protein and carbohydrate content in g, the Calcium, Iron and Phosphorus content, and the vitamin B1, B2, B6 and C content in mg. Energy intake is then calculated by multiplying the cumulative content of carbohydrates in g by 4 Kcal, protein in g by 4 Kcal and lipids in g by 9 Kcal, according to the standards for converting g into Kcal for these substrates. Energy intake is the sum of the three results. For Calcium, Iron, Phosphorus and vitamins, the total constitutes the subject's intake.

2.3. Validation of the Food Survey Tool

2.3.1. Participants and Sample Size

The study carried out in 2021 involved a group of 63 practitioners of combat sports: Taekwondo (n = 26), Wrestling (n = 14), Karate (n = 13) and Judo (n = 10) in preparation for the African Games in Brazzaville. According to a statistical estimate carried out using the G*Power programme for four sports disciplines, the minimum sample size required, with a significance level of 0.05 and statistical power of 0.95, should be between 76 individuals (for strong effects) and 92.

The selection criteria for participants included competitive practice of a combat sport at the highest level of the federation in Chad and at least three years' experience. Conversely, exclusion criteria included a low level of sporting performance, less than three years' professional experience or an injury-related interruption in training.

The research was conducted in accordance with the ethical principles of the 1964 Declaration of Helsinki. Informed consent was obtained from all participants. The protocol was approved by the Ethics Committee (reference no. 101/LBT/OIL/2021, dated 11 April 2021).

2.3.2. Study Design

A team consisting of a nutritionist and a professional photographer collected data over a four-week period. They used a food frequency questionnaire [14] to identify the main foods consumed. A booklet containing photos of food portions, their standard household measurements, their gross weights and the ingredients that make them up was produced [15]. Equipment such as a dietary scale, experiments and a camera were used for this task.

In the absence of a food composition table for use in Chad, a rigorous compilation of data from existing tables in accordance with FAO/INFOOD guidelines was used to create the databases. The conversion of food into macronutrients (proteins, lipids, carbohydrates), vitamins (B1, B2, B6, C), minerals (Calcium, iron, phosphorus) and energy was carried out using the improved FAO food table for use in Africa [16], the Souci table (2004), data from the US Department of Agriculture [5], the Department of Health of England [17], studies by [18], as well as the food composition table for countries in the Congo Basin [19] and West Africa. The results of scientific publications on food content in Chad's neighbouring countries (Cameroon, Nigeria) are also included. For local foods whose composition does not appear on the tables identified, the results of physico-chemical analyses of local foods are carried out at the N'Djamena biochemical laboratory: CECOQDA (Centre de Contrôle des Qualités des Denrés Alimentaires) and the Pointe-Noire laboratory in Congo.

A computer engineer has designed an innovative application called Food Survey, which integrates food data and photographed portions. The tool can be used to record and project data to help participants make their choices. This computerised, dynamic and adaptable application modernises traditional methods such as the 24-hour dietary recall.

Two research teams worked simultaneously for 7 days. The first, made up of a nutritionist and trained students, conducted surveys using the classic 24-hour recall method. It recorded the names of the foods, their quantities (using household measurements such as a ladle or cup), the ingredients, as well as the times and types of meal. Three non-consecutive days were chosen to minimise errors.

The second team, also led by a nutritionist and assisted by students, used the Food Survey. The data was projected onto a screen, and the participants made their choices directly. This tool overcomes the challenges associated with quantifying food, managing collective meals and the errors of manual methods.

2.3.3. Measures

Data were collected using a structured questionnaire, completed independently by the participants. The questionnaire included information on socio-demographics, weight, height and body mass index (BMI), in accordance with the usual measurement standards.

1) Anthropometry

Anthropometric data were collected using precise, standardised protocols from barefoot and lightly clothed athletes. Body mass was measured using a digital impedance meter (Tanita brand model: BC-545) with an accuracy of 0.1 kg, and height was measured using a portable stadiometer (Sanny brand, American Medical of Brazil) with a maximum height of 2.20 m and an accuracy of 0.1 cm. BMI in Kg/m^2 was calculated using the Quételet formula: BMI= [Weight (kg)/Height^2 (m)].

