Title: Prevalence of metabolic risk factors and associated 10-year prediction of cardiovascular disease and diabetes in female employees.

Running head: Cardio-metabolic health in female health board workers.

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Abstract

Aims: Cardiovascular disease (CVD) and type 2 diabetes (T2DM) remain two of the greatest health challenges in the United Kingdom. Guidelines currently advocate screening individuals to identify those at 'high risk' (10-year risk ≥20%) of CVD and T2DM. This study examined the prevalence of undiagnosed risk factors associated with these two conditions and predicted 10-year risk.

Methods: Female local health board employees (n=371) with no prior diagnosis of CVD or T2DM accepted an invitation for a workplace-based health assessment. Demographic, anthropometric, systolic and diastolic blood pressure, family and medical histories were all recorded and capillary blood samples obtained for analysis of Total and HDL Cholesterol and HbA1c. 10-year CVD and T2DM risk were predicted using the QRISK2 and QDiabetes algorithms, respectively.

Results: A significant proportion of females were either overweight (37.2%) or obese (23.5%) coupled with a high percentage with central obesity (77.6%). Systolic hypertension (42.0%), diastolic hypertension (39.4%) and/or reduced HDL concentrations (32.6%) were also prevalent in a large number of female workers. However less than 1% of all workers were at 'high risk' of CVD and only 3.2% predicted to be at 'high risk' of developing T2DM in the next ten years. The vast majority of females assessed were at 'low risk' (<10%) of either CVD or T2DM.

Conclusions: Despite strong evidence of metabolic risk factors observed in female employees, only a small proportion of workers were predicted to be at 10-year high risk of either CVD or T2DM.

Keywords: Cardiovascular disease; Type 2 diabetes; Risk Prediction; Workplace

Introduction

Cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) remain two of the major health challenges in the United Kingdom. Almost one third of all deaths (190,857 of 579,677) in the United Kingdom are currently attributable to CVD[1] whilst latest figures also report that just over 3 million individuals (6.8% of the national population) are estimated to be living with diabetes[2]. The United Kingdom government through the National Institute for Health and Care Excellence (NICE) have acknowledged these health concerns with recommendations to target individuals aged 40-74 years at 'high risk' (those with a predicted 10-year risk ≥20%) for the primary prevention of both CVD[3] and T2DM[4].

As employment becomes more sedentary in nature coupled with the emerging association between such behaviour and both diabetes and cardiovascular disease[5-6], there is a greater potential for more working individuals to be at an increased predisposition of these two conditions. Therefore, one obvious and under-utilised setting for such service-based health assessments in the United Kingdom is the workplace. The workplace is also an attractive option since many adults of various socio-economic statuses, lifestyles, and risk profiles can be targeted at once[7]. Workplace health schemes are routine within the United States and are periodically reviewed for their clinical and/or economic benefits[8-9]. Blood pressure, physical activity, diet, smoking cessation, cholesterol and obesity have all been shown to improve through workplace-based intervention schemes[10-13]. More specifically, workplace interventions focussing on the cardiovascular health of employees in the health sector have generated encouraging results with respect to lipid profiles where high levels of total cholesterol (≥13.3 $mmol.l^{-1}$) were reduced by 2.75 $mmol.l^{-1}$ and raised blood pressure (Systolic: ≥120 mmHg; Diastolic: ≥80 mmHg) improved by 16 mmHg and 11 mmHg in systolic and diastolic levels respectively, following the intervention[11].

The aim of this study was to investigate the prevalence of isolated risk factors that contribute to both CVD and Type 2 diabetes and predicted risk of these two conditions in female employees of a local health board in Carmarthenshire, South Wales, UK. This region has a high prevalence of T2DM and CVD with latest statistics documenting that in 2010, death rates per 100,000 individuals were 196.69 and 91.80 from all forms of CVD and CHD, respectively[14].

Methods

Study Population

All participants in this study were female employees of the local health board (LHB; Hywel Dda Health Board) within the Welsh region of Carmarthenshire. This worksite was part of an established project entitled 'Prosiect Sir Gâr' (PSG; The 'Carmarthenshire Project'[15]). All current employees over the age of 40 years if Caucasian, or 25 years if South Asian with no prior diagnosis of CVD or diabetes were invited to participate in the project. Individuals with a previous cardiovascular event, established diabetes or a family history of hypercholesterolaemia were excluded from the programme. In total, 371 female LHB employees accepted the invite for a cardiovascular and diabetes baseline assessment. All participants provided written consent and this study was approved by Dyfed Powys Local Research Ethics Committee (reference number: 11/WA/0101).

