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A CASE FOR A NUTRITION INTERVENTION TRIAL FOR HEAVY GOODS VEHICLE DRIVERS AT RISK OF STRESS AND FATIGUE

ABSTRACT:

Fatigue is a known factor in accident causation for heavy goods vehicle drivers, however there appears to be a paucity of recent work concerning the relationship of nutrition to fatigue in this domain. HGV drivers experience many stressors, both physical and mental, on an ongoing basis, while many also have restricted access to healthy food choices as a consequence of their occupation. This may predispose them to respond poorly to stress, giving rise to symptoms such as fatigue.

A review of literature relating the subject of nutrition and HGV drivers was carried out in order to inform any potential future research into the relationship between nutrition and the experience of stress and fatigue in the HGV driver. It was concluded that although diet is generally acknowledged as a contributory factor to fatigue in HGV drivers, the importance of nutrition in mitigating the effects have not been quantitatively assessed. It is proposed that further research in the form of a nutrition intervention trial using the truck simulator be carried out.

INTRODUCTION

This report discusses the role that stress, that is physiological and psychological stress, may play in the dysregulation of normal body processes in drivers of heavy goods vehicles (HGV)[1], how this relates to fatigue, and the importance of nutrition in this area. It will also review existing literature regarding nutrition in the context of HGV drivers to assess whether this gives any information which could inform those doing research into the performance of HGV drivers, and will suggest future research to provide quantitative data in this domain.

Accident statistics in the UK show that there were approximately 8,890 injury only or fatal incidents involving heavy goods vehicles in 2005 (DfT 2006) (see figure 1), and research has found that around16% of all vehicle accidents may be sleep related (Horne & Reyner 1995), a figure which rises to around 20% on motorways. In Australia, between 1992 and 1998, 33.5% of articulated heavy goods vehicle crashes

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[1] The definition of a heavy goods vehicle varies considerably between studies and countries, but for the purposes of this research HGV refers to vehicles over 7.5 tonnes.

involved driver fatigue (ATSB 2002). Fatigue or sleep related incident statistics may well be under-reported however, as the driver may not be aware that they were falling asleep, or may not wish to admit to the fact that they were sleepy. A study of 593 long distance goods vehicle drivers in the US found that 47.1% of the survey respondents admitted to having fallen asleep at the wheel of a truck, and 25.4% had done so in the past year (McCartt et al 1999). The health and well-being of the heavy goods vehicle driver is of particular interest, because as Solomon et al (2004) pointed out, the workplace of commercial drivers is in fact the community, and accidents may therefore involve other more vulnerable road users. Accidents involving heavy goods vehicles are often severe for the other involved vehicle, and more so where fatigue is a factor, because there may be no braking or avoidance manoeuvres prior to impact.

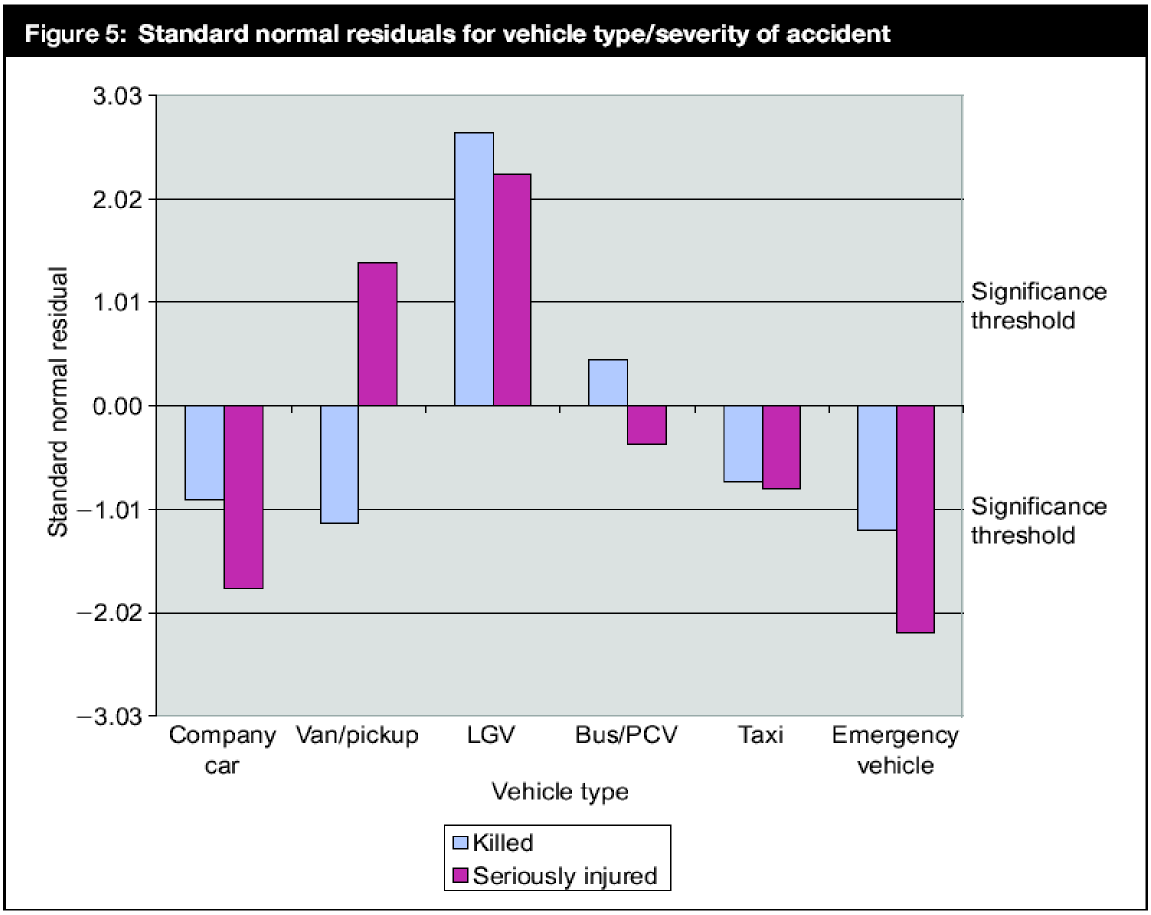

Fig 1: taken from DfT Road Safety Report no.58 (2005) showing that large goods vehicles (LGVs) were more likely than other vehicle groups to be involved in fatal and serious accidents. In fatal accidents the majority are as a result of poor observation or distraction. There was evidence of fatigue or illness in around fifth of all fatalities caused by LGV drivers

The reasons for the increased levels of accidents/fatalities among commercial drivers have been extensively studied, and associations have been found with reduced levels of cognitive function, for instance in perception time and reaction time, related to fatigue and sleepiness (Orris & Buchanan 2005). Some studies focus specifically on fatigue arising as a result of loss of sleep, others recognise that fatigue can also arise from an accumulation of stressors. In Brown (1994) fatigue is defined as a subjectively experienced disinclination to continue performing the task at hand which involves a conflict between the desire to rest and the commercial pressure to complete the planned journey, and drivers who ignore fatigue do so at the expense of increasing physiological stress, which heightens accident risk.

