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Circadian adaption, dietary intake and metabolic responses in offshore shift workers

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Circadian adaption, dietary intake and metabolic responses in offshore shift workers

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SUMMARY

This report presents the outcome of the pilot study to establish the methods and feasibility of a 3-year research project investigating the effects of night-shift work on offshore oil installation workers (Agreement no MaTSU/8950/3729).

The pilot study aims were to establish and trial the experimental design for:

- Determination of circadian adaptation time, or lack of adaptation, to various specific shift schedules.
- Assessment of dietary patterns, timing and composition of meals on day & nightshift.
- Determination of post-prandial hormone and metabolic responses to day and night-time meals in adapted and unadapted shiftworkers.
- Identification of the presence of potential risk factors associated with coronary heart disease, atherosclerosis and diabetes in offshore shiftworkers.

Subjects were recruited from two BP Amoco North Sea installations. All subjects (n =11) were working the same 'swing' shift schedule of a two week tour of 12 hour shifts on 7 nights (1800 to 0600h) followed by 7 days (0600 to 1800h). Over a 14 day period subjects were required to provide 3 to 4 hourly or oversleep urine collections and 4 blood samples. Additionally each subject completed a daily dietary intake record and one diet and lifestyle questionnaire. A site visit was made to the BP Miller installation by the study investigator.

All urine and blood sample collection was co-ordinated by the installation medic. The urine samples and dietary records were returned to the University of Surrey for analysis. The frozen plasma samples were collected and transported by the study investigator. Data collection was completed on one study site (n=7) and the data from the second site (n=4) will be returned early in the year 2000.

The pilot study has successfully demonstrated the feasibility of data and sample collection from an offshore field site, and return to the University of Surrey in a condition appropriate for analysis. Analysis of the urine samples was completed and provides a preliminary measure of the level and rate of adaptation to shift change. Plasma triacylglycerol (TAG) analysis showed a trend towards higher post prandial TAG at the beginning of the night shift tour. However it did not reach significance in this small subject sample. The analysis of diet diaries will allow the influence of dietary fat intakes to be considered in relation to the TAG responses. Further analysis of the data collected will continue using methods established at the University of Surrey, and the results incorporated into the full study.

CONTENTS

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Shift work is becoming more and more a necessary part of working life as the demand for a 24 hour society increases, yet it introduces some concerns for the health & safety of the worker. Shift work has been associated with several independent risk factors for heart disease in several publications, including increased incidence of diabetes, hypertension, insulin resistance and impaired lipid metabolism (Hampton et al. 1996, Nicholson and D'Aurie 1999). Reported symptoms of reduced well being amongst shift workers include fatigue, reduced sleep quality, digestive disorders, altered bowel habits, stress and irritability (Nicholson and D'Aurie 1999). In addition to long term health issues, when the working environment incorporates dangerous activity fatigue and reduced cognitive performance present a more immediate health and safety risk.

Working shifts, especially night shift, causes the body to attempt to make physiological adjustments in order to adapt to the different working times. This can result in altered metabolic responses. The shift worker may also have to make concessions and adjustments to their lifestyle in order to meet the demands of working shifts. These physiological and lifestyle adjustments require investigation, not only to identify changes that may have health and safety implications, but also to distinguish if certain shift patterns offer greater or lesser risk than others, and to find solutions.

Most of the research into shift work and health has focussed on rotating shift patterns in onshore industries with little work in offshore industries. Only recently has it been highlighted that offshore oil and gas installation workers have different shift patterns and environmental factors to consider, producing different physiological responses particularly with regard to circadian adaptation to night shifts.

The offshore oil industry is the only industry working 12 hour shifts for 7 or 14 days on permanent nights with managed meal times, segregated shifts and day time darkness for night workers. These workers follow regular rotating shifts and night shifts. While it has been shown that, in some schedules they do physiologically adapt to a night shift (Barnes et al 1998b), the process takes days, so they may be working a significant percentage of their tour in an unadapted state on both the day and night shifts.

The health and safety problems of shift workers on offshore oil rigs are unique to this population. This situation requires management strategies and advice that differ significantly from any solutions derived from onshore practice. It is foreseeable that strategies designed to comply with the EEC Working Time Directive (WTD) may be inappropriate when implemented offshore, coming as they do from an assumption of non-adjustment. Any advice based on the premise that night shift workers do not adapt, as is usually the case onshore, is not appropriate as complete biological adaptation to night shift is seen with some schedules (Barnes et al. 1998). If improved adaptation brings with it an improvement in coping with the effects of shift changes, then strategies to encourage adaptation should be investigated.

