Demographic and lifestyle predictors of body mass index among offshore oil industry workers: cross-sectional and longitudinal findings

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Background
Significant overweight among offshore workers on North Sea oil and gas installations has been linked to high calorie intake, lack of active leisure-time pursuits, and environmental factors conducive to weight gain. However, the prevalence of overweight among offshore workers has not been examined in recent data, and no longitudinal studies of body mass index (BMI) in this occupational group have been reported.

Aims
The present study sought to examine BMI levels in a sample of UK offshore personnel, and to evaluate demographic factors, smoking and work-related physical activity as predictors of BMI, and 5 year change in BMI.

Methods
Survey data (including age, education, marital status, work-related physical activity and height/weight) were collected in 1995 from male workers on 17 North Sea installations (n = 1581, 83% response rate); follow-up data were obtained in 2000 (n = 354, 34.9% of the potential sample).

Results
Overall mean BMI was 25.6 (2.8) kg/m²; rates of obesity (BMI > 30) and overweight (BMI = 25–30) were 7.5 and 47.3%, respectively. Mean age was 38.7 (8.9) years; linear and quadratic age terms predicted BMI. Age-adjusted BMI values were very similar to those reported from other offshore studies over the past 15 years. Age, marital status, education, smoking and physical activity significantly predicted baseline BMI, but only age (and some interactive effects) predicted 5 year BMI change.

Conclusions
The present age-adjusted BMI values were closely similar to those found offshore in the mid-1980s, but also to recent national data; thus, North Sea personnel do not appear to reflect current population trends towards increased BMI levels. This result accords with the emphasis now given to health promotion (particularly dietary change) on offshore installations; the present findings also highlight the need to focus these initiatives on workers with sedentary jobs and/or low education.

Key words
Age; diet; environment; health promotion; physical activity; smoking.

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Introduction
An important issue in research into health and safety on North Sea oil and gas installations is whether the lifestyle of offshore personnel is conducive to the development of overweight and obesity [defined in terms of body mass index (BMI) as BMI range 25–30 and BMI > 30, respectively]. These conditions are associated not only with risks of cardiovascular disease and other serious
health problems [1–3] but also with increased rates of accidents and injuries at work [4–6]. Moreover, the offshore environment exposes employees to work-related demands that may be especially hazardous to individuals with high BMI levels; for example, negotiating narrow walkways and steep stairs (particularly in emergencies), and escape from helicopter exits in the event of a forced landing, are likely to be hindered by excess weight [7]. From a health and safety perspective, therefore, the possibility that offshore personnel are at particular risk of becoming overweight merits attention, especially in view of the increasing age profile of the offshore workforce, and the rise in sedentary jobs and automated tasks on North Sea installations [8,9].

The trend towards increased age and reduced physical exertion is particularly significant when considered in the context of a work environment in which social and behavioural patterns also tend to lead to weight gain. Thus, a typical offshore work rota is 2–3 weeks offshore followed by a similar period of shore leave. While offshore, personnel work long hours, live in crowded conditions, and are isolated from family life; in this environment, meals provide the main focus for relaxation and social interaction. Large amounts of food are served (cooked meals are provided every 6 h round the clock), and hot drinks and snacks are always available. All these factors may lead to a greater calorie intake than is justified by the energy expended. Among UK offshore personnel, average daily intake was found to be high (3000+ calories) relative to that of men in a national population survey; fat accounted for 40% of calorie intake offshore, and cholesterol levels were also elevated [8]. Moreover, the offshore diet is perceived to be less healthy than that onshore [9]. Similarly, a detailed dietary study, carried out on Norwegian offshore installations (based on interviews and food purchase records) revealed high calorie intake, excessive consumption of fat, insufficient dietary fibre and poor adherence to dietary recommendations [10].

