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Nutrition knowledge, diet quality and hypertension in a working population

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ABSTRACT

Objective. To examine if employees with higher nutrition knowledge have better diet quality and lower prevalence of hypertension.

Method. Cross-sectional baseline data were obtained from the complex workplace dietary intervention trial, the Food Choice at Work Study. Participants included 828 randomly selected employees (18–64 years) recruited from four multinational manufacturing workplaces in Ireland, 2013. A validated questionnaire assessed nutrition knowledge. Food Frequency Questionnaires (FFQ) measured diet quality from which a DASH (Dietary Approaches to Stop Hypertension) score was constructed. Standardised digital blood pressure monitors measured hypertension.

Results. Nutrition knowledge was positively associated with diet quality after adjustment for age, gender, health status, lifestyle and socio-demographic characteristics. The odds of having a high DASH score (better diet quality) were 6 times higher in the highest nutrition knowledge group compared to the lowest group (OR = 5.8, 95% CI 3.5 to 9.6). Employees in the highest nutrition knowledge group were 60% less likely to be hypertensive compared to the lowest group (OR = 0.4, 95% CI 0.2 to 0.87). However, multivariate analyses were not consistent with a mediation effect of the DASH score on the association between nutrition knowledge and blood pressure.

Conclusion. Higher nutrition knowledge is associated with better diet quality and lower blood pressure but the interrelationships between these variables are complex.

Introduction

Hypertension remains a global public health challenge. An estimated 26% of all adults worldwide have hypertension (Kearney et al., 2005). Hypertension is the primary cause of cardiovascular diseases (CVD) and 13% of deaths are associated with CVD, 62% of strokes and 49% of ischemic heart disease events are attributable to raised blood pressure (WHO, 2002, 2011).

It is possible to reduce the prevalence of hypertension by improving individuals' diet quality (Darnton-Hill et al., 2004; Hajjar and Kotchen, 2003). Adherence to the Mediterranean diet has been shown to decrease the risk of cardiovascular diseases (Bonaccio et al., 2013). The Dietary Approaches to Stop Hypertension (DASH) dietary pattern has significantly reduced blood pressure among both normotensive and hypertensive adults. This pattern promotes low intakes of fat, sodium and processed foods with high intakes of fruit and vegetables (Fung et al., 2008).

Ambiguity exists regarding the relationship between nutrition knowledge and diet quality. Previous research has indicated that individuals with greater nutrition knowledge are more likely to consume healthier diets (Ball et al., 2006; Turrell and Kavanagh, 2006; Wardle et al., 2000). Yet, this suggested relationship between nutrition knowledge and diet quality is negated by research advocating that nutritional knowledge alone is not sufficient to influence healthy dietary behaviours (Darmon and Drewnowski, 2008; Worsley, 2002; Drewnowski and Specter, 2004).

The workplace is an ideal setting to promote healthy dietary behaviours as employees spend many of their waking hours there (Quintiliani et al., 2010; WHO, 2004). Some workplace dietary interventions focus on behavioural change techniques, such as nutrition education methods alone to improve employees' dietary behaviours. These behavioural change approaches including group and individual nutrition counselling, supervised shopping tours and weekly emails have shown a moderate positive effect on fruit and vegetable consumption (Maes et al., 2011; Ni Mhurchu et al., 2010; Michie et al., 2013). However, the value of these methods is still uncertain as these studies failed to measure changes in nutrition knowledge. Furthermore, the extended effect of nutrition knowledge on diet-related diseases like hypertension also remains unknown (Anderson et al., 2009). The study aim was to measure if employees with high nutrition knowledge have better diet quality and lower prevalence of hypertension than those with low nutrition knowledge. We hypothesised that higher nutrition knowledge would predict better diet quality and lower blood pressure and that the relationship between nutrition knowledge and blood pressure would be largely explained by diet quality (Bonaccio et al., 2013; Wardle et al., 2000).

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Materials and methods

Study design

Cross-sectional baseline data were obtained from a large clustered controlled trial, The Food Choice at Work Study (Geaney et al., 2013a). It was a study of the effectiveness and cost-effectiveness of complex dietary interventions that were focused on environmental dietary modifications alone or in combination with nutrition education in four multinational manufacturing workplace settings.

Study population

A random sample of 828 participants aged 18–64 years were recruited from the selected workplaces (workplace A: 100 (70% response rate), workplace B: 224 (70% response rate), workplace C: 392 (60% response rate), workplace D: 112 (91% response rate)). The number of employees recruited per workplace reflected the difference in company size. The sample was powered to detect a decrease in BMI by 1 kg/m^2 and a 2 g average fall in dietary salt intake between the control and intervention groups post-delivery of the interventions. Eligible employees were permanent, full-time employees who purchased and consumed at least one daily meal at work. A wide variety of hot and cold meal options were available for employees during working hours. Many food options were served using a buffet-style so employees' managed the frequency and quantity of their own food items.

Data collection

Participants were asked to complete food frequency questionnaires (FFQ), nutrition knowledge questionnaires and demographic questionnaires. Physical assessments were conducted by trained research assistants as per the Standard Operating Procedures (SOP) manual (Geaney et al., 2013b). All data were collected during work hours in the individual workplaces. Participants who did not complete all assessments were excluded from analysis. No incentives were provided to employees participating in the study.

FFQ

The FFQ was an adapted version of the European Prospective Investigation of Cancer (EPIC) FFQ (Ocke et al., 1997) and has been validated for use in the Irish population (Friel et al., 2003; Harrington et al., 2008). Full details of the FFQ have been published elsewhere (Harrington et al., 2008). Participants recorded their average frequency of consumption of each food item over the previous year. The FFQ assessed the whole diet and included 150 food items arranged into the main food groups. Frequency of consumption of a medium serving was reported for each food item and converted into quantities (mg/g) using standard portion sizes. A medium serving was based on the recommendations established by the Food Standards Agency (FSA, 2002) and McCance and Widdowson's Food Composition Tables (McCance and Widdowson, 1997). A specifically designed nutrition software programme, NetWISP4© (Weighed Intake Software Program; Tinuviel Software, Warrington, UK), converted the dietary information to food quantities and nutrient values.

Diet quality was investigated using the DASH score which was constructed based on standard food groups within the FFQ (Fung et al., 2008). This score which has been previously used within the Irish population was based on the intake of nine food groups: wholegrains, fruit, vegetables, legumes, low-fat dairy foods, red processed meat, sweetened snacks and beverages, salty snacks and sodium consumption (Harrington et al., 2011). Consumption was divided into quintiles and participants were classified according to their intake. For the consumption of the healthy food groups, a higher score reflected a higher consumption of those groups. These groups were rated on a scale of 1–5; participants in quintile 5 had the highest consumption and scored 5. Less healthy food groups, where a lower consumption is recommended were scored using a reverse scale. Participants in quintile 1 reported the lowest consumption and scored 5. All food group scores were collated. An overall DASH score was calculated for each participant and was also divided into quintiles. Participants in quintile 5 had the highest DASH score and best diet quality.