The current diversity of shift patterns being worked offshore cannot be supported on health or safety grounds and clearly only those patterns which maximise safety and performance should be worked. While the principal critical features of safe shift patterns can be identified, the required level of certainty does not exist for optimal strategies to be developed and implemented.

1.2 LITERATURE REVIEW

1.2.1 Circadian adaptation to shifts

The natural tendency of the human circadian clock, when light and social cues are removed, is to free run to a period of 24.1 to 24.3 hours. There are many factors that influence the body clock; other than endogenous circadian rhythms, the most important being the Earth's light dark cycle, as well as time and social cues, including working hours. Exogenous factors become more important in shift workers, as they may be altered or absent and can be manipulated. The common fast rotating shifts and social cues of onshore shift workers interact such that complete adaptation of the circadian clock to a night shift is unlikely to occur, however the offshore oil installation provides an environment where some factors can be controlled. Time, social, and meal cues exist for both day and night workers, and even light exposure may be manipulated to some degree.

It has been shown that offshore shift workers can physiologically adapt to a specific night shift schedule. The rate of adaptation to night shift on various

North Sea oil rigs has been investigated, using the best marker for the internal body clock: the rhythmic production of the hormone melatonin, assessed via its urinary metabolite 6-sulphatoxymelatonin, together with sleep and activity measures. This research indicated that on North Sea rigs, for a 14 day, 12 hour night shift, 1800-0600h, subjects are out of phase for at least the first 4-5 days of the night shift and for 4-5 days on returning home (Barnes et al 1998a). For a 7 day sequence, 12 hour shift, starting with night shift (1800-0600h), subjects would be out of phase for at least 4-5 days out of 7 days on night shift followed by 4-5 days out of phase on day shift. Thus in the latter case optimal working conditions might only be achieved for 4-6 days of a 14 day period on the rigs. For a 7 day sequence starting with day shift (1200-2400h) then switching to night shift (2400-1200h) the majority of crew do not adapt to night shift (Barnes et al 1998b). These observations require further confirmation, and, if appropriate, strategies to counter the actual and potential health hazards should be investigated. Thus during an adaptation period workers are exposed to a number of unusual factors potentially deleterious to health.

1.2.2 Shift work and performance

Monk suggested that there are five areas of concern for performance and safety in shift workers: Errors, sleep and fatigue problems, mood related disruptions, absences, and off work accidents (Monk et al. 1996), while Costa (1997) suggests that performance efficiency may parallel the circadian rhythm of body temperature and discusses the desynchronisation of circadian rhythms as a probable factor in decreased work efficiency and vulnerability to human error during night work. While the effects of shiftwork on performance, safety and well-being have been widely studied onshore there is little information on problems in the offshore oil industry. However, recent research (Parkes 1996, HMSO OTH 96 530) has shown that shift patterns, job types and installation characteristics were significant predictors of safety, work and health measures.

Research by Prof. Jo Arendt's group at Surrey University demonstrating that offshore workers on night shift schedules referred to above undergo physiological adjustment in circadian rhythms is supported by the data on cognitive performance collected by Dr. Kathy Parkes at Oxford University, which showed that performance plateaued after three to four days before falling sharply after a "swing" shift. Prof. Arendt and colleagues have also found that some shift patterns lead to very variable circadian adjustment with strong seasonal effects (Barnes 1998b), probably due to lack of synchronisation with daylight and large summer/winter day length effects in the northern North Sea. A current reanalysis of some 4000 incident reports from the UK offshore industry by Kathy Parkes, is showing that shift and tour explain the greatest proportion of variance in the occurrence and severity of reported injury.

1.2.3 Shift work and health

Nicholson and D'Aurie in a review of several studies found no statistical increase in morbidity in shift workers, however there are many studies that do show increased incidence or risk of ill-health amongst shift workers

(Nicholson and D'Aurie 1999, Boggild and Knutsson 1999, Tenkanen et al.1998, Costa 1997). The majority of the work has concentrated on cardiovascular disease risk, associated diseases such as diabetes and lipid intolerance, or on sleep disorders and stress related problems.

Independent risk factors for heart disease such as lipid metabolism and hypertension have been linked with shift work. (Nicholson and D'Aurie 1999, Boggild and Knutsson 1999, Tenkanen et al.1998, Hampton et al. 1996), with each risk factor present having a compounding effect on the risk. Overall the increase in CHD risk associated with shift work is 1.4, while the relative risk for shift workers with obesity or who smoke are 1.7 and 2.7 respectively (Nicholson and D'Aurie 1999, Tenkanen et al.1998).

Nicholson and D'Aurie (1999) in a review of shift work and health also found associations with stress, sleep disturbances, gastro-intestinal disorders, and possibly with asthma, epilepsy, and chronic fatigue syndrome.