2) Dietary profile

The 24-hour recall questionnaire was completed by each athlete on a self-report basis on non-consecutive days. It covered the food and drink consumed the previous day. To promote accurate recall and limit potential bias, detailed written instructions were provided to the athletes prior to completion.

2.4. Statistical Analysis

The data were analysed using SPSS 21.0 and STATA 14 software. Firstly, a t-test for independent samples was used to assess the differences in indices between the various types of addicts. The Bland-Altman plot was used to assess the agreement between the values recorded in the RA24H and Food Survey methods. The Shapiro-Wilk test confirmed that the data followed a normal distribution ($P > 0.05$). The threshold for statistical significance was set at $\alpha = 0.05$.

3. Results

A total of 63 combat sports athletes took part in the study, 49.2% of whom were women and 50.79% men. The average age of the participants was 15.58 ± 2.36 years, with a height and body mass index of 1.69 ± 0.04 m and 21.79 ± 2.27 kg/m^2 respectively. The athletes came from a variety of specialities, including taekwondo (41.26%), wrestling (22.22%), karate (20.63%) and judo (15.87%).

Table 1. General characteristics of participants. (n = 63)

Variables	m ± SD	n (%)
Gender		
- Men's		32 (50.79)
- Ladies		31 (49.20)
Speciality		
- Taekwondo		26 (41.26)
- Lutte		14 (22.22)
- karaté		13 (20.63)
- Judo		10 (15.87)
Age (years)	18.58 ± 2.36	/
Height (m)	1.69 ± 0.04	/
BMI (kg/m^2)	21.79 ± 2.27	/

Table 2 compares mean energy and macronutrient intakes between female (n = 31) and male (n = 32) participants obtained using two assessment methods: RA24h (24-hour dietary recall) and Food Servey. These two assessment methods showed very similar results for most nutrients, suggesting overall consistency. The greater variations for certain micronutrients, such as iron, Calcium and Phosphorus in women, may reflect greater sensitivity of the data to the method used. The variations in vitamin C in men, with a notable drop in Food Servey, merit further exploration.

Table 2. Energy, macro- and micronutrient intakes of participants.

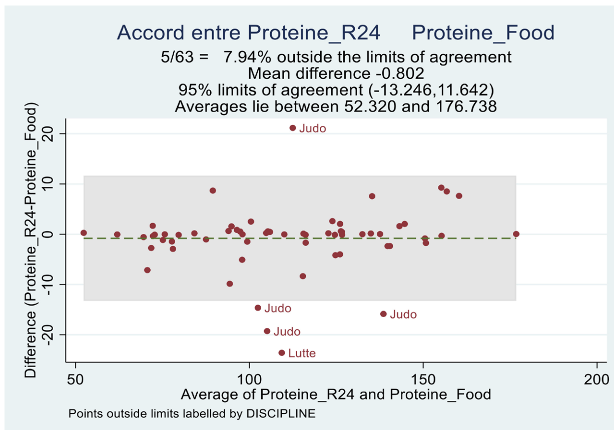
	Ladies (n = 31)			Men's (n = 32)		
	RA24h	Food servey	Δ (%)	RA24 h	Food servey	Δ (%)
DEI (kcal)	2665.54 ± 257.0	2667.43 ± 250.5	0.07	3414.44 ± 210.2	3470.89 ± 316.76	1.65
Proteins (g)	96.72 ± 27.69	98.12 ± 26.06	1.44	123.89 ± 23.61	124.12 ± 23.95	0.17
Lipids (g)	84.01 ± 30.0	82.72 ± 28.56	1.53	113.48 ± 34.02	117.95 ± 36.06	3.93
Glucides (g)	380.37 ± 80.24	382.61 ± 79.75	0.58	474.38 ± 84.75	478.22 ± 87.93	0.80
Calcium (mg)	337.52 ± 133.85	362.18 ± 185.32	7.83	411.11 ± 122.67	417.29 ± 108.41	1.50
Fer (mg)	20.78 ± 4.54	22.54 ± 4.05	8.49	27.27 ± 5.79	27.37 ± 5.41	0.28