Studies have shown that as a group, the prevalence of work related factors among commercial drivers which may be stressful are significantly higher than among clerical workers (Koda, Yasuda et al 2000). Factors such as irregular shift work, working environment, working posture, handling heavy materials, job stress due to overloading, long working time and limited time off were cited. Other stressors such as constant vibration have been found to have an impact on drivers' well-being (Robb & Mansfield 2007). The stress response, also known as the "fight or flight" response, has been studied extensively, and Selye (1984) presented the general adaptation syndrome which suggests that we progress from the initial alarm state to a resistance stage whereby extra cortisol is produced in addition to normal levels in order to keep the body in an alert state (allostasis). If cortisol is produced at this rate for a long period, adrenal exhaustion may follow, whereby the adrenal glands can no longer produce the hormones required to respond to the stress signals and fatigue can result. Nutrients are diverted away from normal repair and maintenance processes, to support the stress response, which is highly nutrient dependent, as demonstrated in the abundance of research into the importance of post injury nutrition. In addition, various external factors can also either increase our need for nutrients, or reduce the body's ability to absorb them, for instance smoking uses up large amounts of vitamin C (Schectman et al 1989), which is one of the body's major anti-oxidants and is also vital for good adrenal function (Padyatti et al 2007).

The physical condition of the heavy goods vehicle driver may also influence the stress response, as the impact of stress very much depends upon the pre-existing health status of the individual. As Selye points out, although the stress response itself is general, the way the resulting stimuli are received is more specific. For instance, someone already depleted of nutrients because of a diet high in processed food, or who is obese with raised blood sugar levels, may handle stress comparatively badly, and is likely to progress more quickly to the exhaustion phase. Resulting symptoms include loss of concentration, confusion, “brain fog”, sleepiness after meals, irritability, poor sleep patterns, sweats and headaches (see figure 2). Research by Rosmond & Bjorntop (2000) shows that abdominally obese individuals are more often exhausted, and Stoohs et al (1994) reported that obese drivers have a significantly higher accident rate than non-obese drivers.

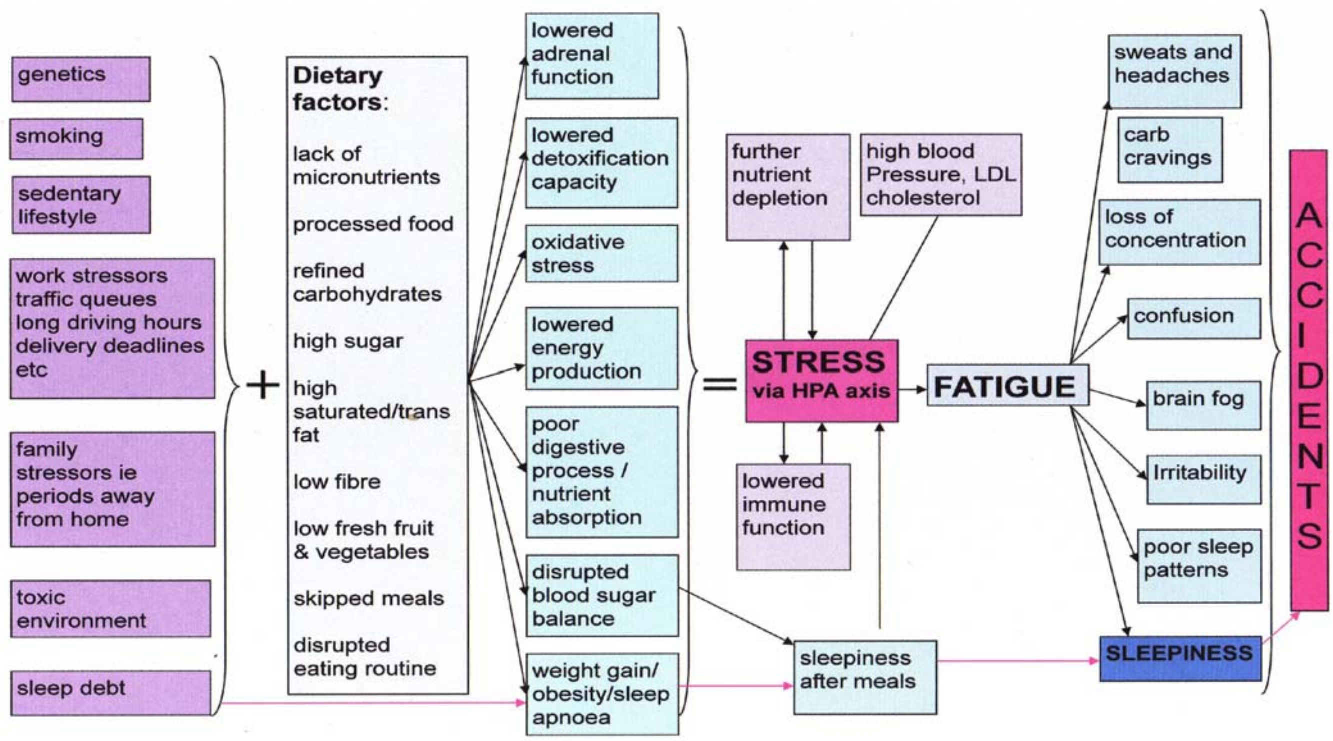

Figure 2: How nutrition relates to stress and fatigue in heavy goods vehicle drivers

As a group, HGV drivers’ nutrient intake may be compromised, as research has shown that their food choices may be limited both by attitude and availability. A trial carried out in Scotland to assess HGV drivers’ attitudes to fruit in their diets (Jack et al 1998) discovered that eating while at work was characterised by extensive and irregular snacking. These snacks tended to be bought at garage kiosks, motorway services and HGV stops, and fruit did not feature highly as it was considered both inconvenient and expensive. A study of heavy vehicle drivers' lifestyle in Queensland Australia (Plowman et al 2000) concluded that the drivers conformed to a lifestyle that was not conducive to healthy meals. An informal questionnaire handed out to drivers at a trucker trade show in the USA revealed that out of those participating, 50% were overweight compared to 25% of the general population and 92% did not exercise regularly (Korelitz et al 1993). A study based on a truck stop in Sweden noted that: *"Truckers have a collective awareness of themselves as a risk group. However in general this risk awareness is not reflected in their choice of food or where to consume it…"* (Gill & Wijk 2004).

