Title Prevalence of undiagnosed cardiovascular risk factors and 10-year CVD risk in male steel industry workers.

Running head: Undiagnosed CVD risk in male steel workers

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Abstract

Objective: To assess the prevalence of undiagnosed cardiovascular disease (CVD) in a cohort of male steel workers in South Wales, UK.

Methods: Male steel industry workers (n=221) with no prior diagnosis of CVD or diabetes accepted a CVD risk assessment within the work environment. Demographic, anthropometric, family and medical histories were all recorded and capillary blood samples obtained. 10-year CVD risk was predicted using the QRISK2-2012 algorithm.

Results: 81.5% of workers were either overweight or obese. >20% of workers were found to have diastolic hypertension, high total cholesterol and/or a TC:HDL ratio ≥6. Over one quarter of workers assessed had an increased 10-year CVD risk.

Conclusions: Despite a physically demanding occupation, risk assessment in the workplace uncovered significant occult factors in CVD risk in a sample of male heavy industry workers.

Introduction

Cardiovascular disease (CVD) remains one of the major health challenges in the United Kingdom. A third of all deaths in the United Kingdom are currently attributed to cardiovascular disease (CVD) (1) and specifically, the most common cause of premature death in those aged below 75 years is coronary heart disease (CHD) (1). CVD risk is influenced by obesity, physical inactivity, smoking, hypertension, dyslipidaemia and impaired glucose regulation. These all have independent and additive effects on risk (2-3). Furthermore, in males alone, 80% of all premature CHD can be attributed to the combination of smoking, hypertension and high levels of total cholesterol (>5.2 mmol.l^{-1}) (4).

CVD risk may be reduced effectively by lifestyle and/or therapeutic approaches that target the reduction of systolic blood pressure, body weight and smoking. In addition, the adoption of increased physical activity can also influence lipid profiles with those individuals more physically active displaying lower total cholesterol concentrations, lower LDL cholesterol concentrations and higher HDL cholesterol concentrations than those individuals who were sedentary (5). Early detection of CVD risk factors could potentially reduce the growing public health burden of this disease with evidence that a multifactorial strategy treating glycaemic control, lipid profiles and blood pressure together through either medication or behavioural therapy has been shown to be highly effective in reducing cardiovascular mortality compared to conventional treatment (6).

Current guidelines recommend screening for the primary prevention of CVD in those individuals aged between 40-74 years, especially for those at high risk (7). However, only specifically targeting those individuals identified as having a high risk (CVD risk prediction assessment score of $\geq 20\%$) of developing CVD excludes those individuals with an

intermediate risk (CVD risk prediction assessment score of 10–19.9%) who through earlier intervention and engagement with a lifestyle intervention programme could have the potential to reduce their risk factors and hence CVD without the need for pharmacological treatments. This approach would not only benefit the individual but result in economic benefits for the National Health Service (NHS) as a whole through lower morbidity and a reduced prescription of lipid-lowering agents.

An obvious and under-utilised setting in the United Kingdom to perform service-based delivery of health assessment and basic intervention is the workplace. Employed individuals, especially within the industrial sector, are perceived to be a 'hard to reach' population (8) since they are unable to attend primary care services during the working day and may not wish to utilise their 'citizen time' (time spent outside of work) for this. The workplace is also an attractive option since many adults of various socio-economic statuses, lifestyles, and risk profiles can be targeted at once (9). In addition, males are also less likely than their female counterparts to schedule annual health checks, seek medical advice or attend educational meetings (10). Therefore, a health assessment programme with basic intervention within the workplace has potential benefits to both employee (better individual health) and the employer (better workforce health and productivity). For example, individuals with higher BMI values are less work efficient and higher rates of presenteeism are observed in working individuals with a BMI $\geq$35 kg.m^{-2} where extra time is required to complete tasks (11).

The aim of this study was to examine the prevalence of baseline cardiovascular risk factors in male employees from a local steel works who participated in a service-based delivery of a CVD risk identification programme in the Carmarthenshire region of South Wales. This region has a high prevalence of CVD with current statistics documenting that in 2010, death

rates were 196.69 and 91.80 per 100,000 individuals from all forms of CVD and CHD, respectively (12). Furthermore, existing research in several countries examining the prevalence of CVD and diabetes risk factors in construction workers also demonstrated an increased CVD risk despite a more physically demanding occupation (13-14).

