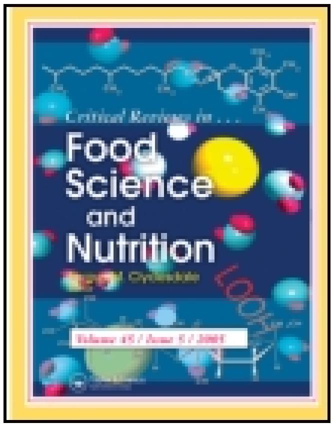

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Association of Out-of-Home Eating with Anthropometric Changes: A Systematic Review of Prospective Studies

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Association of Out-of-Home Eating with Anthropometric Changes: A Systematic Review of Prospective Studies

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In the present review, the association of out-of-home eating with anthropometric changes was examined. Peer-reviewed studies in eight databases were searched, and 15 prospective studies were included in the review. The quality of the data was assessed by considering risks of bias in sample selection, data collection methods, and the appropriateness of statistical tests. From this, seven studies, which used relatively large samples or had a follow-up period longer than 10 years, were retained for further analysis. It was concluded that eating out-of-home frequently, in the broad sense, is positively associated with the risk of becoming overweight or obese and weight change. With regard to specific out-of-home sources, the review shows that eating at fast-food outlets is associated with a greater increase in body weight and waist circumference over time than eating at restaurants and takeaway foods positively predict BMI change in women. More research is needed on out-of-home foods other than fast-foods and restaurant foods, such as street, canteen, and school foods.

Keywords Overweight, obesity, lifestyle, diet

INTRODUCTION

Obesity constitutes one of the most serious public health problems nowadays (Groves, 2006). It is a major burden to public health due to its short- and long-term adverse health consequences. The most significant health-related consequences are cardiovascular diseases, hypertension, diabetes, cancer, and osteoporosis (Kopelman, 2000). Obesity affects various populations, of all age groups and both sexes, in high-income as well as low- and middle-income countries (LMIC). A fundamental cause of obesity, in addition to the increasingly sedentary lifestyles of today populations, is the change in dietary habits.

A substantial increase in out-of-home eating is an important worldwide change in food habits. For instance, three nationwide surveys in the USA showed an increase in the daily energy contribution of out-of-home foods in people older than two years from 23 to 36%, between 1977 and 1996 (Nielsen et al., 2002). In 1994, 56% of the US population ate outside their home at least once a day (Borrud et al., 1996). In a recent study in Benin, foods prepared out-of-home were shown to provide 45% of the daily energy intake in a sample of urban adolescents (Nago et al., 2010).

Away-from-home foods are perceived as contributing to the obesity pandemic because of their high energy density, low nutrient density, and large portion sizes (French et al., 2001a; Young and Nestle, 2002). Weight gain is induced by an imbalance between energy intake and energy expenditure and is driven by the consumption of foods with a high energy density and increased portion sizes (Kral et al., 2004; Rolls et al., 2004; Rolls, 2010). Several interventions addressing various sources of out-of-home foods, such as worksites (Lowe et al., 2010; Maruyama et al., 2010), schools (Whatley Blum et al., 2007; Sichieri et al., 2009), and vending machines (Davee et al. 2005; French et al., 2001b), have been developed to improve the nutritional quality of the food offered or manage weight status. These initiatives have encountered moderate success.

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Table 1 Inclusion and exclusion criteria

	Inclusion criteria	Exclusion criteria
Type of study	Prospective study, including intervention study targeting dietary modification or weight management	– Cross-sectional study – Review – Conference paper – Qualitative study – Editorials, book or article comments, policy briefs – Case study
Topic	Uses any definition of out-of-home eating, including only one kind of out-of-home foods	– Not about out-of-home eating – About the cost of or expenditures on out-of-home foods – About food safety – About food choices or preferences
Measures included	– Reports longitudinally at least an indicator of weight status (weight, BMI, waist circumference, waist-and-hip ratio, skinfolds, body composition indices) as primary or secondary outcome – Reports longitudinally or not at least the percentage of energy or the frequency of out-of-home eating as primary or secondary outcome	– Reports no indicator of weight status – No report of the percentage of energy or the frequency of out-of-home eating – Reports cross sectionally an indicator of weight status
Subjects	– Human subjects from all age groups, healthy and without specific dietary requirements – Infants, children, adolescents and/or adults, males and/or females of any race or ethnicity and from any country	– Patients or institutionalized subjects – Subjects with particular nutrient requirements such as sport people or soldiers, pregnant or lactating women – Underweight, overweight, or obese people only

To our knowledge, there is little evidence on the association of out-of-home eating with an increased risk of obesity. It is important to review the available literature on this topic to design relevant obesity prevention programs directed toward people who consume food outside their home. There has been a recent review but restricted to fast-foods (Rosenheck, 2008). The present systematic review aimed at assessing the association of out-of-home food consumption, in the broad sense, with anthropometric changes in various population groups. In particular, we looked at its association with the risk of becoming overweight or obese and increases in body weight, BMI, BMI z-score, and waist circumference. We report the importance and the nutritional characteristics of out-of-home eating in another review (Lachat et al., 2009).

METHODS

Inclusion and Exclusion Criteria

Original studies reporting longitudinally at least an anthropometric measure and, longitudinally or not, the energy contribution or frequency of out-of-home eating, were retained. Any definition of out-of-home eating was considered (for instance the definitions using the place of preparation or of consumption of foods) as well as studies, which used a single source of out-of-home foods, e.g., fast-foods or school-foods. The review targeted free living humans who were healthy at baseline, without specific dietary requirements, from both sexes, from any age, race or ethnicity, and any country. Therefore, studies reporting only on overweight or obese subjects at baseline, pregnant women, or elderly in nursing homes, prisoners and patients were excluded. Papers reporting on food safety and qualitative papers, such as editorials and comments, were not considered. The references of the papers retained for data extraction were also screened to see whether additional papers emerged. The inclusion and exclusion criteria that were used in the screening process are listed in Table 1.

Literature Search

Studies were identified by searching through eight electronic databases: MEDLINE, CAB Abstracts, the Cochrane Library, ISI Web of Knowledge, EMBASE, AGRICOLA, Ingenta, and Bioline International. All contents were first assessed, without date and language restriction, from July 7 to July 10, 2010. There was an update from March 10 to March 18, 2011. The search syntax was elaborated in Medline and adapted to the other databases. Combinations of the following terms were searched for in titles or abstracts: out-of-home, eating out, street food, junk food, outside the home, away-from-home, takeaway, cafeteria, food dispenser, catering, fast-food, canteen, restaurant, worksite, food, diet, food habits, eating, nutrition assessment, and feeding behavior.