Demographic questionnaire

Socio-demographic (gender, age, ethnicity, education, marital status and work-life) and lifestyle characteristics (smoking, alcohol consumption and physical activity) were recorded. 'Non-smokers' never smoked more than 100 cigarettes. 'Former smokers' had smoked at least 100 cigarettes but do not smoke at present. 'Current smokers' were smoking at present (Harrington et al., 2008). Alcohol consumption was estimated using the units of alcohol consumed per week. An International Physical Activity Questionnaire (IPAQ) score was calculated for each participant (http://www.ipaq.ki.se/scoring.pdf). Scores were classified as low (<5000 steps/day), moderate (5000–10,000 steps/day) and high (>10,000 steps/day). Consumption of food supplements, salt usage and self-rated health was also reported.

Nutrition knowledge questionnaire

Nutrition knowledge was assessed using the validated General Nutrition Knowledge Questionnaire which included four domains (1) advice from health experts (11 items, e.g. which fat do experts say is most important to cut down on?), (2) food groups and food sources (71 items, e.g. are these foods high in salt?), (3) food choice (12 items, e.g. what is the best choice for a low-fat, high fibre snack?) and (4) diet–disease relationships (22 items, e.g. what major health problems are related to a low fibre intake?) (Parmenter and Wardle, 1999). Nine questions were modified to include recent evidence in nutrition knowledge (e.g. what health problems are related to excess sugar?). Food items were altered to increase participants' understanding (e.g. orange juice instead of orange squash).

Participants were asked to complete all questions. Each correct answer scored 1. Incorrect and missing values scored 0. Subscale scores were calculated for each domain. The sum of the four sections was calculated to give a maximum potential score of 116. The overall nutrition knowledge score was divided into quintiles. Participants in quintile 5 scored highest for nutrition knowledge.

Physical assessment

Weight was measured using an electronic TANITA weighing scales and height was measured using a Seca Leicester measure. BMI was calculated as kg/m^2 (WHO, 2000). Participants were classified as underweight (BMI ≤18.49 kg/m^2),normal (BMI = 18.50–24.99 kg/m^2), overweight (BMI = 25.00–29.99 kg/m^2) or obese (BMI ≥30.00 kg/m^2) (WHO, 2000). Midway waist circumference was measured using a Seca 200 measuring tape. Participants were classified as centrally obese if their midway waist circumference was recorded at ≥94 cm for men and ≥80 cm for women (WHO, 2008).

Resting blood pressure was measured using the Omron M7 digital blood pressure monitor. At a seated state, three readings were recorded from each participant on their right arm. Resting blood pressure was based on the average of the 2nd and 3rd readings. A participant was identified as hypertensive if their average systolic was ≥140 mm Hg or average diastolic was ≥90 mm Hg based on the American Heart Association guidelines (Pickering et al., 2005).

Spot urine samples were obtained for analyses of sodium excretion (Perry et al., 2010). Each participant provided one early morning sample and one evening sample, taken 12 hours apart. Daily average salt intakes were estimated based on the average between both samples and compared to the upper tolerable limit of 6 g/day for Irish populations based on the national guidelines (FSAI, 2005).

Statistical analysis

Data were analysed using Stata 12 (StataCorp, College Station, TX, US). Internal consistency of the nutrition knowledge score was measured using the Cronbach's alpha statistic. Univariate analyses were performed to assess the relationship between nutrition knowledge, the DASH score and blood pressure. Baron and Kenny's approach to mediation analyses was used to assess the DASH score (diet quality) as a mediator (Baron and Kenny, 1986). For the multivariate logistic regression, the DASH score variable was collapsed to an ordinal variable based on the DASH score quintiles. Participants in quintile 5 had the highest DASH score and best diet quality and quintiles 4–1 had lower DASH scores and progressively poorer quality diets. The high DASH score and hypertension variables were entered into the models as dichotomous, dependent variables. The nutrition knowledge score variable was recoded as an ordinal variable based on the quintiles and entered into all models as an independent variable. Results were adjusted for potential confounding variables including socio-demographic, lifestyle and health characteristics.

Ethics

Ethical approval was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospitals in Ireland, March 2013. All participants provided written informed consent.

Results

Characteristics of study population

Table 1 summarises the socio-demographic characteristics of the study population. The highest proportion of participants were aged 30–44 years (65.9%), were white Irish (90%), male (68.7%) and had a tertiary education (77.3%). Most employees were not in a managerial or supervisory role (78.4%) and usually worked during the day (68.1%). Table 2 shows the lifestyle, physical status and dietary data for men and women. Almost half of the study population had low physical activity levels (45%). A total of 16.7% of employees were classified as current smokers. A higher proportion of males (13.4%) reported consuming at least 14 units of alcohol/week compared to females (3.1%). Almost half of all employees reported their general health as 'good' (47%) and

Table 1
Socio-demographic characteristics for men and women.

Socio-demographic	Men n = 569 (68.7%) n (%)	Women n = 259 (31.3%) n (%)	Total n = 828 (100%) n (%)
Age group (years)			
18–29	54 (9.5)	36 (13.9)	90 (10.9)
30–44	383 (67.3)	163 (62.9)	546 (65.9)
45–65	132 (23.2)	60 (23.2)	192 (23.2)
Missing	0	0	0
Ethnicity			
White Irish	516 (90.7)	229 (88.4)	745 (90.0)
Other[a]	52 (9.1)	29 (11.2)	81 (9.8)
Missing	1 (0.2)	1 (0.4)	2 (0.2)
Educational level			
None/primary	5 (0.9)	1 (0.4)	6 (0.7)
Secondary	98 (17.2)	84 (32.4)	182 (22.0)
Tertiary	466 (81.9)	174 (67.2)	640 (77.3)
Missing	0	0	0
Marital status			
Married/cohabiting	420 (73.8)	149 (57.5)	569 (68.7)
Separated/divorced/widowed	18 (3.2)	16 (6.2)	34 (4.1)
Single/never married	130 (22.8)	94 (36.3)	224 (27.1)
Missing	1 (0.2)	0	1 (0.1)
Job position			
Manager	77 (13.5)	15 (5.8)	92 (11.1)
Supervisor	65 (11.4)	22 (8.5)	87 (10.5)
Non-manager/Non-supervisor	427 (75.0)	222 (85.7)	649 (78.4)
Missing	0	0	0
Usual working hours			
Day-time (≤8 hours)	381 (67.0)	183 (70.7)	564 (68.1)
Night-time (≤8 hours)	6 (1.1)	8 (3.1)	14 (1.7)
Shift-work	182 (32.0)	68 (26.3)	250 (30.2)
Missing	0	0	0

[a] Other: any other White, Black or Asian ethnicities including mixed backgrounds.

