Examining the levels of occupational physical activity and the risk of developing type 2 diabetes

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On behalf of the Prosiect Sir Gâr Group*

Occupational physical activity has been previously shown to have a protective benefit against developing type 2 diabetes. The study presented here investigated diabetes risk in two contrasting workplaces in South Wales. Two-hundred and four steel workers (SW) and 83 local health board employees (LHB) participated in this study. Demographic and anthropometric data, blood pressure, smoking status, physical activity levels, and family and medical histories were recorded and diabetes risk calculated using the QDiabetes® algorithm. A higher proportion of SW were assessed to be either physically "active" or "moderately active" compared with the LHB (93.6% versus 67.5%; *P*<0.001). However, the SW were observed to have larger BMI values (29.0 kg/m² [standard deviation, 4.4 kg/m²] versus 27.5 kg/m² [3.0 kg/m²]; *P*=0.004) and a greater proportion of them observed to be obese (38.7% versus 22.9%; *P*=0.01). Almost one-third of all workers assessed were predicted to be at either "intermediate" or "high" 10-year risk of developing diabetes. However, despite the higher BMI values observed in the SW, predicted risk of diabetes was comparable between workforces (QDiabetes, 6.3% [2.5%] versus 6.8% [2.2%]; *P*=0.494), thus suggesting that routine physical activity at work mitigates against the risk of developing type 2 diabetes.

Occupational (or work-time) physical activity has been previously shown to have a protective benefit against the development of type 2 diabetes (Hu et al, 2003). However, with employment becoming more sedentary in nature and an association between such behaviour and an increased risk of diabetes (Wilmot et al, 2012), there is potential for more individuals to develop the condition within the working environment. Diabetes remains a major health challenge in the UK. In 2011, just over 3 million individuals (6.8% of the national population) were estimated to be living with diabetes (Whiting et al, 2011), with a quarter of these individuals believed to be undiagnosed (Holman et al, 2011). The vast majority of these undiagnosed cases are working-age professionals (Holman et al, 2011) and individuals of working age, especially within the industrial workforce, are perceived to be a "hard-to-reach" population (Limm et al,

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Article points

1. This article examines prevalence of diabetes risk factors and 10-year risk in males in two contrasting workplaces.
2. Despite differences in occupational physical activity, comparable levels of diabetes risk factors and 10-year risk were observed.
3. About one-third of males assessed were at an increased risk (>10% 10-year risk of type 2 diabetes) and there was a high prevalence of males who were overweight or obese, or who were observed to have central obesity.
4. There was a higher BMI and a greater proportion of workers who were obese in the more physically active steel workers.
5. The data suggest that routine occupational physical activity mitigates the risk of developing type 2 diabetes.

Key words

- Diabetes risk
- Occupational health
- Physical activity

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Page points

1. This study examined the prevalence of baseline diabetes risk factors for employees based in two workplaces of contrasting work-time physical activity (steel works and local health board) in the same geographical region (Carmarthenshire, Wales).
2. All participants in this study were employees of either the local steel works or health board within the Welsh region of Carmarthenshire. These two worksites were part of an established project entitled "Prosiect Sir Gâr".
3. All recruited individuals attended a standardised screening appointment with an occupational health nurse, which lasted 30–40 minutes.

2011) as they are unable to attend primary care services during the working day and may not wish to utilise their "citizen time" for such purposes. Therefore, it would be of interest to explore if there is still evidence of a protective benefit against type 2 diabetes from work-time physical activity.

Aims

This study examined the prevalence of baseline diabetes risk factors for employees based in two workplaces of contrasting work-time physical activity (steel works and local health board) in the same geographical region (Carmarthenshire, Wales), with a secondary aim to examine the differences in risk factors for diabetes between the two workplaces.