Continued

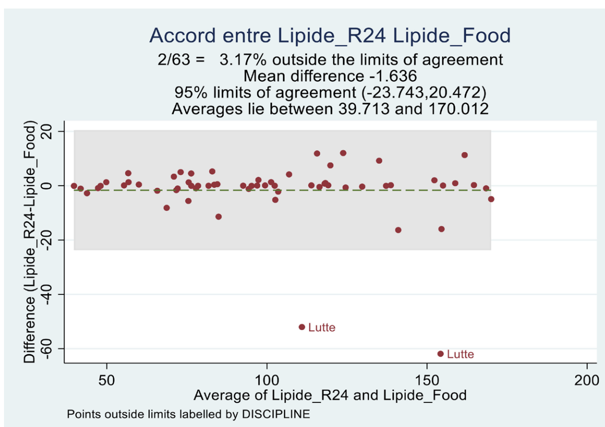
Phosphore (mg)	1401.54 ± 309.1	1524.52 ± 573.0	8.77	1777.51 ± 399.8	1777.55 ± 376.9	0.002
Vitamine B1	1.13 ± 0.25	1.22 ± 0.19	8.42	1.55 ± 0.30	1.52 ± 0.24	2.57
Vitamine B2	1.95 ± 0.44	1.91 ± 0.48	2.10	2.43 ± 0.87	2.46 ± 0.82	1.19
Vitamine B6	2.14 ± 0.45	2.19 ± 0.47	2.56	2.84 ± 0.79	2.82 ± 0.72	0.63
Vitamine C	114.68 ± 45.0	115.95 ± 45.82	1.09	146.12 ± 54.13	136.54 ± 54.27	6.5

The figures in the tables are expressed as averages ± standard deviations and as percentages. Δ: difference between the values recorded by the RA24h (24-hour recall) and Food Survey; DEI: daily energy intake

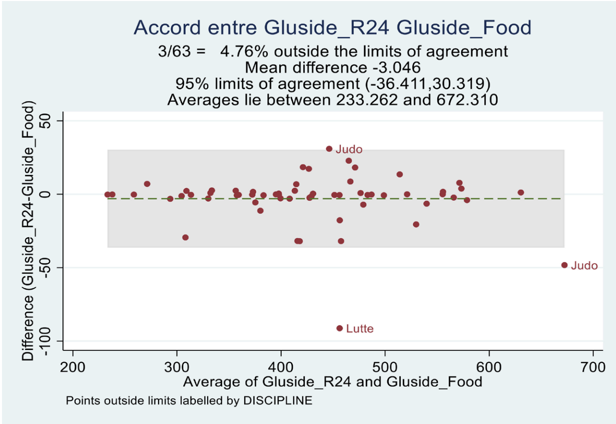
Bland-Altman curves of energy-adjusted carbohydrate, protein, and fat intakes between methods are presented in Figure 9(a)-Figure 9(c). The reported intakes were within the limits of agreement for most individuals; however, the differences between methods appeared to be greater at moderate levels of intake Figure 9(a). The bias value (zero mean difference) is −0.802 close to zero, a perfect but negative bias (−0.802), which means that the Food Survey (new method) underestimates the series by 0.802 g (negligible) of protein compared with RA24h (reference method). Intakes adjusted for fat content Figure 9(b) and carbohydrate content Figure 9(c) showed acceptable agreement.