All the 7319 papers found were merged into a single database (Reference manager version 9, The Thomson Corporation, NY) and doubles were deleted. A researcher (CKL) screened the titles of the remaining papers. The next steps were the reading of abstracts and full papers by two coauthors (CKL and ESN) independently. In case of doubt at any stage, the paper concerned was kept in the review database. A discussion followed to solve the divergence between the two independent appraisals, and when necessary, the expertise of a third coauthor (PWK) was requested. A flow chart of the screening is represented in Fig. 1.

Analysis of the Papers

Information, such as authors and year of publication, countries, participants to the study, and sample size, was extracted to present each study included in this review. Baseline characteristics of the subjects, the exposure (quantity, energy intake

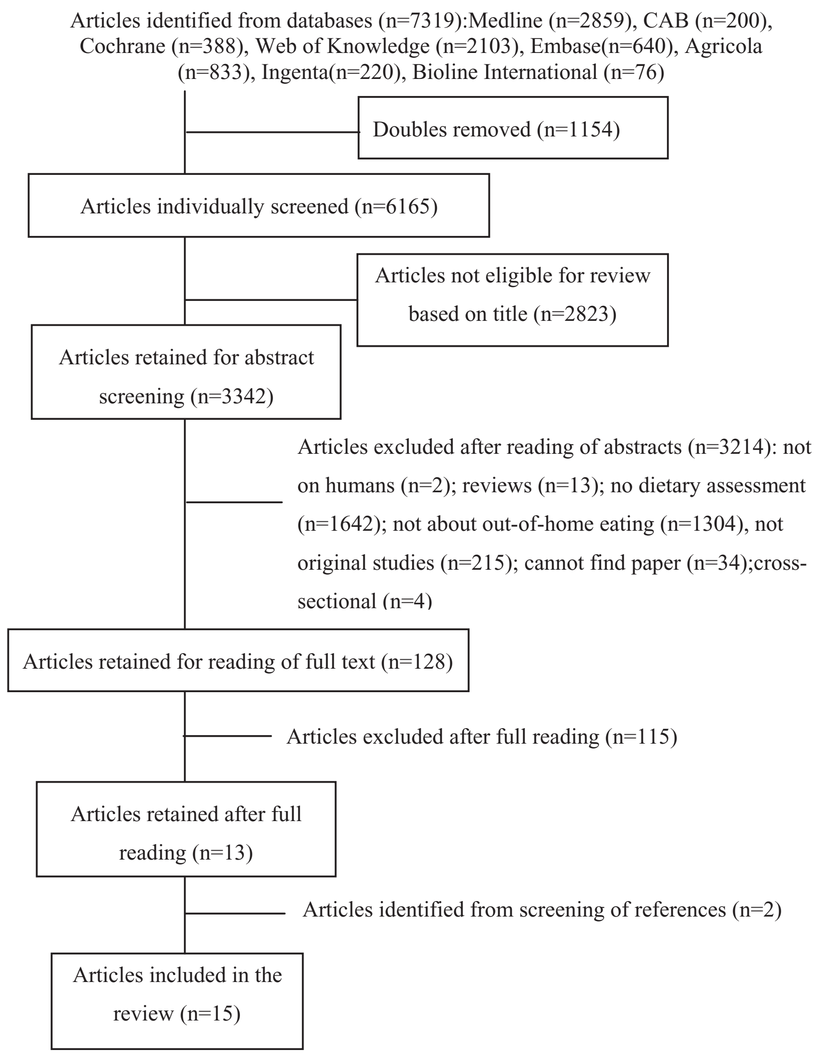

Figure 1 Flow chart of the screening.

or frequency of out-of-home eating), and the outcome measures (risk of becoming overweight or obese, changes in body weight, BMI, BMI z-score, and waist circumference) were also retrieved. Results are presented in terms of change or absence of change in the outcome measure over time, as an effect of a longitudinal change in out-of-home eating or of the consumption of out-of-home foods at baseline.

The methodological quality of the studies was assessed by considering the risk of bias in sample selection (representativeness and participation rate), the design (controlled trial or not), data collection methods (validity and reliability), the appropriateness of statistical tests, and whether they accounted for potential confounders.

RESULTS

Description of the Papers of the Review

Of the 7319 papers, 128 were retained for full text reading. Thirteen papers were kept after full reading and from the screening of their references, two additional studies were retrieved. Hence, 15 papers were included in this review (Table 2). Eight studies (Ma et al., 2003; Levitsky et al., 2004; Pereira et al., 2005; Niemeier et al., 2006; Duffey et al., 2007; Bes-Rastrollo et al., 2009; Duffey et al., 2009; Naska et al., 2011) used the place of consumption to define out-of-home eating. Most studies focused on fast-foods (Jeffery and French, 1998; French et al., 2000; Pereira et al., 2005; Niemeier et al., 2006; Viner and Cole, 2006; Duffey et al., 2007; Duffey et al., 2009; Li et al., 2009; Bédard et al., 2010). The other type of out-of-home foods that were assessed by the studies were restaurant foods (Levitsky et al., 2004; Duffey et al., 2007; Duffey et al., 2009; Naska et al., 2011) quick-service and coffee shop foods (Thompson et al., 2004), takeaway foods (Ball et al., 2002; Viner and Cole, 2006), and workplace foods (Naska et al., 2011).

All the papers have been published in the last 13 years. Among the 15 papers, 10 reported studies conducted in the USA (Jeffery and French, 1998; French et al., 2000; Ma et al., 2003; Levitsky et al., 2004; Thompson et al., 2004; Pereira et al., 2005; Niemeier et al., 2006; Duffey et al., 2007; Duffey et al., 2009; Li et al., 2009). One paper (Naska et al., 2011) analyzed data from