These findings suggest that obesity and overweight among offshore personnel are likely to be more prevalent than in the general population. However, the literature provides little detailed information about BMI levels among UK offshore personnel, with the exception of a study carried out in the mid-1980s by Light and Gibson [11]. This study showed that among 419 males, 40.1% were overweight, while an additional 5.5% were obese; within three age bands, the incidence of overweight was found to be significantly greater than that in the general UK population [12]. In addition, a study of cardiovascular risk factors [13], based on 372 Norwegian offshore personnel assessed in 1993, reported a mean age-adjusted BMI value comparable to that found by Light and Gibson.

The present study sought to provide more recent information about rates of overweight and obesity, and levels of BMI generally, among UK offshore personnel (n = 1581); the available data allowed cross-sectional analysis of BMI in relation to age, and comparison with published values. The study also extended previous studies of BMI among offshore personnel in examining associations not only with age, but also with other demographic variables (education and marital status), smoking and work-related physical activity. In addition, following the recommendation that longitudinal research into overweight among offshore personnel should be undertaken [11], the present study also assessed change in BMI over a 5 year period in a follow-up group (n = 354).

**Method**

**Baseline data collection**

Baseline survey data were collected in 1995 from personnel working on 17 UK offshore installations, operated by 11 different companies. Researchers visited each installation on two occasions; individual letters describing the research aims and guaranteeing confidentiality of the data were distributed to all potential participants. Further details of data collection are given elsewhere [14]. Questionnaires were identified only by research numbers; a confidential name/number list was compiled by the researcher. Completed questionnaires were obtained from 1598 male personnel (overall response rate 82.6%). Deletion of missing data cases reduced the sample size to n = 1581.

**Baseline measures**

**Demographic variables**

Age was recorded in years/months. Education was coded in terms of the highest level achieved. Three levels were identified: level 1, ‘Certificate of secondary school education, or equivalent’ (n = 281, 18%); level 2, ‘Technical certificates/college diplomas’ (n = 819, 52%); and level 3, ‘Advanced level examinations and/or university degree’ (n = 193, 12%); 288 (18%) personnel reported no formal qualifications (level 0). Marital status was coded 1 (single/divorced, n = 412, 26%) or 2 (married/living with partner, n = 1169, 74%).

**Physical workload**

Participants recorded job titles and a brief description of their work. Eight job types were identified. Physical exertion levels in these job types were examined by reference to participants’ survey ratings (on a five-point, 0–4 scale) of the extent to which their jobs involved heavy physical workload. A one-way ANOVA of responses showed a highly significant difference across jobs (F = 50.7, df = 7,1566, P < 0.001). Using a post-hoc multiple
range test (the Student–Newman–Keuls procedure), three homogeneous subsets of jobs were identified. Across these subsets, differences in physical workload scores were significant; within the subsets, jobs did not differ significantly in physical workload. The subsets were: (i) drilling/construction/deck operations ($n = 408, 26\%$ of the total sample); (ii) production, maintenance, technical and catering/flotel ($n = 881, 56\%$); and (iii) management and administration jobs ($n = 292, 18\%$). The three categories were designated ‘physically demanding’ (mean physical workload score 2.52), ‘active’ (1.94) and ‘sedentary’ (0.97), respectively.

Smoking habits
Participants were asked if they were current smokers. Responses were coded 0 (non-smoker, $n = 1012, 64\%$) or 1 (smoker, $n = 569, 36\%$).

Body mass index
Participants reported height (without shoes) and weight (light clothing, no shoes). BMI was calculated from the formula:

$$\text{BMI} = \frac{\text{weight in kg}}{\text{height in m}^2}$$

Follow-up data collection
Individual letters were mailed in 2000 to personnel who had agreed in 1995 to be contacted for follow-up purposes ($n = 1013, 61.5\%$); if necessary, further attempts to contact this group were made through employing companies. Responses were received from 485 personnel, but some declined to take part or failed to return the questionnaire ($n = 126$), or had data missing ($n = 5$). Complete follow-up data were obtained from 354 personnel (34.9\% of the potential sample). Data on current weight and smoking habits, and whether respondents were ($n = 286, 81\%$) or were not ($n = 68, 19\%$) still employed offshore were used in the present study.

