Title:

Dietary intake by food group of individuals with type 2 diabetes mellitus: a systematic review.

Author names and affiliations:

Emily Burch^a, Lauren Ball^a, Mari Somerville^a, Lauren T Williams^a

^aMenzies Health Institute Queensland, Griffith University, Queensland, Australia

Author email addresses:

Emily Burch - emily.burch@griffithuni.edu.au

Lauren Ball - l.ball@griffith.edu.au

Mari Somerville - mari.somerville@griffithuni.edu.au

Lauren Williams - lauren.williams@griffith.edu.au

Corresponding author:

Emily Burch

Mailing address: 180 Johnston street, Collingwood, Victoria, Australia, 3066.

Telephone number: (61) 410227668

Email address: emily.burch@griffithuni.edu.au

Abstract

Aims

To synthesise peer-reviewed literature that investigates the dietary intake by food group of individuals with type 2 diabetes mellitus (T2DM) and compare intakes to national and international dietary guidelines.

Methods

Four electronic databases (MEDLINE, EMBASE, CINAHL and Web of Sciences) were searched for studies that investigated the dietary intake of adults (≥ 18 years) with T2DM using the five main food groups (fruit, vegetables, dairy, grains and meat/meat alternatives). Food group intake in serves was compared against national guidelines and fruit and vegetable intake in grams was compared against the World Health Organization (WHO) guidelines.

Results

After screening 13 662 publications, 11 studies were included. All reported cross-sectional data. Majority of participants were consuming less than the recommended serves of fruit, vegetables, grains and dairy and were meeting or exceeding the recommended serves for meat/meat alternatives. Two of six studies reported fruit and vegetable recommendations were being met, two reported dairy recommendations were being met and two reported grain recommendations were being met. Of the five studies reporting intake in grams, four met the WHO minimum intake for fruit and vegetables.

Conclusions

Individuals with T2DM do not comply with food group recommendations; particularly for fruit, vegetables, dairy and grains. Longitudinal research is required to better understand how food group intake changes over time after diagnosis.

Key words

Food groups, diet, systematic-review, type 2 diabetes, dietary intake, nutrition.

1. Introduction

Diabetes is a leading global health emergency estimated to cost US\$827 billion per year [1]. In 2015 it was estimated that 415 million adults were living with diabetes worldwide, with 90-95% living with type 2 diabetes mellitus (T2DM) [1, 2]. Most of the burden of T2DM is attributed to macro- and micro-vascular complications, and co-morbidities such as cardiovascular disease; many of which are associated with sub-optimal glycaemic control [3]. Effective glycaemic control can help to prevent or delay such complications and co-morbidities [4]. Strategies to assist individuals to optimize glycaemic control to reduce the individual and economic burden associated with T2DM are urgently required.

Dietary intake is well recognized as influencing glycaemic control [5]. Recommendations to manage T2DM include eating healthy foods to have a high-quality diet [6, 7]. A randomized controlled trial (RCT) conducted in New Zealand that provided healthy foods to a group of individuals ($n = 53$) with T2DM, saw reductions in HbA1c of 0.4% [8]. A cohort study conducted in the United States (US) showed that individuals ($n = 234$) with T2DM who followed a healthy diet for 12 months experienced improved HbA1c levels of 0.54% [9]. Clearly, having a healthy diet can improve glycaemic control [8, 9].

A variety of different dietary patterns have been shown to be effective at improving glycaemic control in individuals with T2DM [10, 11]. Assessing dietary intake using dietary patterns based on foods and food groups has become increasingly common in nutritional epidemiology studies [12]. This approach provides a more accurate

representation of dietary intake then analysing intake of specific nutrients (e.g. carbohydrate) or dietary constituents (eg. fibre), that are generally not consumed in isolation [13]. Improvements in diet based on foods and food groups have shown stronger and more consistent associations with reduced risk of adverse health outcomes, compared with improvements of specific nutrients [14]. A systematic review and meta-analysis of 20 RCTs compared the following dietary patterns: low-carbohydrate, high-carbohydrate, Mediterranean, low glycaemic-index, high-protein, vegan and vegetarian, and high-fibre to controls for six months or more in individuals with T2DM [10]. Results showed the low-carbohydrate, Mediterranean, low-glycaemic-index and high-protein diets all led to greater improvements in HbA1c than their respective control diets [10]. While these diets have some differing characteristics, they all encourage consuming unprocessed foods from the five food groups; fruit, vegetables, grains, dairy, and meat/meat alternatives. As a result, management guidelines from several countries recommend that individuals with T2DM adhere to national dietary guidelines expressed in terms of the five food groups [6, 7, 15].

The actual food group intake of individuals with T2DM after diagnosis is currently unclear. Evaluating dietary intake is recognized as an important research activity that can help influence dietary education materials and target nutritional interventions [16]. The purpose of this systematic review was to synthesize and evaluate the peer-reviewed literature that investigates the dietary intake by food group of individuals diagnosed with T2DM and compare intakes to national and international guidelines.

2. Methods

A systematic review of peer-reviewed observational studies investigating the food group intake of individuals diagnosed with T2DM was conducted. The review was registered with the International Prospective Register of Systematic Reviews, PROSPERO (Registration ID: CRD42017074756). The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) checklist. The PRISMA flow diagram (Figure 1) has been included to document the systematic review search and selection processes [17].

2.1 Search strategy

A systematic literature search was conducted between June and August 2017 with support by a research librarian. The following databases were searched to identify studies: MEDLINE, EMBASE, CINAHL and Web of Science. The full search strategy including key terms and Medical Subject Headings (MESH) as applied to Medline is shown in Figure 2. In addition, forward citation searching and cross-matching reference lists were undertaken to broaden studies considered for review.

2.2 Study selection

For inclusion, studies were required to: (i) include adults (18 years old and over) who had been diagnosed with T2DM; (ii) be published in a peer-reviewed journal; (iii) be available in full English text; and (vi) have been published between 1990 and 2017. This period was selected as 1990 is recognized as the time when major changes in

global food systems, known as the 'global nutrition transition', began to occur [18]. Case-control, cross-sectional and cohort studies were considered for review. Studies with an intervention arm that assessed "usual" diet at baseline were also considered. No limit was placed on the length of time since participants were diagnosed with T2DM, ethnicity, gender or level of diabetes education. Studies were required to assess the outcome of dietary intake by quantifying daily intake of five food groups: fruits, vegetables, dairy, grains, and meat/meat alternatives by grams or number of serves. Detailed inclusion and exclusion criteria are provided in Table 1.

2.3 Data extraction and analysis

All results were imported into an EndNote library (version X8) and duplicates removed. The titles and abstracts of all studies were reviewed independently by two researchers to screen for eligibility. Studies that appeared to be eligible or had an unclear eligibility were retrieved in full text. The full text article was then reviewed by two researchers and the final included studies determined. Any disagreement on the inclusion of a study was discussed and agreed upon with help from a third researcher. Data from each included study were extracted by two researchers.

If a study listed specific foods (eg. types of fruit) separately from their constituent food group, these were added to a food group according to the study's national dietary guidelines. A summary of the foods listed in each study's national dietary guidelines are provided in Supplementary Table 1. For the studies reporting food group intake in serves consumed per day, intakes were compared against the relevant national guidelines of the study country. Mean deficits were calculated using the lower figure of the reference standard range and when a study reported the

intake of two or more groups (eg. males and females), the highest mean intake figure was used. For the studies reporting fruit and vegetable intake in grams consumed per day, mean combined fruit and vegetable intake was compared to the World Health Organization (WHO) recommendation of ≥ 400 grams per day [19].