Table 2
Lifestyle, physical status and dietary data for men and women.

	Men n = 569 (68.7%) n (%)	Women n = 259 (31.3%) n (%)	Total n = 828 (100%) n (%)
Lifestyle			
Smoking status			
Never smoked	307 (54.0)	130 (50.2)	437 (52.8)
Former smoker	186 (32.7)	66 (25.5)	252 (30.4)
Current smoker	75 (13.2)	63 (24.3)	138 (16.7)
Missing	1 (0.2)	0	1 (0.1)
Alcohol consumption (units/week)			
No drink	117 (20.6)	68 (26.3)	185 (22.3)
1- < 7	106 (18.6)	60 (23.2)	166 (20.0)
7– < 14	80 (14.1)	32 (12.4)	112 (13.5)
14– < 21/>21	76 (13.4)	8 (3.1)	84 (10.1)
Missing	190 (33.4)	91 (35.1)	281 (33.9)
Physical activity			
Low	335 (58.9)	37 (14.3)	372 (44.9)
Moderate	127 (22.3)	96 (37.1)	223 (26.9)
High	104 (18.3)	124 (47.8)	228 (27.5)
Missing	3 (0.5)	2 (0.8)	5 (0.6)
Health			
BMI (kg/m^2)[a]			
Underweight/normal weight	132 (23.2)	114 (44.0)	246 (29.7)
Overweight	308 (54.1)	94 (36.3)	402 (48.6)
Obese	129 (22.7)	51 (19.7)	180 (21.7)
Missing	0	0	0
Central obesity[b]			
Normal	298 (52.4)	106 (40.9)	404 (48.8)
Centrally obese	271 (47.6)	153 (59.1)	424 (51.2)
Missing	0	0	0
Hypertension[c]			
Not hypertensive	478 (84)	243 (93.8)	721 (87.1)
Hypertensive	91 (16)	15 (5.8)	106 (12.8)
Missing	0	1 (0.4)	1 (0.1)
Self-reported general health			
Excellent	50 (8.8)	30 (11.6)	80 (9.7)
Very good	177 (31.1)	100 (38.6)	277 (33.5)
Good	288 (50.6)	101 (39.0)	389 (47.0)
Fair/poor	53 (9.3)	28 (10.8)	81 (9.8)
Missing	1 (0.2)	0	1 (0.1)
Diet			
Consumption of food supplements			
Yes	223 (39.2)	128 (49.4)	351 (42.4)
No	334 (58.7)	127 (49.0)	461 (55.7)
Missing	12 (2.1)	4 (1.5)	16 (1.9)
Daily salt intake (measured from urinary sodium)			
≤6 g/day	347 (61.0)	173 (66.8)	520 (62.8)
>6 g/day	219 (38.5)	85 (32.8)	304 (36.7)
Missing	3 (0.5)	1 (0.4)	4 (0.5)
DASH score (quintiles)			
Lowest	63 (11.1)	8 (3.1)	71 (8.6)
Second	66 (11.6)	17 (6.6)	83 (10.0)
Third	71 (12.5)	22 (8.5)	93 (11.2)
Fourth	155 (27.2)	73 (28.2)	228 (27.5)
Highest	205 (36.0)	137 (52.9)	342 (41.3)
Missing	9 (1.6)	2 (0.8)	11 (1.3)

Abbreviations: BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension.
[a] BMI: underweight = ≤18.49; normal weight = 18.50–24.99; overweight = 25.00–29.99, obese = ≥30.00.
[b] Central obesity: average mid-way waist circumference ≥94 cm for men or ≥80 cm for women.
[c] Hypertension: average systolic blood pressure ≥140 mm Hg or average diastolic blood pressure ≥90 mm Hg.

consumed food supplements (42.4%). Half of participants were overweight (48.6%) and centrally obese (51.2%). Overweight and obesity were higher among males (54.1% and 22.7%) compared to females (36.3% and 19.7%). Similarly, more men (16%) than women (5.8%) were classified as hypertensive and 36.7% of the total study population exceeded the tolerable upper limit of 6 g of salt per day according to their urinary sodium intakes (36.7%). A higher proportion of women (52.9%) than men (36%) had a DASH score in the highest quintile, indicating better diet quality (Table 1).

Nutrition knowledge and DASH scores

The internal consistency for the overall nutrition knowledge score was 0.91. It was measured for each domain: advice from the health experts: 0.56; food groups and food sources: 0.89; food choice: 0.39 and diet–disease relationships; 0.74. Cronbach's alpha ranges from 0 to 1 and a score of ≥0.7 is adequately reliable (Nunnally and Bernstein, 1994). Employees with nutrition related qualifications (n = 11 (1.3%)) had a higher mean nutrition knowledge score (men 78.8 (SD 13.9),