Methods

Study population

All participants in this study were employees of either the local steel works or health board within the Welsh region of Carmarthenshire. These two worksites were part of an established project entitled "Prosiect Sir Gâr" (the "Carmarthenshire Project"). 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, 226 male steel industry workers accepted the invite for a risk assessment at baseline. Of these, five individual records could not be verified and 17 family histories were unknown, leaving a total of 204 employees in the steel workers (SW*) cohort for subsequent analysis. One hundred and fifteen male health board employees accepted a diabetes risk assessment. However, 20 of these individual records could not be verified and 12 family histories of diabetes were unknown, resulting in a local health board (LHB*) cohort of 83 males. All participants provided written consent and this study was approved by Dyfed Powys Local Research Ethics Committee (reference number: 11/WA/0101).

*Abbreviation used in methods and results only.

Baseline measurements and risk prediction

All recruited individuals attended a standardised screening appointment with an occupational health nurse, which lasted 30–40 minutes. During the session, demographic (date of birth, gender and postcode of residence) and anthropometric (body mass, height and waist circumference) data were collected. Systolic and diastolic blood pressure, smoking status, and family and medical histories were recorded and blood samples obtained via capillary puncture for HbA_{1c} analysis (DCA 2000™; Siemens Healthcare Diagnostics Ltd, Frimley). In addition, current physical activity levels were measured by the General Practice Physical Activity Questionnaire (GPPAQ [Department of Health, 2009]), which incorporates both work-time and leisure-time physical activity in its assessment. Once all baseline measurements were collected, 10-year predicted diabetes risk was calculated by entering the relevant variables into the online QDiabetes® risk algorithm (www.qdiabetes.org) devised by Hippisley-Cox and colleagues (2009). The QDiabetes algorithm has been validated and compared against the Cambridge Diabetes Risk Score and shown to have improved discrimination (Hippisley-Cox et al, 2009). Those individuals identified as being at "high risk" (10-year risk ≥20%) were referred to an internal lifestyle intervention programme, the details of which have been published elsewhere (Gray et al, 2014). This article focuses on the prevalence data collected at baseline and the diabetes risk within the samples.

Data analysis

The focus of our analysis within this study was to examine the prevalence of diabetes risk factors and 10-year diabetes risk between the two workforces. Statistical analysis was performed using SPSS software (version 19; SPSS Inc, Chicago, IL, USA) with significance set at $P<0.05$. Normality of data was assessed

using the one-sample Kolmogorov–Smirnov test. BMI and systolic and diastolic blood pressure data are represented as mean ± standard deviation. Age, waist circumference and QDiabetes scores did not have a normal distribution. These data were consequently log-transformed for analysis and are represented as the geometric mean and approximate standard deviation. Analysis of variance (ANOVA) was used for between-group comparisons of these data (LHB versus SW). Discrete variables are represented as number of workers and percentage of workforce in brackets. Chi-square testing was used to analyse between-group differences in these data. HbA_{1c} data did not have a normal distribution following log-transformation and these data are represented as median and interquartile range. These data were analysed using Mann–Whitney testing.

Results

Table 1 details the baseline characteristics of the SW and LHB cohorts. Compared with the SW, the LHB were older (50 ± 3 years versus 48 ± 2 years; P=0.004) and had elevated levels of systolic blood pressure (133 ± 14 mmHg versus 127 ± 12 mmHg; P=0.001). In contrast, the SW were found to have a higher BMI than the LHB (29.0 ± 4.4 kg/m^2 versus 27.5 ± 3.0 kg/m^2; P=0.004). No differences were found between the male employees of each worksite in regard to waist circumference, diastolic blood pressure, HbA_{1c} or QDiabetes scores (all P>0.05). However, when self-reported physical activity levels were examined, a number of differences were observed (*Figure 1*). A higher proportion of the SW were physically "active" (62.7% versus 20.5%; P<0.001), and fewer were "moderately inactive" (5.9% versus 26.5%; P<0.001), compared with the LHB. Furthermore, a greater percentage of the SW were either physically "active" or "moderately active" (93.6% versus 67.5%; P<0.001).

