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REVIEW

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The validity of technology-based dietary assessment methods in childhood and adolescence: a systematic review

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ABSTRACT

Technology-based dietary assessment has promising benefits on improving accuracy and reducing cost of dietary data collection. The validity of technology-based tools in children/adolescents was examined. A systematic literature search was performed to identify studies published till September 2019. In total, 26 studies with 29 validation-related estimations were selected; 13 web-based 24-hdietary recalls (image assisted; $n = 12$, drop-down food list; $n = 13$), 4 mobile applications and 3 web-based dietary records (image based; $n = 2$ and image assisted; $n = 1$, drop-down food list; $n = 3$) and 6 web-based food frequency questionnaires (FFQs) (image assisted; $n = 3$). Fourteen studies were addressed to adolescents, ten studies to children (principally 9–11 years old) and two studies to mixed study samples. Validation was mostly performed through 24-h dietary recalls and dietary records while in some cases objective methods were used. Image-assisted 24-h dietary recalls presented good level of agreement with paper-based methods, yet principally in adolescents. Mobile-application dietary records with image-based facilities and drop-down food lists were found to accurately record dietary intake even when compared with objective methods. FFQs, mainly examined in adolescents, had good level of agreement with the "gold standard" dietary records method. The validity of technology-based methods could be supported yet various technical/methodological issues need better clarification.

Introduction

Trying to accurately record people's dietary exposure, through a feasible and cost-effective way, is definitely not an easy task, both in research and in clinical practice (Probst and Zammit 2016). The widely used dietary assessment methods, i.e. dietary records, food frequency questionnaires (FFQ) and 24-h dietary recalls (24-h dietary recalls), are self-reported and paper-based or printed (Thompson and Subar 2008). The strengths and weaknesses of these methods have been extensively discussed (Thompson and Subar 2008, Poslusna et al. 2009, Garden et al. 2018). In this complicated field of dietary assessment, the younger age groups, i.e. children and adolescents, remain the most challenging groups to be evaluated (Walker, Ardouin, and Burrows 2018; Zalewski et al. 2017). Valid dietary assessment in the early life stages is a major step for evaluating diet adequacy and designing tailor-made dietary interventions for the prevention or management of nutrition-dependent conditions in childhood and adolescence, such as obesity and diabetes mellitus type II. Childhood obesity rates remain alarmingly high with global estimates from 2016 reporting about 124 million obese school-aged children (NCD Risk Factor

Collaboration (NCD-RisC)) 2017), while the prevalence of type II diabetes occurs increasingly frequently to children and adolescents as a result of unhealthy lifestyle habits and excess body weight (WHO, 2016). However, children's and adolescents' limited health literacy and writing skills, inadequate food knowledge and difficulties in self-estimation of portion size make the dietary assessment procedure prone to misreporting errors (Foster and Adamson 2014; Livingstone, Robson, and Wallace 2004). In addition to this, the extent to which parents or caregivers have the potential to accurately report their children's actual dietary intake has been questioned (Walker, Ardouin, and Burrows 2018).

On the other side, considering the rapid grow of digital resources, the scientific focus has been oriented toward alternative dietary assessment methods with an increasing interest on the technology-based versions of the traditional tools, especially for the younger age groups mentioned above (Thompson et al. 2010). This novelty has been investigated regarding the potential added value of these tools that exploit various technological facilities, namely the advantages of low cost, the provision of real-time results, the potential of including gadgets to support portion size estimation or connecting with nutrition databases supporting data

extraction (Thompson et al. 2010). The hypothesis that such novelties are to be more attractive to the younger age groups, due to their enthusiasm and curiosity in adopting new technologies, provides an additional incentive for further investigation (Boushey et al. 2009; Lazarou et al. 2011).

However, there is no critical evaluation of their ability to effectively assess dietary intake and more specifically the extent to which they are of comparable validity to the traditional dietary assessment methods. Hence, the aim of the present systematic review was to examine the validity of technology-based dietary assessment tools in relation to traditional paper-based/printed dietary assessment methods as well as to objective tools assessing children's and adolescents' dietary intake on the basis of food groups, nutrients and energy intake.

Materials and methods

Search strategy

Following the Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) 2009 guidelines, a computer-assisted systematic literature search was performed by two independent experts (MK and EM), using Medline (PubMed) and Scopus for validation studies that examined the validity of technology-based dietary assessment methods over the traditional (paper-based) ones. The search strategy was mainly based on Medical Subject Headings terms, as follows; (digital health OR ehealth OR mhealth OR applications OR technology OR assessment tool OR smartphone OR mobile phone OR cell phone OR computer OR ICT) AND (dietary assessment OR nutritional assessment OR food intake OR dietary intake) AND (children OR adolescents OR pediatric) AND (intervention OR clinical trial OR validation). The search was limited to publications in English, published till September 2019. The reference lists of retrieved articles were also considered when these were relevant to the issue examined yet not allocated in the basic search. The relevance of studies was assessed by using a hierarchical approach based on: title, abstract, and full manuscript. For papers in which additional information was required, the authors were contacted via email.

Selection criteria

Studies were eligible if the evaluation of the level of agreement between the reported dietary intake through a technology-based dietary assessment method and the dietary intake through subjective traditional methods (e.g. paper-based dietary records, paper-based 24-h dietary recalls, printed FFQ) or through objective traditional methods (e.g. double-labeled water method, biomarkers) was performed using appropriate statistical methods (e.g. Blant–Altman plot, Pearson' correlation, kappa statistics) in samples of children and/or adolescents (age range: 2–18 years old). The exclusion criteria were: review articles, letters-to-the editors, editorials, articles based on studies with adults, articles providing only feasibility/acceptance level of the applied technology-based dietary assessment

methods and articles where the validation method used was technology-based and no traditional techniques were included.

Quality assessment of selected studies

Two researchers (MK and EM) independently implemented the quality assessment of the selected validation studies using the quality assessment score for validation studies in the field of dietary assessment performed by the EURopean Micronutrient RECommendations Aligned (EURRECA) network (Serra-Majem et al. 2009). The variables considered were sample characteristics (homogeneous or not) and sample size, statistics to assess validity, data collection, seasonality and dietary supplements. Scores could range from 0 (poorest quality) to a maximum of 7 (highest quality).

Results

Flow of included studies

Literature search flow diagram is illustrated in Figure 1. Initially, 7108 papers were retrieved; after removal of duplicate papers, 4350 were selected for evaluation. The 4292 manuscripts were removed on the basis of their Title/Abstract, as they were irrelevant to the scope of the present work. Among the rest ($n = 58$), 25 studies with 29 validation-related estimations were considered as relevant. All the other manuscripts ($n = 33$) were excluded from the analyses, as they did not meet the inclusion criteria of the present systematic review (Supplementary material, Table 1). Finally, we had 12 studies with technology-based 24-h dietary recalls, 7 with technology-based dietary records and 6 studies with technology-based FFQs.