Methods

Study Population

All participants in this study were employees of the local steel works within the Welsh region of Carmarthenshire. This worksite was part of an established project entitled 'Prosiect Sir Gâr' (PSG; The 'Carmarthenshire Project' (15)). This collaborative project between Carmarthenshire County Council, Hywel Dda Health Board, TATA Steel, Public Health Wales and Swansea University was developed in 2005 and introduced in 2009 with the overarching aim(s) to identify, and then reduce the prevalence of CVD and diabetes of the working population aged over 40 (Caucasian) or 25 (South Asian) years old in Carmarthenshire. 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 who had experienced a previous cardiovascular event (myocardial infarction or angina), had established diabetes or a family history of hypercholesterolaemia were excluded from the programme. The secondary aim of this programme was to ensure individuals had access to appropriate care and treatment. In the case of the excluded individuals, it was assumed that their predicted CVD risk would already be high ($\geq$20 %) and that they would already be under medical care through appropriate treatment pathways and as such did not have undiagnosed or unmanaged disease. In total, 226 male steel industry workers accepted the invite for a cardiovascular risk assessment at baseline. Of these, 5 individual records could not be verified leaving a total of 221 employees in the steel workers cohort for subsequent analysis. 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 appointment for risk assessment 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) data were collected. Blood pressure, pulse rate and rhythm, smoking status, family and medical histories were recorded and blood samples obtained. Blood samples were collected via capillary puncture and analysed for total, high-density-lipoprotein (HDL) and low-density-lipoprotein (LDL) cholesterol and triglycerides (Cholestech LDX® System, Alere Inc., Orlando, USA). 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 risk was calculated by entering the relevant variables into the online QRISK2-2012 risk algorithm (17). Following the risk assessment calculation, the occupational health nurse staged a brief intervention with tailored advice dependent on the individual CVD risk. Employees identified as having a 10-year CVD risk of 20% or higher, impaired glucose regulation (HbA$_{1c}$: 42 – 47 mmol.mol^{-1} (6.0 – 6.4%)), obese (BMI: $\geq$ 30kg.m^{-2} (Caucasian); BMI: $\geq$ 27.5 kg.m^{-2} (South Asian)) or a raised waist circumference (Male: $\geq$ 94 cm (Caucasian); $\geq$ 90 cm (South Asian)(18)), were offered a structured intensive lifestyle management programme where attendance was voluntary. The intensive group session lifestyle intervention programme involved an 8-week course of weekly meetings lasting between 60 – 75 minutes with a dietician and/or exercise specialist with particular focus on behavioural change. Individuals were also referred to their general practitioner (GP) for further investigations and/or medical intervention if they had specific findings such as hypertension, a HbA$_{1c}$ value greater than 48 mmol.mol^{-1} (6.5%), cardiac arrhythmia (atrial fibrillation) or hyperlipidaemia. This paper will focus on the prevalence data collected at baseline and the CVD risk within the sample.

Data Analysis

The focus of our analysis within this study was to examine the prevalence of undiagnosed cardiovascular risk factors and 10-year CVD risk 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. One-way analysis of variance (ANOVA) with post-hoc Bonferroni correction factor was used to locate any differences within groups. Data are represented as mean $\pm$ SD or as numbers with percentage of workforce in brackets. TC:HDL ratios, HDL cholesterol levels, triglyceride concentrations and QRISK2-2012 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.

Results

Table 1 summarises the baseline data from the study participants. Given the inclusion criteria of the participants, the mean age of the steel workers was 48±3 years. The average body mass index of the workers was found to be 'overweight', whilst both systolic and diastolic blood pressure levels were above the optimum 120/80 mmHg values. The steel workers were found to have high concentrations of total cholesterol in combination with low concentrations of HDL cholesterol, thus resulting in a somewhat elevated TC:HDL ratio. The average predicted QRISK2-2012 score equated to a 1 in 20 risk of an individual experiencing a CVD event. Of the available data, the non-fasted concentrations of triglycerides and LDL cholesterol were also raised to some extent.