1.2.4 Shift work and diet

There is no existing data on diet in relation to shift work on UK offshore oil installations to enable any relationships between diet and hormonal/ metabolic responses to be identified. However Lennernas (1994,1995) found that patterns of eating were altered in shiftworkers and total energy intakes were lowered at night. Lennernas (1995) also showed that night time intakes of total energy were correlated with lipid profiles.

In simulation shift work experiments, on the first and possibly other nights of a night shift the response to a meal taken in the middle of the night (effectively during the work period) shows evidence of lipid intolerance and insulin resistance - both are risk factors for coronary heart disease (Hampton et al 1996; Ribeiro et al 1998). These are findings that have been confirmed in hospital midwives working night shifts and in night-shift personnel on a British base in Antarctica (Lunn 1999).

It is widely accepted that dietary advice is of value in the prevention of CHD, so if it is found that there is an increased CHD risk amongst offshore shift workers, as there is in most reports of onshore shift workers, dietary advice or intervention may be necessary.

1.2.5 Shift schedules

The complexity of designing shift schedules requires consideration of factors other than simply the most appropriate for circadian adaptation. Operational constraints, such as helicopter schedules and crew change arrangements, further complicate decisions about shift rotation schedules.

The range of shift schedules worked offshore is extensive, tour length varying from one week to four weeks, and shift combinations including straight days, straight nights or swing shifts combining days and nights in a number of ways. Additionally shifts commence and complete at different times, running from 0600h to 1800h, 0700h to 1900h, 0800h to 2000h, or 1200 to 2400h.

Commonly used schedules include: swing shift of 7 nights and 7 days or 14 nights and 7 days and shifts of 14-21 straight days/nights either continuously or rotating.

In assessments of sleep, alertness, mood, workload and psychomotor and cognitive performance, adaptation to night work was evident during the second week offshore in the subjects working a continuous 14 nights (Barnes et al 1998). Although this showed a significant advantage of the 14D/14N rotation patterns, a survey showed a marked preference for the 7N+7D pattern as this allowed adjustment to a normal routine before going on leave (Parkes 1997 OTO 97012). While this provides evidence of problems in existing shift patterns it is not at a level required to recommend changes. It is now essential to confirm and extend the findings in further studies which also include physiological measures.

1.3 PROJECT AIMS AND OBJECTIVES

Concept for this study

A research project was proposed to investigate further circadian adaptation to different shift systems and to look at relationships between the adaptation and physiological, cognitive and metabolic responses, taking into consideration some lifestyle factors.

The proposed research aimed to specify the psychological and physiological response to different work schedules on North Sea oil rigs. Performance and mood offshore would be evaluated by distance testing using email. In these same individuals, biological adaptation, risk factors for heart disease (including diet and temporal patterns of nutrition) and metabolic responses would also be assessed. The multidisciplinary and integrated approach would permit for the first time the simultaneous evaluation of psychological and physiological variables in the same individual while offshore.

The final objectives of the proposed main project were to advise the Industry and the Regulator as to:

a) work schedules which maximise performance.

b) strategies to minimise risk to health and safety.

The complexity of studying all the different aspects in an offshore field environment presented a challenge in terms of field research, and indicated a need for a pilot study to demonstrate the feasibility of the proposed full study.

The objectives of commencing with the pilot study were to:

1.Establish the experimental design

2.Trial the subject testing procedures (excluding cognitive performance)

3.Trial the interface with data management procedures

4.Identify the environmental and situational variables to be included in the study

5.Make recommendations as to the feasibility and size of any necessary further full scale study.

In research terms the aims of the pilot study were to establish and trial the experimental design for:

- Determination of circadian adaptation time, or lack of adaptation, to various specific shift schedules.
- Assessment of dietary patterns, timing and composition of meals on day & nightshift.
- Determination of post-prandial hormone and metabolic responses to day and night-time meals in adapted and unadapted shiftworkers.
- Identification of the presence of potential risk factors associated with coronary heart disease, atherosclerosis and diabetes in offshore shiftworkers.

This six month feasibility study has developed the experimental design and protocols necessary to measure physiological adjustments, metabolic responses to meals and dietary records of shift workers on offshore installations on the UK Continental shelf, including physiological measurements at specific times by the collection of blood and urine samples, with concurrent measurement of diet. The collection of biological data was co-ordinated by the offshore rig medics, and dietary and lifestyle data was recorded by diet diaries and questionnaires.

2 METHODS

2.1 SUBJECT RECRUITMENT

The interest of members of the OSD/industry Occupational Health Research Committee in the study was established, identifying BP AMOCO and Stena Drilling as interested parties. Two BP North Sea installations were selected for participation in the pilot study. They identified the shift schedules that they run, and from this the 14 day swing shift was selected for the study.