2.4 Quality assessment

Included studies were assessed for quality by two researchers using the Mixed Methods Appraisal Tool (MMAT). The MMAT is recognized to have substantive validity and has been tested for efficiency and reliability [20]. The tool contains two screening questions for all study designs and four specific questions applicable to different study designs. These questions relate to participant recruitment, appropriateness of measurements, comparability of participants (if appropriate) and completeness of outcome data and response rates [20]. Scores from the studies included in this review are presented in five categories according to the percentage of quality criteria met. Results of this quality assessment are provided in Table 3.

3. Results

The search identified 13 662 unique publications, from which 120 full-text articles were retrieved. Eleven publications met the criteria for inclusion in the final review (see Figure 1). The most common reason for excluding studies was a lack of applicable outcomes. For example, many studies reported the dietary intake of participants using macronutrients (carbohydrate, protein and fat) rather than food groups [21]. Other studies analysed the intake of only one food group rather than all five, [22] or described only a particular dietary habit, such as “eating a regular

breakfast” [23].

Characteristics of the 11 included studies are outlined in Table 2. The studies were published within an eight-year period, between 2009 and 2017 and were conducted in seven countries including; Canada (n=2), Japan (n=2), the US (n=2), Jordan (n=1), Algeria (n=1), Sri Lanka (n=1), Ireland (n=1) and Italy (n=1). All studies reported cross-sectional data. Five publications analysed data previously collected in other studies, [24, 25-28] with three reporting baseline data collected prior to conducting an intervention trial [25, 27, 28]. A total of 10, 672 individuals participated in the 11 studies, 9, 718 of which had T2DM. All studies included both males and females with a slightly higher percentage of females (53%). Detailed results of quality attributes for individual studies are reported in Table 3. Four studies received a rating of 50% or less [28-30, 32] and seven received a rating of more than 50% [24, 25-27, 31, 33, 34]. The most common reason for a lower score was the sample not being representative of the population under study or the sample being recruited in a way that did not minimize selection bias.

The methods for collecting dietary intake data were diverse. The most common tool utilized was a food frequency questionnaire (FFQ), [24, 25-28, 32] followed by a 24-hour recall [31, 34]. One study utilized both a three-day food diary and a diet questionnaire, [29] and one utilized both a food diary and a FFQ, however, it did not specify the number of days the diary was administered [33]. Another study employed a food consumption survey, however, little information was provided on survey content [30]. The dietary intake period varied from the previous 24 hours to the previous year. Four studies did not discuss the recall period specified to participants [24, 25, 28, 30].

Five of the 11 studies reported intake of all foods in their relevant food groups [24, 26, 27, 33, 34]. Six studies reported certain foods separately to their corresponding food group (eg. “green vegetables” independently from the main “vegetable” food group) [25, 28-32]. Findings from the 11 studies are outlined in Table 3. Participants’ food group intake was reported in diverse ways. Six studies described participants’ dietary intake as mean or median servings per day for each food group, [24, 26, 27, 31, 33, 34] three studies described participants’ dietary intake as mean grams per day for each food group [25, 29, 32] and one study described participants’ dietary intake as grams per 1000 kilocalories consumed per day [28]. One study described participants’ dietary intake as grams per day or grams per week for each food group [30]. Three studies reported fruit and vegetable intake as one food group, [26, 30, 34] with the remainder listing fruit and vegetables as separate food groups [24, 25, 27-29, 31-33].

Results from the six studies that described food group intake as mean or median servings per day are listed in Tables 3 and 4 [24, 26, 27, 31, 33, 34]. Figures are bolded where intake met recommendations in Table 3. No study found that all food group recommendations were being achieved by the study sample. The majority of participants were consuming below the recommended serves of fruit, vegetables, grains and dairy and were meeting or exceeding the recommended serves for meat/meat alternatives. Two studies reported that fruit and vegetable recommendations were being met, [27, 33] two studies reported dairy recommendations were being met [24, 27] and two studies reported grain recommendations were being met [31, 33]. Four studies reported meat/meat

alternative recommendations were being met or exceeded [24, 26, 27, 34]. Of the two studies that did not meet recommendations for fruit and vegetables (reported together), the mean deficit was 2.6 serves and of the two studies that did not meet recommendations for fruit and vegetables (reported separately) the mean deficit was 0.65 and 0.45 serves respectively. Of the four studies that did not meet grain recommendations, the mean deficit was 1.78 serves and of the four studies that did not meet dairy recommendations, the mean deficit was 0.39 serves.

Of the five studies that described food group intake in grams per day, [25, 28-30, 32] four met the WHO recommended fruit and vegetable amount of ≥ 400 grams per day [25, 28, 30, 32]. These results are listed in Table 5.

4. Discussion

This systematic review provides the first synthesis of the peer-reviewed literature on the food group intake of individuals diagnosed with T2DM. The findings suggest individuals do not adhere to national food group recommendations. However, majority of studies met the minimum daily gram recommendation for fruit and vegetables outlined by the WHO. This review highlights several methodological issues for future research on this topic.

Of the six studies that assessed intake by daily food group servings, none found their study sample met recommendations for all five food groups. This raises concerns around the diet quality of individuals with T2DM given the consumption of healthy diets is associated with a lower risk of developing the disease [35]. For example, a large prospective cohort study conducted in the United Kingdom showed individuals

who reported consuming all five food groups had a 30% reduced incidence of T2DM [36]. Further research determining factors that impact long term adherence to dietary guidelines is needed [11].

The most consistent finding of this review was that individuals with T2DM consumed less than recommended serves of fruit, vegetables, dairy and grains (one study reported excessive grain consumption) [33]. Although none of the studies found that the group mean for participants met all dietary recommendations, some populations were closer to meeting specified food group recommendations (eg. Fruit) than others. Two of six studies reported adequate fruit and vegetable serves, [27, 33] two of six studies reported adequate dairy intake [24, 27] and two of six reported adequate grain intake [31, 33]. Of the two studies that did not meet recommendations for fruit and vegetables (reported together), the mean deficit was 2.6 serves and of the two studies that did not meet recommendations for fruit and vegetables (reported separately) the mean deficit was 0.65 and 0.45 serves respectively. These findings are concerning considering that dietary fibre (present in fruit, vegetables and grains) impacts positively on HbA1c and fasting blood glucose levels in individuals with T2DM [37]. A recent systematic review of 13 RCTs analysed the effect of fibre on glycaemic control and reported high-fibre diets reduced absolute values of HbA1c by 0.55% and fasting blood glucose levels by 9.97 mg/d [37]. Findings from the present review suggest intake of fibre-rich foods requires greater emphasis during nutrition care by clinicians. Key actions may involve: delivering targeted nutrition education on the impact of fibre on glycaemic control, providing individualized dietary advice and sharing behavioural change techniques that encourage increased consumption of fruits, vegetables and grains.

Furthermore, the development and testing of population-based intervention strategies to increase the consumption of fibre are warranted.

The findings of the present review appear to reflect the food group intake of the general population [38, 39]. In the 2011-2012 National Nutrition and Physical Activity Survey, most Australians consumed inadequate serves for all five main food groups [38]. Less than 4% met recommendations for vegetables, 31% met recommendations for fruit, 10% met recommendations for dairy, 30% met recommendations for grains and 14% met recommendations for meat/meat alternatives (lean meats only) [38]. A study that used data from the National Health and Nutrition Examination Survey conducted in the US between 2001 and 2004 showed similar results [39]. In the adult population, 12.9% met recommendations for vegetables, 17.5% met recommendations for fruit, 7.7% met recommendations for dairy, 58.9% met recommendations for grains and 54.1% met recommendations for meat/meat alternatives [39]. This evidence and the findings from the present review show that low adherence to food group recommendations is a global behavioural issue, prevalent in those with, and without T2DM. Comprehensive nutrition actions and policies are required to increase diet quality worldwide, however the issue is of particular priority for those with T2DM given the negative health outcomes associated with poor glycaemic control.