All-age diabetes risk analysis

Further analysis was performed to examine the proportion of individuals with specific diabetes risk factors. In regard to specific diabetes risk factors, as detailed in *Table 2*, a higher proportion of the SW were obese (38.7% versus 22.9%; P=0.01); more than half the LHB were overweight (60.2% versus 43.1%; P<0.01). When combined, the percentage of both worksites either overweight or obese was

Table 1. Baseline differences in diabetes risk factors between the two workplace settings.

Variable	Steel workers (n=204)	Local health board (n=83)	P-value
Age (years)*	48 ± 2	50 ± 3	0.004‡
BMI (kg/m^2)	29.0 ± 4.4	27.5 ± 3.0	0.004‡
Waist circumference (cm)*	100.5 ± 5.0	99.9 ± 3.9	0.660
Systolic blood pressure (mmHg)	127 ± 12	133 ± 14	<0.001‡
Diastolic blood pressure (mmHg)	85 ± 10	84 ± 9	0.304
HbA_{1c} (mmol/mol)†	38 [36–40]	37 [34–39]	0.140
HbA_{1c} (%)†	5.6 [5.4–5.8]	5.5 [5.3–5.7]	0.140
QDiabetes® (%)*	6.3 ± 2.5	6.8 ± 2.2	0.494

Data are expressed as means ± standard deviation, except: *Log-transformed data – geometric mean and approximate standard deviation reported. †Data not normally distributed following log-transformation – median [interquartile range] reported.

‡Significant difference between workforces (P<0.05).

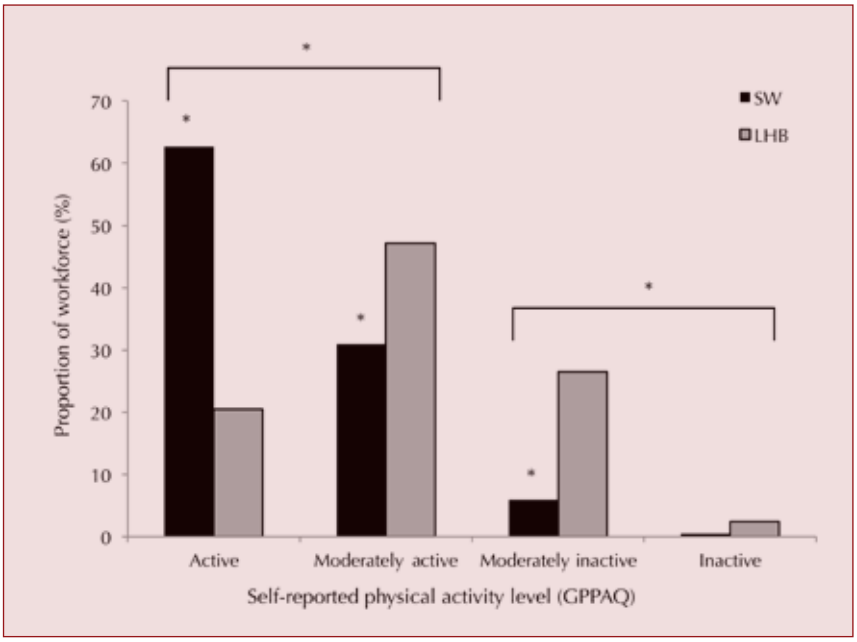

*Figure 1. Proportion of workforce, for steel workers (SW) and local health board employees (LHB), in each self-reported physical activity category as calculated by the General Practice Physical Activity Questionnaire (GPPAQ). *Significant differences between workforce groups (P<0.05).*

Table 2. Proportion of male workers with diabetes specific risk factors (above divide) and categorised by high, intermediate and low overall risk (below divide).