The installations paramedical staff were recruited to co-ordinate the sample and data collection offshore, and to recruit subjects from their workforce. Information packs and recruitment posters were supplied.

All subjects (n = 11) worked the same swing shift schedule: a two-week tour of 12 hour shifts for 7 nights followed by 7 days.

2.2 STUDY DESIGN

The study was designed to run in 14 day study periods. Over the 14 days subjects were required to provide 3 to 4 hourly and overnight continuous urine collections and 4 blood samples, also a record of their dietary intake and completion of a questionnaire about diet and lifestyle on shore. Table 2.2.1 shows a summary of the study design for a 14-day shift of 7 nights followed by 7 days.

Table 2.2.1 – Study design for a 14 day shift of 7 nights and 7 days.

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Urine	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Blood		P 💧				P 💧							P💧 F💧	
Diet		🍽	🍽	🍽		🍽	🍽	🍽			🍽	🍽	🍽	

KEY

U = Urine collection

F💧 = Fasting blood sample

P💧 = Post prandial blood

🍽 = The dietary intake record

All data and sample collection was co-ordinated by the installation medic, and the data returned to the University of Surrey for analysis.

2.3 MEASUREMENT OF SHIFT ADAPTATION

The direction and rate of adaptation of the internal clock to 12 hour night and day shifts over 7-day rotations was assessed using urinary 6-sulphatoxymelatonin measurements. Urine was collected from all subjects every 3-4 hours and overnight, total volume was recorded and a 3ml aliquot taken and frozen for analysis by a specific radioimmunoassay technique.

2.4 MEASUREMENT OF HORMONAL & METABOLIC CHANGES

Four (25ml) venous blood samples were taken from each volunteer, and the blood centrifugally separated, by the rig medic.

Plasma was aliquoted and frozen immediately.

Sample 1. Baseline sample, taken on study day 13, in the morning after an overnight fast of at least 8 hours.

Samples 2, 3, and 4. Postprandial samples, taken 6 hours post consumption of a midshift main meal (night or daytime, according to shift pattern).

Insulated packaging, previously tested at the University of Surrey to keep samples frozen for more than 7 hours, was provided for the transport of the plasma samples at the end of the study.

2.5 ASSESSMENT OF DIETARY INTAKE

A record of dietary intake and portions consumed was made by the subjects at each mealtime, recording all food and drinks consumed at that meal and since the last meal. Dietary intake was recorded for a total 9 days of the study period (3 x 3 days), to coincide with the taking of post prandial blood samples.

Additionally dietary habits on-shore were established by subject's completion of a diet and lifestyle questionnaire.

The dietary records were returned by post to the University of Surrey for analysis.

2.6 OFFSHORE VISIT

The study investigator visited the Miller platform to clarify the study protocol to the installation medic, and to answer any questions from either the medic or the subjects.

2.7 DATA ANALYSIS

2.7.1 Urine analysis

Urinary 6-sulphatoxymelatonin (melatonin metabolite) was measured by a specific radioimmunoassay technique, to assess circadian status (Arendt et al 1985 adapted by Aldous and Arendt 1988).

Acrophase was calculated by cosinor analysis (Minors Dr D, University of Manchester).

2.7.2 Plasma analysis

Glucose, insulin, C peptide, TAG, non-esterified fatty acids (NEFA), gamma- (γ–GT) and low density lipoproteins (LDL) will be measured on all samples. Glucose, TAG, non-esterified fatty acids (NEFA), gamma- (γ–GT) are measured by methods established at the University using Cobas Mira with appropriate reagents. The TAG analyses have been completed. The insulin, and C-peptide are to be measured by in house radioimmunoassays (Hampton 1983).

2.7.3 Dietary record analysis

Dietary records will be analysed using a recognised diet analysis program to establish 24 hour total energy intake, macro and micronutrient consumption, 24h patterns of dietary intake and differences in content and timing of food consumption on day and night shifts. To date an approximate estimation of fat content of selected meals has been made following scrutiny of the diet diaries, to provide a preliminary indicator of the influence of meals on plasma TAGs.

2.7.4 Statistical Measures and Justification

Plasma TAG is one of the major outcome variables. Previous studies indicate that 11 subjects are sufficient to detect a 0.3mmol/L difference in postprandial TAG levels with a power of 80%.

TAG results were compared using one-way analysis of variance. P values of <0.05 were accepted as statistically significant.
Summary statistics were used to present the subjects data.

3 RESULTS

The results shown here are a record of the outcome of the methods trialed in this study. Some analytical results of the data collected are available, where it is appropriate in order to demonstrate the study feasibility.