The body of evidence in this review has several limitations. Firstly, the majority of studies were conducted in developed countries, therefore results may not be representative of the entire population of individuals diagnosed with T2DM. Secondly, most studies utilized FFQs to collect their data. FFQs are often limited by

measurement errors relating to incomplete food lists and inaccuracies in frequency and portion size estimations [40]. Thirdly, it was not considered in the search whether individuals had received dietary education which may have. Finally, all were cross-sectional in design. This exposes the studies to confounding, selection and information biases and impacts the generalizability of their results [41]. A limitation of study comparability is that no study controlled for length of time with diabetes among participants. This, in combination with the cross-sectional nature of the data makes it impossible to know if adherence to food group recommendations varies over time. Future longitudinal research that tracks changes in diet quality from diagnosis and the factors that influence those changes is clearly of high priority.

Significant diversity in the way the reviewed studies reported food group intake made comparisons challenging. Six studies measured food group intake as servings consumed per day, while others reported intake in grams. Both measures would have been useful for each report. Lack of detailed reporting of the specific foods included in each food group calculation (eg. French fries counted in vegetable group or as a discretionary item) made a meta-analysis impossible. Development and application of a standardized method of food group intake reporting is a distinct priority arising from this research.

A separate, but related issue, was the fact that guidelines for population food group intake varied between nations. For example, the minimum number of serves for fruit and vegetables recommended for Canadians is seven, [43] but only five for Arabs [45]. To overcome this limitation, we compared the fruit and vegetable intake data reported in grams to the WHO standard of ≥ 400 grams. Four of the five studies

exceeded this amount, however, it should be noted that this is a relatively low level (the total daily amount in Australia is 675 grams) [42]. Standardizing dietary guidelines across countries would vastly improve the ability to accurately compare data.

4.1 Strengths and limitations

The present review has several strengths. Bias in data extraction and quality assessment were reduced by having two individual researchers examine each study. The review used an explicit inclusion criteria and the search strategy included four large databases providing broad coverage of the international health literature. Forward citation searching and cross-matching of reference lists reduced the possibility of missing studies. However, the review has some limitations. English language restrictions may have caused studies in some countries to be missed and diversity in the way data was collected and described prevented a meta-analysis from being conducted. Finally, grey literature was not sought, therefore, publication bias may have occurred and relevant ongoing studies may have been excluded.

5. Conclusion

This review synthesized literature that investigated the food group intake of individuals with T2DM. Individuals with T2DM appear to consume insufficient amounts of fruit, vegetables, dairy and grains. Future longitudinal research is required to examine the relationship of time from diagnosis with food group intake to

facilitate targeted and effective strategies that enhance glycaemic control in this population.

Acknowledgements

None.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest statement

The authors declare no conflicts of interest.

Authors contributions

EB, LW, and LB designed the research; all authors conducted the research and analysed the data and EB, LW and LB wrote the paper. All authors had primary responsibility for final content. All authors read and approved the final manuscript.

References

- [1] International Diabetes Federation (IDF). IDF Diabetes Atlas. United Kingdom: IDF; 2015.
- [2] Centers for Disease Control and Prevention. Diabetes [internet]. 2016 [cited 2017 Aug 1]. Available from: <https://www.cdc.gov/chronicdisease/resources/publications/aag/diabetes.htm>
- [3] Leon BM, Maddox TM. Diabetes and cardiovascular disease: epidemiology, biological mechanisms, treatment recommendations and future research. *World J Diabetes* 2015;6(13):1246-58.
- [4] Stratton IM, Adler AI, Neil HA, Matthews DE, Manley SE, Cull CA, et al. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ* 2000;321(7258):405-12.
- [5] Franz JM, MacLeod J, Evert A, Brown C, Gradwell E, Handu D, et al. Academy of Nutrition and Dietetics Nutrition Practice Guideline for Type 1 and Type 2 Diabetes in Adults: Systematic Review of Evidence for Medical Nutrition Therapy Effectiveness and Recommendations for Integration into the Nutrition Care Process. *J Acad Nutr Diet* 2017;117(10):1659-79.
- [6] Dyson PA, Kelly T, Deakin T, Duncan A, Frost G, Harrison Z, et al. Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. *Diabetic Med* 2011;28(11):1282-8.
- [7] Cheng AY, et al. Canadian Diabetes Association 2013 clinical practice guidelines for the prevention and management of diabetes in Canada. *Canadian J Diabetes* 2013;37:S291-S360.
- [8] Coppel KJ, Kataoka M, Williams SM, Chisholm AW, Vorgers SM, Mann JI, et al. Nutritional intervention in patients with type 2 diabetes who are hyperglycaemic despite optimised drug treatment—Lifestyle Over and Above Drugs in Diabetes (LOADD) study: randomised controlled trial. *BMJ* 2010;341(7766):237.
- [9] Houle J, Beaulieu MD, Chiasson JL, Lespérance F, Côté J, Strychar I, et al. Glycaemic control and self-management behaviours in type 2 diabetes: results from a 1-year longitudinal cohort study. *Diabetic Med* 2015;32(9):1247-54.

- [10] Ajala O, English P, Pinkney J. Systematic review and meta-analysis of different dietary approaches to the management of type 2 diabetes. *Am J Clin Nutr* 2013;97(3):505-16.
- [11] Ley SH, Mohan V, Hu FB. Prevention and management of type 2 diabetes: dietary components and nutritional strategies. *Lancet* 2014;383.9933:1999-2007.
- [12] Previdelli AN, de Andrade SC, Fisberg RM, Marchioni DM. Using two different approaches to assess dietary patterns: hypothesis-driven and data-driven analysis. *Nutrients* 2016;8(10):593.
- [13] Cespedes EM, Hu FB. Dietary patterns: from nutritional epidemiologic analysis to national guidelines. *Am J Clin Nutr* 2015;101(5):899-900.
- [14] Fardet A, Boirie Y. Associations between food and beverage groups and major diet-related chronic diseases: an exhaustive review of pooled/meta-analyses and systematic reviews. *Nutr Rev* 2014;72(12):741-62.
- [15] Diabetes Australia. What should I eat? [internet]. 2016 [cited Sep 1 2017]. Available from: <https://www.diabetesaustralia.com.au/what-should-i-eat>.
- [16] Anderson E, Perloff B, Ahuja JK, Raper N. Tracking nutrient changes for trends analysis in the United States. *J Food Comp Anal* 2001;14(3):287-94.
- [17] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS med* 2009;6(7):e1000097.
- [18] Popkin BM, Adair LS, Ng SW. Now and then: the global nutrition transition: the pandemic of obesity in developing countries. *Nutr Rev* 2012;70(1):3-21.
- [19] World Health Organization (WHO). Diet, Nutrition and the Prevention of Chronic Diseases. Geneva: WHO; 2003.
- [20] Pluye P. Mixed kinds of evidence: synthesis designs and critical appraisal for systematic mixed studies reviews including qualitative, quantitative and mixed methods studies. *Evid Based Med* 2015;20(2):79.
- [21] Joshi SR, Bhansali A, Bajaj S, Banzal SS, Dharmalingam M, Gupta S, et al. Results from a dietary survey in an Indian T2DM population: a STARCH study. *BMJ Open* 2014;4(10):e005138-e.
- [22] Breen C, Ryan M, Gibney MJ, O'Shea D. Diabetes-related nutrition knowledge and dietary intake among adults with type 2 diabetes. *Br J Nutr* 2015;114(3):439-47.
- [23] Chourdakis M, Kontogiannis V, Malachas K, Pliakas T, Kritis A. Self-care behaviors of adults with type 2 diabetes in Greece. *J Community Health* 2014;39(5):972-9.
- [24] Crichton GE, Elias MF, Dearborn P, Robbins M. Habitual chocolate intake and type 2 diabetes in the Maine-Syracuse Longitudinal Study: (1975-2010): prospective observations. *Appetite* 2017;108:263-9.
- [25] Horikawa C, Yoshimura Y, Kamada C, Tanaka S, Tanaka S, Takahashi A, et al. Dietary intake in Japanese patients with type 2 diabetes: analysis from Japan Diabetes Complications Study. *J Diabetes Invest* 2014;5(2):176-87.