(a)



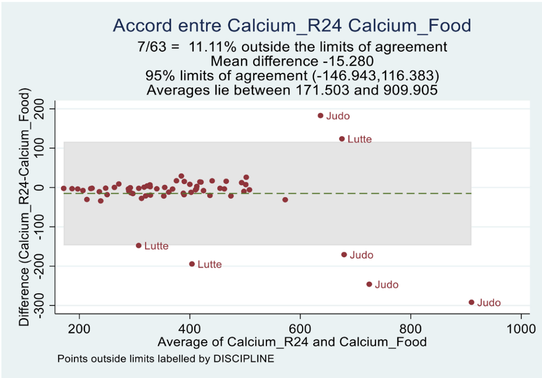
(b)



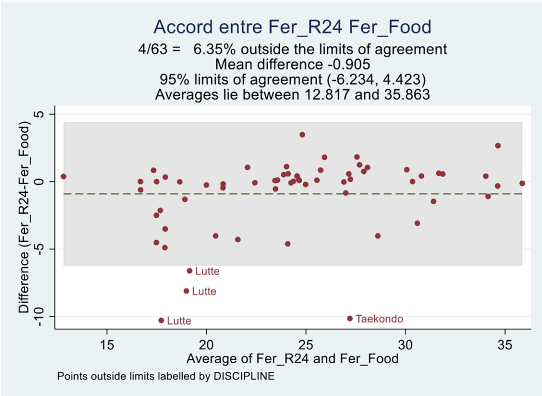
(c)

Figure 9. Bland-Altman plot of protein (a), fat (b) and carbohydrate (c) intakes of all Chadian martial arts practitioners (n = 63). The graphs present the mean difference between the two methods and the limits of agreement at 95%.

The Bland-Altman curves of mineral content; Calcium, Iron and Phosphorus between methods are presented in Figure 10(a)-Figure 10(c). Reported intakes were within the limits of agreement for most individuals; however, differences between methods appeared to be greatest at moderate levels of intake Figure 10(b). Calcium Figure 10(a) and phosphorus Figure 10(c) intakes showed acceptable agreement.



(a)



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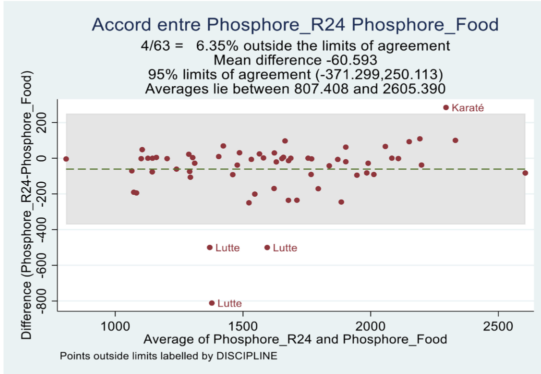
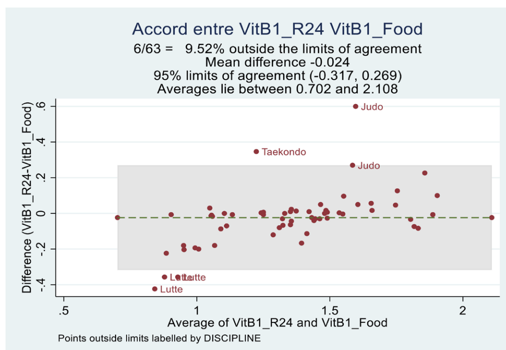


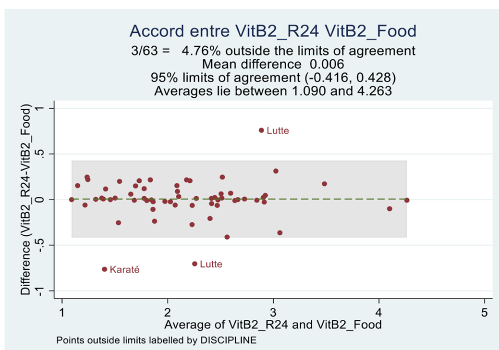
(c)

Figure 10. Bland-Altman plot of Calcium (a), Iron (b), and Phosphorus (c) intakes of all Chadian (((martial arts practitioners (n = 63). The graphs present the mean difference between the two methods as well as the agreement limits at 95%.