Technology-based 24-h dietary recalls

In total, 12 studies (6 from USA and 8 from Europe) with 15 validation-related estimations were identified that used a technology-based 24-h dietary recall, which mimicked the format of a traditional interviewer-administered 24-h dietary recall, validated by subjective and/or objective dietary assessment methods. In brief, all the selected technology-based tools were web-based. Additionally, the 12 out of the 13 tools were image-assisted (i.e. standard food images were provided to participants to choose the portion size they consumed), providing from 3 to 7 different portion sizes per food product or beverage. All of them included a drop-down food list which was either linked with national/international nutrition database or, mostly, with a food database constructed on the basis of national surveys regarding the typical nutritional habits of children and adolescents. Seven technology-based dietary assessment methods were examined in children's samples (>8 years old), asked to report their dietary intake themselves (no parent assistance), while the rest 6 tools were assessed for their validity in young adolescents (mostly 13–15 years old). More details on the selected technology-based tools are summarized in Table 1.
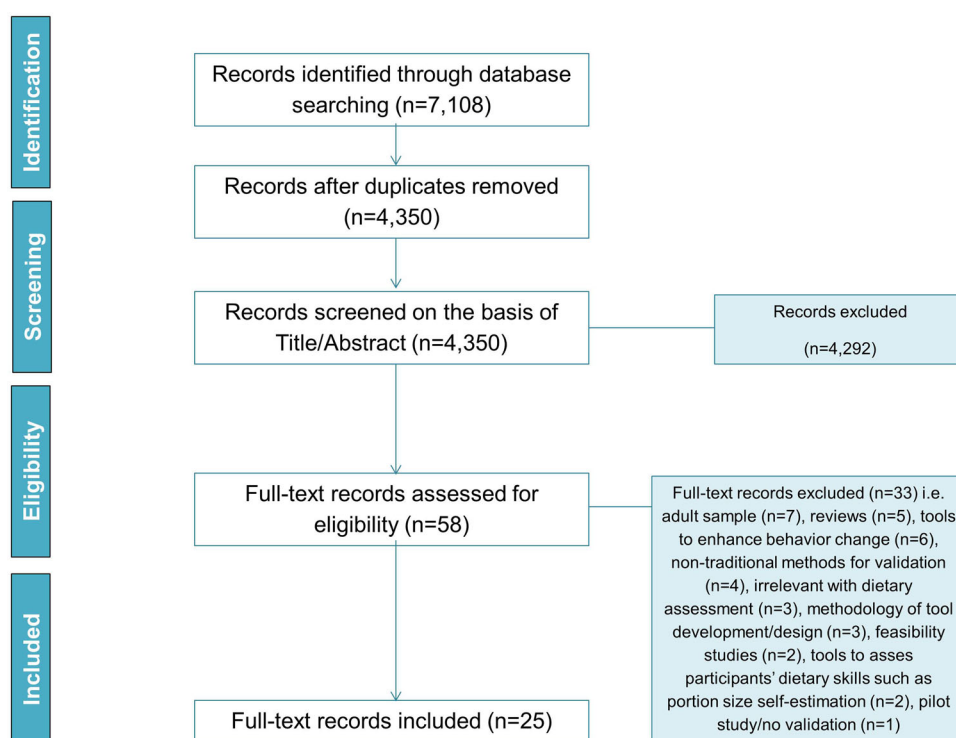
Figure 1. Flow diagram describing the literature review process.

Validation method-traditional (paper-based) 24-h dietary recalls

The samples of the studies, which validated a technology-based 24-h dietary recall with its traditional counterpart, consisted principally of children (Baranowski et al. 2002; Baranowski et al. 2012; Diep et al. 2015; Moore et al. 2008) and 3 of them of adolescents (Albar et al. 2016; Bradley et al. 2016; Vereecken et al. 2005). The results were age-dependent and indicated in children moderate agreement with the traditional 24-h dietary recalls and in the case of adolescents, in general, good agreement.

In specific, starting with children's samples, two versions of Automated Self-Administered 24-h (ASA24) tool (Baranowski et al. 2012; Diep et al. 2015) and the Food Intake Recording Software System (FIRSSt) tool (Baranowski et al. 2002) showed about 50% level of agreement, accompanied by increased rate of omissions (i.e. foods omitted in the digital tools but recorded in the paper-based 24 h dietary recall). A study with a wider age-range revealed that the aforementioned omissions were age-dependent: younger children had higher omission rates and lower level of agreement compared with their older counterparts (Baranowski et al. 2012). On the other hand, the study with the Synchronized Nutrition and Activity ProgramTM (SNAPTM) tool revealed a generally high level of agreement (mean difference for most food groups was ±1 count compared to the traditional one). In this case, no images with portion sizes were provided and responders had to select number of standard counts consumed per food product (Moore et al. 2008).

As for the studies in adolescents, different results emerged. The Young Adolescent's Nutrition Assessment on Computer (YANA-C) tool, examined in young adolescents, was found to over-estimate only fiber intake, whereas for energy and other nutrients intake the correlations were good, at the level of 0.44 and 0.79, respectively (Vereecken et al. 2005). Partially in line with this, two other studies conducted in participants aged 11–16 years old and 11–18 years old found that there were no significant differences between the two methods regarding energy intake, macronutrients and most reported micro-nutrients (Albar et al. 2016; Bradley et al. 2016). In specific for energy intake, the web-based tool slightly under-estimated calories by 55 kcal (Albar et al. 2016) and by 1% (Bradley et al. 2016) in comparison with the traditional paper-based method.

Validation method-traditional (paper-based) dietary records

Paper-based dietary record was used as validation method in only two studies, both of which were implemented in adolescents (Storey and McCargar 2012; Vereecken et al. 2005). The examined tools did not show high level of agreement when compared with the "gold standard" subjective dietary assessment method. In the case of the YANA-C tool evaluated in young adolescents, the estimated nutrients and energy intake based on the participants' responses (for most of the nutrients excluding calcium) were significantly higher in the web-based method compared with the traditional dietary record (Vereecken et al. 2005). In the second study conducted in adolescents aged 11–15 years old, using the (Web-Survey of Physical Activity and Nutrition) Web-SPAN tool, the correlations were not strong, but were stronger for macronutrients compared to micronutrients (Storey and McCargar 2012).

Table 1. Characteristics and principle outcomes of validation studies with technology-based 24-h dietary recalls (n = 15 from 12 studies).