Baseline Measurements and Risk Prediction

According to a standard operational policy all recruited individuals attended a standardised risk assessment appointment with an occupational health nurse which lasted 30-40 minutes. During the session, demographic (date of birth, gender, postcode of residence) and anthropometric (body mass, height, waist circumference) data were collected. Systolic and diastolic blood pressure, pulse rate and rhythm, smoking status, family and medical histories were all recorded and blood samples obtained. Blood samples were collected via capillary puncture and analysed for both total and high-density-lipoprotein (HDL) cholesterol (Cholestech LDX® System, Alere Inc., Orlando, USA) and HbA_{1c} (DCA 2000, Siemens Healthcare Diagnostics Ltd, Frimley, UK). In addition, current physical activity levels were assessed by the General Practice Physical Activity Questionnaire (GPPAQ)[16]. Once all baseline measurements were collected, 10-year predicted CVD and diabetes risk were

calculated by entering the relevant variables into the online QRISK2-2012[17] and QDiabetes[18] risk algorithms, respectively. Following the risk assessment calculations, the occupational health nurse staged a brief intervention with tailored advice dependent on the individual CVD and diabetes risk. Individuals were also referred to their general practitioner for further investigations and/or medical intervention if they had specific findings such as hypertension, HbA_{1c} value ≥6.5% (48 $mmol.mol^{-1}$), cardiac arrhythmia (atrial fibrillation) or hyperlipidaemia. This paper will focus on the prevalence data collected at baseline, the predicted CVD and diabetes risk within the sample and presence of metabolic risk factors.

Data Analysis

The focus of our analysis within this study was to examine the prevalence of undiagnosed cardiovascular and diabetes risk factors and associated 10-year predicted risk of the two conditions in the workforce. Within the analysis we chose from the outset to stratify the samples by age. Statistical analysis was performed using SPSS software (version 19, SPSS Inc, Chicago, USA) with significance set at $P < 0.05$. Normality of data was assessed by one-sample Kolmogorov-Smirnov test. Homogeneity of variance was determined by Levene's statistic and one-way analysis of variance (ANOVA) with post-hoc Bonferroni or Tamhane's T2 correction factor used to locate any differences within groups. Data are represented as mean ± SD or as numbers with percentage of workforce in brackets. Age, QRISK2-2012 and QDiabetes scores did not have a normal distribution. These datasets were consequently log transformed for analysis and represented as the geometric mean and approximate standard deviation. BMI, Waist Circumference, TC:HDL ratio and HbA_{1c} concentrations did not have a normal distribution following log transformation and this data is represented as median and interquartile range. Kruskal-Wallis and Mann-Whitney tests were used to analyse these data variables.

Results

Table 1 summarises the baseline data from the study participants. As a result of the inclusion criteria, the mean age of the LHB employees was 49 ± 2 years. The average body mass index of the workers was found to be 'overweight' and the median waist circumference of the females was somewhat elevated. Systolic blood pressure values and total cholesterol concentrations were also observed to be raised. The average predicted 10-year QRISK2-2012 and QDiabetes scores were both very low, 2.4 ± 0.9% and 3.5 ± 1.5%, respectively.

*****TABLE 1 NEAR HERE*****

Stratifying by age

We chose from the outset to examine differences after stratifying by age within the workforce as shown in Table 2 and Figure 1 for the QRISK2 and QDiabetes data. This allowed the data to be examined in five predefined age categories (<45, 45-49, 50-54, 55-59 and ≥60 years). Systolic blood pressure levels and HbA_{1c} values were higher in all age groups compared to <45 years and HbA_{1c} values were higher again after 55 years in comparison to the 45-49 years age range. Total cholesterol concentrations increased with age with the 50-54 years age group being higher than the <45 years age group, whilst the final two age groups (55-59 years and ≥60 years) had higher concentrations than both the <45 years and 45-49 years age groups.

****TABLE 2 NEAR HERE*****

The mean QRISK2 scores increased concomitantly with age and the predicted CVD risk was nearly ten times higher in the LHB employees at ≥60 years (7.7 ± 1.1%) compared to the

<45 years group (0.8 ± 0.2%). The QDiabetes predicted scores did not increase with age and predicted risk was comparable after 45 years old in the females.