Research to date has concentrated on various areas of concern in relation to the causation of fatigue; however, many of these areas such as shift working, short sleep, disrupted circadian rhythms and long driving time are integral to being a professional driver, and it is therefore difficult to substantially mitigate this stress load. Nutrition is a variable factor and could significantly modulate the response of the driver to his stress inputs. Daily nutrient intake may have a significant influence on the fatigue status of the driver, although applied research may be fraught with confounding factors.

METHODOLOGY

In order to inform any potential future research into the relationship between nutrition and the experience of stress and fatigue in the heavy goods vehicle driver, it was considered necessary to carry out a review of existing literature to discover what, if any, research has been carried out and what data it provided.

The PubMed access service was used, which contains bibliographic citations and author abstracts from more than 4,800 biomedical journals published in more than 80 countries.

A search for articles published after 1975 was performed using the following terms:

- Commercial driver
- Driver occupation
- Professional driver
- Truck driver
- HGV driver

Each of these terms was entered with the following key words:

- Food
- Nutrition
- Meals
- Eating
- Health

The initial search in PubMed resulted in around 2,500 articles. The abstracts of these were reviewed for the inclusion of nutrition in the context of driver fatigue. Of those that remained, those not in English were excluded. The remaining articles have been summarised in the tables contained in Appendix A to evaluate their contribution to the subject. Additional material has also been sourced from relevant university departments in Australia, UK and USA, and from the Australian Road Research Bureau (ARRB) and the Transport Research Laboratory (TRL Ltd) in the UK.

RESULTS

The paucity of literature on the subject of nutrition and heavy goods vehicle drivers is evidenced by the quantity of papers found suitable for review. Many of the studies refer to nutrition as a contributory factor to fatigue, but deal with influences such as poor quality sleep, disrupted sleep patterns, and long driving hours as the main contributory factors. There has however been considerable interest in nutrition in relation to energy and fatigue in the general population, and there are a multitude of studies on the intake of macronutrients and their effect on cognitive function, albeit not in a driving context. These have observed the short term effect of protein, carbohydrate and fat ingestion on cognitive performance, mainly on young healthy volunteers. For instance one study in 2001 found that pure macronutrient ingestion in the morning influenced specific cognitive functions with different efficacy and time delay (Fischer et al 2001). Benton et al (2003) showed that a low GI breakfast allowed better cognitive performance later in the morning and a study by Wells et al (1998) concerning meal intake and daytime sleepiness concluded that food intake did indeed result in an increase in sleepiness after eating, not solely due to circadian effects. These are important findings in that they indicate how the body uses macronutrients, however they do not take into account the effects of micronutrients, nor can their results necessarily be extrapolated into the lorry driving community.

The studies that have been carried out using a driving simulator have tested the efficacy of various energy drinks in relieving fatigue, or sleepiness, in drivers (though not truck drivers). These show that glucose and caffeine in sufficient quantity can relieve sleepiness for a short period. The study by Parkes et al (2005) evaluated the administration of the energy drink "Red Bull" which also contains B vitamins, taurine and glucoronolactone, to drivers. The study concluded that this drink may be more effective than a glucose/caffeine drink, although there was no attempt to define the role of the value of the micronutrients in this drink, which may have had some effect. In nutritional terms such a drink could have a negative impact on nutrient status in a driver who relied on it as a stimulant, as short term energy is gained at the expense of energy and nutrient reserves. In addition, a driver with already dysregulated blood sugar (i.e. in obesity) may experience a blunted cortisol response which may not provide the energy required, and may have adverse effects over a four hour drive, for instance. These studies therefore offer generalised conclusions regarding the application of such drinks, which cannot necessarily be applied to the heavy goods vehicle driver.

The papers presenting results of wellness programs among haulage companies on the other hand place emphasis on a wide range of health inputs, including diet, exercise and stress relief to mitigate fatigue. These programs aim to improve both occupational health and road casualty statistics. Their scope is therefore necessarily broad, but stress reduction is included as an important aspect. In the "Getting into Gear" project reviewed by Roberts & York (1999), stress was approached with stretching, breathing and muscle relaxation and by making drivers aware of stress signs and stress health effects; having a healthy body was seen as a contributory factor to achieving more relaxation. As this was a pilot study, there was no long term evaluation of the interventions, however the dietary changes made by the drivers were significant. When asked what they did differently after the intervention, these were sample responses:

- "*More exercise. Eating better: no vending snacks, no fried foods, no soft drinks, more veggies and fruit.*
- *I'm eating better: more fat free margarine, vegetables. More exercising….*
- *I eat better: 1) eating less meat and 2) less fatty food and 3) started oatmeal for breakfast and 4) more fruits.*
- *Quit eating red meat and fried foods. Walk dog every night.*
- *I walk 4-5 days a week, ride bike. Eat more fruit, make carrot-raisin salad, buy juices, less fried foods, less sweets.*
- *Helped me eat better, more vegetables*
- *I pay more attention to exercise and stress reduction. Reinforced my eating habits."*

However both initial participation and compliance is evidently a problem with wellness programs, and Roberts & York (ibid) noted that most haulage companies do not have health programs, and the few that did had problems reaching the drivers and therefore had much less participation than companies outside the industry. The "Getting in to Gear" pilot study began with 128 drivers, 74 of whom dropped out before the four month study was complete. This illustrates the difficulties of carrying out research in this area, and a large initial group may be required to account for later non-compliance.

In the Swedish study (Gill & Wijk 2004) the authors noted that only half of the interviewed drivers aspired to change their eating habits, and while the drivers acknowledged stress as a recurring element of their working day, they seemed to accept it as an inevitable part of the truck driver's life. The authors also pointed out that unusually for such a large workforce, they do not have a shared workplace, and therefore they can prove difficult to reach. This intervention was carried out at a truck stop, and managed to successfully interview over 600 drivers, indicating the importance of location for achieving good results. This study proved successful in terms of improving the nutrient content of the meals provided to the drivers, and in turn the drivers proved receptive and likely to choose healthier options following the health education stage. However even though the project ran for three years, no evidence is provided of any improvements found in the drivers, or in subsequent accident statistics.

Studies carried out in Australia confirm findings of the US wellness survey that show that many drivers identify poor diet as a problem, but it is not generally recognised as a contributory factor to fatigue. An extensive review of fatigue-related literature carried out by Krueger, Belzer et al (2007) reveals that nutrition is considered as a "common health risk" among drivers; however, including dietary changes in fatigue management programmes does bring results, albeit unquantified; one haulage company involved in a programme in the USA which included nutrition advice consequently reported a reduction in accident statistics and has been recognised for its consistent safety performance as a result of implementing the program. (Krueger, Brewster et al 2007).

The results of an early study (Lisper & Eriksson 1980) compared the effects of driving for 8 hours with a break and no food to driving for 8 hours with a break and food. Interestingly, the results showed that food intake has a positive effect on reaction times, but that a break alone may have a negative effect.