- [26] Jarvandi S, Gougeon R, Bader A, Dasgupta K. Differences in food intake among obese and nonobese women and men with type 2 diabetes. *J Am Coll Nutr* 2011;30(4):225-32.
- [27] Vitolins MZ, Anderson AM, Delahanty L, Raynor H, Miller GD, Mobley C, et al. Action for Health in Diabetes (Look AHEAD) trial: baseline evaluation of selected nutrients and food group intake. *J Am Diet Assoc* 2009;109(8):1367-75.
- [28] Vitale M, Masulli M, Cocozza S, Anichini R, Babini AC, Boemi M, et al. Sex differences in food choices, adherence to dietary recommendations and plasma lipid profile in type 2 diabetes – The TOSCA.IT study. *Nutr Metab Cardiovasc Dis* 2016;26(10):879-85.
- [29] Murray AE, McMorrow AM, O'Connor E, Kiely C, Mac Ananey O, O'Shea D, et al. Dietary quality in a sample of adults with type 2 diabetes in Ireland; a cross-sectional case control study. *Nutr J*. 2013;12(1):110.
- [30] Laissaoui A, Allem R. The eating habits of patients with type 2 diabetes in Algeria. *Pak J Med Sci* 2016;32(2):289-93.
- [31] Medagama A, Fernando D, Widanapathirana H. Energy and nutrient intakes of Sri Lankan patients with type 2 diabetes: a cross-sectional survey. *BMC Res Notes* 2015;8:753.
- [32] Kobayashi Y, Hattori M, Wada S, Iwase H, Kadono M, Tatsumi H, et al. Assessment of daily food and nutrient intake in Japanese type 2 diabetes patients using dietary reference intakes. *Nutrients* 2013;5(7):2276-88.
- [33] Bawadi H, Abu-Jamous D, Tayyem RF. Evaluation of the dietary pattern of patients with type 2 diabetes in Northern Jordan: an inconvenient truth! *Int J Diabetes Dev Ctries* 2014;34(3):134-8.
- [34] Asaad G, Chan CB. Relationship of diet quality to food security and nutrition knowledge in low-income, community-dwelling elders with type 2 diabetes: a pilot study. *Can J Diabetes* 2012;36(6):310-3.
- [35] Maiorino MI, Bellastella G, Giugliano D, Esposito K. Can diet prevent diabetes? *J Diabetes Complications* 2017;31(1):288-290.
- [36] Conklin AI, Monsivais P, Khaw K-T, Wareham NJ, Forouhi NG. Dietary Diversity, Diet Cost, and Incidence of Type 2 Diabetes in the United Kingdom: A Prospective Cohort Study. *PLoS Med* 2016;13(7):e1002085.
- [37] Silva FM, Kramer CK, de Almeida JC, Steemburgo T, Gross JL, Azevedo MJ. Fiber intake and glycemic control in patients with type 2 diabetes: a systematic review with meta-analysis of randomized controlled trials. *Nutr Rev* 2013;71(12):790-801.
- [38] Australian Bureau of Statistics. Australian Health Survey: consumption of food groups from the Australian Dietary Guidelines 2011-12 [internet]. 2016 [cited 2017 Jun 27]; ABS cat. no. 4364.0.55.0122016. Available from: <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4364.0.55.012Main+Features12011-12?OpenDocument>
- [39] Kirkpatrick SI, Dodd KW, Reedy J, Krebs-Smith SM. Income and race/ethnicity are associated with adherence to food-based dietary guidance among US adults and children. *J Acad Nutr Diet* 2012;112(5):624-e6.

- [40] Ishihara J. Challenges in dietary exposure assessment in epidemiology: research trends. *J Nutr Sci Vitaminol* 2015;61:S33-S5.
- [41] Simunovic N, Bhandari M. Methodological issues in systematic reviews and meta-analyses of observational studies in orthopaedic research. *J Bone Joint Surg Am* 2009;91(suppl 3):87-94.
- [42] National Health and Medical Research Council (NHMRC). Australian Dietary Guidelines. Canberra: NHMRC; 2013.
- [43] Government of Canada. Eating Well With Canada's Food Guide. Canada; 2007.
- [44] Statistics Canada. Nutrition: Findings from the Canadian Community Healthy Survey – overview of Canadians' eating habits. Health Statistics Division. Ottawa; 2007.
- [45] Musaiger A. The Food Dome: dietary guidelines for Arab countries. *Nutr Hosp* 2012;27(1):109.
- [46] Golzarand M, Mirmiran P, Jessri M, Toolabi K, Mojarrad M. Dietary trends in the Middle East and North Africa: an ecological study (1961 to 2007). *Public Health Nutr* 2012;15(10):1835-44.
- [47] United States Department of Agriculture (USDA). Dietary Guidelines for Americans. Washington: USDA; 2000.
- [48] National Cancer Institute. Usual Dietary Intakes: Food Intakes, U.S. Population, 2007-10 [internet]. 2015 [cited 2017 Dec 1]. Available from: <http://epi.grants.cancer.gov/diet/usualintakes/pop/2007-10/>.
- [49] Yoshiike N, Hayashi F, Takemi Y, Mizoguchi K, Seino F. A new food guide in Japan: the Japanese food guide spinning top. *Nutr Rev* 2007;65(4):149-54.
- [50] Ministry of Health, Labour and Welfare (MHLW). National Health and Nutrition Survey results 2012. Japan: (MHLW); 2012.
- [51] Naude C. Food-based dietary guidelines for South Africa. *South African J Clin Nutr* 2013;3:2221-1268.
- [52] Micha R, Khatibzadeh S, Shi P on behalf of the Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE), et al. Global, regional and national consumption of major food groups in 1990 and 2010: a systematic analysis including 266 country-specific nutrition surveys worldwide. *BMJ Open* 2015;5:e008705.
- [53] Ministry of Health - Nutrition Division. Food Based Dietary Guidelines for Sri Lankans. Sri Lanka; 2011.
- [54] Jayawardena R, Byrne NM, Soares MJ, Katulanda P, Hills AP. Food consumption of Sri Lankan adults: an appraisal of serving characteristics. *Public Health Nutr* 2013;16(4):653-8.
- [55] Department of Health. Healthy Food for Life – the healthy eating guidelines 2016. Ireland; 2012.
- [56] Food Standards Agency Northern Ireland. National Diet and Nutrition Survey. Results from Years 1-4 (combined) of the Rolling Programme. Northern Ireland; 2017.
- [57] CRA-NUT Research Center for Food and Nutrition. Guidelines for healthy Italian food habits 2003. Rome: CRA-NUT; 2003.