First Author, year	Sample/Origin	Age, years	Sex, B/G	Tool name	Type	Image (assisted, no)	Drop-down food list	Short description of digital tool	Statistical analysis	Validation target	Principal outcomes
Validation method: 24-h dietary recalls (n = 7)											
Albar, 2016	75/ UK	11-18	37/36	myfood24	web based	Image-assisted	Yes	Online 24-h dietary assessment tool. users were requested to go through as few webpages as possible to complete the food recall; pop-ups and prompts were limited. The program was linked to an extensive (approximately 50 000 items) branded electronic food composition database.	% agreement; intraclass correlations	Energy, nutrients and food groups intake	There was no significant bias between the two methods for energy intake, macronutrients and most reported nutrients. The mean difference between myfood24 and the interviewer-administered DR for energy intake was −55 kcal with limits of agreement ranging between 39 % lower and 34 % higher than the interviewer-administered DR
Bradley, 2016	52/ UK	11-16	19/33	INTAKE24	web based	Image-assisted	Yes	INTAKE24 automatically codes the recall and provides nutritional output. Foods contained in the system are linked to databank, food codes and portion size images are linked to a database of weights.	% agreement	Energy, nutrients and food groups intake	Mean intakes reported using INTAKE24 were similar to the intakes reported in the interviewer-led recall for energy and macronutrients. INTAKE24 was found to underestimate energy intake by 1% on average compared to the interviewer-led recall. Mean intakes of all macronutrients and micronutrients (except non-milk extrinsic sugars) were within 4% of the interviewer-led recall.
Diep, 2015	69/ USA	9-11	31/38	ASA24-Kids-2012	web based	Image-assisted	Yes	ASA24-Kids-2012 was completed on a laptop and a staff member was present to observe the child.	% agreement; unadjusted correlations	Food group intake	Match, intrusions and omissions rates were 57%,20% and 23% compared to the interviewer-administered 24-h DR
Baranowski, 2012	120/ USA	8-13	60/60	ASA24	web-based	Image-assisted	Yes	ASA24 recalls were self-administered using Food and Nutrient Database for Dietary Studies	multiadjusted correlations	Food group and nutrient intake	Overall matches between interviewer-administered and ASA24 was 47.8%. Matches were significantly lower among younger compared to older children. Omissions on ASA24 (18.9%) were most common among eight year olds and intermediate among nine year olds. Eight and nine year olds had substantial difficulties and often required aid in completing.
Moore, 2008	121/ UK	10.7 (2.2)	49/72	SNAPTM	web based	No (images of a drop-down list of commonly consumed foods – no different portion sizes)	Yes	The software was developed around the principles of dietary intake and physical activity recall, integrating new and established methods to enhance recall in children, such as 24 h recall of the structured school day, which has been shown to be more accurate for children within this age group, when compared with periods of longer duration u	%agreement; mean difference	Food group intake	In general, SNAPTM underestimated mean counts of dietary constituents and the accuracy decreased with increasing counts. However, the mean difference between methods was substantially less than 1 count for all but three categories– confectionery and cakes, total energy dense foods (1-52 counts), and total carbohydrate rich foods
Vereecken, 2005	237/ Belgium	13.3 (0.7)	79/158	YANA-C	web-based	Image- assisted	Yes	The computer-based instrument structured around six meal occasions (breakfast, mid-morning snack, lunch, afternoon snack, dinner and evening snack) and embedded in a group of questions that take the respondents through a range of sequential activities.	% agreement; unadjusted correlations	Food group and nutrient intake	YANA-C proved to agree well in categorizing subjects in consumers and nonconsumers. Spearman's correlations for energy and nutrient intakes ranged between 0.44 and 0.86. Nutrient and energy intakes were in general (excluding calcium) not significantly different in YANA-C
Baranowski, 2002	138/ USA	9-10	62/76	FIRSSt	web-based	Image-assisted	Yes	The FIRSSt is a software program, designed for use with fourth-grade children, that uses interactive multimedia to facilitate a child's self-report of diet by simulating a multiple pass 24hDR.	unadjusted correlations; % agreement	Food group and nutrient intake	FIRSSt attained 60% match, 15% intrusion, and 24% omission rates for all meals when assessed against a 24hDR.

Table 1. Continued.

First Author, year	Sample/Origin	Age, years	Sex, B/G	Tool name	Type	Image (assisted, no)	Drop-down food list	Short description of digital tool	Statistical analysis	Validation target	Principal outcomes
Validation method: 7-day or 3-day dietary records (n = 2)											
Story, 2011	459/ USA	11-15	225/233	Web-SPAN	web-based	Image-assisted	Yes	The web-based 24-h recall mimicked a traditional multiple pass 24-h recall, whereas students first selected the food consumed, and then selected the appropriate portion size.	unadjusted correlations	Nutrients intake	Correlations for nutrients were not as strong, in the range 0.24–0.40; mean differences were small but generally significantly different. Correlations were generally stronger for macronutrients than micronutrients. Significant differences were not observed for protein, fat, iron and zinc based on paired t-tests; all other nutrient comparisons were significantly different.
Vereecken, 2005	237/ Belgium	13.3 (0.7)	79/158	YANA-C	web-based	Image-assisted	Yes	The computer-based instrument structured around six meal occasions (breakfast, mid-morning snack, lunch, afternoon snack, dinner and evening snack) and embedded in a group of questions that take the respondents through a range of sequential activities.	% agreement; unadjusted correlations	Food groups and nutrients intake	YANA-C proved to agree in categorizing subjects in consumers and nonconsumers. Spearman's correlations for energy and nutrient intakes ranged between 0.44 and 0.79. Nutrient and energy intakes were in general (excluding calcium) significantly higher in YANA-C in comparison with the food record.
Validation method: Real-time (direct) observation of meal consumption (n = 6)											
Raffoul, 2019	98/ USA	10-13	49/49	ASA24	web based	Image-assisted	Yes	The ASA24 system prompts participants to report all foods and beverages consumed in the prior 24-h period, including optional queries regarding the meal time, location, and sources of foods and beverages; although true intake data were recorded for lunch only, to avoid focusing the children on that meal specifically, these instructions were not altered	unadjusted correlations	Nutrient and food group intake	Intakes of energy (39%), protein (33%) and sodium (78%) were significantly overestimated. The overall match rates were 60.4% for 10-year-olds, 65.0% for 11-year-olds, 42.8% for 12 year-olds, and 71.6% for 13-year-olds. portion sizes for cookies (53%) and juice (69%) were underestimated.
Krebbiel, 2016	123/ USA	12-17	54/69	ASA24 Kids-2014	web based	Image-assisted	Yes	ASA24 Kids-2014 applies the Automated Multiple PassMethod to prompt respondents to list all foods and beverages consumed in the previous 24 h, to identify each portion size, and to estimate how much of the portion was consumed.	unadjusted correlations	Food group intake	Statistically nonsignificant portion-size estimates emerged between students' self reports and direct observation for fruit, vegetables, grains, protein-rich foods, oil, and added sugar. Statistically significant differences did occur for dairy and solid fat; small, though slightly larger effect sizes characterized these findings.
Carvalho, 2015	41/ Portugal	7-10	27/24	PAC24	web based	Image-assisted	Yes	The PAC24 comprises software, uses interactive multimedia to facilitate a child's self report of diet by simulating a multiple pass 24-h DR. The system automatically records and stores the appropriate food composition code and-weight of each item selected with portion size assessment based on a system developed specifically for use with children	% agreement	Food group intake	Comparison of PAC24 against observations at the food level resulted in values of 67.0% for matches, 11.5% for intrusions and 21.5% for omissions. Total inaccuracy was 3.44 servings. For amounts, accuracy was high for matches (0.17 and 0.23 servings for arithmetic and absolute differences, respectively) and lower for omissions (0.61 servings) and intrusions (0.55 servings).PAC24 was found to under-estimate the weight of food on average by 32% of actual intake
Diep, 2015	69/ USA	9-11	31/38	ASA24-Kids-2012	web based	Image-assisted	Yes	ASA24-Kids-2012 was completed on a laptop and a staff member was present to observe the child.	% agreement; unadjusted correlations	Food group intake	ASA24 Kids-2012 demonstrated 37% food item matches, 35% omissions, and 27% intrusions