The study was completed on the BP Miller positioned in the North sea at 58” 43’ N, during the months of October and November 1999.

3.1 SUBJECT RECRUITMENT

Two BP AMOCO installations provided eleven male subjects, and data was collected from seven subjects aged between 25 and 54 years (mean 44.7±9.38), with mean BMI 25.7 (±2.45), and free of medications stated in the exclusion criteria as stated in the study protocol.

3.2 COLLECTION OF URINE SAMPLES

Urine collections were provided by the subjects (n = 7) at three to four hour intervals and overnight.

All aliquots of urine stored frozen by the installation medic, were returned to the university by post, and received within 48 hours of sending.

3.3 MEASUREMENT OF CIRCADIAN ADAPTATION

All subjects (urine analysis completed on 6 subjects) showed normal 6-sulphatoxymelatonin (aMT6s) production. A preliminary screen of the data suggested that most subjects adapted to night shift. This was confirmed in four subjects by calculation of the peak time of the aMT6s on each day of the shift sequence. These very preliminary results are shown in Fig 3.3.1. Analysis will be completed with the incorporation of a further subject from this installation.

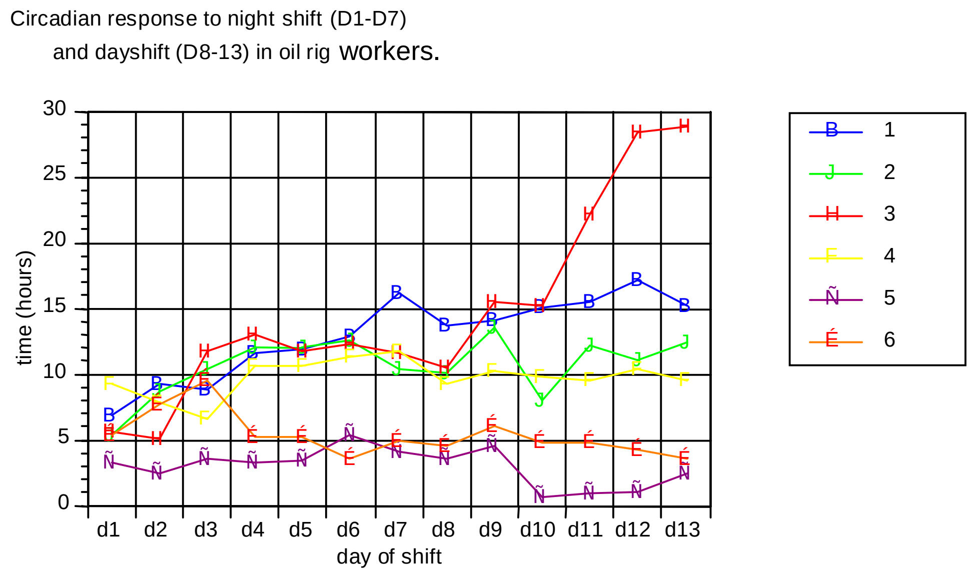

Figure 3.3.1 Circadian response to night shift and dayshift in oil rig workers

Figure 3.3.1

Preliminary data showing change in phase of individual melatonin rhythms as assessed by measurement of urinary 6-sulphatoxymelatonin (aMT6s) in sequential samples throughout 7 days night shift (1800-0600h), followed by day shift (0600-1800h). The calculated peak time of the rhythm is shown. Note that 4 subjects show adaptation to night shift by a shift in timing of the rhythm to a later phase (ca 0500h to 1200h) and that 3 of these subjects do not adapt back to a normal phase position during the day shift. One subject (subject 3) adapts back by delay during the day shift. Two subjects show no adaptation to night shift.

3.4 COLLECTION OF PLASMA SAMPLES

The subjects' (n =7) blood sampling and plasma separation was successfully completed in accordance with the study design. Six subjects' samples were transported to frozen storage on shore in insulated packaging within 6 hours, and transported back to the University of Surrey by the study investigator again in insulated packaging within 6 hours. One subject's samples remain in frozen storage on the study site until the next insulated packaging transport is arranged. The samples were still in frozen condition when placed in frozen storage at the University of Surrey.

3.5 PLASMA TAG ANALYSIS

Plasma TAG levels are displayed in figure 3.5.1, and show a trend towards higher post prandial TAGs after night shift meals.