*****FIGURE 1 NEAR HERE*****

All age cardiovascular risk analysis

Further analysis was performed to examine the number of individuals with specific cardio-metabolic risk factors and the proportion of workers categorised by risk (low, intermediate or high) for CVD and T2DM (Table 3). Only 4% of workers had an increased CVD risk (QRISK2: >10%), however 15% of females were found to be at either an intermediate or high risk of developing T2DM in the next 10 years. A significant proportion of females were either overweight (37.2%) or obese (23.5%) coupled with a high percentage with central obesity (77.6%). Systolic hypertension (42.0%), diastolic hypertension (39.4%) and/or reduced HDL concentrations (32.6%) were also prevalent in a large number of female workers. Over one third of female workers were also determined to be either physically 'inactive' or 'moderately inactive' by self-reported physical activity levels. In addition, 4% of employees were observed to have a HbA_{1c} value ≥42 $mmol.mol^{-1}$ (6.0%) with 5 individuals found to have a HbA_{1c} value ≥48 $mmol.mol^{-1}$ (6.5%).

*****TABLE 3 NEAR HERE*****

Discussion

This study investigated the prevalence of undiagnosed risk factors for CVD and diabetes and predicted risk of these two conditions in a sample of female local health board employees. A high proportion of central obesity was observed in the workforce coupled with a significant amount of individuals who were either overweight or obese. There was also evidence of metabolic risk factors such as hypertension and reduced HDL cholesterol levels in nearly one third of female employees. However despite these findings, the predicted CVD and diabetes risk scores were both relatively low. Less than 1% of all workers were at 'high risk' of CVD and only 3.2% of the workforce was at 'high risk' of developing diabetes in the next ten years.

The high prevalence of individuals either overweight or obese in the workforce is of concern for both employees and employers. Obesity has been shown to influence concentrations of elevated non-HDL cholesterol, reduced HDL cholesterol and also be associated with systolic and diastolic hypertension[20], and furthermore, fatal coronary events are independently associated with obesity[21]. In terms of employers' interests obese workers take more sick days and have longer sick leaves (increased absenteeism), incur greater productivity losses (increased presenteeism) and raise more expensive compensation claims than do non-obese workers[22].

One of the strengths of this paper documenting the prevalence of metabolic risk factors and current predicted 10-year of either condition is that the data is derived from real-life situations and are likely reflected in other workplaces in the United Kingdom. For example, the number of females that were observed to have 'pre-diabetes' and be at increased risk of T2DM in terms of their HbA_{1c} values ($\geq$42 $mmol.mol^{-1}$(6.0%)) was 1 in 25. In 2011, HbA_{1c}

scores became diagnostic criteria for Type 2 diabetes. The threshold value of 48 mmol.mol-1 (6.5 %) is now recognised as the cut off point for Type 2 diabetes[23], therefore from our data 5 of the individuals would have undiagnosed diabetes and arguably justifies the importance of a workplace initiative. In addition, HbA_{1c} values are have been shown to be an independent risk factor for coronary heart disease[24] and have also been proven to be better at predicting cardiovascular risk than total cholesterol in some risk prediction models[25].

Age stratification revealed a number of changes in baseline variables and predicted risk. The changes in total cholesterol concentrations in the older age groups are consistent with previous studies[26-27]. Alongside total cholesterol, LDL cholesterol concentrations and apolipoprotein B are primary cardiovascular risk factors affected by the menopause[26]. It has also been documented that following the menopause, females have similar lipid profiles and CHD risk to their age-matched male counterparts[27]. It may be interpreted that these observations are reflected in the concomitant changes in predicted 10-year CVD risk in Figure 1A. However, age is the single most important determinant in cardiovascular risk[28], an increase in age is the strongest predictor for morbidity and mortality and all CVD risk tables reflect this in their estimations[28].

In conclusion, a baseline workplace-based risk assessment for CVD and type 2 diabetes uncovered a number of occult risk factors. However, despite these significant observations in regards to metabolic risk factors the proportion of females predicted at ‘high risk’ of either CVD or T2DM was very low. Therefore, examining for specific metabolic risk factors as opposed to absolute risk of either condition may be of more benefit in females.

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Competing interests

All authors wish to declare no conflict of interest resulting from the findings of this study.