(continued)

Table 1. Continued.

First Author, year	Sample/Origin	Age, years	Sex, B/G	Tool name	Type	Image (assisted, no)	Drop-down food list	Short description of digital tool	Statistical analysis	Validation target	Principal outcomes
Davies, 2014	602/ USA	8-11	279/323	CAAFE	web based	Image-assisted	Yes	CAAFE is an online questionnaire to self-report diet (using 24h DR) and physical activity. The food consumption section of the CAAFE is divided into six meals (breakfast, morning snack, lunch, afternoon snack, dinner and supper).	% agreement	Food group intake	43% matches, 29% intrusions and 28% omissions. Matches doubled in third grade compared to the second grade; matches almost tripled for afternoon snack compared to morning snack; and matches were 69% higher for children with access to a computer at home
Baranowski, 2002	138/ USA	9-10	62/76	FIRSSt	web-based	Image-assisted	Yes	The FIRSSt is a software program, designed for use with fourth-grade children, that uses interactive multimedia to facilitate a child's self-report of diet by simulating a multiple pass 24hDR.	unadjusted correlations; % agreement	Food group intake	FIRSSt attained lower match (46%) and higher intrusion (24%) and omission (30%) rates when compared against the most objective standard, observation of the previous day's school lunch.

Abbreviations: Boys (B); Girls (G); Personal Digital Assistance (PDA); Not available (na)

Validation method-real time observation of meal consumption

In total, 6 studies used direct observation of school lunch, mainly, as a means to validate 5 web-based 24-h dietary recalls (Baranowski et al. 2002; Carvalho et al. 2015; Davies et al. 2015; Diep et al. 2015; Krehbiel, DuPaul, and Hoffman 2017; Raffoul et al. 2019). In samples with children aged about 9–10 years old, results indicated that the matches (foods recalled by respondents and recorded in direct observation i.e. fruits, vegetables, grains, protein-rich foods) rates ranged from 37% to 67%, intrusion (foods not observed as eaten but recalled as eaten) rates ranged from 11% to 27% and omission (foods recorded in direct observation but not recalled by respondents i.e. sweets and beverages) rates ranged from 21% to 35% (Baranowski et al. 2002; Carvalho et al. 2015; Davies et al. 2015; Diep et al. 2015). However, results referring to older children/adolescents indicated non significant differences in portion-size estimates of the basic food groups (i.e. fruits, vegetables, dairy, protein-rich foods) between the web-based tool and the direct observation (Krehbiel, DuPaul, and Hoffman 2017). This comes in line with the observation that more advanced age is related with higher matches, when the ASA24 tool was examined; although total daily energy and protein intake was significantly overestimated with the web-based tool (Raffoul et al. 2019). What should be outlined here is that an alternate version of the same tool, with technical advances and fewer prompts about food preparation, that was examined in adolescents revealed better level of agreement when compared with the direct observation method (Krehbiel, DuPaul, and Hoffman 2017). Similarly, in a study that used the CAAFE tool, the matched rates doubled in third grade responders compared with their second grade counterparts (Davies et al. 2015).

Technology-based dietary records

In total, 7 studies (6 from Europe and 1 from Asia) with 8 validation methods were identified and referred to technology-based dietary records validated by traditional subjective and/or objective dietary assessment methods. Among the selected studies, about 4 mobile applications and 3 web-based tools were identified; two mobile-application tools were image-based [i.e. participants were instructed to take a photo of the consumed item(s) placed next to fiducial (reference) markers] and one web-based tool was image-assisted. Drop-down food list was provided in three technology-based dietary records. Two studies were implemented in adolescents, two studies in both children and young adolescents, two studies in children about 8–12 years old and one study in very young children i.e. 5 years old. More details on the selected technology-based dietary records are summarized in Table 2.

Validation method-traditional (paper-based) dietary records

Only one pilot study was conducted to validate a Personal Digital Assistant-based dietary record against the traditional, paper-based one in a sample of children and adolescents

Table 2. Characteristics and principle outcomes of validation studies with technology-based dietary records ($n = 8$ from $n = 7$ studies).

First Author, Year	Sample/Origin	Age, years	Sex, B/G	Tool name	Type	Image (based, assisted, no)	Drop-down food list	Short description of digital tool	Statistical analysis	Validation target	Principal outcomes
Validation method: 7-day or 3-day dietary records ($n = 1$)											
Oliver, 2013	30/ Spain	9–15	16/14	PDA	Web-based	No	No	This record system for PDAs include two sections: Dietary Record and Physical Activity Record	unadjusted correlations	Total number of self-registers and number of self-registers/day	Participants filled out more records using traditional FR than PDA when "total" number was considered but PDA produced more accurate registers than the traditional.
Validation method: 24-h dietary recalls ($n = 2$)											
Lee, 2017	21/ Korea	14–17	8/13	Diet A	Mobile phone application	No	No	The structure of the Diet-A system allows input of dietary data, calculation of nutrients, comparison with dietary reference intake, production of descriptive statistics of nutrient intakes, and display of personalized advice, and a food recommendation list.	unadjusted correlations	Energy and nutrient intake	The differences between the two methods were statistically significant in energy, carbohydrates, protein, fat, sodium and calcium. The nutrient intakes estimated by Diet-A were lower than those obtained from 24-h recalls. There was no significant difference except for fat and calcium in the male group.
Delisle Nyström, 2016	39/ Sweden	5.5 (0.5)	22/17	TECH (Tool for Energy Balance in Children)	Mobile phone application	Image-based	No	Parents and other caretakers were instructed to take pre-meal and post-meal photographs of all the food items and beverages consumed by their child during one 24-h period using a mobile phone provided for the study. At each meal, they also answered 6-7 questions regarding the type of food consumed	unadjusted correlations	Food group intake	In all of these food categories, there were no significant differences between the mean values assessed using TECH and the 24 h dietary recalls. No significant trends were observed for seven of the eight categories.
Validation method: Total energy expenditure assessment ($n = 4$)											
Delisle Nyström, 2016	39/ Sweden	5.5 (0.5)	22/17	TECH (Tool for Energy Balance in Children)	Mobile phone application	Image-based	No	Parents and other caretakers were instructed to take pre-meal and post-meal photographs of all the food items and beverages consumed by their child during one 24-h period using a mobile phone provided for the study. At each meal, they also answered 6-7 questions regarding the type of food consumed	%agreement	Energy intake	The mean difference between energy intake and total energy expenditure using TECH and doubly labeled water, respectively was small (−220 kJ/24 h, i.e., −4%) and not statistically different. The Bland and Altman plot showed no systematic error in Energy intake assessed using TECH across Energy intake l levels.