Statistical treatment
Multiple regression was used to control for confounding between the independent variables in the cross-sectional model predicting baseline BMI, and in the longitudinal analysis of change in BMI (controlled for baseline BMI) over the 5 year follow-up period. The analyses were run on SPSS Version 10.0.5, using the GLM procedure.

Results

Baseline data analyses

Overall BMI levels
As shown in Table 1, which summarizes the BMI data from the present study, the mean (± SD) BMI in the baseline sample was 25.6 ± 2.8, range 18.1–37.3. Mean height and weight were 1.77 ± 0.77 m and 80.3 ± 10.4 kg, respectively. Of the sample, 7.5\% ($n = 118$) were rated as obese (BMI > 30), including three individuals with BMI > 35. The proportion of overweight (BMI = 25–30) individuals was 47.3\% ($n = 748$). The remaining 45.2\% ($n = 715$) of the sample had BMI values <25, including a small proportion (1.3\% of the total, $n = 20$) with BMI < 20.

BMI in relation to age
The mean age of the sample was 38.7 ± 8.9 years. The correlation between age and BMI was 0.23 ($P < 0.001$), but the relationship was curvilinear, with significant linear ($P < 0.001$) and quadratic ($P < 0.02$) components. The equation took the form

$$\text{BMI} = 20.328 + (0.207 \times \text{age}) – (0.0017 \times \text{age}^2)$$

Figure 1 shows mean BMI values in 5 year age bands, together with the regression line plotted from the quadratic equation.

Multivariate prediction of BMI
Multiple regression was used to examine the extent to which demographic factors (marital status and education), physical activity, and smoking, predicted BMI over and above the linear and quadratic age terms. Smoking was the strongest predictor ($F = 27.2$, df = 1,1571, $P < 0.001$), smokers having significantly lower BMI than non-smokers. Physical activity ($F = 5.1$, df = 2,1571, $P < 0.01$) and education ($F = 3.3$, df = 3,1571, $P < 0.02$) were also significant. Personnel in

Table 1. Summary of BMI data: total sample in 1995, follow-up group in 1995 and 2000, and increase over the 5-year period

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean age ± SD</th>
<th>Mean BMI ± SD</th>
<th>Range Low</th>
<th>Range High</th>
<th>% overweight (BMI 25–30)</th>
<th>% obese (BMI &gt; 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sample in 1995</td>
<td>38.7 ± 8.9</td>
<td>25.6 ± 2.8</td>
<td>18.1</td>
<td>37.3</td>
<td>47.3</td>
<td>7.5</td>
</tr>
<tr>
<td>Follow-up group in 1995</td>
<td>39.9 ± 8.3</td>
<td>25.9 ± 2.8</td>
<td>19.0</td>
<td>34.8</td>
<td>51.1</td>
<td>9.0</td>
</tr>
<tr>
<td>Follow-up group in 2000</td>
<td>44.9 ± 8.3</td>
<td>26.6 ± 2.9</td>
<td>19.0</td>
<td>35.4</td>
<td>54.5</td>
<td>14.4</td>
</tr>
<tr>
<td>Change from 1995 to 2000</td>
<td>+ 5.0 years</td>
<td>+0.7 ± 1.3</td>
<td>−3.6</td>
<td>+4.4</td>
<td>+3.4</td>
<td>+5.4</td>
</tr>
</tbody>
</table>
sedentary jobs had a higher BMI than those in active or physically demanding jobs, and those with no formal educational qualifications had significantly higher BMI than those with qualifications. Also, marriage or co-habitation was associated with higher BMI than single status \( (F = 4.9, \text{df} = 1,1571, P < 0.05) \). Table 2 shows the raw and adjusted BMI means and 95% confidence intervals (95% CIs) for each level of the categorical variables.