Table 2 Description of the articles of the review

Reference	Countries	Participants	Sample size	Start of data collection	Follow-up length	Source of data	Type of study	Definition or source of OH foods
(Ball et al., 2002)	Australia	18–23-year-old women, nationally representative	$n = 14{,}779$	1996	Four years	WHA	Interrupted time series	Takeaway food
(Bédard et al., 2010)	Canada	30–65-year-old women, urban	$n = 77$	2001[1]	12 weeks	Primary data	Cohort study, intervention promoting the Mediterranean food pattern	Fast-food
(Bes-Rastrollo et al., 2009)	Spain	University graduates mean age 37-year-old males, females	$n = 14{,}106$	1999	4.4 years on average	SUN	Interrupted time series	Place of consumption
(Viner and Cole, 2006)	UK	16 years, males and females, nationally representative	$n = 5723$	1970	15 years: from 16 to 29–30 years	1970 British Birth Cohort	Interrupted time series	Fast-food and takeaway
(Naska et al., 2011)	Denmark, UK, France, Italy, Germany, Spain, Greece, Norway, The Netherlands, Sweden	35–74-year-old men and women	$n = 36{,}994$	1995	1.1 to 9.4 years	EPIC-PANACEA	Interrupted time series	Place of consumption: restaurant (restaurant cafeteria, bar, fast-food) and work (workplace)
(Duffey et al., 2009)	USA	18–30 years, Black and White, males and females, urban	$n = 5115$	1985	13 years: 7, 10, and 20 years	CARDIA	Interrupted time series	Place of consumption: fast-food and restaurant
(Li et al., 2009)	USA	50–75-year-old men and women	$n = 1221$	2006	one year	Portland Neighborhood Environment and Health Study	Interrupted time series	Fast-food
(Duffey et al., 2007)	USA	18–30 years, Black and White, males and females, urban	$n = 5115$	1985	Three years: from 7th to 10th year	CARDIA	Interrupted time series	Place of consumption: fast-food and restaurant
(Niemeier et al., 2006)	USA	11–21 years, 7–12th graders, males and females, nationally representative	$n = 14{,}738$	1996	Five years	Add Health	Interrupted time series	Place of consumption: fast-food
(Pereira et al., 2005)	USA	18–30 years	$n = 5115$	1985	15 years: baseline to 15th year	CARDIA	Interrupted time series	Place of consumption: fast-food
(Levitsky et al., 2004)	USA	University freshmen	$n = 68$	2000	12 weeks	Primary data	Interrupted time series	Place of consumption: all-you-can-eat hall, pay-cash hall, restaurant
(Thompson et al., 2004)	USA	8–12-year-old girls	$n = 196$	1990	1 to 10 years	Primary data	Interrupted time series	Quick-service food, coffee-shop food, and restaurant food
(Ma et al., 2003)	USA	20–70-year-old men and women	$n = 641$	1994	One year	SEASONS	Interrupted time series	Place of consumption
(French et al., 2000)	USA	20–45-year-old low- and high-income women	$n = 998$	NR	Three years	Pound of Prevention study (POP)	Controlled trial[2] weight gain prevention intervention	Fast-food
(Jeffery and French, 1998)	USA	20–45-year-old men, low-income and high-income women	$n = 1226$[3]	NR	One year	Pound of Prevention study (POP)[3]	Controlled trial[2] weight gain prevention intervention	Fast-food

[1]This information was retrieved from Goulet et al., 2003.
[2]Studies reporting on a controlled trial but without comparing controls and treatments in regard to the association of out-of-home eating and weight status.
[3]This information was retrieved from the study by French et al. (2000), also included in this review.
NR = Not reported, WHA = Australian Longitudinal Study on Women's Health, SUN = Seguimiento Universidad de Navarra (University of Navarro Follow-up), CARDIA = Coronary Artery Risk Development in Young Adults, EPIC-PANACEA = European Prospective Investigation into Cancer-Physical Activity, Nutrition, Alcohol, Cessation of Smoking, Eating Out of Home and Obesity, SEASONS = Seasonal Variation of Blood Cholesterol Study, Add Health = National Longitudinal Study of Adolescent Health.

the European Prospective Investigation into Cancer-Physical Activity, Nutrition, Alcohol, Cessation of Smoking, Eating Out of Home and Obesity (EPIC-PANACEA) (Riboli et al., 2002; Slimani et al., 2002), which is carried out in 10 European countries. One study in Australia (Ball et al., 2002), one in the United Kingdom (Viner and Cole, 2006), one in Spain (Bes-Rastrollo et al., 2009), and one in Canada (Bédard et al., 2010) were also included in this review. Three papers (Pereira et al., 2005; Duffey et al., 2007; Duffey et al., 2009) analyzed data from the Coronary Artery Risk Development in Young Adults (CARDIA) study (Hughes et al., 1987; Friedman et al., 1988. Two other studies (Jeffery and French, 1998; French et al., 2000) reported data from the only controlled trial included in the review, the Pound of Prevention Study (Jeffery and French, 1999).

Subjects were in a large age-range, going from 8 to 75 years and mostly of both sexes. Twelve of the papers reported on adults above 18 years of age (Jeffery and French, 1998; French et al., 2000; Ball et al., 2002; Ma et al., 2003; Levitsky et al., 2004; Pereira et al., 2005; Duffey et al., 2007; Bes-Rastrollo et al., 2009; Duffey et al., 2009; Li et al., 2009; Bédard et al., 2010; Naska et al., 2011). Eight studies sampled at baseline children and adolescents (Thompson et al., 2004; Viner and Cole, 2006; Niemeier et al., 2006) and/or young adults (Ball et al., 2002; Levitsky et al., 2004; Pereira et al., 2005; Niemeier et al., 2006; Duffey et al., 2007; Duffey et al., 2009). The sample size at baseline varied from 68 subjects (Levitsky et al., 2004) to 36,994 subjects (Naska et al., 2011), with eight studies that can be considered as large studies (Ball et al., 2002; Pereira et al., 2005; Niemeier et al., 2006; Viner and Cole, 2006; Duffey et al., 2007; Bes-Rastrollo et al., 2009; Duffey et al., 2009; Naska et al., 2011). The follow-up period reported in the papers was variable and ranged from 12 weeks (Levitsky et al., 2004; Bédard et al., 2010) to 15 years (Pereira et al., 2005; Viner and Cole, 2006). Four studies followed subjects for more than 10 years (Thompson et al., 2004; Pereira et al., 2005; Viner and Cole, 2006; Duffey et al., 2009).

Quality Appraisal of the Findings

Studies reviewed used appropriate methods for data collection, but most did not prevalidate the tool used to measure out-of-home eating. Two studies conducted 24-hour dietary recalls (Ma et al., 2003; Naska et al., 2011), and one paper used seven-day dietary records (Thompson et al., 2004) to estimate the importance of eating out (Table 3). The remaining papers used frequency questionnaires. Ten papers (Jeffery and French, 1998; French et al., 2000; Ma et al., 2003; Pereira et al., 2005; Niemeier et al., 2006; Duffey et al., 2007; Duffey et al., 2009; Li et al., 2009; Bédard et al., 2010; Naska et al., 2011) reported that the dietary assessment was carried out by an interviewer and in most papers (Jeffery and French, 1998; French et al., 2000; Ma et al., 2003; Levitsky et al., 2004; Pereira et al., 2005; Niemeier et al., 2006; Viner and Cole, 2006; Duffey et al., 2007; Duffey et al., 2009; Li et al., 2009; Bédard et al., 2010), anthropometric variables were measured and not self-reported. In all studies, except three (Ball et al., 2002; Bédard et al., 2010; Naska et al., 2011), assessment of weight status was done with a standard method or a method, which validity and reliability had been previously established. However, to evaluate the quantity, energy intake or frequency of away-from-home foods, only three studies (Bes-Rastrollo et al., 2009; Bédard et al., 2010; Naska et al., 2011) used prevalidated tools.