Table 2. Continued.

First Author, Year	Sample/Origin	Age, years	Sex, B/G	Tool name	Type	Image (based, assisted, no)	Drop-down food list	Short description of digital tool	Statistical analysis	Validation target	Principal outcomes
Henriksson, 2015	30/ Sweden	12	na	TECH (Tool for Energy Balance in Children)	Mobile phone application	Image-based	No	Parents and other caretakers were instructed to take pre- and post-meal photographs of all the food items and beverages consumed by their child during one 24-h period using a mobile phone provided for the study. At each meal, they also answered 6-7 questions regarding the type of food consumed	unadjusted correlations; % agreement	Energy intake	The average energy intake estimated using TECH was not significantly different from the average total energy expenditure (mean difference +7%). However, the limits of agreement in the Bland-Altman plot were wide, indicating low accuracy for TECH in estimating energy intake for individuals. A bias was observed where high energy intakes were overestimated while low energy intakes were underestimated.
Svensson, 2015	81/ Sweden	14–16	31/80	–	Mobile phone application	Image-based	Yes	The participants were asked to record for three days and to search for the consumed food in the food database by using a free-text search, choosing from a category or type of dish.	unadjusted correlations & interaction analyses	Energy intake	The mobile phone application for the recording of dietary intake captured a median energy intake that was 71% of total energy expenditure assessed through double-labeled water
Biltoft-Jensen, 2013	81/ Denmark	8–11	34/47	WebDASC	Web based	No	Yes	WebDASC guides respondents through six daily eating occasions (breakfast, morning snack, lunch, afternoon snack, dinner, and evening snack). For the diet recording, a database of 1,300 food items was available. Recall for 48 h per dietary episode.	unadjusted correlations; % agreement	Energy intake	Comparison of the WebDASC-estimated energy intake and the accelerometer-derived total energy expenditure indicated agreement at the group level. The proportion of participants appearing in the same or adjacent quartile for both energy intake and total energy expenditure was 73%; 20% was misclassified and 7% was grossly misclassified
Validation method: Biomarkers concentration measurement (n = 1)											
Medin, 2016	261/ Norway	8–9 and 12–14	116/145	WebFR	Web-based	Image-assisted	Yes	Participants were instructed to enter everything they ate and drank during a period of four consecutive days in the WebFR, including one weekend day. They were asked to do the recordings at home, every evening, after they had	unadjusted correlations	Selected carotenoid-rich foods	Spearman's rank correlation coefficients ranged from 0.30 to 0.44, and cross-classification showed that 71.6–76.6 % of the participants were correctly classified, when comparing the reported intakes of carotenoid-rich foods and concentrations of

(continued)

Table 2. Continued.

First Author, Year	Sample/Origin	Age, years	Sex, B/G	Tool name	Type	Image (based, assisted, no)	Drop-down food list	Short description of digital tool	Statistical analysis	Validation target	Principal outcomes
								consumed the last meal of the day. Anything consumed after the completion of a day's recording could be entered into an open text field in the WebFR the following day.			the corresponding carotenoids in plasma.

Abbreviations: Boys (B); Girls (G); Personal Digital Assistance (PDA)

(Oliver et al. 2013). The aim of the study was to compare the total number of self-registers and the number of self-registers per day, for a week period. The results indicated that, when total number of registries was considered, participants filled out more records using the traditional compared to the technology-based dietary record; yet the later method produced higher percentages of complete self-registers, meaning all the items were answered, indicating higher accuracy of the dietary information received (Oliver et al. 2013). However, the accuracy of the recorded information (in terms of food and as a result energy, nutrients etc.) was not examined.

Validation method-traditional (paper-based) 24-h dietary recalls

Two studies examined the technology-based dietary records over the paper-based 24-h dietary recalls with mixed results. One study used the Diet-A application, where adolescents were asked to fill in the dietary records for a mean of 12 days and their responses were correlated with two 24-h dietary recalls. The results showed that energy, carbohydrate, protein, fat, sodium and calcium intakes estimated by the app-based dietary record were lower than those obtained from the 24-h dietary recalls (Lee et al. 2017). On the other side, the image-based TECH app was compared with paper-based 24-h dietary recall in a sample of very young children (supported by their parents) and no significant differences between the two methods were observed (Delisle Nyström et al. 2016).

Validation method-total energy expenditure assessment

The validity of energy intake assessment by technology-based dietary records against objective energy assessment methods was examined in 4 studies. Specifically, in a study conducted in adolescents aged 14–16 years old, dietary records were provided through a mobile phone application (Svensson and Larsson 2015). The adolescents were asked to record all the foods consumed for 3 days and they were able to take pictures of the foods as a memory aid. Results indicated that the technology-based dietary records underestimated energy intake by 71% when compared with the total energy expenditure generated from accelerometers. Similarly, no significant differences were observed between the energy intake estimated through the previously mentioned TECH mobile application and the energy expenditure using the gold standard method of double-labeled water in both younger and older children (Delisle Nyström et al. 2016; Henriksson et al. 2015). Another study with image-based dietary records in adolescent sample showed levels of energy intake comparable to the energy expenditure assessment using double-labeled water method (Svensson and Larsson 2015). On the contrary, a study in children indicated slightly different results (Biltoft-Jensen et al. 2013). Energy intake derived from the web-based dietary record was in agreement with the calculated energy expenditure from the accelerometers at the group level. However, at the individual level, the data showed variation in accuracy, as 20% of the

participants were misclassified in the energy intake quartiles based on the calculation of energy expenditure (Biltoft-Jensen et al. 2013). What should be noted here is that this method was not image-based, while participants were able to complete a dietary record even two days later, a fact that raises the hypothesis for recall bias.