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Tables and Figures

Table 1. Baseline characteristics of female local health board staff

Baseline Variable	**LHB employees (n = 371)**
Age (years)[#]	49 ± 2
Body Mass Index ($kg.m^{-2}$)[‡]	25.9 [23.7 – 29.7]
Waist Circumference[‡]	87.5 [81.0 – 96.5]
Systolic Blood Pressure (mmHg)	127 ± 15
Diastolic Blood Pressure (mmHg)	82 ± 9
Total Cholesterol ($mmol.l^{-1}$)	4.85 ± 0.85
HDL Cholesterol ($mmol.l^{-1}$)	1.51 ± 0.40
Total: HDL Ratio[‡]	3.2 [2.7 – 4.0]
HbA_{1c} (%)[‡]	5.5 [5.2 – 5.7]
HbA_{1c} ($mmol.mol^{-1}$)[‡]	37 [33 – 39]
QRISK2-2012 (%)[#]	2.4 ± 0.9
QDiabetes (%)[#]	3.5 ± 1.5

Data expressed as means ± SD with gender data represented as numbers with percentage of workforce in brackets [#] log transformed data, geometric mean and approximate standard deviation reported [‡] data not normally distributed following log transformation, median and interquartile range reported.

Table 2. Characteristics of local health board female workforce following age stratification

Baseline Variable	<45 Years (n = 92)	45 – 49 Years (n = 108)	50 – 54 Years (n = 82)	55 – 59 Years (n = 60)	≥60 Years (n = 29)
Body Mass Index ($kg.m^{-2}$) ‡	25.3 [22.5 – 28.6]	25.9 [23.8 – 30.8]	27.4 [24.3 – 30.3]	25.3 [23.8 – 27.4]	26.6 [23.2 – 29.3]
Waist Circumference (cm) ‡	86.0 [79.0 – 94.0]	89.0 [82.0 – 99.5]	91.0 [81.5 – 100.5]	85.5 [79.5 – 93.5]	85.0 [79.0 – 94.0]
Systolic Blood Pressure (mmHg)	120 ± 14	126 ± 14[a]	131 ± 17[a]	132 ± 17[a]	129 ± 11[a]
Diastolic Blood Pressure (mmHg)	80 ± 9	83 ± 9	83 ± 10	84 ± 9	81 ± 10
Total Cholesterol ($mmol.l^{-1}$)	4.48 ± 0.80	4.72 ± 0.77	5.03 ± 0.82[a]	5.22 ± 0.88[a,b]	5.21 ± 0.74[a,b]
HDL Cholesterol ($mmol.l^{-1}$)	1.49 ± 0.37	1.46 ± 0.41	1.45 ± 0.38	1.60 ± 0.44	1.71 ± 0.39[b,c]
Total: HDL Ratio‡	3.0 [2.4 – 3.8]	3.2 [2.6 – 4.1]	3.4 [2.8 – 4.3][a]	3.3 [2.7 – 4.1]	2.9 [2.7 – 3.5][c]
HbA_{1c} (%)‡	5.3 [5.1 – 5.5]	5.4 [5.3 – 5.6][a]	5.5 [5.3 – 5.7][a]	5.7 [5.4 – 5.8][a,b]	5.6 [5.5 – 5.8][a,b]
HbA_{1c} ($mmol.mol^{-1}$)‡	34 [32 – 37]	36 [34 – 38][a]	37 [34 – 39][a]	39 [36 – 40][a,b]	38 [37 – 40][a,b]

Data expressed as means ± SD with gender data represented as numbers with percentage of workforce in brackets # log transformed data, geometric mean and approximate standard deviation reported ‡ data not normally distributed following log transformation, median and interquartile range reported. [a] significantly different from <45 years ($P<0.05$), [b] significantly different from 45 – 49 years ($P<0.05$), [c] significantly different from 50 - 54 years ($P< 0.05$).

Table 3. Proportion of workers with specific metabolic risk factors and categorised by low, intermediate and high CVD and T2DM risk.

Risk Variable	LHB Employees (n=371)
Body Mass Index ≥30 $kg.m^{-2}$†	87 (23.5)
Body Mass Index 25 – 29.9 $kg.m^{-2}$	138 (37.2)
Central Obesity (Waist Circumference ≥80 cm)†	288 (77.6)
TC:HDL Ratio ≥6	9 (2.4)
Reduced HDL Cholesterol <1.29 $mmol.l^{-1}$†	121 (32.6)
Systolic Blood Pressure ≥130 mmHg†	156 (42.0)
Diastolic Blood Pressure ≥85 mmHg†	146 (39.4)
Current Smoker	32 (8.7)
HbA_{1c} ≥6.5% (48 $mmol.mol^{-1}$)	5 (1.3)
HbA_{1c} 6.0 – 6.4% (42 – 47 $mmol.mol^{-1}$)	10 (2.7)
Physically Inactive or Moderately Inactive	136 (36.7)
10-year High Risk of CVD (QRISK2 ≥20%)	2 (0.5)
10-year Intermediate Risk of CVD (QRISK2 10 – 19.9%)	13 (3.5)
10-year Low Risk of CVD (QRISK2 <10%)	356 (96.0)
10-year High Risk of T2DM (QDiabetes ≥20%)	12 (3.2)
10-year Intermediate Risk of T2DM (QDiabetes 10 – 19.9%)	45 (12.1)
10-year Low Risk of T2DM (QDiabetes <10%)	314 (84.6)

Data expressed as numbers with percentage of workforce in brackets. † Metabolic risk factors based on IDF guidelines[19].