**Comparison with published data**

Light and Gibson [11] reported a mean BMI of 24.8 ± 2.9 for 419 UK offshore personnel, mean age 32.5 ± 8.2 years. For comparison purposes, the linear regression equation relating BMI to age derived by these authors \( (\text{BMI} = 0.132 \times \text{age} + 20.552) \) was applied to the present data; the predicted mean BMI calculated on this basis was 25.65, as compared with the present observed value of 25.61. Thus, the observed difference in BMI between the two samples was attributable to the difference in age. Similarly, although overall rates of obesity and overweight in the present sample were higher than the corresponding values reported by Light and Gibson (5.5 and 40.1%, respectively), when comparisons were made within age groups, there was close correspondence between the prevalences observed.

The present data were also compared with data reported by Oshaug et al. [13] for 372 male Norwegian offshore personnel of mean age 38.6 ± 7.8 years, similar to the present sample. Allowing for the adjustment made by Oshaug et al. for clothing (subtracting 1.5 kg from the measured weights), the appropriate comparison BMI value in the Norwegian sample was 25.59 ± 2.7. Neither of these two studies tested a curvilinear relationship between age and BMI, whereas in the present analysis, BMI was predicted by significant linear (0.207) and quadratic (–0.0017) age terms. However, these coefficients agreed closely with the values of 0.212 and –0.002, respectively, reported for a male general population sample [15].

**Analysis of follow-up data**

To assess the extent to which the sample included in the longitudinal analysis was representative of the initial 1995 sample, baseline means for BMI and age were compared for two groups: those who were (group I, \( n = 354 \)) or were not (group II, \( n = 1227 \)) included in the follow-up analysis. Mean baseline BMI was higher for group I, 25.9 (2.8), than for group II, 25.5 (2.8), but the two groups also differed in age, group I, 39.9 (8.3) years in 1995; group II, 38.3 (9.1) years. The two groups did not differ

![Figure 1. The relationship between age and BMI; age-grouped means (with corresponding 95% confidence limits) are shown, together with the regression line from the quadratic equation.](https://academic.oup.com/occmed/article/53/3/213/1404163)

**Table 2.** Raw means and standard deviations, adjusted BMI values and 95% CI for marital status, educational level, activity level and smoking

<table>
<thead>
<tr>
<th>Marital status</th>
<th>( n )</th>
<th>Raw BMI (mean ± SD)</th>
<th>Adjusted BMI</th>
<th>95% CI</th>
<th>( P^a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Married</td>
<td>1169</td>
<td>25.9 ± 2.8</td>
<td>25.6</td>
<td>25.5–25.8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Single/divorced(^b)</td>
<td>412</td>
<td>24.8 ± 2.6</td>
<td>25.3</td>
<td>24.9–25.6</td>
<td>–</td>
</tr>
<tr>
<td>Educational level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td>193</td>
<td>25.1 ± 3.0</td>
<td>25.0</td>
<td>24.6–25.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Level 2</td>
<td>819</td>
<td>25.6 ± 2.7</td>
<td>25.5</td>
<td>25.2–25.7</td>
<td>&lt;0.10</td>
</tr>
<tr>
<td>Level 1</td>
<td>281</td>
<td>25.5 ± 2.7</td>
<td>25.6</td>
<td>25.2–25.9</td>
<td>ns</td>
</tr>
<tr>
<td>No qualifications(^b)</td>
<td>288</td>
<td>26.0 (2.9)</td>
<td>25.8</td>
<td>25.5–26.1</td>
<td>–</td>
</tr>
<tr>
<td>Work activity level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physically demanding</td>
<td>408</td>
<td>25.2 ± 2.7</td>
<td>25.2</td>
<td>24.9–25.5</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Active</td>
<td>881</td>
<td>25.5 ± 2.7</td>
<td>25.3</td>
<td>25.1–25.5</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Sedentary(^b)</td>
<td>292</td>
<td>26.3 ± 2.9</td>
<td>25.9</td>
<td>25.5–26.2</td>
<td>–</td>
</tr>
<tr>
<td>Smoking habits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-smoker</td>
<td>1012</td>
<td>25.9 ± 2.8</td>
<td>25.8</td>
<td>25.6–26.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Smoker(^b)</td>
<td>569</td>
<td>25.1 ± 2.7</td>
<td>25.1</td>
<td>24.8–25.3</td>
<td>–</td>
</tr>
<tr>
<td>Total sample</td>
<td>1581</td>
<td>25.6 ± 2.8</td>
<td>25.5</td>
<td>25.3–25.6</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Significance levels are shown relative to the reference groups.