The studies also used appropriate statistical methods. Except for the study by Bédard et al. (2010), they adjusted for potential confounders, like demographic characteristics and socioeconomic status, nondietary behavior, such as smoking, baseline weight status, energy intake, and physical activity.

However, none of the papers had a study design that could infer causality. Only two papers (Jeffery and French, 1998; French et al., 2000) described a controlled trial but gave no details on the randomization process. Furthermore, as the primary objective of this intervention was weight gain prevention and was not related to out-of-home eating, these studies did not compare the association of out-of-home eating and weight status between treatments and controls. One paper (Bédard et al., 2010) reported a cohort study, and the remaining papers were about interrupted time series.

Furthermore, most of the studies were to some extent subjected to selection bias. Seven studies used a small or a convenience sample (Jeffery and French, 1998; French et al., 2000; Ma et al., 2003; Levitsky et al., 2004; Thompson et al., 2004; Li et al., 2009; Bédard et al., 2010). Four other studies (Pereira et al., 2005; Duffey et al., 2007; Bes-Rastrollo et al., 2009; Duffey et al., 2009; Naska et al., 2011) reported on large samples but were restricted to four urban areas in the USA, in the framework of the CARDIA study (Pereira et al., 2005; Duffey et al., 2007; Duffey et al., 2009) or University graduates in Spain (Bes-Rastrollo et al., 2009). Moreover, three out of the four studies had an average participation rate (<80%). Only the study by Bes-Rastrollo et al. (2009) had a high participation rate (95%). The remaining studies (Ball et al., 2002; Niemeier et al., 2006; Viner and Cole, 2006; Naska et al., 2011) had an average participation rate, but the report by Naska et al. (2011) used a large sample from nine European countries and the studies by Niemeier et al. (2006), Viner and Cole (2006), and Ball et al. (2002) covered large national samples.

Analyzing the risks of bias did not allow a differentiation among the studies. Thus, sample size and follow-up duration were used as criteria to select the best quality studies. Seven papers were subsequently retained among which three studies that used large national samples (Ball et al., 2002; Niemeier et al., 2006; Viner and Cole, 2006), the EPIC-PANACEA study by Naska et al. (2011), two papers with a follow-up period longer than 10 years (Pereira et al., 2005; Duffey et al., 2009), and the study by Bes-Rastrollo et al. (2009), which followed a large sample of university graduates.

Table 3 Summary of the methodology of the studies

	Sampling		Measurements				Analysis	
Reference	Representativeness	Participation rate	Anthropometrics	Validity and reliability tested	Food intake	Validity/reliability of OH measure	Statistical method	Under/over-reporting and adjustment
(Ball et al., 2002)	National sample Only young women	65% ($n = 9657$)	Self-report of weight and height at baseline and follow-up. Used BMI	No	Questionnaire on food habits, at baseline only self-reported	No	Multivariate logistic regression	Adjustment for occupation, student status, marital status, parity, and new parity
(Bédard et al., 2010)	Convenience sample only urban women	94% ($n = 72$)	Measurement of weight, height and WC at baseline, 6 and 12 weeks. Used BMI and WC	NR	Quantitative FFQ, IA, at baseline, 6 and 12 weeks	Yes	Mixed procedures for repeated measurements and Tukey-Kramer test	one over-reporter excluded. No adjustment for confounders
(Bes-Rastrollo et al., 2009)	Only university graduates males and females	95% ($n =$ 13,373)	Self-report of weight at baseline and every two years. NR on height measurement. Used weight and BMI changes and incidence of overweight and obesity with WHO references	Yes (for weight)	Semiquantitative FFQ, SA, at baseline only	Yes	Least-squares multivariate regression, nonconditional logistic regression and Cox proportional hazards analysis	Under and over-reporters excluded. Tested similar to subjects included. Adjustment for age, sex, smoking, fiber, alcohol and energy intakes, education, following special diet, PA and baseline BMI
(Viner and Cole, 2006)	National sample males and females	78% ($n = 4461$)	Measurement of height and weight at 16 years and self-report at 30. Used BMI z-score with UK 1990 growth references	Standard methods (at baseline). No (for self-report)	Questionnaire on food habits, at baseline only, SA	NR	Regression of BMI z-score at 30 years on fast-food/takeaway eating at 16years	Adjustment for BMI z-score at 16 years, height at 16 and 30, sex and social class
(Naska et al., 2011)	Samples from 10 European countries. General population but only women in France, Norway, Naples (Italy) and Utrecht (The Netherlands)	66% ($n =$ 24,310)	Mainly self-report of height and weight on day of 24-hour recall, then weight at follow-up. Used weight change	No	Single-day 24-hour dietary recall, mainly IA	Yes	Multivariate mixed-effects linear regression	Under and over-reporters excluded. Adjustment for age, education, smoking status, occupation, BMI on dietary recall day, follow-up time, total EI and PA
(Duffey et al., 2009)	Males and females, Black and White from four US urban areas	81% (year 7) 74% (year 10)[1]; 72% (year 20)	Measurement of height, weight, and WC at years 7, 10, and 20. Used weight and WC	Standard methods	Questionnaire on dietary habits, at years 7, 10, and 20, IA	No	Fixed-effect longitudinal regression	Adjustment for age, education, family structure, smoking status, hours of television viewing, total EI and PA
(Li et al., 2009)	Convenience sample males and females, urban, incentives	94% ($n = 1145$)	Measurement of height, weight, and WC, at baseline and follow-up. Used weight and WC	Standard methods	Questionnaire on dietary intake, at baseline and follow-up, IA	No	Multilevel linear regression	Adjustment for neighborhood-level variables and resident-level variables like age, sex, education, smoking, BMI
(Duffey et al., 2007)	Males and females, Black and White from four US urban areas	81% (year 7) 79% (year 10)[1]	Measurement of height and weight, at years 7 and10. Used BMI and BMI change	Standard methods	Questionnaire on dietary habits, at years 7 and 10, IA	No	Multivariate linear regression	Adjustment for race, sex, age, study center and year 7 education, income, family structure, smoking status, fast-food and restaurant frequency, PA and EI