The main conclusions from this review of literature are that there is a paucity of quantitative research in the area of the impact of nutrition on stress and fatigue in heavy goods vehicle drivers. The research confirms anecdotal evidence that drivers generally show restricted eating habits, tending to rely on unhealthy snacks and stimulants; also it appears that drivers are very aware of dietary issues, and even show some resentment that they are often unable to access healthy options because of their occupation. Health interventions have been generally welcomed, but compliance is an issue, perhaps reflecting methodological weaknesses. Wellness studies show that drivers do not necessarily identify obesity and an unhealthy diet as contributory factors to fatigue. Short term stimulation of the HPA axis with energy drinks produces only short term relief from fatigue symptoms, and due to the

complexity of the stress response via the HPA axis, and the ongoing stress inputs for heavy goods vehicle drivers, a more in depth evaluation of drivers' nutritional requirements seems to be indicated.
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DISCUSSION

Selye (1984) determined that any stress, good or bad, has the same effect on the body. Stress signals act on both the sympathetic nervous system, which releases catecholamines (adrenalin, noradrenalin and dopamine) and the hypothalamic-pituitary-adrenal (HPA) axis, which produces the glucocorticoid, cortisol. Generally, the sympathetic nervous system acts to divert blood from the peripheral organs to the muscles and brain for action; it shuts down digestive processes and increases the heart rate to take on more oxygen to create fuel. Cortisol encourages the release of glucose stores from the liver and antagonises insulin, so that glucose remains available in the blood for use by muscles and brain. When the stressful situation has passed, the parasympathetic nervous system takes over and returns the body to its normal state.

If however, as may occur in the daily routine of the heavy goods vehicle driver, stressors become excessive or continuous, Selye's theory of the general adaptation syndrome suggests that we progress from the initial alarm stage to a resistance stage whereby cortisol levels do not decrease but continue in order to keep the body in an alert state. If cortisol is produced at this rate for a long period, adrenal exhaustion may follow, whereby the adrenal glands can no longer produce the hormones required to respond to the stress signals and fatigue may result (see figure 3). The complex feedback mechanisms can also become disrupted by various factors, for instance obesity, lack of sleep or poor diet and an inflammatory state may predominate, feeding back into the HPA axis. Symptoms of fatigue can become evident even at the resistance stage, and a continued stress response without micronutrient support may deplete the body's reserves, resulting in both exhaustion of the adrenal glands and the diversion of nutrients from the body's attempts to continue the normal repair and maintenance of other physiological systems.

To compound this, the general population in the western world have been found to have a less than acceptable intake of essential nutrients (Schmidhuber & Shetty 2004) and this, in addition to the knowledge that the food choices of HGV drivers may be limited by both availability and attitude, as previously discussed, leave them vulnerable as a group.

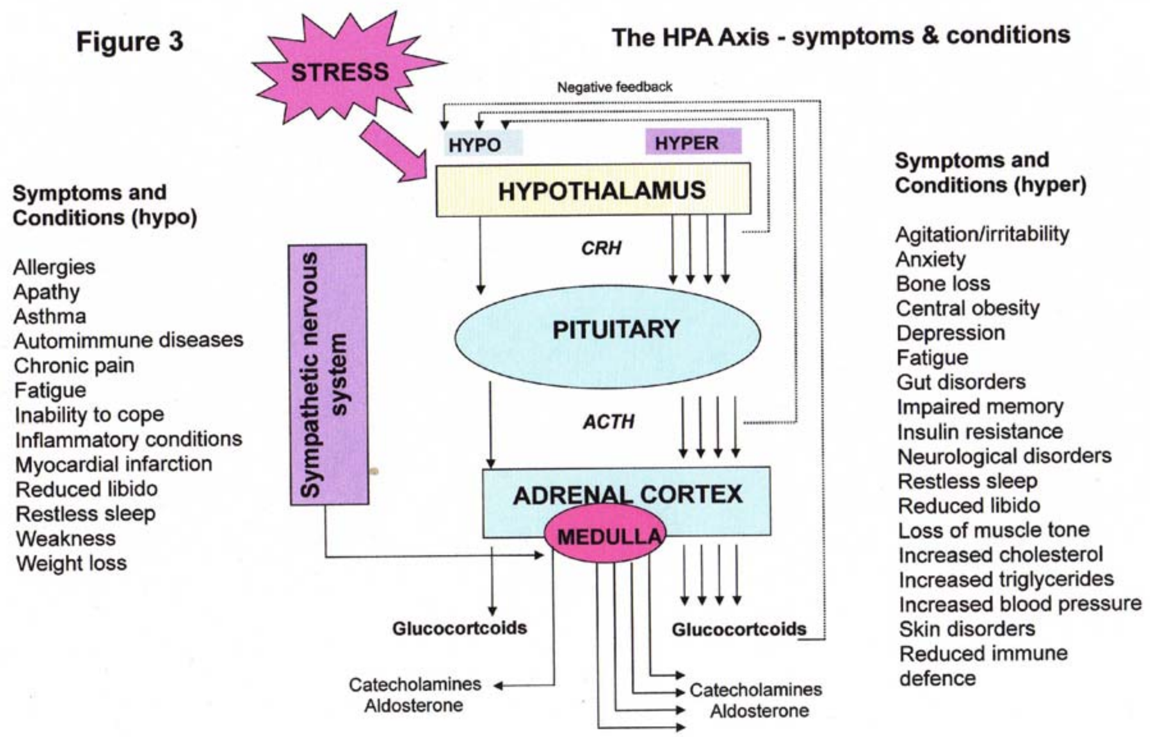

Figure 3: Symptoms and conditions resulting from hypo and hyper function of the HPA axis (adapted from J Bland "Nutritional Endocrinology: Breakthrough Approaches for Improving Adrenal and Thyroid Function" Seminar 2002)

There are several main areas which contribute to the overall stress load of the truck driver which could be mitigated by proper nutritional support. Although these areas are not unique to truck drivers, research shows that as a group they may experience many more stressors on a daily basis than many other occupational groups (Koda, Yasuda et al 2000).