The Bland-Altman plots of Vit B1, Vit B2, Vit B6 and Vit C intakes between the methods (RA24H and Food Survey) are presented in **Figure 11(a)-Figure 11(d)**. The reported macronutrient values were within the limits of agreement (y = absolute bias ± 1.96 × S.D) for most individuals. However, the differences between the methods appeared to be greater at more moderate levels of intake **Figure 11(a)**. Energy-adjusted intakes of Vit B2 (**Figure 11(b)** and Vit B6 (**Figure 11(c)**) and Vit C **Figure 11(d)** showed acceptable agreement, while agreement for Vit B1 intake (**Figure 11(a)**) was higher between methods (*i.e.* 15% outliers of the 95% limits of agreement).



(a)



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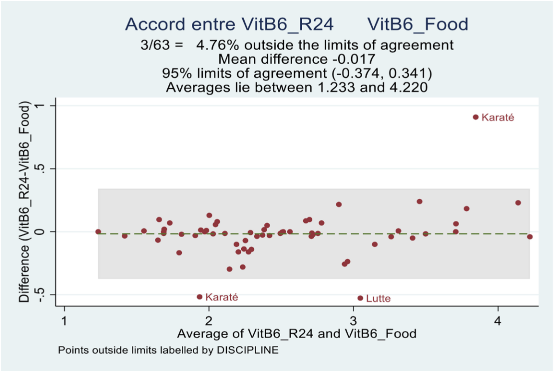
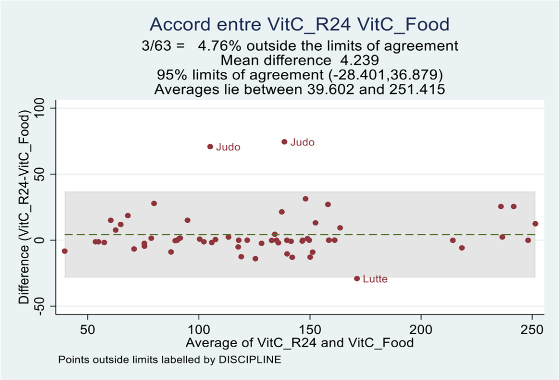


(c)



(d)

Figure 11. Bland-Altman graph of vitamin B1 (a), B2 (b), B6 (c) and vitamin C (d) levels in all Chadian martial arts practitioners (n = 63). The graphs present the mean difference between the two methods and the limits of agreement at 95%.

4. Discussion

The aim of this study was to create and validate a digital tool designed to assess the dietary habits of elite Chadian martial arts practitioners. The results show that, with regard to the Bland-Altman diagrams of the various parameters investigated, all the points are homogeneously dispersed around the lines averaging the differences in all the parameters (AEJ, macro and nutrients) with limits on either side of zero representing the upper and lower limits of agreement at 95%. This suggests that energy, mineral and macronutrient intakes were in normal agreement between the two methods: Food Survey (new) and RA24h (reference).

Comparison of energy and macronutrient intakes between female (n = 31) and male (n = 32) participants obtained by the RA24h and Food Servey showed very close results for most nutrients, suggesting overall consistency. The greater variations in certain micronutrients, such as iron, calcium, and phosphorus in women, could reflect a greater sensitivity of the data to the method used. However, the variations in vitamin C in men, with a notable drop in Food Servey, merit further exploration.

These energy values are similar to those found in the [20] study of archery athletes. For these authors, these nutritional loads correspond to the daily physical loads of archers. This implies that the values recorded from the Food Survey are not sufficiently biased. Our results are in line with those of a recent study which suggested that Bland-Altman diagrams revealed no systematic bias concerning energy, protein, fat or carbohydrate intake [21]. For these authors, the data collected via the IOS application can be exploited to assess the distribution of food consumption within a target group. On the basis of these results, it appears that IOS data could be used effectively to monitor dietary habits on campus, in particular to identify sub-groups with potentially insufficient or excessive dietary intake. However, this method is not suitable for directly comparing observed dietary intakes with absolute dietary recommendations.