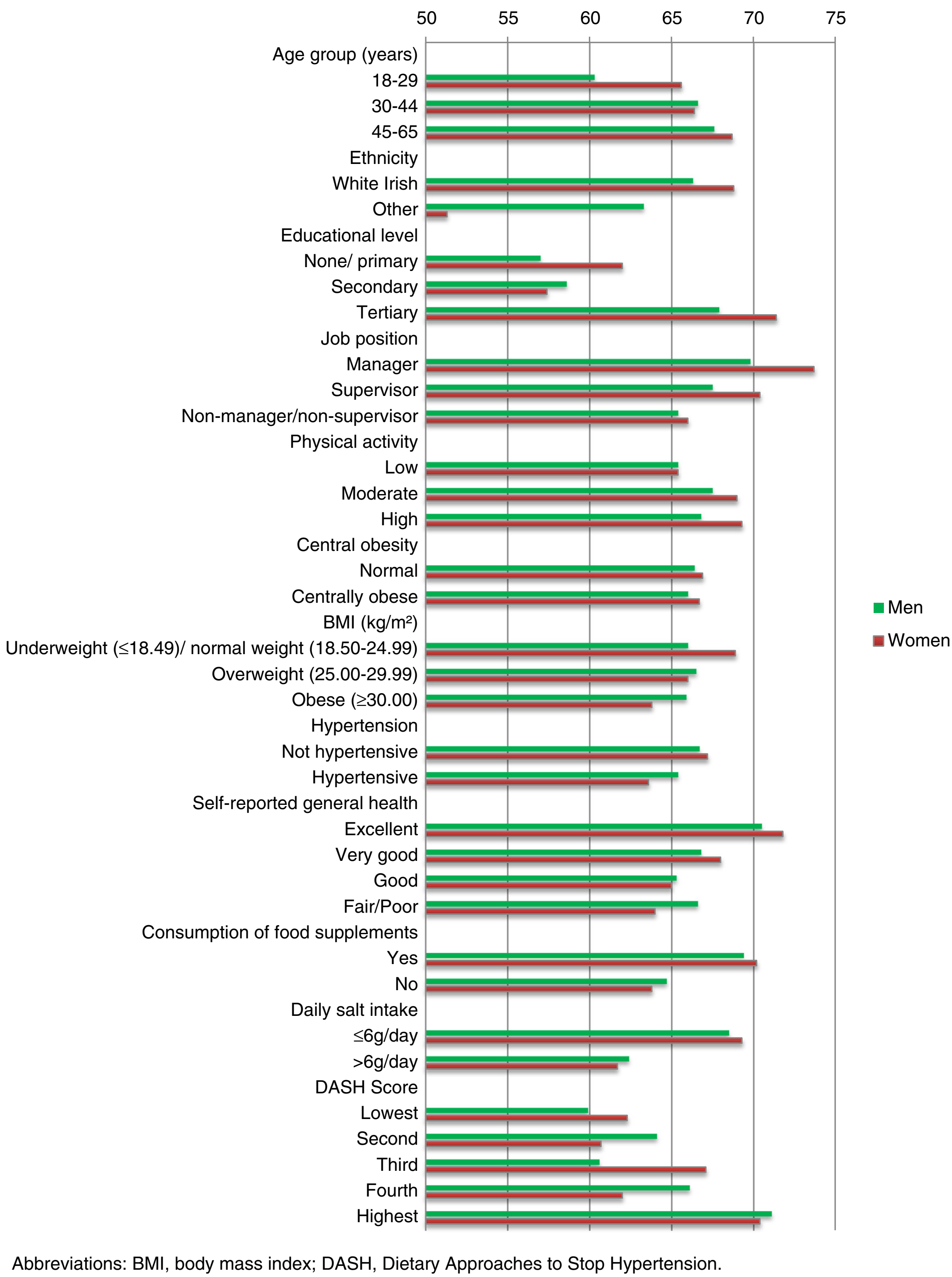

Fig. 1. Unadjusted mean nutrition knowledge scores for men and women. Abbreviations: BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension.

women 76.8 (SD 17.8)) than employees without these qualifications (men 66.1 (SD 13.4), women 66.6 (SD 16.5)).

The DASH score was tested against variables not included in the original score. Participants who 'always' added salt to food at the table had a lower DASH score (men 20.8 (4.2), women 22.5 (SD 3.6)) than those who reported 'never' adding salt to food (men 25.1 (SD 4.1), women 25.4 (SD 4.5)). According to Cohen's standard effect size cut-off points (Cohen, 1988), differences in nutritional knowledge scores of 2.9, 4.6 and 7.4 represented a small, moderate and large effect size, respectively. Changes in DASH scores of 0.85, 2.0 and 3.2 represented a small, moderate and large effect sizes, respectively.

The unadjusted mean nutrition knowledge scores for men and women are shown in Fig. 1. Employees with higher nutrition knowledge scores had a tertiary education (men 67.9 (SD 13.0), women 71.4 (SD 13.3)), were not hypertensive (men 66.7 (SD 13.4), women 67.2 (SD 16.4)), consumed ≤6 g/day of salt (men 68.5 (SD 12.4), women 69.3 (SD 15.6)) and were in the highest DASH score quintile (men 71.1 (SD 15.2), women 70.4 (SD 14.7)).

The mean nutrition knowledge score for all employees was 66.4 out of a maximum 116. On average, employees scored better in the 'advice from the health experts' (mean score = 8.0 out of 11) and the 'food choice' domains (mean score = 7.2 out of 12). Overall, nutrition knowledge scores were lower for the other two domains including food groups and food sources (mean score = 42.0 out of 71) and diet–disease relationships (mean score = 6.7 out of 22).

Nutrition knowledge, diet quality and hypertension

The relationship between nutrition knowledge and diet quality is evident in Fig. 2, showing significant positive trends between nutrition knowledge scores and diet quality (DASH score) for each of the four domains ($p < 0.001$).

In multivariate analysis adjusted for age, gender and energy intake, employees in the highest nutrition knowledge quintile had a higher overall DASH score (p for trend < 0.001) (Table 3). Employees in this quintile only consumed the recommended servings for vegetables (4.82 (SD, 2.9), p for trend < 0.001) and did not meet the recommendations for whole grains, fruit, legumes and low-fat dairy foods. Nevertheless, employees in this group also had the lowest consumption of red processed meat, sweetened snacks and beverages and salty snacks (p for trend < 0.05). All quintiles exceeded the recommended sodium consumption of 2300 mg.

Inverse associations with nutrition knowledge and blood pressure were evident in Table 4. Between the lowest nutrition knowledge quintile and the highest quintile, systolic blood pressure and diastolic blood pressure differed by 2.2 mm Hg and 2.1 mm Hg respectively. The proportion of hypertensive employees also differed by 16.1%.

For the mediation analysis, nutrition knowledge was directly associated with hypertension ($\beta = -0.02$ (CI = 0.97–1.0), $p < 0.05$). Nutrition knowledge was positively associated with the DASH score ($\beta = 0.09$ (CI = 0.07–0.11), $p < 0.001$). The DASH score was associated