Validation method-biomarkers concentration assessment
An alternative objective dietary assessment method is the measurement of plasma biomarkers, the levels of which reflect the levels of consumption of specific food groups. In only one work, plasma biomarkers were used to assess the consumption of carotenoid-rich foods to validate the potential of using a web-based dietary record (Medin, Carlsen, and Andersen 2016). The results showed that 71.6–76.6% of the participants were correctly classified when comparing the reported intakes of carotenoid-rich foods and concentrations of the corresponding carotenoids in plasma (Medin, Carlsen, and Andersen 2016). Nevertheless, results should be cautiously translated as the validity of this objective dietary assessment method is highly questioned (Dragsted et al. 2018).

Technology-based FFQs
In total, only 6 validation studies (1 from USA and 5 from Europe) were identified evaluating the dietary assessment potential of technology-based FFQs in comparison with traditional subjective methods in samples of principally adolescents. The selected tools were web-based, with half of them being image-assisted. Their length ranged from 69 to 145 questions, while the recall time period was mainly 1 month with the exception of one FFQ for which the recall period was 3 months. More details on the selected technology-based FFQs are summarized in Table 3.

Validation method-traditional (paper-based) FFQ
Only one study with adolescents examined the validity of a web-based FFQ over the traditional printed version in relation to food groups and specific nutrients intake (Barchitta et al. 2019). It was found that the self-administrated, web-based FFQ had moderate to substantial ability to rank adolescents into the same or adjacent quartile as the printed version. However, on an individual basis, the level of agreement between the two dietary assessment tools was low (Barchitta et al. 2019).

Validation method-traditional (paper-based) 24-h dietary recalls
Two studies in adolescents compared the technology-based FFQs with the paper-based 24-h dietary recalls, indicated that the technology-based FFQs over-estimated the dietary intake. More specifically, the validation of a self-administrated web-based Denmark-adapted youth/adolescent questionnaire was tested in relation to three telephone-based 24-h dietary recalls, in a sample of adolescents (Bjerregaard et al. 2018). The relative validity of the FFQ compared with

24-h dietary recalls showed that the ranking ability differed across food groups and nutrients; 4 (fish, fruits, vegetables, and oils and dressing) out of 10 food groups and 3 (% protein, dietary fiber, and vitamin C) out of the 11 nutrients were overestimated by the FFQ (Bjerregaard et al. 2018). In another work, the HELENA web-based FFQ that was validated against 24-h dietary recalls, overestimated the dietary intake in the vast majority of food groups and nutrients except for calcium (Vereecken, De Bourdeaudhuij and Maes 2010). Nevertheless, considering the recall bias existing on both kinds of dietary assessment methods, all the aforementioned findings should be interpreted with caution. The lack of image assistance may have contributed to this outcome.

Validation method-traditional (paper-based) dietary records
Three studies compared the validity of a web-based FFQ compared with three- to seven-day dietary records with mixed results. In particular, in a recent work the adult-validated VioScreen web-based FFQ was examined against its validity to assess food groups and macronutrient/micronutrient intake compared with 3-day dietary records, in a sample of elementary and middle school students (Deierlein et al. 2019). Correlation coefficients between students' intakes reported on the VioScreen FFQ and the 3-day dietary records were moderate to low. The highest agreement between the two tools was found in relation to the estimated energy, carbohydrate, iron, sugars and vegetable intake (Deierlein et al. 2019). Nevertheless, it should be outlined that this FFQ had a recall-time period of 3 months which may have biased the final outcome. In contrast, more promising results in favor of the web-based FFQs were revealed in two other studies where the FFQs had only 1-month recall period (Tabacchi et al. 2015). Specifically, in a sample of boys and girls aged 14–17 years, the reliability of the ASSO-FFQ was investigated against a traditional 7-day dietary record. Results showed that the tested FFQ was an appropriate tool for ranking adolescents in classes of food groups, even though it was not suitable for measuring the absolute intakes of all food groups (Tabacchi et al. 2015). Similarly, in a sample of adolescents the validity of a web-based FFQ was examined against a 3-day dietary record revealing mixed results; the suggested technology-based material had generally good performance in assessing intake of various food groups and water presenting misclassifications in relation to sweets, beverages or snacks (Matthys et al. 2007).

Feasibility and acceptability of the selected technology-based tools
An additional point that was investigated here is related with the level of acceptability and feasibility of the selected dietary assessment methods. Various claims were recorded, highly dependent on the technology-based tool itself as well as the target audience. In particular, in studies with older children and adolescents, although the level of satisfaction

Table 3. Characteristics and principle outcomes of validation studies with technology-based FFQs (n = 6).

First Author, year	Sample/Origin	Age, years	Sex, B/G	Tool name	Type	Image (assisted, no)	Short description of digital tool	Statistical analysis	Validation target	Principal outcomes
Validation method: FFQs (n = 1)										
Barchita, 2019	174/ Italy	15–18	Na	–	web-based	Image-assisted	Web-based self-administered FFQ. Portion sizes were assessed by using images extracted from a photographic atlas. **Number of food items questioned:**95 **Recall time period:** 1 month	Unadjusted correlations; % agreement	Nutrient and food group intake	Food and nutrient intakes were comparable between two FFQs, except for nuts, shellfish, fruit juices and monounsaturated fatty acids. The web-FFQ significantly overestimated shellfish and fruit juice intakes, while it underestimated nuts, canned fish, olive oil, total energy intake, fatty acids and calcium.
Validation method: 24-h dietary recalls (n = 2)										
Bjerregaar, 2018	124/ Denmark	12–15	Na	Denmark-adapted youth/adolescent questionnaire	web based	No	The web-based self-administered FFQ developed for this study was based on a validated youth/adolescent questionnaire. **Number of food items questioned:**145 **Recall time period:** 1 month	Unadjusted correlations; % agreement	Nutrient and food group intake	Overestimation by the FFQ compared with the validation method for fish, fruits, vegetables, oils and dressing and underestimation by the FFQ for meat/poultry and sweets. Median intake of beverages, dairy, bread, cereals, the mean total energy and carbohydrate intake did not differ significantly. Protein and vitamin C intake were overestimated.
Vereecken 2010	48/ Belgium	14.6 (1.1)	22/26	online HELENA FFQ	web-based	No	In total 137 food groups (for example, fresh fruit) and individual food items (for example, white bread) were identified as contributing substantially to the overall intake of these components. These food items were divided over 21 screens grouping 2–9 related foods per food group. **Number of food items questioned:** 137 **Recall time period:** 1 month	De-attenuated correlations; % agreement	Nutrient and food group intake	Reproducibility correlations were good (0.46–0.90). De-attenuated correlations between both methods were high (≥0.51) for all nutrients and nutrient densities, except for fiber (g), vitamin C (mg) and percent energy from fat (respectively 0.23, 0.40 and 0.30). On a food group level correlations were significant (unadjusted > 0.3) for most (17/22) food groups.
Validation method: 7-day or 3-day dietary records (n = 3)										
Deierlein 2019	55/ USA	8–14	21/34	VioScreen FFQ	web based	Image-assisted	This tool uses graphics, branching questions, and up-to-date nutrition databases to generate detailed reports on nutrient intakes and food use patterns for the previous 90 days. **Number of food items questioned:** 155 **Recall time period:** 3 months	unadjusted correlations	Energy, nutrient and food group intake	The highest de-attenuated Pearson correlations (0.50) between the VioScreen FFQ and the 3-day dietary records were observed for iron (0.69), saturated fat (0.59), vegetables (0.56), calories (0.52), carbohydrates (0.51), and sugar (0.50). The lowest correlations were observed for whole grains (0.11) and vitamin C.
Tabacchi 2015	92/ Italy	14–17	na	ASSOFFQ	web based	Image-assisted	Semi-quantitative questionnaire structured in three sections (foods, beverages and dietary supplements). Portion sizes where assessed using pictures. **Number of food items questioned:** 106 **Recall time period:** 1 month	multiadjusted correlations; % agreement	Energy, nutrient and food group intake	Overestimation of intake from ASSOFFQ compared to the weighted food record, with significant difference in 17 food groups except for white bread, sweets, eggs, animal fats, and soft drinks and in 12 of out 52 nutrients. Energy intake provided by the ASSOFFQ was on average 54% higher than the food record.