Toxic environment:

Truck drivers are exposed to exhaust fumes on a daily basis, by the side of the road, at truck stops, at the depot. In addition, many petrol tanker drivers, or those transporting other chemical substances, may be subject to additional chemical exposure. There is research that shows that workers exposed to diesel motor exhaust over 20 to 30 years have significantly higher rates of lung cancer (Bruske-Hohfeld et al 1999). Also, diesel fumes generate substances such as hydrocarbons and formaldehyde, also ultrafine particles including carbon and transition metals which can enter the bloodstream (Sydbom et al 2001). The effect of toxins on the body varies according to the individual's capability for detoxification, and while genetic factors may be involved here, nutritional deficiency leading to enzyme or cofactor inhibition is a major factor in determining detoxification capacity. The body deals with exogenous toxins via the liver's complex detoxification system, which converts lipid soluble substances to water soluble substances that can then be excreted via the urine/stool. This conversion is particularly important, since toxins tend to be lipid-soluble and can thus be stored away in fat cells, which may add to a propensity for fat accumulation. The mucosal wall of the intestine and the liver are the major sites of detoxification, and the first phase involves adding a functional group to the toxic molecule, which allows it to undergo phase II conjugation reactions, which render them suitable for excretion. This process produces reactive molecules as an intermediate product, and the more efficient phase II is, the less likely that tissue damage will occur from excess free radicals. It is therefore vital that a balance exists between the two phases, and both phases require nutrient support in the form of B vitamins, folic acid, the tripeptide glutathione, and the branched chain amino acids, along with flavenoids and phospholipids (Bland 2004). A further effect of a nutrient poor diet may be that the role of the gut in eliminating toxins becomes impaired (Wilmore et al 1988). The gut microflora plays an important role in helping to eliminate toxins, and a diet low in fibre, for instance, may allow toxins to be re-absorbed. Typically, the result of poor detoxification capacity and high toxic load is oxidative stress and tissue damage, causing inflammatory cytokines to stimulate the HPA axis (Tsigos et al 1997), and leading to symptoms such as fatigue, brain fog and lethargy.

Pain:

Drivers are exposed to long hours sitting, poor seating or posture, and vibration, while other factors may include strenuous physical work including heavy lifting, jumping up and down from cabs, strapping down loads. Studies have confirmed that musculo-skeletal problems, particularly low back pain, are prevalent among heavy goods vehicle drivers. Robb & Mansfield (2007) surveyed 192 truck drivers in the UK, and found that 60% reported low back pain, while 81% reported musculo skeletal problems such as ache, pain or discomfort. The authors discuss contributory factors and note that the mean BMI of the study group was 28.6, the group's range being from 18 to 44. Significantly, higher BMI correlated with knee foot/ankle problems rather than low back pain, and the authors point out that other lifestyle factors are probably involved, such as insufficient exercise and smoking (which may deplete vitamin C and may lead to malnutrition of the spinal discs). They also note that drivers often feel constrained to an unhealthy diet, and cite Jack et al (1998).

While stress diverts nutrients from the repair processes, a diet high in processed food or refined carbohydrates can stimulate a high insulin response, which in turn encourages release of amino acids from muscle tissue, adding to musculo-skeletal distress. Another result of musculo-skeletal pain is an inflammatory response via cytokines such as TNFalpha, IL-1ß and IL-6 which profoundly stimulate the HPA axis (Tsigos et al 1997) and contribute further to the ongoing stress burden of the driver. A diet lacking in omega 3 fatty acids may also contribute to the inflammatory response, as these long chain fatty acids have been found to have anti-inflammatory effects (Simopoulos 2002).

Sedentary lifestyle:

The body's uptake of glucose is reliant on demand rather than supply, that is, insulin receptors are stimulated and multiply in response to exercise (Duncan et al 2003), thereby responding to the demand for energy. High intakes of sugar in a sedentary subject may stimulate the production of insulin, but not necessarily its uptake into cells, due to possible lack of receptors. This may lead to both high insulin levels and high blood sugar levels, leading to dysregulation of blood sugar control, which in turn impacts on the cortisol feedback mechanism in the stress response (Tsigos et al 1997). The research by Duncan et al (2003) shows that even a modest amount of exercise in the absence of fat loss improves markers of glucose and fat metabolism in previously sedentary, middle-aged adults. Long haul vehicle drivers in particular are necessarily sedentary in their occupation, however, many admit to a sedentary lifestyle generally. An excess of dietary refined carbohydrates may not be helpful in insulin resistance, and the liver can respond by turning excess sugar to fat, leading to both increased visceral fat and increased cholesterol production.

Gastrointestinal dysfunction:

Stress affects serotonin production in the gut during sympathetic stimulation, aimed at down-regulating digestive processes as part of the “fight or flight” response. However, if the sympathetic nervous system predominates, as in chronic stress, serotonin production may become dysregulated, leading to irritable bowel type symptoms, as serotonin is involved in regulating the involuntary contraction and relaxation of the bowel in the waste removal process (Nakade et al 2007). Evidence suggests that gastrointestinal problems are experienced by many truck drivers, and a retrospective study examined the health conditions of heavy vehicle drivers admitted to hospital as a result of a road crash. Digestive disorders were noted as the second most common condition which characterised this group, after musculo-skeletal disorders (Meuleners et al 2005). In addition, a study carried out on shift workers in an auto factory in the USA concluded that evening shift and widely varying work start and end times may increase risks for GI disturbances (Caruso et al 2004). Poor digestive function may perpetuate poor dietary habits as food intolerances or GIT symptoms develop, adding to the cycle of restricted food intake and poor nutrient absorption, while gut wall inflammation may initiate inflammatory cytokine activity, impacting further on the HPA axis (Kojima et al 2002).

Sleep debt:

In some studies sleepiness is defined as a separate problem from fatigue (Brown 1994) and functionally, the difference between fatigue and sleepiness is that sleepiness (i.e. acute fatigue) may be relieved by sleep, whereas fatigue, in its more chronic form, may not be relieved by sleep; in fact a major characteristic of someone who is chronically fatigued is that they may wake up unrefreshed after a night’s sleep (Mosby 2006).

Long haul drivers in particular routinely experience abnormal sleep/wake schedules and sleep deprivation. A study of 227 drivers found that 12.3% had slept less than 6 hours in the previous 24 hours, and 17.1% had been awake for longer than 16 hours. In particular the last night at home prior to a new working week often gave a shorter sleep time, and shifting sleep schedules between work and rest periods can generate long episodes of wakefulness (Philip 2005). A randomized crossover design study under sleep deprived and non sleep deprived conditions concluded that duration of driving is not the main factor to explain driver impairment, but time awake and previous sleep duration have a much bigger impact (Philip et al 2005). Thus lack of sleep can accumulate, leading to a "sleep debt".

Sleep debt can also arise from restricted sleep, or sleep fragmentation, but in addition a large percentage of drivers may suffer from sleep disordered breathing, or sleep apnoea (Stoohs et al 1994), a condition associated with obesity. Sleep apnoea is acknowledged as a common cause of sleepiness, and sleep disordered breathing can significantly impair the brain functions which normally maintain daytime alertness (Stoohs 1996). One study showed that people with moderate to severe sleep apnoea syndrome have an up to fifteen-fold risk increase of motor vehicle accidents (Horstmann al 2000). In this condition, the subject may be unaware that the quality of their sleep is not providing the recovery that they require, and a "sleep debt" builds up.