\(^b\)Indicates the reference group in each category.
significantly \( F = 3.44, \text{df} = 1,1581, \text{ns (not significant)} \) in age-adjusted baseline BMI values (group I, 25.8, 95% CI = 25.6–26.1; group II, 25.5, 95% CI = 25.4–25.7). All further analyses were carried out on the group I data.

**Change in BMI from baseline to 5 year follow-up**

Over the 5 year interval from 1995 to 2000, mean BMI increased from 25.9 (2.8) to 26.6 (2.9) (see Table 1). The increase of 0.7 (1.33) was highly significant \( (t = 9.23, \text{df} = 353, P < 0.001) \), and was equivalent to an increase of 2.1 (4.2) kg in weight. The proportion in the obese category increased from 9.0 to 14.4%, while the proportion overweight increased from 51.1 to 54.5%. Changes in BMI and weight were negatively related to age, \( B = −0.032 \ (P < 0.001) \) and \( B = −106 \ (P < 0.001) \), respectively, but there were no significant quadratic age effects. Among those aged <40 years in 1995 (\( n = 158 \)), BMI increased by 0.86 ± 1.33 over the 5 year period, equivalent to a weight increase of 2.7 ± 4.3 kg; for the 40–59 years age group (\( n = 196 \)), the BMI increase was 0.48 ± 1.23, equivalent to a weight increase of 1.5 ± 4.0 kg. Neither mean age nor mean change in BMI differed significantly between those who moved onshore prior to follow-up (\( n = 68 \)) and those continuing to work offshore (\( n = 286 \)).

**Multivariate analysis of follow-up data**

The independent variables used to predict BMI change were the same as those in the cross-sectional analysis, with the addition of baseline BMI to control for initial level. Age was the only significant main effect; it was inversely related to BMI change (\( F = 6.7, \text{df} = 1,344, P = 0.01 \)). There was also a weak overall effect of educational level (\( P = 0.15 \)). In the light of published comparisons of BMI between groups with and without formal qualifications [16], this contrast was evaluated in the present analysis; it was found to be significant (\( F = 4.9, \text{df} = 1,346, P < 0.03 \)), those without qualifications showing a larger increase in BMI than those with qualifications. Adjusted scores were 0.72 (95% CI = 0.50/0.95) for those with qualifications (\( n = 314 \)) and 1.21 (95% CI = 0.78/1.65) for those with no qualifications (\( n = 40 \)).

The analysis was extended to take account of changes between 1995 and 2000 in environment (continuing offshore versus moving onshore) and in smoking behaviour (ceasing or initiating smoking). Confirming the univariate findings, BMI change was not significantly affected by whether or not individuals were still working offshore at follow-up (\( F < 1 \)); moreover, there were no significant interactions involving this variable. The effect of change in smoking habits depended on baseline smoking behaviour (\( F = 16.23, \text{df} = 1,343, P < 0.001 \)): continuing smokers did not differ from continuing non-smokers in BMI increase (0.74 and 0.69, respectively), but BMI increased (1.42) among smokers who quit, and decreased among those who started smoking (-0.72). Over and above these effects, there was a weak interaction between age and physical activity level (\( F = 2.72, \text{df} = 2,341, P < 0.07 \)); this interaction reflected the trend for the negative relationship between age and increase in BMI to be more marked for physically demanding jobs (\( B = −0.071, \text{df} = 1,346, P = 0.002, n = 70 \)) than for either active (\( B = −0.023, \text{df} = 194, P < 0.10, n = 194 \)) or sedentary jobs (\( B = −0.016, \text{ns}, n = 90 \)). Thus, the magnitude of BMI increase with age was inversely related to physical activity.