Variable	Steel workers (*n*=204)	Local health board (*n*=83)	*P*-value
BMI ≥30 kg/m²	79 (38.7)	19 (22.9)	0.01*
BMI of 25–29.9 kg/m²	88 (43.1)	50 (60.2)	<0.01*
Central obesity†	154 (75.5)	68 (81.9)	0.24
HbA_{1c} ≥48 mmol/mol (≥6.5%)	3 (1.5)	0 (0.0)	0.27
HbA_{1c} of 42–47 mmol/mol (6.0–6.4%)	27 (13.2)	8 (9.6)	0.40
Systolic blood pressure ≥140 mmHg	35 (17.2)	27 (32.5)	0.004*
Diastolic blood pressure ≥90 mmHg	71 (34.8)	23 (27.7)	0.25
Current smoker	30 (14.7)	9 (10.8)	0.39
QDiabetes® ≥20%	22 (10.8)	6 (7.2)	0.36
QDiabetes of 10–19.9%	45 (22.1)	17 (20.5)	0.77
QDiabetes <10%	137 (67.1)	60 (72.3)	0.40

Data are represented as numbers of workers with percentage of workforce in brackets.
*Denotes significant difference between workforces (*P*<0.05). †Central obesity as defined by International Diabetes Federation (2006) criteria: waist circumference ≥94 cm.

similar (81.8% of the SW versus 83.1% of the LHB, *P*=0.80). In addition, a significant proportion of both workforces were observed with central obesity (75.5% of the SW versus 81.9% of the LHB; *P*=0.24), as defined by International Diabetes Federation (IDF; 2006) criteria. Both workforces had somewhat high proportions of diastolic hypertension (*Table 2*), while the prevalence of systolic hypertension was greater in the LHB (32.5% versus 17.2%; *P*=0.004) and approximately one-tenth of workers from each worksite were diagnosed with impaired glucose regulation. In addition, the number of individuals at high, intermediate and low 10-year risk of developing diabetes was comparable between worksites, and more than one in four workers in each worksite were at an increased risk (QDiabetes ≥10%) of developing diabetes in the next 10 years.

Discussion

This study examined the prevalence of diabetes risk factors and 10-year diabetes risk in male employees within two different workplace settings in the same geographical location. Significant differences were observed in regard to self-reported levels of physical activity, with the male steel workers observed to be more physically "active" or "moderately active" than their more sedentary male health board counterparts. Despite this observation, there were few differences in regard to baseline and diabetes-specific risk variables between the two contrasting worksites.

We observed that 32.9% of steel workers and 27.7% of health board workers had either an intermediate (QDiabetes of 10.0–19.9%) or high (QDiabetes ≥20%) risk of developing diabetes. In addition to the number of workers at an increased predicted risk of developing diabetes, there were also a vast proportion of male employees observed to be either overweight or obese, coupled with a significant proportion of central obesity (*Table 2*) in both worksites. These two observations are of some concern, primarily as existing studies have documented that men develop diabetes at a lower BMI than their female counterparts (Logue et al, 2011; Paul et al, 2012), which could mean that the prevalence of obesity in both these worksites is leading to many workers having an increased susceptibility to the condition. Secondly, there is a high prevalence of individuals in both workplaces who had central obesity, which is a recognised risk factor for the metabolic syndrome, type 2 diabetes and CVD (Siren et al, 2012). However, waist circumference is not used in the QDiabetes algorithm (Hippisley-Cox et al, 2009) to predict type 2 diabetes. This suggests that despite significant levels of "central obesity" being observed in both workforces, this did not translate into an even greater number of individuals being deemed to be at intermediate or high risk of developing the condition.