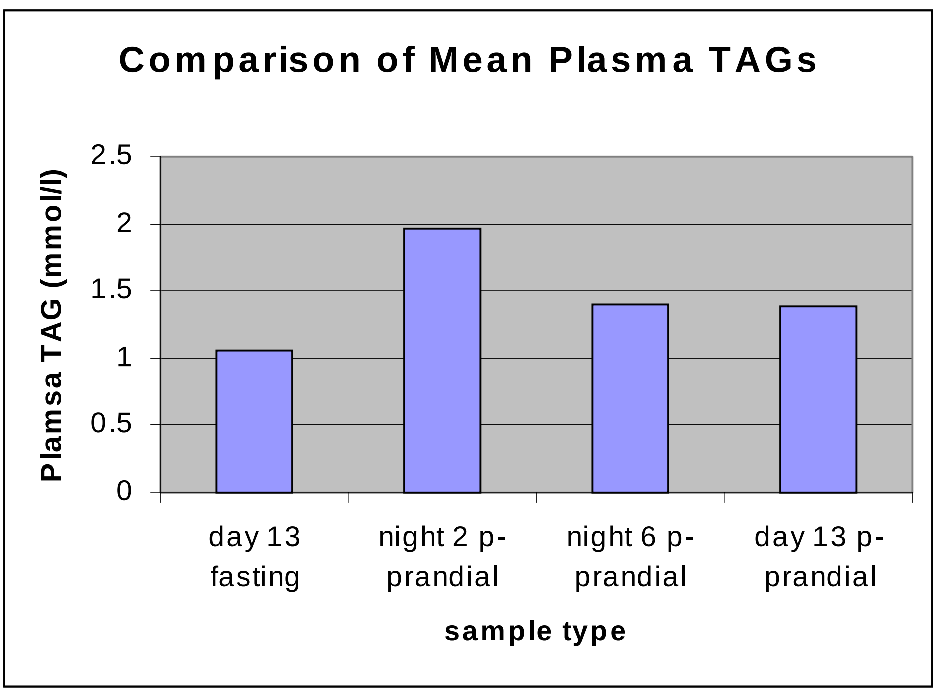

Figure 3.5.1 Comparison of Mean Plasma TAGs

3.6 COLLECTION OF DIETARY INTAKE DATA

Dietary intake records and the on-shore diet and lifestyle questionnaire were completed in accordance with the study design, and returned from the study site, to the study investigator by post at the end of each study period.

A preliminary subjective assessment was made of the fat content of meals consumed prior to blood sampling, identifying low, medium or high fat meals in order to consider the influence of the shift on dietary choice and the effect of dietary fat intake on the plasma TAGs.

Figure 3.6.1 shows selection frequency of high and low fat meals.

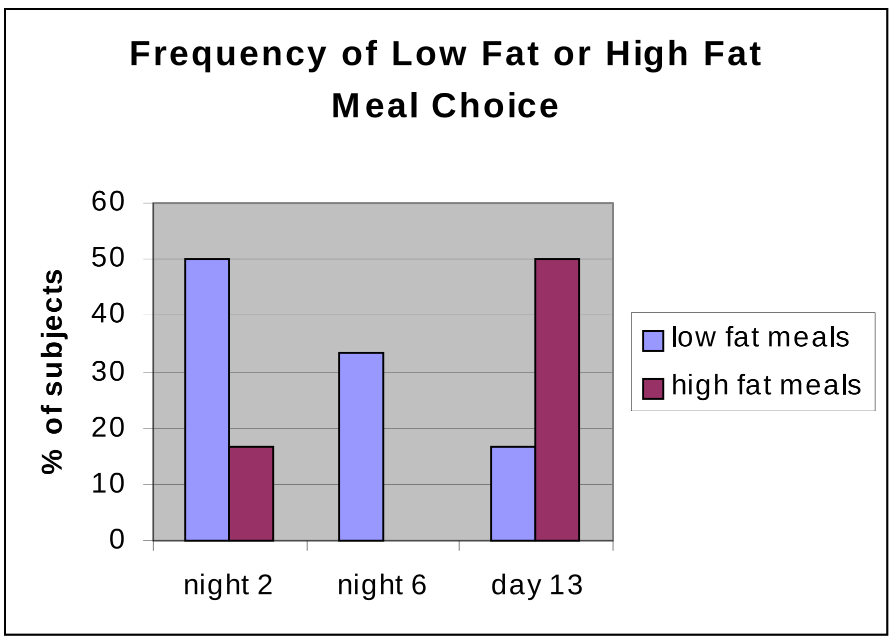

Figure 3.6.1.

3.7 OUTCOME OF VISIT TO OFFSHORE STUDY SITE

A successful visit was made to the Miller Platform in the North Sea prior to the start of the study period on the installation. Any uncertainties regarding the procedures of the study were clarified with the medic, and with any subjects who were present.

Light monitoring procedures were tested and methods of communication or transmitting data were also investigated for inclusion in future studies.