(continued)

Table 3. Continued.

First Author, year	Sample/Origin	Age, years	Sex, B/G	Tool name	Type	Image (assisted, no)	Short description of digital tool	Statistical analysis	Validation target	Principal outcomes
Matthys 2007	104/ Belgium	12–18	na	–	web-based	No	The Web-based FFQ is a computerized self-administered semi-quantitative food frequency questionnaire, which contained 15 food groups. **Number of food items questioned: 69 Recall time period: 1 month**	unadjusted correlations	Water and food group intake	For all participants, the measured intakes of water, fruit, breakfast cereals, fish/eggs/meat, pasta/rice, and potatoes were not significantly different between the two methods. Web-based FFQ showed significantly lower estimates for soft drinks, sweet and savory snacks/fillings, sauces and fat spreads, cheese, pasta/rice, and vegetables. validation only showed reliable intakes for water, fruit, bread, and fish/eggs/meat

Abbreviations: Boys (B); Food frequency questionnaire (FFQ); Girls (G); Not available (na).

was quite high (e.g. >65% of the participants reported high acceptance as regards the use of the gadget), about 7 out of 10 found it burdensome to systematically record their dietary intake or even to remember to do this (Lee et al. 2017), while they were bored enough to answer to large sets of questions (Deierlein et al. 2019). Time of completion was always being detrimental for older children and adolescents to comply with the dietary assessment procedure (Moore et al. 2008). On the other side, in case of younger children i.e. below the age of 8 years old, the cognitive immaturity, resulting in difficulties through the technology-based dietary recording, was the principle barrier identified, mainly in boys, demanding their parents' support (Baranowski et al. 2012; Diep et al. 2015). Besides these, the access to the mean through which the dietary assessment was performed was a major issue (e.g. younger children do not have a systematic access to computers or mobile phones) (Davies et al. 2015).

Quality scoring of the selected studies

Results from the quality assessment of the validation studies discussed here are summarized in Table 4 and more extensively presented in Supplementary material, Table 2. In brief, it was revealed that more than half of the selected studies were of good quality and one out of three of them were of acceptable quality. The highest mean quality scoring was observed in studies related with the validation of technology-based 24-h dietary calls followed by the technology-based FFQs and the technology-based dietary records. The overall quality score was around 3.4–3.5 which corresponds to a moderate (acceptable to good) quality.

Discussion

Web-based and mobile technologies offer a wide range of feasible options to be incorporated in the dietary assessment in clinical or research practice. Previous research on healthy adults or patients with established chronic diseases such as diabetes indicate that many of new technology-based tools present close agreement to traditional methods of dietary intake, but gaps are wider when compared with objective measures like total energy expenditure through double-labeled water where limited studies exist (Eldridge et al. 2018). Dietary assessment methods that utilize new technology may be more appealing and engaging than paper-based methods, particularly for children and young adults. The present systematic review provides an overview of these options and critically evaluates the evidence on the validity of these novel technology-based tools, with a focus on children and adolescents. The results reveal that the web- or mobile- based tools may provide, in most cases moderate to good validity compared to the reported dietary intake compared with conventional methods. Interestingly, image-assisted and image-based technology-based methods seem to prevent in some cases misreporting. In general, based on the selected validation studies, measurement errors related to

Table 4. Quality score of validation studies of technology-based dietary assessment tools ($n = 25$).

Quality score categories	Technology-based dietary records ($n = 12$)		Technology-based 24-h dietary recalls ($n = 7$)		Technology-based FFQs ($n = 6$)		Overall studies ($n = 25$)	
	n	%	n	%	n	%	n	%
Very good (≥ 5)	0	0	0	0	0	0	0	0
Good ($3.5 \leq$ score < 5)	8	66.6	5	71.4	2	33.3	15	60.0
Acceptable ($2.5 \leq$ score < 3.5)	4	33.3	1	14.3	4	66.6	9	36.0
Poor (< 2.5)	0	0	1	14.3	0	0	1	4.0
Mean quality score, mean (SD)	3.54 (0.62)		3.28 (0.63)		3.33 (0.75)		3.42 (0.64)	
Median quality score, median (IQR)	3.50 (0.88)		3.50 (0.50)		3.00 (1.25)		3.50 (1.00)	

Quality assessment was performed through the quality assessment of validation studies tool in dietary assessment described by Serra-Majem et al. 2009 (*ref:* Br J Nutr. 2009;102 Suppl 1:S3–S9). **Abbreviations:** Food frequency questionnaire (FFQ); Interquartile range (IQR); Standard deviation (SD).

the relative validity are most likely irrespective to the administration mode.

It has been suggested that technology provides several facilities that are to improve major matters in dietary assessment process. For instance, implementing digital pictures may improve food identification, browsing among hierarchically organized food groups or typing specific food names may ameliorate the limitations in the context of self-reported dietary intake (i.e. memory, attention, categorization skills). Moreover, certain technical functionalities can facilitate the whole process from the responder's perspective through standardization of the sequence of questions, audio-visual stimuli, provision of immediate results and increased flexibility (Boushey et al. 2017). The added value of these facilities in the dietary assessment process were somehow revealed and discussed in the present work.