*****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 data. This allowed the data to be examined in five predefined age categories (<45, 45-49, 50-54, 55-59 and ≥60 years). The only significant differences located were in systolic blood levels in 55-59 years group where these individual values were greater than the three preceding age groups (<45, 45-49, 50-54). Although, not significant, diastolic blood pressure, total cholesterol, TC:HDL ratio and LDL concentrations were also higher in the 55-59 year olds.

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

Interestingly, even though statistically significant differences were only observed in systolic blood pressure levels in the 55-59 years age group, the mean QRISK2 score increased concomitantly with age. This difference was significant across age groups up to the 55-59 years age group. Of further note, the predicted CVD risk was five times higher in the steel workers at ≥60 years (15.4±1.6%) compared to the <45 years group (2.8±0.7%).

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

All age cardiovascular risk analysis

Further analysis was performed to examine the proportion of individuals with specific cardiovascular risk factors. Table 3 shows subjects grouped by isolated CVD risk factors and the categories of QRISK2 score (low, intermediate and high risk). Approximately 22% of steel workers had an intermediate CVD risk (QRISK2: 10-19.9 %) and 5% of steel workers had a high CVD risk score (QRISK2: ≥ 20%). The proportion of the workforce with obesity (BMI ≥30 kg.m^{-2}) was approximately 37% and furthermore a significant percentage (44.8%) of the workers were overweight (BMI 25–29.9 kg.m^{-2}). Of interest, more than 1 in 5 steel workers were diagnosed with either diastolic hypertension, family history of premature CVD, elevated total cholesterol concentrations or a raised TC:HDL ratio. Furthermore, over 1 in 7 individuals were current smokers or diagnosed with systolic hypertension. Of the available data, almost half of individuals (49.7%) had an elevated non-fasted triglyceride concentration. One interesting observation is that although many of the working individuals were diagnosed with clinically significant CVD risk factors the vast majority of workers (93.1%) were assessed with the GPPAQ as either physically 'active' or 'moderately active'.

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

Discussion

This study examined the prevalence of undiagnosed cardiovascular risk factors and 10-year CVD risk in a male population of a local steel works in Carmarthenshire, South Wales. We observed that just over one-quarter (28%) of the steel workers had an intermediate (QRISK2: 10–19.9 %) or high (QRISK2: ≥20 %) 10-year risk of CVD. Although the vast majority of workers were assessed as either physically 'active' or 'moderately active' by GPPAQ due to the demanding nature of their employment, paradoxically a high number of individuals were either 'obese' or 'overweight'. A substantial number of individuals were diagnosed with isolated risk factors including high concentrations of total cholesterol and hypertension, which is of concern as these are two of the three major contributors to premature CHD in males (4). Analysis by age stratification revealed only significant differences in systolic blood pressure values; however, QRISK2 scores increased concomitantly, thus suggesting that age is the single most important variable in methods of risk prediction.

This descriptive study is an example of a service-based delivery approach to CVD risk factor assessment as a successful working interaction between industry, health service and academia. The CVD risk assessment was an optional addition to the annual medicals undertaken by the occupational nurses at the steel works. Those males who volunteered for the cardiovascular assessment were given individual tailored advice dependent on the results of the assessment, without having to schedule time off work for an examination with their GP. This is a significant strength, as males are less likely than females to arrange appointments to seek medical advice (10). Within this study we have highlighted the prevalence of cardiovascular risk factors within the workplace setting. Without undertaking the risk assessment programme described in this paper, individuals with significant cardiovascular risk factors and a high QRISK2 would not have been identified and clearly

were not identified prior to the initiative. This study did not only specifically target high-risk individuals but offered the service to all eligible employees. Whilst identifying the individuals with a high CVD risk score (QRISK2: ≥20 %) is important, identifying those at an intermediate risk (QRISK2: 10–19.9%) is equally, if not more crucial. Over 1 in 5 males in this study were at an intermediate risk of CVD. This is an important group to identify as these individuals may gain more from lifestyle advice than those who are defined as high-risk as it could be argued that they have the potential to revert to a low risk category. Furthermore, this group may respond more successfully to lifestyle modification rather than pharmacological based therapy with anti-hypertensives and statins (20). This also has the economic benefit of savings relating to medication and hospitalisation for further investigations or more invasive treatments. One of the limitations is that this article only highlights the current prevalence of CVD risk factors within one employment site at an initial stage of data collection. With regard to follow-up, individuals with an intermediate risk of CVD were scheduled to be re-screened on an annual basis following the initial consultation and individuals with a low risk (>10%) of CVD were scheduled to be invited for a re-screening appointment in five years after their original consultation. However, the data collected still gives the opportunity of a valuable insight into the current cardiovascular health of male industry workers in South Wales.