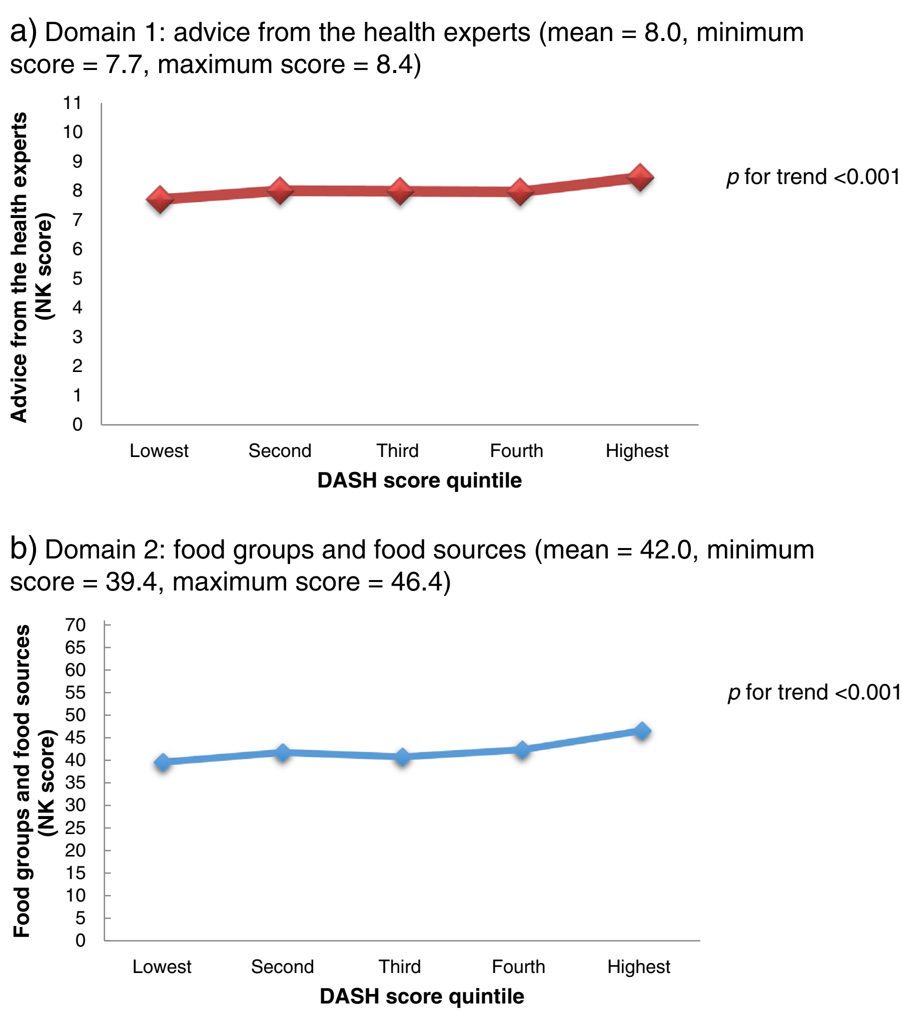

Fig. 2. Comparison of nutrition knowledge (NK) score for each domain by DASH score quintile. Abbreviations: DASH, Dietary Approaches to Stop Hypertension; NK, nutrition knowledge.

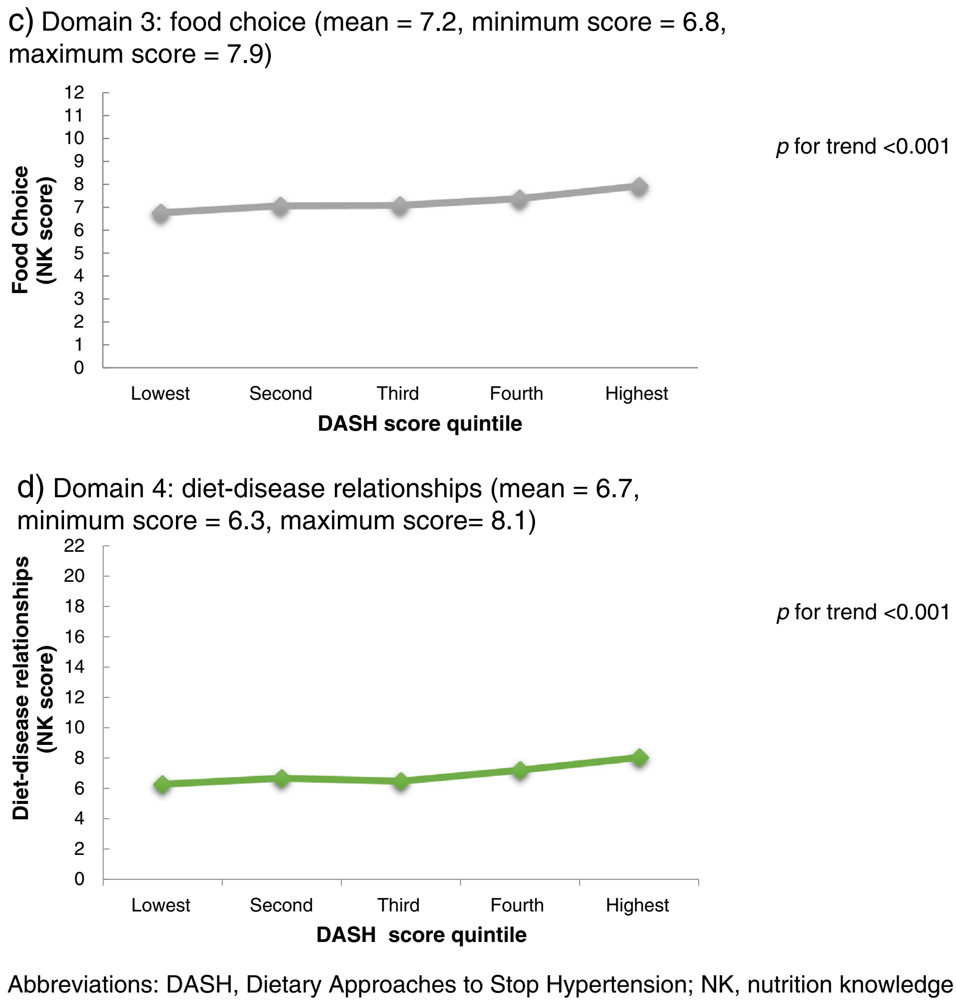

Fig. 2 (*continued*).

with hypertension ($\beta = 0.07$ (CI = 0.89–1.0), $p < 0.05$). If the association between nutrition knowledge and hypertension was primarily mediated via diet quality as reflected by the DASH score, one would expect attenuation of this association on the introduction of the DASH score into the model. The findings of the mediation analysis were not consistent with the hypothesis as the β co-efficient increased (albeit statistically insignificant) in the latter analysis ($\beta = -0.05$ (CI = 0.89–1.01), $p = 0.107$).

In the multivariate logistic regression analysis, there was a positive association and consistent gradient observed between the high DASH score and nutrition knowledge score when the model was adjusted for age, gender and energy intake (Table 5). The odds of having a high DASH score were 6 times higher in the highest nutrition knowledge group when compared to the lowest group (OR = 5.8, 95% CI 3.5 to 9.6). The association remained significant with the sequential addition of each confounding variable (<0.001).

A negative association was observed between nutrition knowledge and hypertension. Employees in the highest nutrition knowledge group were 60% less likely to be hypertensive when compared to the lowest group (OR = 0.4, 95% CI 0.2 to 0.87). The association remained significant in the fully adjusted analysis ($p < 0.05$). Adjusting for the DASH score did not alter the association between nutrition knowledge and hypertension.