(Niemeier et al., 2006)	National sample 7–12th graders males and females	67% ($n = 9919$)	Mainly measurement of height and weight, at baseline and follow-up. Used BMI z-score with CDC growth references	Standard methods	Questionnaire on dietary habits, at baseline and follow-up, IA	No	Multivariate linear regression	For baseline BMI z-score, race/ethnicity, sex, age, month of interview, maternal obesity, parental education, sedentary behavior, change in sedentary behavior, PA
(Pereira et al., 2005)	Males and females, Black and White from four US urban areas	74% at year 15[1]	Measurement of height, weight, and WC at years 0, 2, 5, 7, 10, and 15. Used weight change	Standard methods	Questionnaire on dietary habits, at years 0, 2, 5, 7, 10, and 15, IA	No	Multivariate linear regression	Adjustment for sex, age, study center, education, baseline weight and height, alcohol consumption, smoking status, television viewing, dietary factors, and PA
(Levitsky et al., 2004)	Convenience sample freshmen from one university males and females	88% ($n = 60$)	Measurement of weight at baseline and follow-up. Used weight change	Standard methods	Questionnaire on food habits at follow-up only	NR	Correlation analysis and stepwise multiple regression with maximal R improvement	Adjustment for initial weight
(Thompson et al., 2004)	Convenience sample girls only incentives	52% ($n = 101$)	Measurement of weight and height, at baseline and follow-up. Used BMI z-score with CDC growth references	Standard methods	Seven-day dietary records, at baseline and follow-up, self-reported but probed by telephone	No	Analysis of variance adjusted for unbalanced cell size and Duncan's multiple range test	Adjustment for baseline BMI z-score
(Ma et al., 2003)	Convenience sample Males and females Incentives	78% ($n = 503$)	Measurement of weight, at baseline and 5 time points Measurement of height at baseline BMI averaged over all measurement days. Used average BMI with WHO references	Standard methods	24-hour dietary recall on 2 weekdays and 1 weekend day, at baseline and 5 time points,[2] IA.	No	Multivariate logistic regression	Subjects excluded. Tested similar to subjects included. Adjustment for age, gender, education, EI, and PA
(French et al., 2000)	Convenience sample women (including low-income)	89% ($n = 891$)	Measurement of weight at baseline and each annual visit. Measurement of height at baseline. Used weight change	Standard methods	Questionnaire on food habits, IA, at baseline and each annual visit	No	Multivariate linear regression	Adjustment for baseline fast-food frequency and weight and marital status, ethnicity, income, age, and treatment group
(Jeffery and French,1998)	Convenience sample men and women (including low-income)	86% ($n = 1059$)	Measurement of height and weight at baseline and follow-up. Used BMI	Standard methods	FFQ, IA, at baseline and follow-up	No	Multivariate linear regression	Adjustment for age, education, baseline smoking and BMI, and treatment group

[1]74% at the 10th year represents the participation rate based on the whole cohort, whereas 79% at the 10th year is the participation rate based on the surviving cohort (excluding dead people); 74% at the 15th year is also based on the surviving cohort.
[2]The frequency of eating each meal out-of-home was calculated by dividing the number of each meal out-of-home by the total number of days on which the meal was consumed.
WC = Waist circumference, FFQ = food frequency questionnaire, IA = interviewer-administered, SA = self-administered, PA = physical activity, EI = energy intake.

Table 4 Summary of studies assessing the risk of becoming overweight or obese over time when eating out-of-home

Reference	Country	Baseline characteristics	Exposure	Follow-up length	Outcome	Findings
(Bes-Rastrollo et al., 2009)	Spain	27% ate OH $\geq$ 2 times/ week BMI (kg/m^2): 23.1 $\pm$ 3.6 (subjects not eating out), 23.3 $\pm$ 3.7 (eating out 1 time/week), 23.6 $\pm$ 3.8 (eating out $\geq$ 2 times/ week), $p < .001$	Weekly frequency of away-from-home meals	4.4 years on average	Incidence of overweight/obesity[1]	Eating out $\geq$ 1 time/week associated with a 1.22–1.33 higher risk of becoming overweight/obese compared to not eating out($p < .001$)
(Ma et al., 2003)	USA	29.7% meals OH Men: mean BMI 28.6 kg/m^2, 48% overweight, 27% obese Women: mean BMI 26.6 kg/m^2, 33% overweight, 20% obese	Frequency of breakfasts, lunches, and dinners eaten OH	One year	Average BMI over one year	Compared to first quartile,[2] others associated with 2.21–2.98 higher risk of obesity for breakfast frequency, 1.89–2.25 higher risk for dinner frequency, but 30–60% lower risk for lunch frequency

[1]Participants with BMI < 25 kg/m^2 at baseline and BMI $\geq$ 25 kg/m^2 at follow-up, WHO references.
[2]The frequency of eating each meal out-of-home was calculated by dividing the number of each meal out-of-home by the total number of days on which the meal was consumed. Subjects were then separated into quartiles based on this frequency.
OH = Out-of-home.

Association of Eating Out-of-Home with Anthropometric Changes

Risk of Overweight and Obesity

Two papers (Ma et al., 2003; Bes-Rastrollo et al., 2009) reported data on the risk of overweight and obesity (Table 4). Among these papers, one was retained from data quality appraisal (Bes-Rastrollo et al., 2009). From this, it was concluded that eating frequently at a place out-of-home, in the broad sense, was positively associated with the risk of becoming overweight or obese. The increase was 33% when eating out at least twice a week, compared with not eating out.

Considering the second paper (Ma et al., 2003) confirmed the above conclusion and added more information on how breakfast, lunch, and dinner affect the risk of obesity when consumed out-of-home. In the paper by Ma et al., the frequency of eating each meal (breakfast, lunch, or dinner) out-of-home was calculated by dividing the number of each meal out-of-home by the total number of days on which the meal was consumed. Subjects were then separated into quartiles based on this frequency. Compared with subjects in the first quartile of breakfast or dinner frequency away-from-home, others had about two to three times more risk of becoming obese. At the opposite, being in the second, third, or fourth quartile of lunch frequency out-of-home was associated with a 30–60% lower risk for obesity, compared with being in the first quartile.

Change in Body Weight

Seven papers provided data on weight change (French et al., 2000; Levitsky et al., 2004; Pereira et al., 2005; Bes-Rastrollo et al., 2009; Duffey et al., 2009; Li et al., 2009; Naska et al., 2011), Table 5. Four of these papers were judged of relatively good quality (Pereira et al., 2005; Bes-Rastrollo et al., 2009; Duffey et al., 2009; Naska et al., 2011).