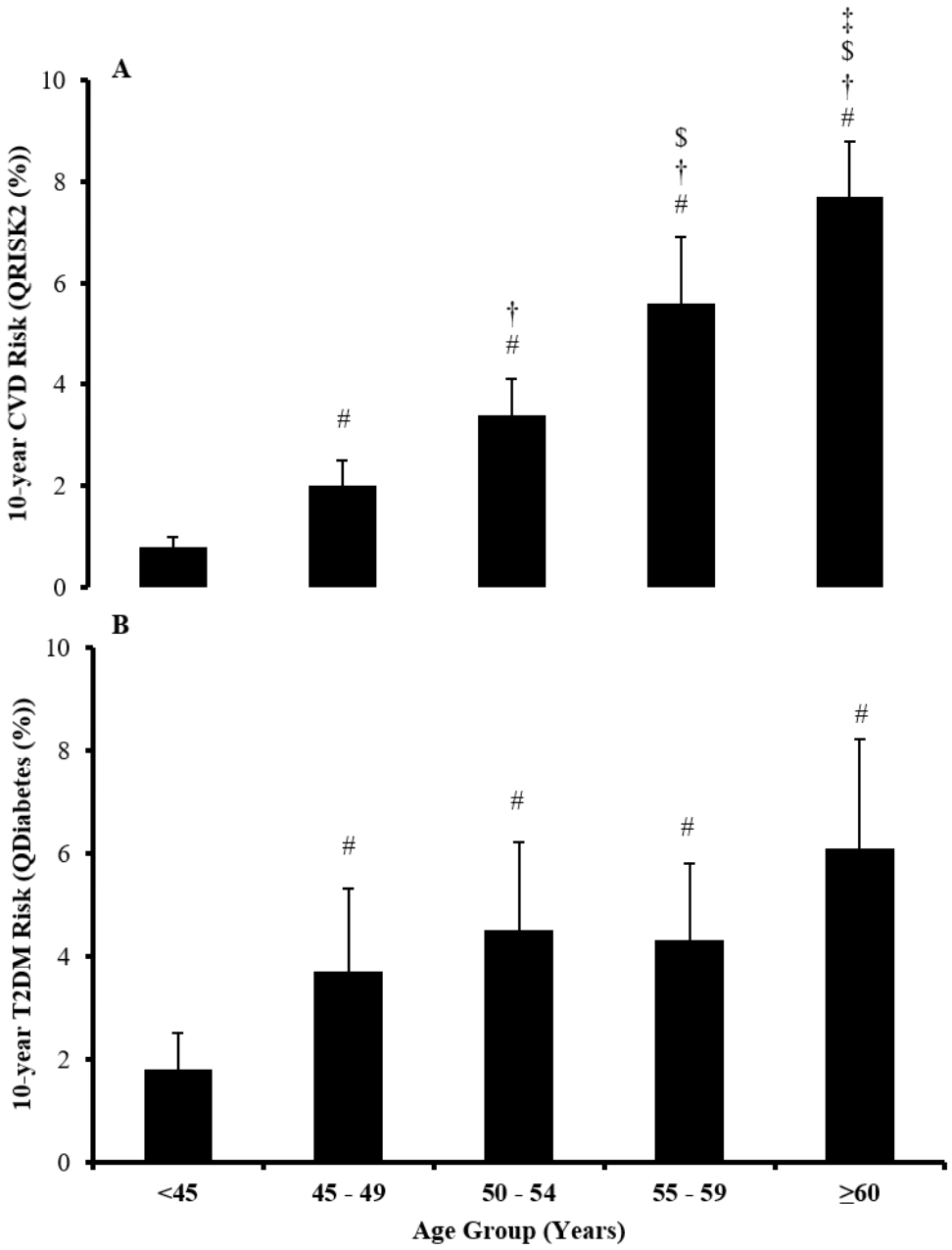

Figure 1. 10-year predicted risk of CVD (A) and type 2 diabetes (B) following age stratification. # denotes significant difference from <45 age group, † denotes significant difference from 45-49 age group, $ denotes significant difference from 50-54 age group, ‡ denotes significant difference from 55-59 age group.