Spiegel at al (2005) looked at the impact of sleep debt on metabolic and endocrine function and concluded that the most likely mediating mechanisms involve elevations of sympathetic neural activity and evening cortisol levels, suggesting disruption of the HPA axis. They found that further impacts of sleep loss include disruption in the production of growth hormone which has a role as a regulator of glucose levels and hence insulin production. A further study (Spiegel et al 2004) looked at the production of leptin, one of the appetite-regulating hormones, and this was also found to decrease with sleep restriction, along with production of TSH (thyroid stimulating hormone), one of the main regulators of metabolic processes. Leptin in particular has been the subject of recent research seeking to understand the aetiology of obesity, and people with disorders whereby they are unable to produce leptin have been found to eat excessive amount of food and become obese (Fletcher et al 2007).

The consequences of sleep debt for a long distance driver can therefore be severe, contributing to increased inflammation, poor appetite control, disrupted blood sugar control, and ultimately obesity, and/or type II diabetes (see figure 4) all of which impact on the HPA axis. A diet low in essential nutrients and high in refined carbohydrates may further impact blood sugar control and contribute to accumulation of visceral fat.

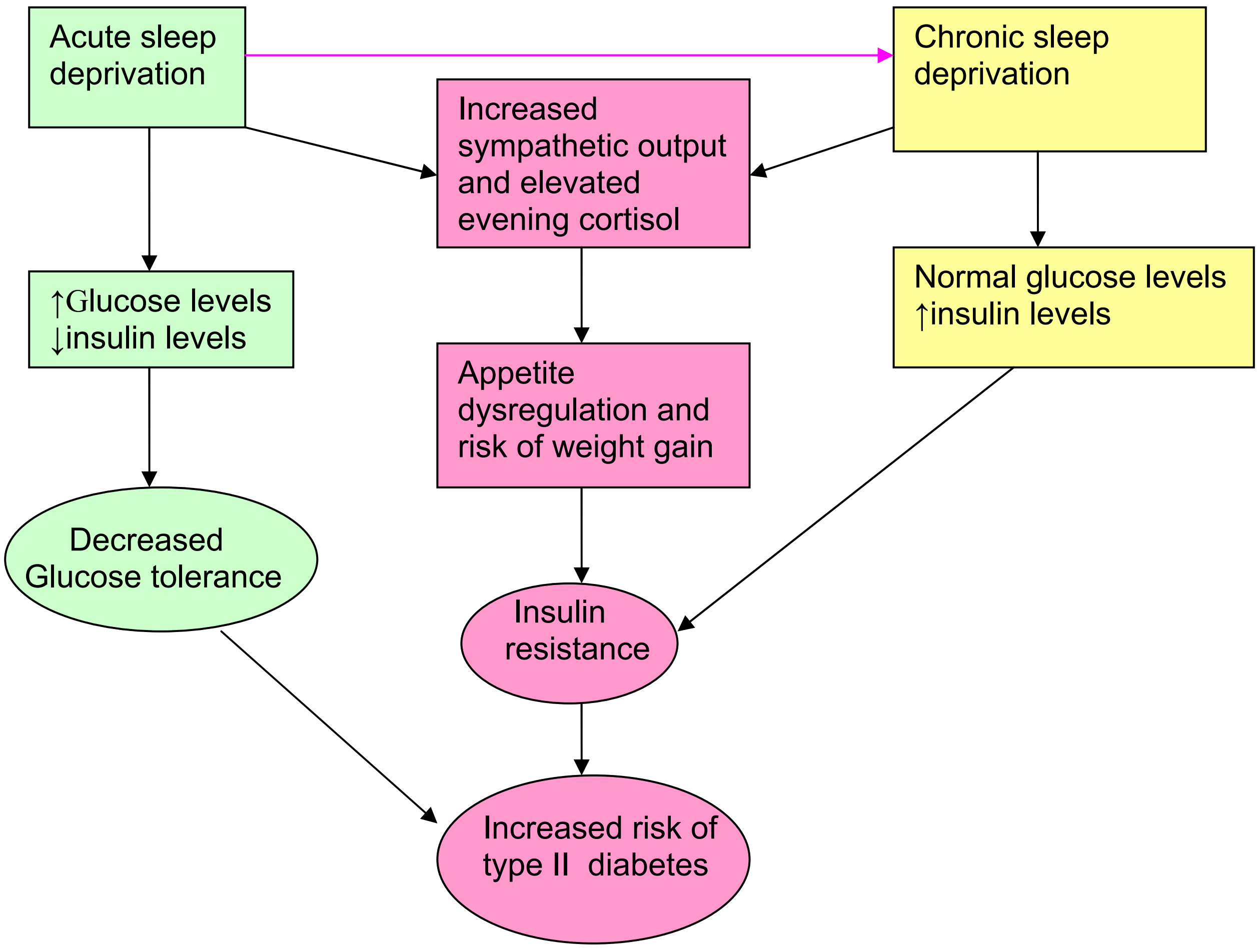

Figure 4: Diagram showing possible mechanisms whereby sleep deprivation may lead to weight gain, altered glucose metabolism and type 2 diabetes. Adapted from Spiegel et al (2005)

Psychological stress:

Among occupational risk factors, stress induced by the responsibility for assuring public safety in heavy urban traffic (in the case of bus/coach drivers), the pressures of meeting deadlines whilst dealing with traffic queues, incidents on the road and finding suitable rest stops and overnight stops, have all been cited as daily concerns for the driver (Siedlecka 2006), particularly among short haul drivers, who have reported more subjective feelings of fatigue than long haul drivers (NTC 2007). Psychological stress has the same impact on the HPA axis as physical stress. Low cortisol, as a result of adrenal insufficiency, allows insulin levels to rise to clear the high blood sugar levels, and insulin resistance may result, whereby not enough glucose enters the cells for energy production. On the other hand, if cortisol levels are high due to over-production, then insulin production is antagonised, again leaving high levels of glucose in the blood, and reduced energy production. The end result is that energy levels drop and fatigue is experienced as the cells (mainly of muscle and brain) are starved of glucose for fuel. Such a condition may result in a craving for more carbohydrate/high fat foods to compensate. The intake of more calories than are expended adds to the probability of weight gain and the continuation of the cycle of blood sugar dysregulation, which in turn reduces the individual's ability to respond positively to stress (Tsigos & Chrousos 2002).

CONCLUSIONS

The main findings of the literature review show that drivers have a self-acknowledged poor nutrient intake, in an occupation where nutritional demands are high. There is some concensus that this contributes to fatigue, but to date there has been no direct measurement of the effect of nutrition on the fatigue status of HGV drivers. It would appear that the whole area of research into fatigue in relation to professional drivers underestimates the importance of nutrition, although diet is included in most fatigue management or health intervention programmes. It would therefore be appropriate to design a study, with the use of a truck simulator, which would attempt to measure and evaluate driving performance, before and after improvements in nutritional intake.