There is limited research available within the United Kingdom in relation to prevalence of CVD risk factors in the workplace. However, the findings of our study are consistent with previous research investigating the prevalence of cardio-metabolic risk factors in a male cohort of construction workers in Ireland (13). Here, the groups were divided in two age groups (<40 years and ≥40 years). When we compared our male workforce with the ≥40 years group we found that BMI values (28.1±3.5 kg.m^{-2}), diastolic blood pressure levels

(84.2±10.1 mmHg) and both total (5.1±0.8 mmol.l^{-1}) and LDL cholesterol (3.2±0.8 mmol.l^{-1}) concentrations were all similar. This finding is mainly due to the likelihood that the ethnicity of the two workforces would be identical (both mostly Caucasian) and therefore comparisons of cardiovascular risk factor prevalence between our workforce and the available Indian workforce data (14) would not be feasible.

This descriptive study demonstrates that provisions within the work environment to assess CVD risk are a useful service-based initiative. Whilst, targeting males for CVD assessment is an advantageous method given previous epidemiological research clearly demonstrates that males are more susceptible to the condition than their age matched female counterparts (21). The males who participated in this study were provided with a valuable insight into their cardiovascular profiles and their GPs informed of any findings that may need further investigation. The working population is considered to be a 'hard to reach' group where individuals do not regularly attend primary care clinics for health checks. This may be related to time constraints outside work (citizen time) and difficulty with evening and weekend primary care appointments. In addition to the employees, there are benefits for the employing organisation of such workplace-based health assessments. Employers now have information on the health of their workforce and have the opportunity to potentially address any prevalent risk factors with targeted health promotion initiatives, for example, through their occupational health department.

The number of workers at increased risk of CVD and the prevalence of isolated risk factors in this study are all causes for concern, however early detection of these is important to alleviate development of the condition (22). The proportion of obese workers could prove to be the greatest burden to employers as the high occurrence of isolated risk factors observed in this

study could all be attributed to obesity. Elevated non-HDL cholesterol, reduced HDL cholesterol and both systolic and diastolic hypertension are all influenced by obesity (23), and furthermore, fatal coronary events are independently associated with obesity (24). 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 (25). Therefore, although CVD risk assessments are beneficial (especially to males) in the working environment, the primary objective of employers should be to attempt to reduce the prevalence of obesity in their workforce. This could be delivered by a number of strategies such as providing information to employees through health promotion schemes in regards to dietary habits and increasing physical activity to encourage weight loss and ultimately, BMI values.

The major unanswered question in this research is the paradox observed between the small numbers of individuals self-reporting sedentary behaviour and the extensive prevalence of individuals either overweight or obese. GPPAQ is a validated tool that accounts for both work and leisure time physical activity and has been previously validated and shown that even small amounts of physical activity improves incidence of CVD and all-cause mortality (26). However, one possible explanation could be the emerging research that has highlighted that work-time physical activity alone does not appear to offer protection against the metabolic syndrome (27), which is an important consideration as this condition is a strong precursor to both CVD and type 2 diabetes (28). This raises the question whether work time or leisure time physical activity is more important at offering cardiovascular protection. Finally, another possible suggestion to the increased 10-year predicted risk of CVD despite high levels of physical activity could be that at the time GPPAQ was validated, current risk

engines such as QRISK2 (17) had not been produced and additionally do not factor physical activity into the risk algorithm.

Competing interests and funding

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Tables and Figures

Table 1. Baseline characteristics of male steel workers.