The study investigator gave presentations on general diet and healthy eating matters to groups of personnel, and answered some individuals' nutrition queries during the visit.

4 DISCUSSION

4.1 SUBJECT RECRUITMENT

The recruitment of subjects to the study was straightforward, although it took longer than anticipated to secure subjects. As this was done in the field by the installation medic acting as co-ordinator, the rotating shift schedules of the medics and workers introduced some unavoidable delays.

It was noted that if too much time passed between the initial agreement of the installation to take part and the request to confirm subjects were ready to commence a study, some enthusiasm was lost. It is therefore suggested that installations be introduced to the study as a new site becomes needed, in order to maintain momentum.

4.2 COLLECTION OF URINE SAMPLES

The collection of urine for the measurement of the melatonin metabolite 6-sulphoxymelatonin is a fundamental aspect of the study, as it is this that enables the assessment of the rate of adaptation to the change in shift. It is therefore essential that records and samples are sufficiently precise to give an accurate measure of the adaptation. All subjects provided urine samples and a record was kept of volumes and collection period times. However the average number of samples provided was less than the anticipated 5-6 per day. Also the precision of the records in terms of volumes and times suggest some rounding off of the data. Although there is a little leeway for this it seems likely that in some cases this has been exceeded. It is suggested that the instructions are altered to be specific regarding the extent of rounding that can be accepted, before precision is reduced. The importance of this should be emphasised to the medics and subjects.

In order to have a starting point for the assessment of the circadian adaptation it is necessary to have a start time to the first urine collection period. This was overlooked in the production of the urine record book and, as this is essential for the precision of the first sample, it should be introduced to the urine record in further studies.

4.3 MEASUREMENT OF CIRCADIAN ADAPTATION

It is evident from Figure 3.3.1 that whilst most subjects adapt to night shift on this schedule at this latitude and during this season. They may not adapt back to dayshift and thus spend nearly all the period offshore out of synchrony with their work and sleep schedule. Two subjects showed no adaptation at all to night shift. This is the case in most onshore shiftworkers and is thought to be due in large part to bright light exposure in the early morning following the night shift acting counter to adaptation. Whilst the overall light levels on this rig have been evaluated it would be highly desirable to assess the light exposure of each individual subject, for example by the wearing of 'Actillumes', wrist born devices that measure light levels continuously.

It will clearly be important to assess the conditions conducive to adaptation (or not) and any individual characteristics that preclude adaptation (for example light sensitivity) in this and other schedules in a larger number of subjects.

4.4 COLLECTION OF PLASMA SAMPLES

Four blood samples were taken for the measurement of hormonal and metabolic responses to meals during night and day shifts, one fasting and three post prandially. The fasting and post prandial samples taken during a day shift at the end of the tour to provide fasting base line and daytime measures as near normal as possible. The other two samples were taken during unadapted and possibly adapted night shifts, to provide comparisons between the adapted and unadapted state and between day and night. This relies on the subjects' ability to adapt to the shift changes. It is suggested that on this shift schedule with two periods of adaptation it may be useful to take a fifth sample during an unadapted day shift i.e. after the swing shift.

The physical collection of blood presented no difficulties. There was a small (n=4) loss of samples during the centrifugation process, which was attributed to the 5ml tube adapters supplied by the manufacturer. This was overcome by producing a more supportive adapter for the 5ml tubes.

Transport of the frozen plasma samples was successful, and the frozen status was maintained. It is suggested that a thermometer is included within the insulated boxes in order to record the temperature at which the samples arrive as a quality control procedure in further studies.

4.5 DIETARY INTAKE DATA AND ANALYSIS

Preliminary results show clear trends in the patterns of nutrient intake differing with shift changes. The estimation of the fat content of the meals was (Figure 3.6.1) indicated that the day time meal choices were of a higher fat content than the night time meal choices. The fat content of a meal is known to influence plasma TAG and this higher fat daytime meal would then produce a higher post prandial plasma TAG. The subjects have free choice of food, and therefore meals were not standardised, however the food intake is recorded so that any confounding influence can be identified. A more precise analysis of the meal fat content will be valuable, and a larger sample number may produce more significant data.

Dietary intake records should provide an adequate measure of intake to assess macronutrient intake, and specifically fat intakes. Specific meals and snacks can be isolated and analysed individually as well as the diet as a whole, this will be used in assessment of food intake as a confounder to the plasma lipid measures.

It is expected that a self reported diet intake will have an element of under-reporting. The extent of this can be calculated, and if under-reporting is found it is suggested that an adjustment be made to account for the lost value. For further studies the accuracy required in the recall of foods and the subjective measure of portions consumed will be conveyed to the subjects. The subjectivity of the portion recall has been controlled for, and should be reduced by the provision of estimated portions in picture format.