Discussion

This study revealed four principal findings. Nutrition knowledge among this working population was relatively low and employees were lacking knowledge in particular areas including ‘food groups and food sources’ and ‘diet–disease relationships’. Independent of age, gender and energy intake, nutrition knowledge was significantly positively associated with diet quality (DASH score). Adjustment for sociodemographic, health status and lifestyle characteristics did not alter the association. Employees with higher nutrition knowledge had a higher DASH score. Higher nutrition knowledge was associated with lower blood pressure. Employees in the highest knowledge group were significantly less likely to be hypertensive when compared to those in the lowest group even after adjustment for potential confounding variables. Conflicting to our original hypothesis, the DASH score did not mediate the relationship between nutrition knowledge and hypertension.

Some studies suggest that nutrition knowledge is a distal predictor for diet quality and that “simply changing knowledge is unlikely to have the desired effect” (Wardle et al., 2000; Shepherd and Towler, 1992). Conversely, our findings support the existing evidence that nutrition knowledge is significantly associated with diet quality (Bonaccio et al., 2013; McLeod et al., 2011; Wardle et al., 2000).

This is the first time that this relationship has been investigated in an educated working population using validated measures for nutrition knowledge (Wardle et al., 2000) and diet quality (Fung et al., 2008). Nutrition knowledge has been shown to act as a partial mediator between socio-economic status (education attainment used as a proxy) (Bonaccio et al., 2013; McLeod et al., 2011; Wardle et al., 2000) and diet quality in other populations. However, education status did not modify the association between nutrition knowledge and diet quality

Table 3
Adherence to daily DASH diet recommendations according to nutrition knowledge score.

Food Group	Recommended daily servings in DASH diet	Nutrition knowledge score quintile[a] Mean (SD) Lowest (≤55) n = 175, 21.1%	Second (56–64) n = 160, 19.3	Third (65–71) n = 160, 19.3%	Fourth (72–79) n = 182, 22%	Highest (80+) n = 151, 18.2%	p trend[b]	p trend[c]
Whole grains	3	1.54 (1.4)	1.59 (1.3)	2.01 (1.8)	1.73 (1.3)	2.19 (1.5)	<0.001	<0.001
Fruit	4–6	1.50 (1.4)	1.57 (1.3)	1.76 (1.3)	1.88 (1.6)	2.23 (1.5)	<0.001	<0.001
Vegetables	4–6	3.13 (2.4)	2.99 (2.1)	3.75 (2.4)	3.83 (2.5)	4.82 (2.9)	<0.001	<0.001
Legumes	0.64 (3–6/week)	0.33 (0.3)	0.42 (0.4)	0.37 (0.4)	0.50 (0.5)	0.62 (1.0)	<0.001	<0.001
Low-fat dairy foods	2–4	0.21 (0.3)	0.19 (0.3)	0.23 (0.3)	0.26 (0.4)	0.30 (0.4)	0.046	0.123
Red processed meat	Limited	1.38 (0.9)	1.15 (0.7)	1.01 (0.7)	1.00 (0.7)	0.88 (0.5)	<0.001	<0.001
Sweetened snacks and beverages	Limited	2.86 (2.8)	2.32 (1.9)	2.99 (2.8)	2.36 (2.4)	2.13 (1.9)	0.004	0.001
Salty snacks	Limited	0.58 (0.6)	0.63 (0.7)	0.52 (0.5)	0.50 (0.4)	0.46 (0.4)	0.027	0.019
Na consumption	2300 mg	3099.60 (1410.7)	3007.77 (1145.4)	3057.26 (1279.8)	3013.43 (1169.0)	3110.51 (1082.1)	0.912	0.558
Overall DASH score		21.87 (4.2)	22.63 (4.6)	23.89 (4.3)	24.45 (4.4)	25.83 (4.1)	<0.001	<0.001

Abbreviations: DASH, Dietary Approaches to Stop Hypertension.
[a] Figures are unadjusted.
[b] p for trend unadjusted.
[c] p for trend adjusted for age, gender and energy intake.

in our study perhaps given that over 80% of the sample had a tertiary education. Nutrition knowledge has also been associated with a lower prevalence of obesity (Bonaccio et al., 2013) and our findings show a similar relationship with hypertension but with employees with the highest nutrition knowledge only.

However, given the complexities of dietary behaviour, it is important to acknowledge that specific psychological resources like memory, attention and self-control also have an impact on the relationship between eating behaviours and diet quality. Although some individuals may have adequate nutrition knowledge and may be mindful of the health benefits of a healthy diet, research indicates that there is a gap between good intentions and actual behaviour (Adriaanse et al., 2011). Nutrition knowledge and intentions are not enough to guarantee goal directed behaviour (Webb and Sheeran, 2006). However, interventions that consider individuals' psychological resources and environmental factors have been shown to be more effective in promoting healthy dietary behaviours (Adriaanse et al., 2011; Geaney et al., 2013c). Furthermore, to increase our understanding, researchers should also concentrate on the underlying theories that may provide explanations for effective dietary behaviour change. For example, previous studies have suggested that the social cognitive theory may be able to explain how other variables like self-regulation and self-efficacy can help to facilitate the adoption of health eating behaviours among individuals (Anderson et al., 2007; Spahn et al., 2010).

Limitations of the present study include the use of a cross-sectional study design, issues regarding participant recruitment, reliability and measurement error in the assessment of diet quality. We have to be cautious when interpreting the findings of a cross-sectional study but findings are consistent with the published data regarding the relationship between nutrition knowledge and diet quality (Ball et al., 2006; Turrell and Kavanagh, 2006; Wardle et al., 2000). Although all employees were randomly selected, selection bias cannot be ruled out as healthy employees may have been more likely to participate. The effect of controlled hypertensives is unknown as medication data was unavailable but excluding self-reported hypertensives from the analysis did not alter the results.

The internal consistency values for the overall score (0.91) and for two domains including food groups and food sources and diet–disease relationships were high in this occupational sample (0.89 and 0.74, respectively). Lower values were recorded for the remaining domains (advice from the health experts: 0.56 and food choice: 0.39, respectively). Reliability coefficients are known to be dependent on the number of items being measured. Lower Cronbach alpha values were obtained for the two domains with the least number of items. This pattern was also evident in other previous studies including the UK and Turkish studies but most similar to the previous Australian study (Parmenter and Wardle, 1999; Alsaffar, 2012; Hendrie et al., 2008). However, the values for the food choice domain were lower in this study (Australian study: 0.55; this study: 0.39). A reason for this could be that there are differences in the recommended healthy eating guidelines between both countries. Nevertheless, the overall questionnaire seems to be a reliable tool for Irish occupational settings but there is a need to review specific items to comply with Irish healthy eating guidelines.