It was concluded from the best papers that eating out-of-home, in the broad sense, was positively associated with change in body weight. Eating out at least twice a week was associated with 129-g weight gain per year and 36% higher risk of gaining 2 kg or more per year (Bes-Rastrollo et al., 2009). With regard to specific out-of-home sources, eating at fast-food outlets positively predicted weight change (Pereira et al., 2005; Duffey et al., 2009). Weight gain associated with frequent fast-food use was higher than for restaurant use (Duffey et al., 2009).

The remaining papers (French et al., 2000; Levitsky et al., 2004; Li et al., 2009) confirmed the positive association between fast-food consumption and change in body weight.

Change in BMI and BMI z-Score

Five papers provided data on BMI change (Jeffery and French, 1998; Ball et al., 2002; Duffey et al., 2007; Bes-Rastrollo et al., 2009; Bédard et al., 2010) and three papers analyzed the change in BMI z-score (Thompson et al., 2004; Niemeier et al., 2006; Viner and Cole, 2006), Table 6. From data quality appraisal, two papers were retained for BMI (Ball et al., 2002; Bes-Rastrollo et al., 2009) and two for BMI z-score (Niemeier et al., 2006; Viner and Cole, 2006).

Considering only the best papers, no association was found between eating out, in the broad sense, and BMI change (Bes-Rastrollo et al., 2009). However, eating takeaway foods frequently was positively associated with BMI change in women (Ball et al., 2002). Women who consumed takeaway foods once a week were 15% less likely to maintain their BMI within a 5% range after four years, compared with those who never or rarely ate them.

The other papers looked at fast-foods specifically, but their results were conflicting. Two studies (Jeffery and French, 1998; Bédard et al., 2010) found no difference in BMI with increasing fast-food use. On the other hand, Duffey et al. (2007)

Table 5 Summary of studies evaluating the longitudinal association of body weight with out-of-home eating

Reference	Country	Baseline characteristics	Exposure	Follow-up length	Outcome	Finding
(Bes-Rastrollo et al., 2009)	Spain	27% ate OH $\geq$ 2 times/week weight (kg): 65.5 $\pm$ 12.7 (subjects not eating out), 67.2 $\pm$ 13.5 (eating out 1 time/week), 69.4 $\pm$ 14.0 (eating out $\geq$2 times/ week), $p < .001$	Weekly frequency of away-from-home meals	4.4 $\pm$ 1.7 years on average	Annual weight change	Eating out 1 time/week and $\geq$2 times/week associated, respectively, with 15 and 129 g weight gain per year ($p < .001$) compared with not eating out. Also associated, respectively, with 1.12 and 1.36 higher risk of gaining $\geq$2 kg per year ($p = .001$)
(Naska et al., 2011)	Denmark, Italy, France, Sweden, Germany, United Kingdom, Greece, The Netherlands, Norway, Spain	% EI from restaurant[1]: men: 3.6–12.4; women: 3.0–7.2 % EI from work[2]: men: 4.3–15.1; women: 1.1–11.4 BMI (kg/m^2)[3]: men: 23.4–28.4; women:22.9–29.0	EI of restaurant eaters, EI at restaurant,% of participants eating at restaurant and at work	1.1 to 9.4 years	Annual weight change (weight at follow-up minus weight on dietary recall day, divided by follow-up time)	In men, weak positive but not significant association of annual weight change and: (1) eating at restaurant with EI close to the average of restaurant eaters ($\beta = +0.05$, $p = .368$); (2) increase of 500 kcal in EI at restaurant ($\beta = +0.01$, $p = .836$)
(Duffey et al., 2009)	USA	1.9 $\pm$ 2.5 times/week at fast-foods[4] 2.3 $\pm$ 3.2 times/week at restaurant[4] 30.3% overweight, 23.2% obese[4]	Change in weekly frequency of fast-food and restaurant food consumption	13 years	Weight change over 13 years	1 time/week more fast-food consumption associated with 0.15 $\pm$ 0.05 kg weight gain over 13 years and for restaurant food, this was 0.09 $\pm$ 0.04 kg
(Li et al., 2009)	USA	Mean BMI: 29.1 $\pm$ 6.5 kg/m^2 21% ate at fast-foods $\geq$ 1 time/week	Weekly frequency of fast-food visits	One year	Weight change over one year	One–two visits per week to fast-foods associated with 0.65-kg weight gain
(Pereira et al., 2005)	USA	Mean fast-food use[5]: Black men:2.4 times/week Black women:1.8 times/week White men: 2.4 times/week White women:1.6 times/week Mean body weight[6]: Black: 72.4–73.5 kg White: 69.8–71.5 kg	Weekly fast-food frequency and change in weekly fast-food frequency	15 years	Weight change over 15 years	Increase of 3 times/week in 15-year fast-food weekly frequency increased weight by 1.8 kg ($p < .0001$) in White people
(Levitsky et al., 2004)	USA	Mean BMI: 20.8 $\pm$ 2.1 kg/m^2. Most subjects had BMI in normal range (19.8–22.7 kg/m^2)	Weekly frequency of breakfast, lunch, and dinner at all-you-can-eat hall, cash-op hall and restaurant	12 weeks	Weight change over 12 weeks	Eating breakfast and lunch at all-you-can-eat hall explains 10% of the variance of weight gain. Initial weight adjusted for, eating lunch at a restaurant explained 5% of the variance of weight gain and dinner at a cash-op, 4%, and variance explained improved from 58 to 71%
(French et al., 2000)	USA	Mean weight :72.8 kg. Mean BMI: 27.0 $\pm$ 6.0 kg/m^2 36.8% ate fast-food $\geq$ 2 times/week	Weekly frequency of fast-food meals	Three years	Weight change over three years	Increase of 1 meal/week at fast-food increases weight by 1.68 kg over three years

[1]Mean contribution to daily energy intake of eating at restaurant, from a country to another.
[2]Mean contribution to daily energy intake of eating at work, from a country to another.
[3]Mean BMI, from a country to another.
[4]Baseline values correspond to values measured at the seventh year.
[5]Significant difference between men and women, between Black and White.
[6]Body weight for Black and White people, varying across subgroups of subjects formed on the basis of weekly fast-food frequency.
OH = Out-of-home.

concluded that a higher fast-food consumption was associated with a greater change in BMI over three years. Increase in BMI was 0.20 kg/m^2 for each additional time per week of fast-food consumption.

Findings with regard to BMI z-score relate to the change from adolescence to adulthood and were conflicting (Table 6). One paper retained from quality appraisal found no correlation between change in fast-food use and change in BMI z-score (Niemeier et al., 2006). On the other hand, in the second paper (Viner and Cole, 2006), eating fast-food or takeaway meals twice a week or more in adolescence was associated with a BMI z-score increase of 0.14 to 0.21 unit between 16 and 30 years.