Baseline Variable	Steel workers (n = 221)
Age (years)	48 ± 3
Body Mass Index (kg.m^{-2})	28.9 ± 4.3
Systolic Blood Pressure (mmHg)	127 ± 12
Diastolic Blood Pressure (mmHg)	85 ± 9
Total Cholesterol (mmol.l^{-1})	5.10 ± 0.96
HDL Cholesterol (mmol.l^{-1})[#]	1.09 ± 0.14
Total: HDL Ratio[#]	4.6 ± 0.7
LDL Cholesterol (mmol.l^{-1})[i]	3.00 ± 0.84
Triglycerides (mmol.l^{-1})[#‡]	1.91 ± 0.51
QRISK2-2012 (%)[#]	5.8 ± 2.0

Data expressed as mean $\pm$ SD. [#] log transformed data, geometric mean and approximate standard deviation reported. [‡] not all individual data available for triglycerides (n = 161).

Table 2. Baseline characteristics of steel workers following age stratification.

Baseline Variable	<45 Years (n = 63)	45 – 49 Years (n = 78)	50 – 54 Years (n = 46)	55 – 59 Years (n = 28)	≥60 Years (n = 6)
Body Mass Index (kg.m^{-2})	28.5 ± 4.8	29.0 ± 4.3	29.2 ± 3.9	29.0 ± 4.5	28.9 ± 2.5
Systolic Blood Pressure (mmHg)	125 ± 12	127 ± 12	125 ± 12	135 ± 14 [a,b,c]	126 ± 12
Diastolic Blood Pressure (mmHg)	83 ± 11	86 ± 8	84 ± 9	89 ± 8	82 ± 9
Total Cholesterol (mmol.l^{-1})	5.04 ± 0.98	5.19 ± 1.03	4.88 ± 0.73	5.37 ± 1.04	4.94 ± 0.71
HDL Cholesterol (mmol.l^{-1})[#]	1.07 ± 0.16	1.11 ± 0.34	1.07 ± 0.14	1.07 ± 0.12	1.17 ± 0.16
Total: HDL Ratio[#]	4.6 ± 0.8	4.6 ± 0.6	4.5 ± 0.7	4.9 ± 0.7	4.2 ± 0.6
LDL Cholesterol (mmol.l^{-1})[i]	2.99 ± 0.79	3.04 ± 0.89	2.83 ± 0.73	3.26 ± 1.00	2.85 ± 0.99
Triglycerides (mmol.l^{-1})[#‡]	1.84 ± 0.53	1.91 ± 0.52	2.09 ± 0.46	1.92 ± 0.57	1.12 ± 0.02

Data expressed as mean ± SD. [#] log transformed data, geometric mean and approximate standard deviation 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 ($P < 0.05$). [i] not all individual data available for LDL cholesterol (<45 years; n = 49, 45 – 49 years; n = 47, 50 – 54 years; n = 31, 55 – 59 years; n = 19, ≥60 years; n = 2).[‡] not all individual data available for triglycerides (<45 years; n = 53, 45 – 49 years; n = 52, 50 – 54 years; n = 32, 55 – 59 years; n = 22, ≥60 years; n = 2).

Table 3: Proportion of workers with specific cardiovascular risk factors and categorised by low, intermediate and high CVD risk

Cardiovascular Risk Variable	Steel Workers (n=221)
Body Mass Index $\geq$30 kg.m^{-2}	81 (36.7)
Body Mass Index 25 – 29.9 kg.m^{-2}	99 (44.8)
Total Cholesterol $\geq$ 5.20 mmol.l$^{-1¥}$	90 (40.7)
TC:HDL Ratio $\geq$6	50 (22.6)
Non-fasted Triglyceride Concentration > 2.00 mmol.l$^{-1†}$	80 (49.7)[‡]
Systolic Blood Pressure $\geq$140 mmHg	35 (15.8)
Diastolic Blood Pressure $\geq$90 mmHg	71 (32.1)
Angina or Myocardial Infarction in first degree relative below 60 years	52 (23.5)
Current Smoker	38 (17.2)
Physically Inactive or Moderately Inactive	15 (6.9)
10-year High Risk of CVD (QRISK2 $\geq$20%)	12 (5.4)
10-year Intermediate Risk of CVD (QRISK2 10 – 19.9%)	50 (22.6)
10-year Low Risk of CVD (QRISK2 <10%)	159 (72.0)