There is also a possibility of measurement error in the assessment of diet quality. Recall bias may have been introduced as the FFQ was self-reported. Social desirability reporting bias cannot be ruled out as employees with higher nutrition knowledge may have overestimated their intakes of healthy foods. However, employees were masked to the study hypothesis. Residual confounding should also be considered in our interpretation of the associations between nutrition knowledge,

Table 4
Distribution of blood pressure according to nutrition knowledge score.

Food Group	Nutrition knowledge score (quintile) Mean (SD) Lowest (≤55) n = 175 (21.1%)	Second (56–64) n = 160 (19.3%)	Third (65–71) n = 160 (19.3%)	Fourth (72–79) n = 182 (22%)	Highest (80+) n = 151 (18.2%)	p trend[b]	p trend[c]
Mean SBP (SD)	120.6 (15.5)	121.1 (13.2)	120.5 (15.4)	122.9 (14.8)	118.4 (14.2)	0.098	0.337
Mean DBP (SD)	75.3 (10.3)	75.1 (9.2)	74.4 (9.5)	75.3 (10.1)	73.2 (8.0)	0.240	0.114
Hypertensive[a], n (%)	29 (27.4)	17 (16)	20 (18.9)	28 (26.4)	12 (11.3)	0.129	0.141

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure.
[a] Hypertension defined on blood pressure ≥140/≥90 mm Hg.
[b] p for trend unadjusted.
[c] p for trend adjusted for age, gender and energy intake.

Table 5
Odds ratios of a high DASH score or being hypertensive according to total nutrition knowledge scores.

	Model 1[a]		Model 2[b]		Model 3[c]		Model 4[d]	
High DASH score[e]	OR	95% CI	OR	95% CI	OR	95% CI		
Nutrition knowledge								
Lowest	1	Referent	1	Referent	1	Referent		
Second	1.5	(0.89–2.45)	1.8	(0.95–3.47)	1.9	(0.96–3.57)		
Third	2.7	(1.63–4.34)	3.0	(1.62–5.64)	3.2	(1.68–6.01)		
Fourth	3.2	(2.00–5.20)	3.5	(1.90–6.33)	3.5	(1.88–6.52)		
Highest	5.8	(3.48–9.57)	7.5	(3.93–14.28)	7.5	(3.83–14.6)		
Hypertension[f]	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Nutrition knowledge								
Lowest	1	Referent	1	Referent	1	Referent	1	Referent
Second	0.6	(0.32–1.19)	0.5	(0.21–1.91)	0.5	(0.21–1.28)	0.6	(0.23–1.39)
Third	0.7	(0.39–1.37)	0.6	(0.24–1.25)	0.6	(0.26–1.40)	0.5	(0.22–1.34)
Fourth	0.9	(0.48–1.54)	0.7	(0.35–1.49)	0.9	(0.39–1.83)	0.8	(0.38–1.89)
Highest	0.4	(0.20–0.87)	0.3	(0.09–0.66)	0.3	(0.11–0.90)	0.3	(0.10–0.89)

Abbreviations: DASH, Dietary Approaches to Stop Hypertension.
[a] Model 1: adjusted for age, gender and energy intake.
[b] Model 2: + BMI, mid-way waist circumference, physical activity, smoking, alcohol.
[c] Model 3: + ethnicity, job position, marital status and education.
[d] Model 4: + DASH (quintile).
[e] High DASH score = highest DASH score quintile 5.
[f] Hypertension defined as average systolic blood pressure ≥140 mm Hg or average diastolic blood pressure ≥90 mm Hg.

DASH score and blood pressure. Specifically, nutrition knowledge is a marker of education attainment and other cognitive skills that were not fully captured in these analyses.

Strengths of the study include that all workplaces had similar characteristics as they were all manufacturing workplaces with similar work schedules. Employees' had comparable demographics, health status and lifestyle characteristics. BMI, BP, central obesity and urinary sodium were objectively measured by trained research assistants according to the SOP manual (Geaney et al., 2013b). The use of 24-hour ambulatory BP monitoring would have however provided a more accurate measure of the employees' BP throughout the day while at work and at home. There was little missing data for all variables besides alcohol consumption but given that this data was collected within the workplace, employees may have been reluctant to report their alcohol intake.

Conclusion

The findings show that higher nutrition knowledge is associated with better diet quality and lower blood pressure in a manufacturing working population even with adjustment for health status, lifestyle behaviours and socio-demographic characteristics. To the contrary of our original hypothesis, we did not find that the association between nutrition knowledge and hypertension was largely mediated by diet quality (DASH score). While the inter-relations between nutrition knowledge, diet quality and health outcomes such as blood pressure are complex, these findings highlight the value of nutrition education as a component of workplace dietary interventions. In addition to nutrition education, future workplace dietary interventions need to implement and evaluate long-term multi-level complex interventions that consider psychological and environmental factors to reduce the burden of hypertension and other diet-related diseases.

Contributions of authors

FG was primarily responsible for the final content of the paper and is the guarantor. FG, JH and IJP worked on the study design and methods. FG and JH constructed the DASH and nutrition knowledge scores. JH, SF, CK and FG were responsible for data analysis. FG, SF, BAG and IJP wrote the paper. All authors approved the final version of the paper for publication.

Conflict of interest

The authors declare that there are no conflicts of interest.

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References

Adriaanse, M.A., Vinkers, C.D., De Ridder, D.T., Hox, J.J., De Wit, J.B., 2011. Do implementation intentions help to eat a healthy diet? A systematic review and meta-analysis of the empirical evidence. Appetite 56 (1), 183–193.
Alsaffar, A.A., 2012. Validation of a general nutrition knowledge questionnaire in a Turkish student sample. Public Health Nutr. 15 (11), 2074–2085.
Anderson, E.S., Winett, R.A., Wojcik, J.R., 2007. Self-regulation, self-efficacy, outcome expectations, and social support: social cognitive theory and nutrition behavior. Ann. Behav. Med. 34 (3), 304–312.
Anderson, L., Quinn, T., Glanz, K., et al., 2009. The effectiveness of worksite nutrition and physical activity interventions for controlling employee overweight and obesity: a systematic review. Am. J. Prev. Med. 37, 340–357.
Ball, K., Crawford, D., Mishra, G., 2006. Socio-economic inequalities in women's fruit and vegetable intakes: a multilevel study of individual social and environmental mediators. Public Health Nutr. 9, 623–630.
Baron, R.M., Kenny, D.A., 1986. The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. J. Pers. Soc. Psychol. 51 (6), 1173–1182.
Bonaccio, M., Castelnuovo, A., Costanzo, S., et al., 2013. Nutrition knowledge is associated with higher adherence to Mediterranean diet and lower of obesity, results from the Moli-sani study. Appetite 68, 139–146.
Cohen, J., 1988. Statistical power analysis for the behavioral sciences. Psychology Press.
Darmon, N., Drewnowski, A., 2008. Does social class predict diet quality? Am. J. Clin. Nutr. 87, 1107–1117.
Darnton-Hill, I., Nishida, C., James, W., 2004. A life course approach to diet, nutrition and the prevention of chronic diseases. Public Health Nutr. 7, 101–122.
Drewnowski, A., Specter, S.E., 2004. Poverty and obesity: the role of energy density and energy costs. Am. J. Clin. Nutr. 79, 6–16.
Food Safety Authority of Ireland, 2005. Salt and Health: Review of the Scientific Evidence and Recommendations for the Public Policy in Ireland. Food Saftey Authority of Ireland (http://www.fsai.ie/uploadedFiles/Science_and_Health/salt_report-1.pdf. Accessed May 2014).