**Discussion**

In reviewing the results presented above, the age-adjusted BMI levels found in the present study are considered in relation to data obtained in previous offshore studies, and in relation to recently published general population findings; underlying issues of nutrition and food consumption, and recent initiatives to promote ‘healthy eating’ in the offshore environment, are discussed in this context. Subsequently, the findings relating to demographic factors, smoking, and physical activity as predictors of BMI, and BMI change, among offshore personnel are reviewed, and several methodological issues are addressed.

**BMI levels among offshore personnel**

The present sample included ~5.5% of the total UK offshore workforce at the time of data collection, and was broadly representative of the UK North Sea population as a whole [14]. In this sample, values closely similar to corresponding data reported for an offshore sample assessed in 1984 [11] were observed for the proportions of obese and overweight individuals in particular age bands, the age-adjusted BMI means, and the overall standard deviation. Thus, the present results do not suggest any general increase in age-adjusted BMI levels in the male offshore workforce between 1984 and 1995, although the increasing age profile of the offshore population is reflected in the higher mean age of the present sample and associated higher raw mean BMI, as compared with the 1984 data. The raw mean BMI value in the present sample was also consistent with the value of 25.65 kg/m² reported for a comparable UK offshore sample in 1989 [17]. Stability of BMI among offshore personnel over time was further demonstrated by the close agreement between the overall BMI mean and SD in the present sample and the corresponding values reported for an offshore sample of similar age assessed in 1993 [13].

Light and Gibson [11] found that rates of overweight in the three main age groups in their sample were significantly higher than general population data obtained in
1980 [12], and the same finding applies to the present data as compared with these norms. However, evidence indicates that in recent years there has been an increase in population BMI values in Europe [18–20], and in developed countries more generally [21,22]. For instance, Midtbjell et al. [20] found that levels of obesity increased from 7.5 to 14.0% between 1984–1986 and 1995–1997 in cross-sectional survey data from large samples of healthy Norwegian men, with a corresponding increase in mean BMI from 25.2 to 26.4. Against this background, the evidence reviewed above does not suggest any general increase in BMI among offshore personnel between 1984 and 1995. Moreover, BMI levels in the present sample were comparable with recently published age-adjusted values for UK male samples [23,24].

Although few studies have reported change in BMI over a time period corresponding to that examined in the present study (1995–2000), some relevant data are available. Thus, the BMI increase of 0.70 ± 1.32 among those in the follow-up sample aged 20–49 years in 1995 (n = 196) was closely comparable with the corresponding increase of 0.8 over a 6 year period (1991–1997) reported for a Dutch cohort in the same initial age range [25]. Similarly, data reported by Sundquist and Johansson [26] showed age-adjusted rates of increase in BMI over a period of 8 years which were in line with the present findings. In terms of weight increase, Coakley et al. [27] found weight increased by 1.4 kg over 4 years among male health professionals in the 44–54 years age range, as compared with an increase of 1.56 kg in the present group for the same age range over 5 years (n = 112). Moreover, in the present study, increase in BMI did not differ significantly between those continuing to work offshore and those who moved onshore during the follow-up period.

Thus, taken together, published data and the present findings suggest that BMI has remained stable in the offshore population (other than age-related changes associated with the increasing age profile of the workforce) since 1984. Moreover, neither cross-sectional nor longitudinal findings of the present study suggest that BMI levels among offshore oil personnel in 1995, or the rate of change of BMI over the follow-up period, were significantly discrepant from recent normative data for males in the general population. Consequently, although there was no decrease in age-adjusted BMI among offshore personnel from 1984 to 1995, the workforce appears to have resisted the general population trend towards increased BMI levels.