Based on the differences between workforces in BMI values (1.5 kg/m²), it might have been inferred from existing research that the steel workers should have been at a predicted higher risk of developing type 2 diabetes than their local health board counterparts. Bombelli and associates (2011) observed that for every 1 kg/m² increase in BMI, an individual was at an 8.4% increased risk of diabetes. One suggestion for why this was not found in our

study is the different physical demands in each of the occupational settings: the health board workers tended to be more sedentary while the steel workers have a physically demanding occupation. It has been well established that BMI does not adequately account for lean muscle mass differences (Rothman, 2008), and this together with there being no statistically significant difference between the waist circumferences of either cohort suggests that the body composition of the two groups of male workers is dissimilar. In general, the steel workers have a greater BMI with the same waist circumference because they may be leaner owing to being more active. The routine daily physical activity of the steel workers may have increased their cardiorespiratory fitness, resulting in their lower systolic blood pressure, with a net effect of reducing their risk of developing type 2 diabetes (Lynch et al, 1996). The findings from this study suggest that the more sedentary health board employees appear to have an increased diabetes risk at a lower BMI, and the more active steel workers have a lower risk than what would be anticipated by their higher BMI. In addition, workplace physical activity undertaken by the steel workers may have also contributed to adaptations in endothelial function, which is an important benefit as endothelial dysfunction is a risk factor for hypertension; this therefore offers an explanation for the differences in systolic blood pressure between workforces (Maiorana et al, 2003).

The GPPAQ (Department of Health, 2009), which considers both work-time and leisure-time physical activity in its assessment, is advocated by NICE for helping people identify which of their activities are of "moderate" or "vigorous" intensity to meet the minimum requirements of physical activity in the prevention of type 2 diabetes (NICE, 2012). Previous research has clearly demonstrated physical activity to have a significant importance in preventing high-risk individuals with impaired glucose tolerance from developing type 2 diabetes (Tuomilehto et al, 2001; Knowler et al, 2002). However, despite the evidence, physical activity is not considered as a risk factor in the QDiabetes risk assessment, which could be viewed as a limitation. For example, the developers of the Finnish Diabetes Risk Score assessment included physical activity into their design to emphasise the importance of a healthy lifestyle in lowering diabetes risk (Lindström and Tuomilehto, 2003). Another limitation with QDiabetes in predicting diabetes risk is the lack of inclusion of waist circumference. Research has demonstrated that "central obesity" (waist circumference >102 cm in males and >88 cm in females) is an independent risk factor for diabetes, regardless of BMI value (Langenberg et al, 2012). A two-fold increase in diabetes incidence and "central obesity" was observed in another study (Freemantle et al, 2008), underlining the importance of waist circumference as a measurement in determining risk of type 2 diabetes. It would be of interest to investigate if our findings were consistent when other validated risk assessments are adopted that incorporate waist circumference as a risk factor in their design.

Conclusion

In summary, despite some of the limitations discussed, the introduction of diabetes risk assessments in two contrasting workplaces has uncovered significant occult risk factors. Workplace physical activity may have improved cardiorespiratory fitness in the steel workers, which would explain the lower systolic blood pressure values and the lower risk at a higher BMI in this cohort. Of note, the prevalence of diabetes-specific risk factors in males is significant regardless of occupation style and work-time physical activity performed. Surprisingly, almost one in three (31.4%) of all participants assessed were predicted to be at either high or intermediate risk of developing diabetes in the next 10 years. Thus, this study identifies a useful place for diabetes risk assessment initiatives to be implemented (in the work environment), especially for reaching working males, and also points to the importance of cardiorespiratory fitness in mitigating diabetes risk. ■

Page points

1. Despite some limitations, the introduction of diabetes risk assessments in two contrasting workplaces has uncovered significant occult risk factors.
2. The prevalence of diabetes-specific risk factors in males is significant regardless of occupation style and work-time physical activity performed.
3. This study identifies a useful place for diabetes risk assessment initiatives to be implemented (in the work environment), especially for reaching working males, and also points to the importance of cardiorespiratory fitness in mitigating diabetes risk.

"Workplace physical activity may have improved cardiorespiratory fitness in the steel workers, which would explain the lower systolic blood pressure values and the lower risk at a higher BMI in this cohort."

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Conflicts of interest

The authors have declared no conflicts of interest.