[58] European Food Safety Authority. The EFSA comprehensive European food consumption database [internet]. 2015 [cited 2017 Dec 1]. Available from: <http://www.efsa.europa.eu/en/food-consumption/comprehensive-database>

Table 1. Inclusion and exclusion criteria

	Inclusion criteria	Exclusion criteria
Setting	Any country. Published 1990-2017.	Published before 1990.
Participants	Any gender and ethnicity. ≥18 years old diagnosed with T2DM (self-reported diagnosis or biochemically confirmed). Individuals who had or had not received prior diabetes education were considered. Studies that compared dietary intake of individuals with T2DM with the intake of individuals with T1DM or those without diabetes were considered if results were reported separately for each group.	<18 years old. T1DM, gestational diabetes or pre-diabetes.
Outcomes	Studies that quantified dietary intake of all 5 food groups (fruit, vegetables, grain, dairy, and meat/meat alternatives) by grams or number of serves.	Studies that reported dietary intake only by: - Macronutrient intake (eg. carbohydrate). - Micronutrient intake (eg. calcium). - Intake of a single food group (eg. fruit). - Intake of total calories or kilojoules. - Intake of one meal (eg. breakfast). - DQI or diet quality score. Studies with no quantifiable diet outcomes.
Study type	Observational studies (case-control, cross-sectional and cohort design). Studies with an intervention arm that reported “usual” dietary	Results of intervention studies or trial analyses, narrative studies and systematic reviews.

intake at baseline.

Publication type	Articles published in a peer-reviewed journal.	Dissertation, review, book, conference report, guidelines or symposium.
	Available in full text.	Abstract only.
Language	English.	All other languages.

DQIs, diet quality indices; T2DM, type 2 diabetes mellitus; T1DM, type 1 diabetes mellitus.

Table 2. Characteristics of included studies that assess dietary intake of individuals with type 2 diabetes mellitus ($n = 11$), in alphabetical order by first author

First author, year & country	Study design	Stated aim	Setting	Inclusion criteria	Participant characteristics & RR	Participant mean (SD) age & diabetes duration (years)	Confirmation of T2DM diagnosis	Use of DM medication
Asaad, 2012 [34] Canada	Cross-sectional survey	Examine nutrient intake and diet quality in relation to CDA food security recommendations of low-income community-dwelling elders with T2DM.	Independent dwellings within a retirement home.	T2DM aged ≥ 60 y, living independently and English speaking.	N = 17 11 F (64.7%), 6 M (35.3%) 94% RR	71.5 (6.3) 17.6 y (12.6)	NS	NS
Bawadi, 2014 [33] Jordan	Cross-sectional survey	Evaluate diets consumed by a sample of individuals with T2DM in northern Jordan.	Tertiary hospital outpatient endocrinology clinic.	T2DM (diagnosed >1 y prior to data collection).	N = 750 459 F (61.2%), 291 M (38.8%) 75% RR	NS NS	NS	NS
Crichton, 2016 [24] United States	Cross-sectional analysis of cohort study data collected between 2001-2006 (study conducted 1975-2010)	Investigate relations between habitual chocolate intake and DM.	Study laboratory.	English speaking adults (those with and without T2DM).	N = 953; $n = 45$ with T2DM, 22 F (48.9%), 23 M (51.1%) + $n = 908$ without diabetes, 541 F (59.6%), 367 M (40.4%) 91% RR	66 (10.7) NS	FBG level ≥ 126 mg/dL	$n = 45$ (100%)
Horikawa, 2014 [25] Japan	Cross-sectional analysis of baseline RCT data (Japan Diabetes Complications Study)	Elucidate dietary intake of Japanese individuals with T2DM participating in nationwide cohort study, and identify differences between Japanese and Western dietary intake.	Outpatient clinics of 59 hospitals.	T2DM aged 40-70 y.	N = 1, 516 709 F (47%), 807 M (53%) 69% RR	58.7 (6.9) 11 (7.1)	HbA1c $\geq 6.5\%$	OHA: $n = 998$ (65.8%) Insulin: $n = 303$ (20%)
Jarvandi, 2011 [26] Canada	Cross-sectional analysis of cohort study data at year 1	Compare dietary intake and vitamin supplement use of obese and non-obese F and M with T2DM to identify gaps in adherence to nutritional management guidelines.	University outpatient clinics.	T2DM (>1 y diagnosis) aged ≥ 19 y, BMI ≤ 40 kg/m ² . Group 1: BMI <30 kg/m ² ($n = 105$); Group 2: BMI ≥ 30 kg/m ² ($n = 95$)	N = 200 93 F (47%), 107 M (53%) 99% RR	NS NS	NS	NS
Kobayashi, 2013 [32] Japan	Cross-sectional	Assess dietary intake of individuals with T2DM and characterize relative to Japanese DRIs and average Japanese dietary intake.	Hospital.	T2DM aged 40-79 y.	N = 149 72 F (48%), 77 M (52%) 57% RR	M 65.3 (9.2) F 66.1 (9.5) NS	NS	OHA: $n = 119$ (80%) Insulin: $n = 33$ (22%)

First author, year & country	Study design	Stated aim	Setting	Inclusion criteria	Participant characteristics & RR	Participant mean (SD) age & diabetes duration (years)	Confirmation of T2DM diagnosis	Use of DM medication
Laissaoui, 2016 [30] Algeria	Cross-sectional	Evaluate dietary habits and PA practices of diabetic individuals in Ain Defla.	NS	Normal and overweight adults with T2DM.	N = 1, 523 988 F (65%), 535 M (35%) NS	58.7 (9.9) 10.5 (5.1)	NS	NS
Medagama, 2015 [31] Sri Lanka	Cross-sectional	Find average number of servings of principal food categories consumed by adults with T2DM attending a tertiary diabetes facility.	Hospital diabetes facility.	T2DM (diagnosed ≥ 6 months) receiving nutrition counselling at the diabetes facility.	N = 123 80 F (65.1%), 43 M (34.9%) 96% RR	M 57.8 F 55.2 NS	'Prevailing diagnostic criteria'	NS
Murray, 2013 [29] Ireland	Cross-sectional with age matched controls	Measure dietary intake of adults with T2DM and assess overall diet quality using a selection of validated DQIs.	Diabetes day care services at two hospitals.	T2DM (diagnosed within previous 10 y) aged 30-75 y and age and PA matched controls.	N = 111; $n = 65$ with T2DM, 26 F (40%), 39 M (60%) + $n = 46$ controls 30 F (65%), 16 M (35%). NS	56 (7.7) NS	HbA1c <10%	OHA: $n = 49$ (75%)
Vitale, 2016 [28] Italy	Cross sectional analysis of baseline RCT data	Differences between gender and diet quality, adherence to nutritional recommendations and their relation with plasma lipid profiles in individuals with T2DM.	60 Italian clinical centres participating in the TOSCA.IT study.	T2DM (diagnosed ≥ 2 y) aged 50-75y, BMI of 20-45 kg/m ² and treated for ≥ 2 mnths with metformin. Excluded those with co-morbidities requiring special diet.	N = 2, 573 1, 038 F (40%), 535 M (60%) NS	62.15 (6.5) 8.5 (5.7)	HbA1c >7.0%	OHA: $n = 2, 573$ (100%)
Vitolins, 2009 [27] United States	Cross-sectional analysis of baseline RCT data	To (i) describe baseline food intake of Look AHEAD participants, (ii) compare nutrient and food intake of Look AHEAD participants to IOM and USDA recommendations, and (iii) describe participant characteristics associated with consumption of specific food groups.	16 clinical centres participating in the Look AHEAD study.	T2DM aged 45-75 y, BMI of ≥ 25 kg/m ² (≥ 27 kg/m ² if using insulin).	N = 2, 757 1, 635 F (41%), 1, 122 M (59%) NS	57.2 (7.2) NS	FBG ≥ 126 mg/dL OR symptoms of hyperglycaemia with non-fasting BG ≥ 200 mg/dL OR 2-hr BG ≥ 200 mg/dL on at least 2 OGTTs	OHA only: $n = 1,858$ (76%) Insulin only: $n = 117$ (4%) Insulin + OHA: $n = 418$ (15%)

AHEAD, Action for Health in Diabetes; BG, blood glucose; BMI, Body Mass Index; CDA, Canadian Diabetes Association; dL, decilitre; DM, diabetes mellitus; F, females; FBG, fasting blood glucose; HbA1c, glycosylated haemoglobin A1c; hr, hour; IOM, Institute of Medicine; M, men; mg, milligrams; NS, not specified; OGTT, oral glucose tolerance test; OHA, oral hypoglycaemic agents; PA, physical activity; RCT, randomized controlled trial; RR, response rate; T2DM, type 2 diabetes mellitus; USDA, United States Department of Agriculture; y, years.