Food Standards Agency, 2002. Food Portion Sizes. 3rd edition. HMSO, London.
Friel, S., Kelleher, C., Noal, G., Harrington, J., 2003. Social diversity of Irish adults nutritional intake. Eur. J. Clin. Nutr. 57, 865–875.
Fung, T., Chiuve, S., McCullough, M., Rexrode, K., Logroscino, G., Hu, F., 2008. Adherence to a dash-style diet and risk of coronary heart disease and stroke in women. Arch. Intern. Med. 168, 713.
Geaney, F., Di Marrazzo, J.S., Kelly, C., et al., 2013a. The food choice at work study: effectiveness of complex workplace dietary interventions on dietary behaviours and diet-related disease risk-study protocol for a clustered controlled trial. Trials 14, 370.
Geaney, F., Di Marrazzo, J.S., Kelly, C., Harrington, J.M., Perry, I.J., 2013b. Food Choice at Work SOP. Department of Epidemiology and Public Health, University College Cork.
Geaney, F., Kelly, C., Greiner, B.A., Harrington, J.M., Perry, I.J., Beirne, P., 2013c. The effectiveness of workplace dietary modification interventions: a systematic review. Prev. Med. 57 (5), 438–447.
Hajjar, I., Kotchen, T., 2003. Regional variations of blood pressure in the United States are associated with regional variations in dietary intakes: the NHANES-III Data. J. Nutr. 133, 211–214.
Harrington, J., Perry, I., Lutomski, J., et al., 2008. Slán 2007: survey of lifestyle, attitudes and nutrition in ireland. Dietary habits of the Irish population. Psychol. Rep. 6.
Harrington, J., Fitzgerald, A., Layte, R., Lutomski, J., Molcho, M., Perry, I., 2011. Sociodemographic, health and lifestyle predictor of poor diets. Public Health Nutr. 14, 2166–2175.
Hendrie, G.A., Cox, D.N., Coveney, J., 2008. Validation of the general nutrition knowledge questionnaire in an Australian community sample. Nutr. Diet. 65, 72–77.
Kearney, P., Whelton, M., Reynolds, K., Munter, P., Whelton, P., He, Jiang, 2005. The global burden of hypertension: analysis of worldwide data. Lancet 365, 217–223.
Maes, L., Van Cauwenberghe, E., Van Lippevelde, W., et al., 2011. Effectiveness of workplace interventions in Europe promoting healthy eating: a systematic review. Eur. J. Pub. Health 22, 677–683.
McCance, R.A., Widdowson, E.M., 1997. The composition of foods. 5th edition. HMSO, London.
McLeod, E.R., Campbell, K.J., Hesketh, K.D., 2011. Nutrition knowledge: a mediator between socioeconomic position and diet quality in Australian first-time mothers. J. Am. Diet. Assoc. 111 (5), 696–704.
Michie, S., Richardson, M., Johnston, M., et al., 2013. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann. Behav. Med. 46 (1), 81–95.
Ni Mhurchu, C., Aston, L.M., Jebb, S.A., 2010. Effects of worksite health promotion interventions on employee diets: a systematic review. BMC Public Health 10, 62.
Nunnally, J.C., Bernstein, I.H., 1994. Psychometric Theory. 3rd ed. McGraw Hill Inc., New York.
Ocke, M.C., Bueno-de-Mesquita, H.B., Goddijn, H.E., et al., 1997. The Dutch epic food frequency questionnaire. I. Description of the questionnaire, and relative validity and reproducibility for food groups. Int. J. Epidemiol. 26, S37.
Parmenter, K., Wardle, J., 1999. Development of a general nutrition knowledge questionnaire for adults. Eur. J. Clin. Nutr. 53, 298–308.
Perry, I.J., Browne, G., Loughrey, M., Harrington, J., Lutomski, J., Fitzgerald, A.P., 2010. Dietary salt intake and related risk factors in the Irish population. A Report for Safefood.
Pickering, T.G., Hall, J.E., Appel, L.J., et al., 2005. Recommendations for blood pressure measurement in humans and experimental animals part 1: blood pressure measurement in humans: a statement for professionals from the subcommittee of professional and public education of the american heart association council on high blood pressure research. Circulation 111, 697–716.
Quintiliani, L., Poulsen, S., Sorensen, G., 2010. Healthy eating strategies in the workplace. Int. J. Workplace Health Manag. 3, 182–196.
Shepherd, R., Towler, G., 1992. Nutrition knowledge, attitudes and fat intake: application of the theory of reasoned action. J. Hum. Nutr. Diet. 5 (6), 387–397.
Spahn, J.M., Reeves, R.S., Keim, K.S., et al., 2010. State of the evidence regarding behavior change theories and strategies in nutrition counseling to facilitate health and food behavior change. J. Am. Diet. Assoc. 110 (6), 879–891.
Turrell, G., Kavanagh, A.M., 2006. Socio-economic pathways to diet: modelling the association between socio-economic position and food purchasing behaviour. Public Health Nutr. 9, 375–383.
Wardle, J., Parmenter, K., Waller, J., 2000. Nutrition knowledge and food intake. Appetite 34, 269–275.
Webb, T.L., Sheeran, P., 2006. Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. Psychol. Bull. 132 (2), 249.
WHO, 2000. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organization Technical Report Series 894. World Health Organisation, Geneva.
WHO, 2002. World Health Report 2002. Popul. Dev. Rev. 28, 205–228.
WHO, 2004. Global Strategy on Diet, Physical Activity and Health. Accessed at:. http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdfWHO.
WHO, 2008. Waist Circumference and Waist–Hip Ratio: Report of a WHO Expert Consultation. World Health Organization (WHO), Geneva.
WHO, 2011. Global Atlas on Cardiovascular Disease Prevention and Control. World Health Organisation (WHO), Geneva (in collaboration with the World Heart Federation and World Stroke Organisation).
Worsley, A., 2002. Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour? Asia Pac. J. Clin. Nutr. 11, 579–585.