Thompson et al. (2004) also reported a positive association between eating frequently at quick-service outlets and change in BMI z-score.

Change in Waist Circumference

There was no clear trend about fast-food use and waist circumference when considering all three related papers (Duffey et al., 2009; Li et al., 2009; Bédard et al., 2010), Table 7. Li et al. (2009) reported more than 1-cm increase in waist circumference with one or two visits per week to fast-food establishments during one year. However, Bédard et al. (2010) showed that fast-food consumption had no effect on change in waist circumference over a 12-week period. Examining only the best paper (Duffey et al., 2009) showed eating at fast-food establishments was associated with a greater increase in waist circumference over time than eating at restaurant. Each additional visit to fast-food outlets per week increased waist circumference by 0.12 cm over 13 years, and for restaurants, it was 0.08 cm.

DISCUSSION

The aim of this systematic review was to assess the link between out-of-home food consumption and anthropometric changes. After a quality appraisal of the 15 prospective studies included, seven studies, which used relatively large samples (Ball et al., 2002; Niemeier et al., 2006; Viner and Cole, 2006; Bes-Rastrollo et al., 2009; Naska et al., 2011) or had a follow-up period longer than 10 years (Pereira et al., 2005; Duffey et al., 2009), were retained for further conclusions. From these papers, it was concluded that eating frequently at a place out-of-home, in the broad sense, is positively associated with the risk of becoming overweight or obese and weight change.

With regard to specific out-of-home sources, weight gain was found to be much higher when eating at fast-food outlets than at restaurants. Eating at fast-food establishments was also associated with a greater increase in waist circumference over time than eating at restaurants. The mechanism that leads to weight gain and obesity is an imbalance between energy intake and energy expenditure and is driven by the consumption of foods with a high energy density and of great portion sizes (Kral et al., 2004; Rolls et al., 2004). A decrease in physical activity, and by consequence a reduction in energy expenditure, is also conducive to obesity (Molnar and Livingstone, 2000). Fast-foods are known to have a high energy density (Prentice and Jebb, 2003; Schröder et al., 2007) and a high fat content and led to a high energy intake (Guthrie et al., 2002; Lachat et al., 2009). The review by Rosenheck (2008) confirmed that more fast-food consumption is associated with increased caloric intake leading to weight gain. Our review adds to this that this association also holds for restaurant foods.

Takeaway foods are foods purchased in a restaurant and often a fast-food establishment to be consumed elsewhere. This review showed that frequent consumption of takeaway foods positively predicted BMI change in Australian women. This finding is in accordance with the fact that fast-foods and restaurant foods are associated with a higher energy intake and led to weight gain. It confirmed longitudinal data from French et al. (2000), showing that fast-food use is associated with higher energy and fat intakes and greater body weight in women in the USA.

This review included data on fast-foods, restaurant foods, and out-of-home foods in the broad sense, without specification of the single out-of-home sources (Ma et al., 2003; Bes-Rastrollo et al., 2009). It provided no evidence on canteen foods or school foods specifically. Studies in adolescents showed that change in the frequency of fast-food visits from adolescence to young adulthood did not predict BMI z-score at young adulthood. Given that adolescents is a critical age group in which out-of-home eating is a predominant source of energy (Guthrie et al., 2002; Nago et al., 2010), it is important to evaluate the quality of their out-of-home food sources and how different eating habits are associated with their nutrition status, particularly regarding the risk of overweight and obesity. Given that previous research has shown cross sectionally how eating in canteens can be associated with optimal dietary patterns (Roos et al., 2004), additional research is needed to see how canteen foods can be used to prevent and control overweight and obesity in adolescents.

All the studies analyzed in this review were conducted in high-income countries, particularly the USA. We did not retrieve studies from low- and middle-income countries. This resulted in conclusions focusing on fast-foods and to a lesser extent on restaurant foods. It is important to note, however, that street foods are a key source of foods away-from-home in LMIC (Lachat et al., 2009; Nago et al., 2010). Although they are important sources of traditional foods (Winarno and Allain, 1991) and have shown to be valuable ways to promote healthy diets (Lee et al., 2002; Raschke and Cheema, 2008), various studies showed that street foods undergo important changes toward high energy-dense fatty and sugary foods (Popkin, 2001; Lachat et al., 2009; Nago et al., 2010).

Strengths of the present review include its sensitive approach in searching potential articles to be included. It has an international scope since it targeted healthy, free-living males and females, from any age, country or race/ethnicity. Moreover, this review was not limited to out-of-home eating in the broad sense but also evaluated studies, which assessed a specific source

Table 6 Summary of studies assessing the longitudinal association of BMI and BMI z-score with out-of-home eating

Reference	Country	Baseline characteristics	Exposure	Follow-up length	Outcome	Findings
			BMI			
(Ball et al., 2002)	Australia	68% ate takeaways ≥ 1time/week 13.9% overweight and 5.9% obese	Frequency of eating takeaway foods	Four years	BMI category (maintainers versus gainers)[1]	Compared with women never or rarely eating takeaway foods, those eating once a week were 15% less likely to be weight maintainers
(Bédard et al., 2010)	Canada	Mean BMI[2]: 25.4 to 25.8 kg/m^2. Mean fast-food intake: 51.7 g/day	Change in weight of fast-foods consumed over 12 weeks	12 weeks	BMI change over 12 weeks	Change in fast-food consumption over 12 weeks not correlated with BMI change
(Bes-Rastrollo et al., 2009)	Spain	cf. Table 3	Weekly frequency of away-from-home meals	4.4 years on average	Annual change in BMI	Eating ≥ 2 times/week associated with +0.07 kg/m2 BMI change per year ($p < .001$) compared with not eating out
(Duffey et al., 2007)	USA	1.9 ± 2.4 times/week at fast-foods[3] 2.6 ± 3.1 times/week at restaurant[3] 30.6% overweight, 23.3% obese[3]	Weekly frequency of fast-food and restaurant food consumption at years 7 and 10, change in the frequencies from year 7 to year 10	Three years	Change in BMI from year 7 to year 10	Increased change in fast-food consumption increases three-year BMI change. Increase in fast-food of 1 time/week increases BMI by 0.20 kg/m^2, of both fast-food and restaurant associated with +0.29 kg/m^2 BMI
(Jeffery and French, 1998)	USA	Fast food (meals/week): Men: 2.2 ± 2.0; HIW: 1.5 ± 1.7; LIW: 1.7 ± 1.7; BMI (kg/m^2): men: 27.8 ± 4.6 HIW: 25.9 ± 4.9; LIW: 27.7 ± 6.9	Number of fast-food meals per week	One year	One-year change in BMI	No correlation between fast-food eating and BMI over one year
			BMI z-score			
(Viner and Cole, 2006)	UK	22% ate fast-food ≥ 2 times/week 8.2% obese[4]	Baseline weekly frequently of eating at fast-food or take-away outlets	15 years	BMI z-score at follow-up	Eating fast-food or takeaway meals twice or more a week at baseline increased BMI z-score by 0.14 to 0.21 unit
(Niemeier et al., 2006)	USA	Mean age: 15.9 years (SEM: 0.11) BMI: 22.9 kg/m^2 (SEM: 0.12) 28.7% overweight; 10.9% obese	Change in the number of days on which fast-foods were consumed in the last seven days	Five years	BMI z-score at follow-up	Change in fast-food consumption from baseline (adolescence) to follow-up (young adulthood) did not predict BMI z-score at follow-up
(Thompson et al., 2004)	USA	Median age: nine years 4% overweight and 0% obese[5] 71% ate OH	Baseline weekly frequency and percentage of weekly energy intake of quick-service, coffee-shop and restaurant foods	1 to 10 years	Change in BMI z-score from baseline to follow-up	Eating at quick-service twice or more a week at baseline associated with greater mean increase in BMI z-score (+0.82 unit) than eating once a week (+0.20 unit) or not at all (+0.28 unit)