Bombelli M, Facchetti R, Sega R et al (2011) Impact of body mass index and waist circumference on the long-term risk of diabetes mellitus, hypertension, and cardiac organ damage. *Hypertension* **58**: 1029–35

Department of Health (2009) The General Practice Physical Activity Questionnaire (GPPAQ): A screening tool to assess adult physical activity levels, within primary care. DH, London. Available at: http://bit.ly/1zyiaMH (accessed 06.11.14)

Freemantle N, Holmes J, Hockey A et al (2008) How strong is the association between abdominal obesity and the incidence of type 2 diabetes. *Int J Clin Pract* **62**: 1391–6

Gray BJ, Bracken RM, Thomas M et al (2014) 'Prosiect Sir Gâr': workplace-based cardiovascular disease and diabetes risk assessments. *Occup Med (Lond)* **64**: 549–56

Hippisley-Cox J, Coupland C, Robson J et al (2009) Predicting risk of type 2 diabetes in England and Wales: prospective derivation and validation of QDScore. *BMJ* **338**: b880

Holman N, Forouhi NG, Goyder E et al (2011) The Association of Public Health Observatories (APHO) Diabetes Prevalence Model: estimates of total diabetes prevalence for England, 2010-2030. *Diabet Med* **28**: 575–82

Hu G, Qiao Q, Silventoinen K et al (2003) Occupational, commuting, and leisure-time physical activity in relation to risk for Type 2 diabetes in middle-aged Finnish men and women. *Diabetologia* **46**: 322–9

International Diabetes Federation (2006) The IDF consensus worldwide definition of the METABOLIC SYNDROME. Available at: http://www.idf.org/webdata/docs/IDF_Meta_def_final.pdf (accessed 06.11.14)

Knowler WC, Barrett-Connor E, Fowler SE et al (2002) Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* **346**: 393–403

Langenberg C, Sharp SJ, Schulze MB et al (2012) Long-term risk of incident type 2 diabetes and measures of overall and regional obesity: the EPIC-InterAct case-cohort study. *PLoS Med* **9**: e1001230

Limm H, Gündel H, Heinmüller M et al (2011) Stress management interventions in the workplace improve stress reactivity: a randomised controlled trial. *Occup Environ Med* **68**: 126–33

Lindström J, Tuomilehto J (2003) The Diabetes Risk Score. A practical tool to predict type 2 diabetes risk. *Diabetes Care* **26**: 725–31

Logue J, Walker JJ, Colhoun HM et al (2011) Do men develop type 2 diabetes at lower body mass indices than women? *Diabetologia* **54**: 3003–6

Lynch J, Helmrich SP, Lakka TA et al (1996) Moderately intense physical activities and high levels of cardiorespiratory fitness reduce the risk of non-insulin-dependent diabetes mellitus in middle-aged men. *Arch Intern Med* **156**: 1307–14

Maiorana A, O'Driscoll G, Taylor R et al (2003) Exercise and the nitric oxide vasodilator system. *Sports Med* **33**: 1013–35

NICE (2012) *Preventing type 2 diabetes: risk identification and interventions for individuals at high risk* (NICE public health guidance 38). Available at: http://www.nice.org.uk/guidance/PH38 (accessed 06.11.14)

Paul S, Thomas G, Majeed A et al (2012) Women develop type 2 diabetes at a higher body mass index than men. *Diabetologia* **55**: 1556–7

Rothman KJ (2008) BMI-related errors in the measurement of obesity. *Int J Obes (Lond)* **32**(Suppl 3): S56–59

Siren R, Eriksson JG, Vanhanen H (2012) Waist circumference a good indicator of future risk for type 2 diabetes and cardiovascular disease. *BMC Public Health* **12**: 631

Tuomilehto J, Lindström J, Eriksson JG et al (2001) Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* **344**: 1343–50

Whiting DR, Guariguata L, Weil C et al (2011) IDF Diabetes Atlas: Global estimates of the prevalence of diabetes for 2011 and 2030. *Diabetes Res Clin Pract* **94**: 311–21

Wilmot EG, Edwardson CL, Achana FA et al (2012) Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia* **55**: 2895–905