The lifestyle questionnaire will be used to assess differences in diet on-shore and offshore, so as to identify any lifestyle factors that may be contributing to CHD risk.

4.6 PLASMA TAG ANALYSIS

The plasma TAG analysis showed a trend towards higher post prandial TAGs following a night shift meal than a day shift meal especially early in the tour of night shifts, despite generally lower fat content of meals at night. This did not demonstrate a statistically significant difference between the subjects responses to meals on a day or night shift, or in the adapted and unadapted state. The meal fat content was not standardised, due to the field environment. Standardisation of mid shift meal prior to blood sampling is recommended in future studies to eliminate the confounding variable of meal fat content. It is expected that if subjects all consume equal fat intakes in the meal prior to a blood sampling that the TAGs would be raised significantly higher after a night time (unadapted night shift) meal than after a day time (adapted day shift) meal.

4.7 OUTCOME OF VISIT TO OFFSHORE STUDY SITE

The value of the study investigator making a visit to an installation prior to or during the study should be fully appreciated. This offers benefits to the subjects as well as to the study outcome, as the installation's paramedic and subjects have direct access to the study investigator, which not only provides an opportunity for further explanation and emphasis of any areas of the study that require it, but also promotes in the subjects a closer feeling of involvement. It is suggested that this is likely to increase motivation and compliance, and could increase interest in volunteering for further studies. It also heightens awareness of the research amongst installation personnel who have currently not volunteered, but may do so in the future. Additionally a visit to the site provides the installation personnel with access to general nutrition information, offered to groups and individuals, or on a professional level to the catering personnel.

The relationship forged during such a visit makes monitoring of the study progress from the University of Surrey more relaxed and contact regarding further studies more likely to be well received. There is minimal cost incurred to the study as, other than travel to the transport site, the cost in this pilot study was accepted by the installation operating company.

5 CONCLUSIONS

The pilot study has established the study design and tested that the methods are feasible for the collection of samples and data necessary for the measurement of shift adaptation, hormonal and metabolic responses to meals, and for the collection of dietary intake data in this field environment.

Analysis of the urine and plasma samples and the resulting data has demonstrated the efficacy of the assay techniques and the data management procedures used and thus has illustrated the feasibility of measuring shift adaptation and metabolic responses to normal meals from the data collected.

Interpretation of the plasma TAG data with regard to coronary heart disease risk has been confounded by the influence of dietary fat intake and is therefore inconclusive at this stage. However the tentative identification of increased TAGs following night time meals is indicative of a potential presence of CHD risk factor, and suggests that further work is required to identify the presence of other known risk factors in this subject group.

6 RECOMMENDATIONS FOR FURTHER STUDY

It is recommended that the methodology designed in this pilot study is used in a three year research project to confirm and expand on the findings of the pilot.

6.1 MODIFICATIONS TO METHODS

- To include a record of the start time of the initial urine collection.
- Introduction of a thermometer to monitor in the transport of frozen plasma samples.
- Introduction of a measure of light exposure e.g. by use of luminometers or actilumes.
- Standardisation of the pre blood sample meal and snack intake.

6.2 FURTHER STUDY

It is suggested that further studies are conducted to assess and compare the levels of adaptation to shifts that is achieved on different shift schedules that require the worker to make the physiological adaptation. It is suggested that the project investigates a number of shift schedules in order to identify any advantages or disadvantages, and that each study should have at least twelve subjects to enable sufficient statistical power to detect the observed TAG changes.

If intervention strategies are identified as an appropriate action then studies to assess the effects of such intervention should also be undertaken. Such strategies may include light exposure, chronobiotics and dietary intervention or advice.

Suitably timed exposure to bright white light (1000 lux or more) is successful in hastening adaptation to night work (Eastman et al 1995) and it has been previously shown that this strategy also improves lipid intolerance (Ribiero et al 1998). Further investigations into the duration, intensity and continuous or intermittent administration of light necessary to normalise responses are required.

The composition of meals on a night shift does affect lipid profiles (Lennernas et al 1994, Lennernas et al 1995, Ribiero et al 1998). A dietary intervention study into the effects of altered meal composition, or altered selection initiated by dietary advice, is suggested to identify if markers of cardiovascular disease risk can be improved in this way.

There is evidence that drugs known as chronobiotics, in particular melatonin (available O.T.C. in the USA and self-administered) can aid adaptation. This needs clarification of efficacy and acceptability.

This pilot study has not investigated cognitive performance testing studies in association with adaptation to shift work. It has been agreed that this will be included in further studies by a collaboration with Cardiff University.

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