Table 3. Description of included studies that assess the dietary intake of individuals with type 2 diabetes mellitus ($n = 11$), in alphabetical order by first author

First author & year	Dietary assessment methodology	Food group intake analyses	Dietary intake of food groups in comparison to recommendations [Rec] and general population intake					Main conclusions	Study limitations & quality ax score	
Asaad 2012 [34]	3 x 24-hour diet recalls conducted face-to-face, 2 wks apart.	Food group intake compared to 2008 CDA recommendations [43]. Mann-Whitney U test used to detect differences in dietary intake for: Group 1 = 'Food Secure' (n = 12) and Group 2 = 'Food Insecure' (n = 5).	Median serves/d:					Less than CDA recommended servings for all food groups except for meat/meat alt. Independent of food security status, overall diet quality was poor.	- Sample recruited from single site, primarily highly educated F restricting generalizability. - Mean age may have adversely impacted recall. - Small sample size, lack of statistical power. - Risk of bias due to under reporting intake. Social desirability bias due to presence of interviewers. 75%	
					Observed intake					
			Food Group	Rec [43]	Population intake [44]	G1	G2			
			F&V	7-10	5.2	3.2	3.3			
			Dairy	2-3	1.5	1.5	1.8			
			Grains	6-8	5.6	3.3	4.7			
Meat/alt	2-3	2	1.7	2.5						
Bawadi 2014 [33]	Validated, semi-quantitative, interviewer administered FFQ based on previous year. Household measures to estimate serving size. Eight frequency options from "more than once a day" to "rarely or never".	Food group intake compared to food based dietary guidelines for Arabs [45]. Independent sample t-test used to detect differences between M and F.	Mean serves/d:					Higher than recommended intakes of fruit and grains, and lower intakes of dairy, and meat/meat alt. Vegetable intake within range.	- Sample recruited from single site, restricting generalizability. - Possible respondent fatigue due to FFQ and food diary both being administered. - Social desirability bias due to presence of interviewers. 75%	
					Observed intake					
			Food Group	Rec [45]	Population intake [46]	M	F			
			Fruit	2-4	2.10	4.74	4.23			
			Vegetables	3-5	3.40	4.41	4.35			
			Dairy	2-3	1.10	1.54	1.43			
Grains	6-11	17.00	18.60	16.96						
Meat/alt	2-3	2.5	1.00	0.75						
Crichton 2016 [24]	Nutrition and Health Questionnaire with mean serves compared with USDA dietary guidelines for Americans [47]. Six frequency options ranging from "never" and "once or more/day".	Independent sample t-test and chi-square test used to detect differences in dietary intake based on participant demographic and health characteristics.	Total (mean serves/d):					Less than recommended servings of all food groups except dairy and meat/meat alt.	- Sample recruited from single site, restricting generalizability. - Small sample of individuals with T2DM, limits statistical power. - Risk of bias due to under reporting intake. - Portion sizes not specified in questionnaire, limits quantification. 100%	
					Observed intake					
			Food Group	Rec [47]	Population intake [48]					
			Fruit	2-4	1.0	1.7				
			Vegetables	3-5	1.5	2.5				
			Dairy	2-3	1.8	2.1				
Grains	6-11	6.3	4.4							
Meat/alt	2-3	5.6	2.3							
Horikawa 2014 [25]	FFQ assessed average intake/wk in commonly used units or portion sizes. 29 food group items and 10 kinds of cookery. Dietitian reviewed FFQ. FFQ validated against 1 wk WFR from sub-sample of participants (n = 66).	Food group intake reported by gender, age (≥60 y and <60 y), occupation (sedentary and non-sedentary), HbA1c levels (<7% and ≥7%) and duration of diabetes (<10 years or ≥10 years). Authors made no comparison to dietary guidelines.	Total (mean g/d):					F&V intake did not meet Japanese dietary guideline recommendations of 550 g/day [49].	- FFQ does not allow for quantification of absolute intake. - No comparison made with dietary guidelines. - Possible respondent fatigue due to FFQ and WFR both being administered in n = 66 participants. 100%	
					Observed intake					
			Food Group	Rec [49]	Population intake [50]					
					M	F				
			Fruit		126	155	133			
			Vegetables		689	694	382			
F&V total	550	815	849	515						
Dairy		91	110	170						
Grains		513	385	191						
Meat/alt		297	245	250						