One likely explanation of this result is the increasing emphasis given to health promotion offshore in recent years on both UK and Norwegian installations. For instance, the ‘lifestyle’ programme introduced by one large company operating North Sea installations identified smoking, weight and alcohol intake as particular health-related targets [28]. This programme included individual advice from a nutritionist, and ‘healthy eating’ seminars for catering staff and platform personnel generally; among other performance indicators, the target of >25% of those with excess weight reducing weight was exceeded 2-fold, a level of 50% being achieved. Reports from catering contractors also indicated that eating patterns among offshore personnel had changed in ways indicative of a healthier diet.

In a more detailed study, carried out on Norwegian installations, the intake of foods and nutrients was found to change significantly, and in the direction recommended by national guidelines, between 1985 and 1993 [29]. Thus, 56% of those surveyed reported having changed their diet since 1985, increasing consumption of cereals, fruits, low-fat milk, vitamin C and dietary fibre. The authors concluded that nutrition promotion activities on the installations concerned, including provision of a health handbook (given to individuals at the time of renewing required offshore medical certificates), were the likely cause of the diet changes. Consistent with the survey data, food availability (assessed from food purchase records over a 5 month period relative to the number of person-days offshore during that period) also changed between 1985 and 1993, reflecting a generally healthier diet.

In addition to health promotion, cost-reduction strategies may have played an indirect role in stabilizing BMI levels among offshore personnel against general population trends. Thus, since the mid-1980s, the North Sea industry has been seeking to reduce costs, particularly on platforms with diminishing production levels. One aspect of cost reduction has been increasingly tight control over catering budgets. Although catering standards remain generally high, these budgetary changes have had some consequences for the amount and quality of food served, and the food choices available, which may have accentuated dietary changes resulting from ‘healthy eating’ initiatives.

**Predictors of BMI: cross-sectional analyses**

**Demographic factors**

The role of age in relation to obesity and overweight, and BMI levels more generally has been widely reported [15,16,23]. Data obtained in the present study reflected the age/BMI relationship found previously among offshore personnel [11] in that the linear regression equation derived in that study closely predicted the mean BMI value for the present sample. However, in the present data, the relationship between age and BMI had both linear and quadratic components; the form of the curvilinear relationship was similar to that reported by Grinker et al. [15], the linear and quadratic coefficients being almost identical in the two sets of data. As also
shown in other studies [16,26], BMI increased more strongly with age at younger ages, the effect becoming less marked as age increased, with little or no further increase (and some tendency to decrease) beyond 50–55 years. In the present study, age was also a significant predictor of change in BMI and in weight over the 5 year follow-up period; consistent with the cross-sectional findings, the relationship was negative. This result accords with other longitudinal findings [15], but contrasts with a recent finding of no significant effect of age on BMI change over a 6 year period [25].

The significance of marital status and educational level in relation to BMI in the present study was also consistent with previously reported findings for the roles of these variables in relation to overweight. Thus, married/cohabiting participants had significantly higher BMI than those who were single or divorced [16,26], and educational level was inversely related to BMI [18,23,25,30]. As also found by Cairney and Wade [16], the contrast between those in the lowest educational category (i.e. those with no educational qualifications in the present study) and those with any of the educational levels above the lowest was particularly marked.

Smoking

The effects of smoking on BMI have been widely reported in the literature. As found previously [31–34], current smokers in the present sample had significantly lower BMI than non-smokers; indeed, smoking was the strongest predictor of BMI in the cross-sectional analysis.

Work-related physical activity

In examining the effects of physical activity on BMI, the present study focused specifically on work-related activity; job type and individual workload ratings were used to identify three levels of work-related physical activity. This factor was significantly related to BMI after adjustment for other factors in the multivariate model; comparison of adjusted BMI values showed that sedentary work was associated with significantly higher BMI than either active or physically demanding jobs. Other authors have found leisure time exercise to be inversely related to rates of overweight and BMI values [26,30] in general population samples, although in one recent study these relationships were found only among women, and occupational/domestic activity did not predict BMI in either men or women [35]. Possibly, the relatively low level of activity assessed (≥1 h per week) contributed to this result. In contrast, increased vigorous activity was found to be associated with weight loss over a 4-year period among men in the 45–54 and 55–64 years age groups (although not among those aged >65 years) [27].