[1]Maintainers were defined as women whose BMI at follow-up was within 5% of their baseline BMI. Gainers were women whose BMI at follow-up was more than 5% greater than their baseline BMI.
[2]Mean BMI, varying among four subgroups of subjects formed on the basis of medians of fast-food consumption and medians of changes in Mediterranean dietary (arbitrary) score.
[3] For this paper, baseline values are those measured at the seventh year.
[4]Defined as ≥ 95th BMI-for-age percentile of the UK 1990 growth reference.
[5]Defined respectively as 85 to 94.9th and ≥ 95th BMI-for-age percentile of the growth reference of the US Center for Disease Control and Prevention (CDC).
OH = Out-of-home, HIW = high-income women, LIW = low-income women, SEM = standard error of the mean.

Table 7 Summary of studies evaluating the longitudinal change in waist circumference when eating out

Reference	Country	Baseline characteristics	Exposure	Follow-up length	Outcome	Findings
(Bédard et al., 2010)	Canada	Mean WC: 81.5 to 84.8 cm mean fast food intake: 51.7 g/day	Change in weight of fast-foods consumed over 12 weeks	12 weeks	Change in WC over 12 weeks	Change in fast-food consumption over 12 weeks not correlated with WC change
(Duffey et al., 2009)	USA	1.9 ± 2.5 times/week at fast-foods[1]; 2.3 ± 3.2 times/week at restaurant[1] 30.3% overweight, 23.2% obese[1]; WC: 84.0 ± 14.1 cm[1]	Change in weekly frequency of fast-food and restaurant food consumption over 13 years	13 years	Change in WC over 13 years	1 time/week more fast-food consumption associated with 0.12 ± 0.04 cm increase in WC over 13 years; for restaurant food, + 0.08 ± 0.03 cm
(Li et al., 2009)	USA	Mean BMI: 29.1 ± 6.5 kg/m^2; 21% ate at fast-foods ≥1 time/week	Weekly frequency of fast-food visits	One year	Change in WC over one year	1.06 cm increase in WC with one–two visits/week to fast-foods during one year

[1]Baseline values correspond to values measured at the seventh year.
WC = Waist circumference.

of out-of-home foods. It included studies with relatively large sample sizes and long follow-up periods. Despite the search approach used, the number of longitudinal studies available and of those that could be included in this paper was small. Findings of this review are potentially biased by the fact that they relate only to out-of-home foods with high fat and energy contents, namely, fast-foods and restaurant foods.

Findings of this paper justify the need to monitor the nutritional quality of out-of-home foods and its implication for public health. Further research should look at the differences in nutrient contents between home and out-of-home foods in general and between types of out-of-home foods to explain changes in consumers' nutrition status. A standardization of the definition of out-of-home eating is needed to make the interpretation and comparison of results from future research easier. Classifying foods according to their place of preparation seems more appropriate compared with using the place of consumption, since the place of preparation is where the nutritional quality of foods could be controlled for.

Research should also go beyond the monitoring of out-of-home eating and its implication for nutrition status. It is important to assess eating out comprehensively. Future studies should measure all sources of out-of-home foods and not focus on a single source such as fast-food or takeaway food. In particular, long-term intervention studies are needed to examine substitution effects between different out-of-home sources or with home foods. Various studies that changed the composition or portion sizes of foods eaten out-of-home showed promising effects on dietary intake and weight status (Ledikwe et al., 2007; Leahy et al., 2008; Lowe et al., 2010; Rolls et al., 2010). Long-term intervention studies are also needed to determine how to offer consumers healthy out-of-home foods. Half of the studies included in the present review used relatively small or convenience samples. Future intervention studies should be well designed, with adequate sample sizes or power calculations. Moreover, study outcomes should be well defined. For instance, the definition of out-of-home eating and how it is measured should be well stated.

The present review calls for more research on the consumption of out-of-home foods and its longitudinal effect on nutrition status. It concludes that evidence on the association of out-of-home eating and anthropometric changes is mostly based on fast-foods and to a lesser extent on restaurant foods. There is not enough research on other out-of-home foods such as street foods, canteen, and school foods. This review also concludes that eating out-of-home frequently, in the broad sense, is positively associated with the risk of becoming overweight or obese and weight change. With regard to specific out-of-home sources, the review shows that eating at fast-food outlets is associated with a greater increase in body weight and waist circumference over time than eating at restaurants. Furthermore, takeaway foods were shown to positively predict BMI change in women.

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ESN drafted the paper, and all authors critically reviewed the manuscript. None of the authors declares a conflict of interest.

ABBREVIATIONS

Add Health	= National Longitudinal Study of Adolescent Health
BMI	= Body mass index
CARDIA	= The Coronary Artery Risk Development in Young Adults study
EI	= Energy intake
EPIC-PANACEA	= The European Prospective Investigation into Cancer-Physical Activity, Nutrition, Alcohol, Cessation of Smoking, Eating Out of Home and Obesity study
IA	= Interview-administered
NR	= Not reported
OH	= Out-of-home
PA	= Physical activity
SA	= Self-administered
SEASONS	= Seasonal Variation of Blood Cholesterol Study
SUN	= Seguimiento Universidad de Navarra (University of Navarro Follow-up)
UK	= The United Kingdom
US	= The United States
USA	= The United States of America
WC	= Waist circumference
WHA	= Australian Longitudinal Study on Women's Health
WHO	= World Health Organization

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