The main nutritional focus of the dietary intervention should aim to support and modulate the cortisol/insulin relationship which is so critical in the fatigue mechanism. It should also aim to support gut function, detoxification, hormonal and neuronal health, as discussed in the previous section, given their bi-directional relationship with the HPA axis.

Given the known difficulties of compliance, a large initial group may need to be recruited, with a possible drop-out rate of up to 50%. A placebo trial is not practical where full dietary intervention is involved, and a crossover trial may also be problematic in that the group benefitting from the improved diet may not want to change back to previous dietary habits, or may carry through physiological improvements to the next stage of the trial, even with a washout period. It would however be possible to provide three groups, one being the control group who would continue with their current dietary intake, the second group would be given an achievable diet plan to follow, and the other the same diet plan plus nutritional supplements. This could evaluate the benefits of dietary intervention and the possible added value of supplemental micronutrients.

Alongside suitable baseline physiological measurements, it would be useful to perform a functional adrenal stress index test before and after the intervention, which measures free cortisol in saliva. This test also measures DHEA levels, a hormone produced by the adrenal gland which has been shown to be affected by stress (Garrow & James 2000) along with secretory IgA, an immunoglobulin which patrols the mucosal membranes and has also been found to be depleted by stress and is a useful marker for the effectiveness of interventions designed to improve diet and reduce fatigue (Carins & Booth 2001). By testing saliva at various stages throughout the day, levels can be compared to the expected diurnal cortisol production. Deviations in these levels are indications that stress has affected cortisol production (Genova Diagnostics 2007) and therefore energy levels may also be affected. A sample ASI test result is attached as Appendix B, in this case indicating a state of adaptation due to continual stress.

Use of the truck simulator could provide driver behaviour measurements such as speed variability, lane deviation, critical incidents and reaction times. It could also provide physiological data of tiredness such as yawning and eye movement. Post trial impairment tests could also be carried out to assess the degree of awareness using adaptive tracking, choice reaction and critical flicker frequency, and a subjective fatigue assessment. These have been found to be good indicators of driving fatigue in previous fatigue related driving trials (Parkes et al 2005).

Given that many of the stressors that lead to fatigue in heavy goods vehicle drivers may not be within their control, for instance work schedules, traffic queues, environmental pollutants etc, diet is one area that presents an opportunity for them to take control of their environment, and mitigate some of the effects of stress that may cumulatively lead to fatigue. This research has found that compliance with health initiatives is an issue among HGV drivers, while access to healthy food is often limited. A trial to quantify the benefits of a healthy diet may provide a more solid basis on which to implement a healthy lifestyle intervention plan, leading to better fatigue management in the trucking community, and also influence those regulating the haulage industry, and those providing roadside catering facilities. However, given that traffic accidents are rare random events that have many causes, it may still prove difficult to isolate and evaluate the effects that diet may have in the long term on accident statistics.

REFERENCES:

ATSB (2002) Fatigue-related crashes, ATSB Road Safety Research Report OR23

Benton D, Ruffin MP et al (2003) The delivery rate of dietary carbohydrates affects cognitive performance in both rats and humans. Psychopharmacology (Berl), Feb 2003; 166(1):86-90 [Abstract only]

Bigert C, Gustavsson P, et al (2003) Myocardial infarction among professional drivers. Epidemiology. May 2003;14(3):333-9

Bland JS Clinical Nutrition, a functional approach. Institute for Functional Medicine 2004, Gig Harbor, Wa.

Braverman E The Healing nutrients within, 3rd ed 2003. Basic Health Publications Inc, North Bergen, NJ.

Brown I (1994) Driver fatigue. Human Factors 1994; 36(2):298-314

Bruske-Hohlfeld I, Mohner M et al (1999) Lung cancer risk in male workers occupationally exposed to diesel motor emissions in Germany. Am J Med Oct 1999;36(4):405-14

Burgess-Limerick R & Bowen-Rotstaert D (2002) Fatigue Management Programme, Pilot Evaluation, Phase 2, Wave 3. Global Institute of Learning & Development Consortium, Queensland, June 2002

Carins JE & Booth CK (2001) Evaluation of a simple immunological test (sIgA) during the RAAF survival course. Australia Dept of Defence DSTO-RR-0224 2001

Caruso CC, Lusk SL & Gillespie BW (2004) Relationship of work schedules to gastrointestinal diagnoses, symptoms, and medication use in auto factory workers. Am J Ind Med, December 2004; 46(6):586-98.

DfT (2005) Road Safety Report no 58

Duncan GE, Perri MG et al (2003) Exercise Training, Without Weight Loss, Increases Insulin Sensitivity and Postheparin Plasma Lipase Activity in Previously Sedentary Adults. Diabetes Care, Mar 2003; 26:557

Fischer K (2001) Short-term effects of macronutrient ingestion on postprandial metabolism and cognitive performance as well as hunger and satiety in the morning. Thesis (PhD) Univ of Kiel

Fletcher H & Fairfield KM (2002) Vitamins for Chronic Disease Prevention Clinical Applications JAMA 287(23)

Garrow JS, James WPT & Ralph A (2000) Human Nutrition & Dietetics, 10th ed. Churchill Livingstone, Edinburgh UK.

Genova Diagnostics Europe, Practitioners Section: Sample ASI Report, accessed 3/10/07; www.iwdl.net

Gill PE & Wijk K (2004) Case study of a healthy eating intervention for Swedish lorry drivers. Health Education Research 19(3)

Hanowski RJ, Wierwille WW & Dingus TA (2003) An on-road study to investigate fatigue in local/shorthaul trucking. Acc Anal Prev 2003; 35:153-160

Horne JA & Reyner LA (1995) Sleep related vehicle accidents. BMJ 1995;310,565-567

Horstmann S, Hess CW et al (2000) Sleepiness-related accidents in sleep apnea patients. Sleep 2000;23(3)

Jack FR, Piacentini MG & Schroder MJ (1998) Perception and role of fruit in the workday diets of Scottish lorry drivers. Appetite 1998; 30(2):139-49

Koda S, Yasuda N et al (2000) Analyses of work-relatedness of health problems among truck drivers by questionnaire survey. Sangyo Eiseigaku Zasshi. 2000 Jan;42(1):6-16. [Abstract only, article in Japanese]

Kojima K, Naruse Y et al (2002) HPA-axis responses during experimental colitis in the rat. J Physiol Regul Integr Comp Physiol,May 2002; 282(5):R1348-R1355

Korelitz JJ, Fernandez AA, Uyeda VJ et al (1993) Health habits and risk factors among truck drivers visiting a helath booth during a trucker trade show. Am J Health Promot Nov 1993; 8(2):117-23