Predictors of change in BMI over 5 year follow-up

Consistent with other findings [25], demographic factors and other variables that predicted BMI cross-sectionally were generally non-significant in the analysis of BMI change (controlled for baseline BMI). The main exceptions in the present analysis were age and change in smoking habits; as found previously [33], ceasing smoking was associated with significant increase, and initiating smoking with significant decrease, in BMI. The effect of age on BMI change was negative overall, older individuals showing less weight gain over the 5 year interval than their younger counterparts, as also found by Grinker et al. [15]; however, the interaction between age and activity level showed that this effect was more marked among those engaged in physically demanding jobs than among those in jobs requiring less energy expenditure.

Implications for health promotion offshore

The oil industry has given considerable attention to health promotion among employees, including assessing health promotion needs and evaluating the effectiveness of the programmes implemented [28,36–38]. However, among medical/nursing staff working on North Sea installations, mixed attitudes to health promotion have been reported [29]; although some offshore ‘medics’ routinely raise nutrition issues at regular installation meetings concerned with health and safety, others are indifferent. In contrast, Fenn [8] observed enthusiasm among offshore medics for health promotion activities, including encouragement of healthy eating. She also noted that offshore personnel are effectively a ‘captive audience’ for health promotion whereas onshore employees are less likely to have contact with occupational health personnel on a daily basis. The importance of maintaining health promotion activities in a work setting in which the dining room is the centre of social interaction, and substantial meals are available round-the-clock, is clear; the present study further indicates that offshore personnel most at risk of overweight are those with minimal education and/or sedentary jobs.

Methodological issues

The present study had the advantage of a high initial response rate (83%), and relatively large sample size. However, the follow-up rate reflected the difficulty of tracing individuals in a highly mobile workforce after an interval of 5 years, and was modest (34.9% of the potential sample) compared with the initial level of response. Nonetheless, it was comparable to that found in similar studies; for instance, Froom et al. [33] reported a follow-up rate of 31.7% for an onshore industrial sample re-assessed after an average interval of 2.6 years. Moreover, age-adjusted baseline BMI levels of personnel
for whom follow-up data were available were not significantly different from those of personnel not followed up.

A further methodological issue that merits attention is the dependence on self-report methods for obtaining information about the predictor variables, and about height and weight. Four of the predictor variables (age, education, marital status and smoking) represented factual information likely to be relatively free of errors and biases. Moreover, work-related physical activity was assessed as a job-related variable, rather than directly at the level of individual perceptions; this approach had the advantage of removing the effects of self-report biases, particularly individual differences in negative affectivity [39], that may influence subjective ratings. However, the use of self-report for height and weight raises potential concerns that such data may be inaccurate and/or biased in ways that could distort research findings. This criticism has been widely addressed in the many published studies that have used self-report methods to obtain such information [16,24–26,30]. The general view is that although less reliable than independent measures, self-reports of height and weight are sufficiently accurate for determining BMI for research purposes [26,40–42]. Moreover, the present longitudinal analysis was based on current data obtained at two time points, rather than depending on retrospective reports of previous weight to infer information about change over time as in some studies [24].

In discussing more general methodological aspects of the present work, the limitations of cross-sectional survey data, particularly the problems of drawing causal inferences, must be considered. In particular, issues of ‘selection’ and ‘survival’ into jobs with different levels of work-related activity are relevant. In onshore work environments, individuals with health problems associated with overweight (e.g. diabetes) may be selectively employed in less physically active jobs; thus, direction of causation of relationships between work activity level and BMI is unclear. The same ambiguity potentially applies to the cross-sectional data analysed in the present study, but the health requirements for offshore employment make this explanation less likely, as all offshore personnel are ledges the assistance of Melanie Clark and Esther Payne-Cook (baseline study), and Susan Carnell (follow-up study) in the collection and processing of data.

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