First author & year	Dietary assessment methodology	Food group intake analyses	Dietary intake of food groups in comparison to recommendations [Rec] and general population intake						Main conclusions	Study limitations & quality ax score																																																	
Jarvandi 2011 [26]	Validated, semi-quantitative, self-administered, FFQ with 73 items based on intake from previous month. Photography to assist quantification. FFQ administered 4 times over 1 y (once per season).	Food group intake compared to CFG recommendations [43]. Data from diet assessments averaged. Mean intakes compared between obese (Group 1 <i>n</i> = 88) and non-obese subjects (Group 2 <i>n</i> = 98).	Mean serves/d: <table><tr><th>Food Group</th><th>Rec [43]</th><th>Population intake [44]</th><th colspan="4">Observed intake</th></tr><tr><td></td><td></td><td></td><th>M</th><th>M</th><th>F</th><th>F</th></tr><tr><td></td><td></td><td></td><th>G1</th><th>G2</th><th>G1</th><th>G2</th></tr><tr><td>F&V</td><td>7-10</td><td>5.2</td><td>4.3</td><td>4.5</td><td>5.4</td><td>5.5</td></tr><tr><td>Dairy</td><td>2-3</td><td>1.5</td><td>1.6</td><td>1.6</td><td>1.8</td><td>2.0</td></tr><tr><td>Grains</td><td>6-8</td><td>5.6</td><td>6.1</td><td>6.0</td><td>4.8</td><td>4.4</td></tr><tr><td>Meat/alt</td><td>2-3</td><td>2.0</td><td>3.2</td><td>3.6</td><td>3.4</td><td>3.6</td></tr></table>						Food Group	Rec [43]	Population intake [44]	Observed intake							M	M	F	F				G1	G2	G1	G2	F&V	7-10	5.2	4.3	4.5	5.4	5.5	Dairy	2-3	1.5	1.6	1.6	1.8	2.0	Grains	6-8	5.6	6.1	6.0	4.8	4.4	Meat/alt	2-3	2.0	3.2	3.6	3.4	3.6	Less than recommended servings for all food groups except meat/meat alt, which exceeded recommendations. Within same-sex groups, food group servings did not differ by weight.	- Results may not be generalizable to population who do not receive regular healthcare services. Small sample size, lack of statistical power. - Self-administered FFQ, relies on literacy and numeracy levels of participants. 75%
Food Group	Rec [43]	Population intake [44]	Observed intake																																																								
			M	M	F	F																																																					
			G1	G2	G1	G2																																																					
F&V	7-10	5.2	4.3	4.5	5.4	5.5																																																					
Dairy	2-3	1.5	1.6	1.6	1.8	2.0																																																					
Grains	6-8	5.6	6.1	6.0	4.8	4.4																																																					
Meat/alt	2-3	2.0	3.2	3.6	3.4	3.6																																																					
Kobayashi 2013 [32]	Validated, self-administered DHQ based on intake from past month. Dietary behaviour, cooking methods, quantity and frequency of consuming 149 food and beverage items, and the amount of rice and miso soup consumed daily.	Food group intake compared to data obtained in NNSJ [50]. Mann-Whitney U test used to evaluate relationships between BMI and biomarkers.	Mean g/d: <table><tr><th></th><th>Rec [49]</th><th>Population Intake [50]</th><th colspan="2">Participant data</th></tr><tr><th>Food Group</th><th></th><th>M</th><th>F</th><th>M</th><th>F</th></tr><tr><td>Fruit</td><td></td><td>126</td><td>155</td><td>94</td><td>128</td></tr><tr><td>Vegetables</td><td></td><td>689</td><td>694</td><td>569</td><td>711</td></tr><tr><td>F&V total</td><td>≥550</td><td>815</td><td>849</td><td>663</td><td>839</td></tr><tr><td>Dairy</td><td></td><td>91</td><td>110</td><td>137</td><td>144</td></tr><tr><td>Grains</td><td></td><td>513</td><td>385</td><td>437</td><td>354</td></tr><tr><td>Meat/alt</td><td></td><td>297</td><td>245</td><td>185</td><td>174</td></tr></table>							Rec [49]	Population Intake [50]	Participant data		Food Group		M	F	M	F	Fruit		126	155	94	128	Vegetables		689	694	569	711	F&V total	≥550	815	849	663	839	Dairy		91	110	137	144	Grains		513	385	437	354	Meat/alt		297	245	185	174	F&V intake exceeded Japanese dietary guideline recommendations of ≥550 g/day [49].	- Sample recruited from single site, restricting generalizability. - Small sample size, lack of statistical power. - No guide to assist portion size estimation – limits quantification. - No comparison made with dietary guidelines. - Self-administered FFQ, relies on literacy and numeracy levels of participants. 50%		
	Rec [49]	Population Intake [50]	Participant data																																																								
Food Group		M	F	M	F																																																						
Fruit		126	155	94	128																																																						
Vegetables		689	694	569	711																																																						
F&V total	≥550	815	849	663	839																																																						
Dairy		91	110	137	144																																																						
Grains		513	385	437	354																																																						
Meat/alt		297	245	185	174																																																						
Laissaoui 2016 [30]	Food consumption survey, no further details provided.	Independent sample t-tests used to compare results according to BMI. Authors made no comparison to dietary guidelines.	Mean intake: <table><tr><th>Food Group</th><th>Rec [51]</th><th>Population intake [52]</th><th>Normal wt</th><th>Overweight & obese</th></tr><tr><td>F&V (g/d)</td><td>≥400</td><td>247.5</td><td>492.74</td><td>421.84</td></tr><tr><td>Dairy (g/d)</td><td></td><td></td><td>194.52</td><td>200.55</td></tr><tr><td>Grains (times/wk)</td><td></td><td></td><td>2 serves</td><td>2 serves</td></tr><tr><td>Meat/alt (g/wk)</td><td></td><td></td><td>440</td><td>540</td></tr><tr><td>Other</td><td></td><td></td><td></td><td></td></tr><tr><td>Leguminous plants (times/wk)¹</td><td></td><td></td><td>1 serve</td><td>1 serve</td></tr><tr><td>Potato (times/wk)¹</td><td></td><td></td><td>4</td><td>5</td></tr></table>						Food Group	Rec [51]	Population intake [52]	Normal wt	Overweight & obese	F&V (g/d)	≥400	247.5	492.74	421.84	Dairy (g/d)			194.52	200.55	Grains (times/wk)			2 serves	2 serves	Meat/alt (g/wk)			440	540	Other					Leguminous plants (times/wk) ¹			1 serve	1 serve	Potato (times/wk) ¹			4	5	F&V intake exceeded South African dietary guideline ² recommendations of ≥400 g/day [51].	- Mean and SD results only available for certain food groups. - Limited information provided about study, difficult to interpret methodological design. - Differences in reporting food group intake caused lack of consistency among results. - No comparison made with dietary guidelines. 0%									
Food Group	Rec [51]	Population intake [52]	Normal wt	Overweight & obese																																																							
F&V (g/d)	≥400	247.5	492.74	421.84																																																							
Dairy (g/d)			194.52	200.55																																																							
Grains (times/wk)			2 serves	2 serves																																																							
Meat/alt (g/wk)			440	540																																																							
Other																																																											
Leguminous plants (times/wk) ¹			1 serve	1 serve																																																							
Potato (times/wk) ¹			4	5																																																							
Medagama 2015 [31]	24-hour dietary recall administered by two interviewers. Household utensils and commonly consumed foods available to assist serving size determination.	Food group intake compared to Sri Lankan dietary guidelines [53]. Student t-test used to evaluate differences in mean age, obesity indices and dietary factors.	Total (median serves/day): <table><tr><th>Food Group</th><th>Rec [53]</th><th>Population intake [54]</th><th>Observed intake</th></tr><tr><td>Fruit</td><td>2-3</td><td>0.43</td><td>1.00</td></tr><tr><td>Vegetables</td><td>3-5</td><td>1.73</td><td>2.60</td></tr><tr><td>Dairy</td><td>1-2</td><td>0.39</td><td>0.30</td></tr><tr><td>Grains</td><td>6-11</td><td>14.06</td><td>10.20</td></tr><tr><td>Meat/alt</td><td>3-4</td><td>2.78</td><td>1.60</td></tr></table>						Food Group	Rec [53]	Population intake [54]	Observed intake	Fruit	2-3	0.43	1.00	Vegetables	3-5	1.73	2.60	Dairy	1-2	0.39	0.30	Grains	6-11	14.06	10.20	Meat/alt	3-4	2.78	1.60	Recommendations not met, except for grains.	- Sample recruited from single site and participants had received at least 1 session of routine nutrition counselling, therefore results may not be generalizable to population. Small sample size, lack of statistical power. - One 24-hour recall does not assess day to day variability of dietary patterns. - Presence of interviewers may have altered responses. 75%																									
Food Group	Rec [53]	Population intake [54]	Observed intake																																																								
Fruit	2-3	0.43	1.00																																																								
Vegetables	3-5	1.73	2.60																																																								
Dairy	1-2	0.39	0.30																																																								
Grains	6-11	14.06	10.20																																																								
Meat/alt	3-4	2.78	1.60																																																								