Krueger GP, Belzer MH et al (2007) Health and Wellness of Commercial Drivers. Transportation Research Circular E-C117:58-91

Krueger GP, Brewster Rm et al (2007) Health and Wellness Programmes for Commercial Drivers. Transportation Research Board, Commercial Truck & Bus Safety Synthesis 15

Lisper HO & Eriksson B (1980) Effects of the length of a rest break and food intake on subsidiary reaction-time performance in an 8-hour driving task. J Appl Psychol,Feb 1980; 65(1):117-22

Lyman S & Braver ER (2003) Occupant deaths in large truck crashes in the United States: 25 years of experience. Accid Anal Prev, Sep 2003; 35(5):731-9

McCartt AT, Rohrbaugh JW et al (1999) Factors associated with falling asleep at the wheel among long-distance truck drivers. Accid Anal Prev. Jul 2000; 32(4):493-504

Meuleners LB, Lee AH, Legge M (2005) Health conditions of heavy vehicle drivers involved in a crash in Western Australia: a retrospective study using linked data. Health Promot J Austr. Apr 2005;16(1):37-40

Morgan WKC, Reger RB & Tucker DM (1997) Health effects of diesel emissions. Ann Occ Hyg, Dec 1997;41: 643-658.

Mosby's Dictionary of Medicine, Nursing and Health Professions, 7th edition, 2006 Mosby Elsevier, St Louis MI.

Murray MT & Pizzorno JE Encylopedia of Natural Medicine, 2nd rev ed. 1998 Little, Brown, London

Nakade Y, Fukuda H et al (1997) Restraint stress stimulates colonic motility via central corticotropin-releasing factor and peripheral 5-HT3 receptors in conscious rats. Am J Physiol Gastrointest Liver Physiol, 2007; 292:G1037-G1044

NTC (2007) Reform Evaluation Survey on Driver Fatigue: A national study of heavy vehicle drivers. National Transport Commission Australia May 2007

O'Connor TM, O'Halloran DJ & Shanahan F (2000) The stress response and the hypothalamic-pituitary-adrenal axis: from molecule to melancholia. Q J Med 2000; 93:323-333

Orris P, Buchanan S et al (2005) Literature Review on Health & Fatigue Issues associated with commercial Motor Vehicle Driver hours of work. Transportation Research Board, Commercial Truck & Bus Safety Synthesis 15

Padayatti SJ, Doppman JL et al (2007) Human adrenal glands secrete vitamin C in response to adrenocorticotrophic hormone. American Journal of Clinical Nutrition, July 2007; 86(1):145-149

Parkes A (2006) Review of Anderson C & Horne JA: A high sugar content low caffeine drink does not alleviate sleepiness but may worsen it. TRL Ltd, unpublished project report UPR 11103719/308

Parkes AM, York I, Burton S & Luke T (2005) An evaluation of energy drinks containing glucose and caffeine, using the TRL simulator. TRL PPR059

Philip P (2005) Sleepiness of occupational drivers. Industrial Health 2005; 43:30-33

Philip P, Sagaspe P et al (2005) Fatigue, sleep restriction and driving performance. Accid Anal Prev, 2005; 37:473-478

Plowman B, Arnold T et al (2000) Shaping up to ship it out: an examination of heavy vehicle drivers' health and lifestyle. Road Safety Research, Policing and Education Conference 2000, Brisbane, Queensland Australia, 501-6

Punjabi NM, Shahar E et al (2004) Sleep-disordered breathing, glucose intolerance and insulin resistance. Am J Epidemiol 2004;160:521-530

Qutob S, Dixon SJ & Wilson JX (1998) Insulin Stimulates Vitamin C Recycling and Ascorbate Accumulation in Osteoblastic Cells1 Endocrinology, 139(1):51-56

Robb MJ, Mansfield NJ (2007) Self-reported musculoskeletal problems amongst professional truck drivers. Ergonomics, 2007 Jun;50(6):814-27.

Roberts S & York J (1999) Design Development and Evaluation of Driver Wellness Programs: pilot test results and marketing plan. FMCSA Tech Mem No.3

Rosmond R & Bjorntorp P (2000) Quality of life, overweight, and body fat distribution in middle-aged men. Behav Med, 2000;26(2):90-4

Schectman G, Byrd JC & Gruchow HW (1989) The influence of smoking on vitamin C status in adults. Am J Public Health, Feb 1989; 79:158-162

Schmidhuber J & Shetty P (2005) Nutrition transition, obesity and noncommunicable diseases: drivers, outlook & concerns. FAO SCN News no.29 2004/05

Selye H The Stress of Life, rev ed 1984, McGraw Hill NY

Siedlecka J (2006) Selected work-related health problems in drivers of public transport vehicles. Med Pr. 2006;57(1):47-52

Simopoulos AP (2002) Omega-3 Fatty Acids in Inflammation and Autoimmune Diseases. Journal of the American College of Nutrition, 2002; 21(6):495-505

Solomon AJ, Doucette JT et al (2004) Healthcare and the Long Haul:Long-Distance Truck Drivers – a medically underserved population. American Journal of Industrial Medicine, 2004; 46:463-471

Spiegel K, Knutson K et al (2005) Sleep loss: a novel risk factor for insulin resistance and type 2 diabetes. J Appl Physiol, 2005; 99:2008-2019

Spiegel K, Leproult R et al (2004) Leptin levels are dependent on sleep duration: relationships with sympathovagal balance, carbohydrate regulation, cortisol and thyrotropin. J Clin Endocrinol Metab 2004; 89: 5762-5771

Stoohs RA (1996) Picking up the pieces: the consequences of sleep fragmentation. Chest 1996; 109:1417-1419

Stoohs RA, Guilleminault C et al (1994) Traffic accidents in commercial long haul truck drivers: the influence of sleep-disordered breathing and obesity. Sleep, Oct 1994; 17(7):619-23

Sydbom A, Blomberg A et al (2001) Health effects of diesel exhaust emissions. Eur Respir J, Apr 2001; 17:733-746.

Tsigos C & Chrousos GP (2002) Hypothalamic-pituitary-adrenal axis, neuroendocrine factors and stress. J Psych Research, 2002; 53:865-871

Tsigos C, Papanicolaou DA et al (1997) Dose-Dependent Effects of Recombinant Human Interleukin-6 on Glucose Regulation J Clin Endocrinol Metab, Dec 1997; 82:4167-4170.

Wells AS, Read NW et al (1998) Effects of meals on objective and subjective measures of daytime sleepiness. J Appl Physiol, Feb 1998; 84:507

Wilmore DW, Smith RJ et al (1998) The gut: a central organ after surgical stress. Surgery, Nov 1988; 104(5):917-23