Examining the validity of dietary assessment tools is definitely a challenging procedure (Bountziouka and Panagiotakos 2010, Bountziouka et al. 2012). Summarizing the results of the present systematic review, several conclusions could be raised. Starting with the technology-based, image-assisted 24-h dietary recalls, those presented a good level of agreement when compared with the paper-based methods, yet principally in adolescents. The less promising outcomes highlighted for children may be attributed to the major limitation of 24-h dietary recall related with the recall bias (Tugault-Lafleur, Black, and Barr 2017). The recall bias is a major problem when applying this dietary assessment method to younger age groups (Tugault-Lafleur, Black, and Barr 2017). The studies selected here examined the level of agreement between paper-based (mostly parent assisted) method and self-administrated (by child) technology-based method. Hence, one hypothesis could be that the more advanced technology-based facilities, such as image assistance and drop-down food lists, cannot eliminate the recall bias and that the contribution of parents remains highly important. Interestingly, the aforementioned age-dependent deviation was replicated when a more objective validation method was used (i.e. direct observation of meal consumption). In addition, lower level of compliance was recorded for children in case of technology-based assessment (i.e. higher omission rates); this partially contradicts the hypothesis that such novelties are more appealing to younger subjects when it comes to children around 8–10 years old (this method was not tested in younger children). What should be noted is that, despite the limited number of studies, the technology-based 24-h dietary recalls present major deviations in the reported dietary intake compared with the

respective information selected though the traditional dietary records (i.e. the "gold standard" subjective dietary assessment method). This may be explained by the lower compliance that adolescents may have with this dietary-recording procedure, which has been previously reported in the literature (Tabacchi et al. 2014). Moreover, all the aforementioned outcomes are related with the level of agreement principally on the basis of food group dietary intake; on the basis of energy intake and nutrients less consistent outcomes were generated.

As for the technology-based FFQs, these were principally examined in adolescents and could be suggested as moderate valid methods to assess dietary intake. Web-based FFQs compared with the gold-standard paper based dietary record showed a good ranking ability and effective assessment of various food groups. It should be noted that image assistance may play a significant role regarding the validity of this dietary assessment method since validation studies based on non image-assisted FFQs showed higher deviations from the traditional tools which comes in line with previous reviews in mixed populations (i.e., adults and children) (Boushey et al. 2017).

Paper-based dietary records are the gold standard subjective dietary assessment method in applied nutrition. The extent to which this validity remains when this method is accompanied by various technological facilities remains inconclusive. Additionally, facilities in terms of the provision of images seem to enhance the accuracy of the estimated energy intake through the technology-based tools and these tools present good level of agreement when compared with objective –of high validity– total energy expenditure methods. This comes in line with previous systematic reviews investigating this topic (Boushey et al. 2017; Burrows, Goldman, and Rollo 2019). What should be highlighted here is that image-based technological dietary records have generally high agreement with the outcomes generated from objective dietary assessment methods; this was not the case in the context of 24-h dietary recalls implying that the advantage of this method is retained even in a technology-based version. However, several concerns should be raised. Firstly, most promising outcomes were revealed in case of children, from the youngest (i.e. 5 years old) to the oldest (i.e. 12 years old) ones, where the selected dietary information (including images) was a parent-assisted procedure. Secondly, energy intake underestimation at a level of even 30% of total energy expenditure accompanied by high rates of energy-intake misclassification (e.g., 20–30% of participants) was observed in case of samples with adolescents where the whole procedure was self-administrated and the

image-based potential still existed (Svensson and Larsson 2015). Even higher underestimations and misclassifications were observed in case of self-administered technology-based dietary recording without the image-based potential (Biltoft-Jensen et al. 2013).

One of the principle problems in the dietary assessment procedure is related with responders' compliance with the method itself and its prerequisites. In this context, beyond the validity of these tools, feasibility and acceptability level are equally important issues. Younger persons are supposed to be the most familiar with such gadgets, applications and web-based programs. This is the main reason for which the exploitation of technology-based facilities to assess dietary intake is principally engaging to younger persons with the recent focus oriented toward children and adolescents. Nevertheless, this hypothesis could be partially doubted by the findings raised here as well as previous reports on this issue (Illner et al. 2012). Indeed, perceptions of "enjoyable" and "easy to use" may be highly rated in many computerized diet programs compared with the traditional ones, principally in adolescents yet practical issues still exist with the level of compliance remaining generally low. For instance, time of completion was usually reported as a limitation with respondents suggesting the inclusion of browse search by food category instead of free text or reformulation to achieve lower time costs (Moore et al. 2008). On the other side, parent or care giver assistance has been highly reported in the literature in case of children to achieve better compliance in recording (Carvalho et al. 2015; Biltoft-Jensen et al. 2013) and confirmed by the studies selected here. Further investigation is demanded to better clarify technical and methodological issues, such as food identification/quantification, customization, outputs and food composition tables used as well as tools features, not only to increase the validity of the selected information but also to enhance the responders' compliance.

Limitations and strengths

For better interpretation of the findings of the present systematic review, several limitations should be mentioned. Firstly, the validation methods used from the selected studies to examine the validity of the technology-based dietary assessment methods were mostly subjective. All these subjective methods are prone to various types of biases such recall bias, noncompliance with the dietary recording, misreporting etc. Secondly, a meta-analysis of the selected data could not be performed due to the large heterogeneity on the study design, the differences in validation procedure (e.g. in terms of energy intake, food groups or macro- and micro- nutrients) as well as the lack of common statistical criteria to assess the level of agreement between the two examined methods (digital vs. traditional). Lastly, the selected studies were principally represented by adolescents or older children (i.e. about 8–11 years old); data on the younger children were limited. However, our review has several strengths that compensate the aforementioned limitations. To the best of our knowledge, this is one of the very

few reviews that systematically searched for validation – and not only feasibility studies – in the field of technology-based dietary assessment, most importantly, orienting our focus to childhood and adolescence.

Conclusion

It is obvious that technology-based dietary assessment methods are a promising alternative for health professionals assessing dietary intake not only on an individual basis but also for population groups probably at relatively low cost and in real time. This seems to be even more evident in case of children and adolescents considering their familiarity with innovative gadgets. The results of the present systematic review suggest that technology-based dietary assessment may be comparably valid to the traditional ones for assessing dietary intake of young people yet specific concerns still exist. The transformation of a traditional dietary assessment method to a technological investment –at least in the meanwhile–seems to retain the well known limitations such as the recall bias. On the other side, the high compliance of youth with more innovative gadgets to record their dietary intake does not seem to be that high. Nevertheless, it should be outlined that the studies selected here were of moderate quality level with various methodological limitations from the study design to the statistical analysis demanding further research to elucidate the aforementioned aspects.

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