The results obtained using the Blan-Atman method for vitamin B2, B6 and vitamin C intake showed concordant intakes on average for both methods, as reported by other authors [22]. These authors suggest that the Bland-Altman diagrams showed no serious bias for any of the 25 nutrients examined by the FFQ and RA24h. However, the vitamin B1 intake values showed higher mean intakes for Food Survey than those reported by RA24h. This trend may be explained by the fact that participants under-reported vitamin C intakes in the RA24h method compared with the Food Survey. Previous studies have reported similar results [23] [24].

However, the findings of the present study contrast with those of the study by [25] on the validation of an online quantitative food frequency questionnaire to assess dietary intake in the adult Emirati population. These authors reported inconsistent agreement in the validation of the 2 methods used with a moderate level of validity for most nutrients after analysis of the Bland-Altman diagram. Previous research has reported significant variability in the validation of dietary assessment methods for estimating nutrient intake. The Bland-Altman diagrams reported showed limited and inconsistent agreement, with no significant advantage over other approaches used to assess nutrient intake in the same studies [26]-[28]. A study by [20] investigated the use of the online dietary assessment tool RiksmatenFlex in Swedish adolescents. The results showed that the energy intake reported via this tool was higher than that obtained using the traditional 24-hour dietary recall interview method (reference tool). As a result, macronutrient intakes were also higher with RiksmatenFlexDiet. This highlights a low level of agreement between the two methods, in contrast to the high level of agreement observed between the validated Food Survey method and the RA24H for the same parameters.

This difference in validation levels can be explained by the context in which each method is applied. The Food Survey approach, carried out in a collective setting, allows better control of the survey process, thus reducing potential bias. On the other hand, the individual nature of the survey carried out with RiksmatenFlexDiet may lead to reporting bias, particularly due to difficulties in checking the information entered by the participants themselves.

The Food Survey offers several notable advantages. First of all, it has the particularity of associating a computerized composition table and the photography of foods and their units of measurement with a "software package" housing the algorithms allowing to obtain the automatic results of individual food consumption surveys in a community diet. Advantageous, also because each subject can, based on their usual consumption, have a mental representation of the portions of food consumed and make a connection with those of the photographs to solve the problem of the individual quantification of rations during collective meals common in Chad where several people share the same meal in a single dish. Then, it takes into account in the calculations, the nutrient content of each ingredient in the mixed dishes. The consideration of traditional units of measurement in digital technology reconciling cultural values with new information and communication technologies (NICT) is also put in the asset of this new tool. Finally, the Food Survey stands out from other technological tools in use today by its dynamic profile, unlike the latter which are static, limited in time and space of their maneuvers. It has the capacity to modify the parameters in existing databases, record new data to complete or reconstruct existing ones. It has the privilege of being operational at all times and in all places.

Although this study provides valuable and still little-explored data, it has certain limitations that deserve to be highlighted. First, The study focused on a small sample of elite Chadian combat athletes, which makes it impossible to generalize the results to all Chadian athletes and other populations. For this reason, a study with a representative and inclusive sample of the entire sporting and/or non-sporting population would be desirable. Second, the data collection took place at a specific time of the season (the pre-season), a period when weight management requirements are often less strict than during competition periods. Furthermore, only certain age categories were included, which could mask potential differences in nutritional needs among young athletes. Thus, future research should verify whether the conclusions of this study are valid for all sports and for various age groups. Finally, conducting a study with large samples would allow for further generalization of the use of this tool to all Chadian athletes.

5. Conclusion

The data show overall consistency between the two methods (RA24h and Food Servely) for the majority of macronutrients. Differences between methods remain overall small for most parameters (<5%), indicating that and RA24h produce similar results. This reinforces the reliability of Food Servely methods for estimating mean energy and nutrient intakes of Chadian martial arts athletes. Developing dietary assessment methods to achieve a limited degree of underreporting is therefore a major challenge for future research.

Author Contribution

All authors reviewed and validated the final version of the manuscript

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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