First author & year	Dietary assessment methodology	Food group intake analyses	Dietary intake of food groups in comparison to recommendations [Rec] and general population intake				Main conclusions	Study limitations & quality ax score	
Murray 2013 [29]	3-day food diary collected by trained participants over 2 consecutive weekdays and 1 weekend day. Food atlas to indicate portion sizes of 5 commonly consumed foods.	Dietary intake of 19 food groups quantified by weight. Independent sample t-test used to examine differences between those with and without T2DM. Authors made no comparison to dietary guidelines.	Total (mean g/d):				F&V intake did not meet Irish dietary guideline recommendations of ≥560 g/day [55].	- n = 31 subjects had missing food group data. - 66% of participants were found to have under-reported their dietary intake, affecting validity. - Small sample size, lack of statistical power. - 86% of participants were overweight or obese and all were Caucasian, limiting generalizability of results. - Dietary advice received may have affected intake. - No comparison made with dietary guidelines. 25%	
			Food Group	Rec [55]	Population intake [56]	Observed intake			
			Fruit			162			
			Vegetables			129.3			
			F&V total	≥560	240.5	291.3			
			Dairy			253.04			
			Grains			344.2			
			Meat/alt			275.7			
Vitale 2016 [28]	EPIC questionnaire examined frequency of food consumption (per day, wk, mnth or y). Included 248 items and pictures to help determine portion sizes.	Unpaired t-test compared means and chi-square test examined differences between proportions. Authors made no comparison to dietary guidelines.	Total (mean g/d)				F&V intake met Italian dietary guideline recommendations of ≥400 g/day [57].	- Dietary data may be prone to recall bias and seasonal variation. - Recall fatigue may have been present due to 248 items in questionnaire. - Selection bias may have been present as participants were required to be on metformin as monotherapy. - No comparison made with dietary guidelines. 50%	
			Food group	Rec [57]	Population intake [58]	Observed intake ³			
						M			F
			Fruit			311.18			320.20
			Vegetables			169.41			172.37
			F&V total	≥400	452	480.59			492.57
			Dairy			198.81			223.27
			Grains			199.00			159.93
Meat/alt			255.67	237.49					
Vitamins 2009 [27]	Validated, semi-quantitative, 134 item FFQ on intake in previous 6 months. Self-administered with staff review. 3 quality control questions.	Data compared to 2000 USDA food guidelines [47]. Kruskal-Wallis test used to assess univariate effects of demographic characteristics on food group consumption.	Total (median serves/d):				Group median intake met USDA minimum number of recommended serves. However, a high proportion of participants failed to meet recommendations. <50% met minimum F&V, dairy and grains. 82% met meat/meat alt.	- FFQ does not allow for quantification of absolute intake. - Recall fatigue may have been present due to size of FFQ. - Self-administered FFQ, relies on literacy and numeracy levels of participants. 100%	
			Food Group	Rec [47]	Population intake [48]	Observed intake			
			Fruit	2-4	1.0	2			
			Vegetables	3-5	1.5	3			
			Dairy	2-3	1.8	2			
			Grains	6-11	6.3	3			
			Meat/alt	2-3	5.6	2			

Alt, alternatives; Ax, assessment; BMI, Body Mass Index; CDA, Canadian Diabetes Association; CFG, Canada's Food Guide; DHQ, Diet History Questionnaire; d, day; DRIs, Dietary Reference Intakes; EPIC, European; F, females; Prospective Investigation of Cancer; FFQ, food frequency questionnaire; F&V, fruit and vegetables; gl, glasses; g, grams; HbA1c, glycosylated haemoglobin A1c; HEI, Healthy Eating Index; kg, kilogram; L, litres; M, men; m, metre; mL, millilitres; NNSJ, National Nutrition Survey in Japan; TOSCA.IT; Thiazolidinediones or Sulphonylureas and Cardiovascular Accidents Intervention Trial; T2DM, type 2 diabetes mellitus; USDA, United States Department of Agriculture; wk, week; WHO, World Health Organization; y, year.

¹ Could not be added to the meat/meat alt group due to difference in quantifying intake; ² Algeria does not have a set of dietary guidelines, therefore the South African dietary guidelines were used as Algeria is in Africa);

³ Authors of the present review recalculated study results from grams/1000 Kcal/day to grams/Kcal/day based on results provided in the study for each gender.

Table 4. Comparison of food group intake against national nutrition guidelines for studies that assessed intake in serves per day [24, 26, 27, 31, 33, 34]

Food group	No. of studies included in assessment	No. of studies that met recommendations	Mean deficit of serves in studies that did not meet recommendations
Fruit	4 [24, 27, 31, 33]	2 [27, 33]	-0.65
Vegetables	4 [24, 27, 31, 33]	2 [27, 33]	-0.45
F&V (reported together)	2 [26, 34]	0	-2.60
Dairy	6 [24, 26, 27, 31, 33, 34]	2 [24, 27]	-0.39
Grains	6 [24, 26, 27, 31, 33, 34]	2 [31, 33]	-1.78
Meat/meat alt	6 [24, 26, 27, 31, 33, 34]	4 [24, 26, 27, 34]	-1.20

Alt, alternative; F&V, fruit and vegetables; No., number

Table 5. Comparison of fruit and vegetable intake against WHO guidelines for studies that assessed intake in grams per day [25, 32, 30, 29, 28]

First author & year	F&V total mean intake (grams)	Met WHO F&V recommendation ≥ 400 grams/day?
Horikawa, 2014 [25]	515	✓
Kobayashi, 2013 [32]	Males = 663 Females = 839	✓
Laissaoui, 2016 [30]	Normal weight = 492.74 Overweight & obese = 421.84	✓
Murray, 2013 [29]	291.3	✗
Vitale, 2016 [28]	Males = 480.59 Females = 492.57	✓

F&V, fruit and vegetables; WHO, World Health Organization

Figure 1. PRISMA flow diagram showing the flow of information through the different phases of the systematic review

1	(All text)	(MH "Diet")OR(MH "Diet, Diabetic")OR(MH "Healthy Diet") OR(MH "Energy Intake")OR(MH "Eating")OR(MH "Feeding Behavior")OR(MH "Food Preferences")OR(MH "Diet, Food, and Nutrition")OR(MH "Portion Size")OR(MH "Serving Size")OR(MH "Data Collection+")OR(MH "Nutrition Assessment")OR(MH "Nutrition Surveys")OR(MH "Health Surveys")OR(MH "Nutrition Assessment")OR(MH "Diet Surveys")OR(MH "Surveys and Questionnaires")OR(MH "Diet Records")OR(MH "Diet Therapy")OR(MH "Nutrition Therapy")OR“Eat*”OR“Diet intake”OR“Dietary intake”OR“Diet pattern*”OR“Dietary pattern*”OR“Diet behavior*”OR“Diet behavior”OR“Dietary behaviour”OR“Dietary behavior”OR“Diet quality”OR“Dietary quality”OR“Macronutrient intake”OR“Food group intake”OR“Nutritional intake”OR“Nutrition intake”OR“Nutrient intake”OR“Diet assessment”OR“Dietary assessment”OR“Food intake”OR“Food quality”
		AND
2	(Title only)	(MH “Diabetes Mellitus, Type 2”)OR“Non Insulin Dependent Diabetes Mellitus”OR“NIDDM”OR“T2DM”OR“Type 2 diabetes”OR“Type 2 diabetes mellitus”
		NOT
3	(Title only)	“Risk”OR“Incidence”OR“Development”OR“Prevention”OR“Prevalence”OR“Mice”OR“Incident”OR“Intervention”
4	Additional limitations	Year of publication: 1990-2017 Age: ALL Adult 18+ years Sources types: Academic, peer-reviewed journals only Language: English Only Types: Human studies (only possible to select in EMBASE database)

Figure 2. Medline search strategy

Accepted Manuscript

Review

Dietary intake by food group of individuals with type 2 diabetes mellitus: a systematic review

Emily Burch, Lauren Ball, Mari Somerville, Lauren T. Williams

PII: S0168-8227(17)31758-8
DOI: <https://doi.org/10.1016/j.diabres.2017.12.016>
Reference: DIAB 7172

To appear in: *Diabetes Research and Clinical Practice*

Received Date: 30 October 2017
Revised Date: 8 December 2017
Accepted Date: 21 December 2017

Please cite this article as: E. Burch, L. Ball, M. Somerville, L.T. Williams, Dietary intake by food group of individuals with type 2 diabetes mellitus: a systematic review, *Diabetes Research and Clinical Practice* (2018), doi: <https://doi.org/10.1016/j.diabres.2017.12.016>

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.