Data expressed as numbers with percentage of workforce in brackets. [i] not all individual data available for LDL cholesterol (n = 148). [‡] not all individual data available for triglycerides (n = 161). [¥] high total cholesterol concentrations defined by Emberson et al (4) and [†]non-fasted triglyceride concentrations as defined by JBS2 guidelines (19).
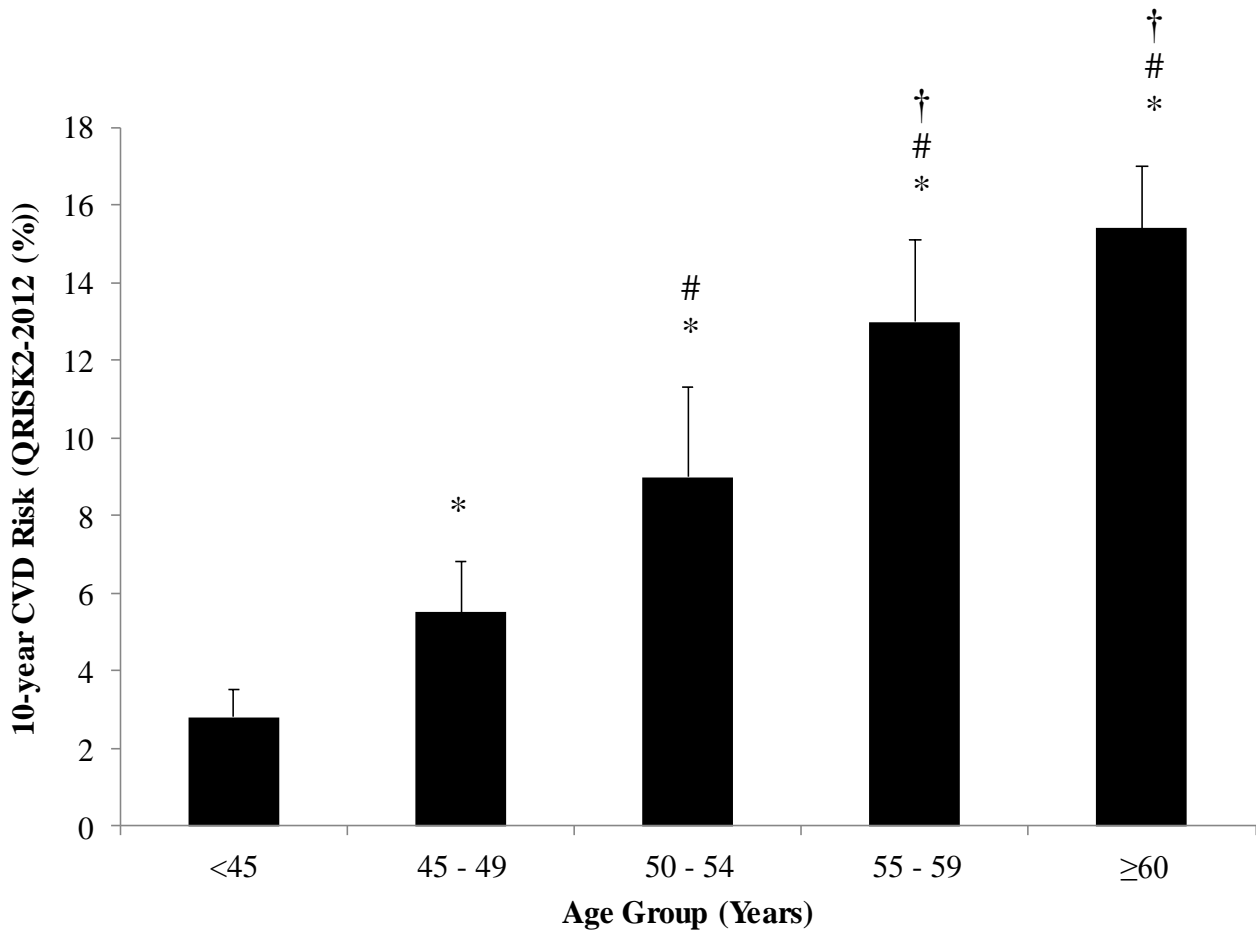
Figure 1. 10-year predicted CVD risk following age stratification of male workers. Data expressed as geometric mean ± approx. SD. * significantly different from <45 years age group (P<0.05), # significantly different from 45 – 49 years age group (P<0.05), † significantly different from 50 – 54 years age group (P<0.05).