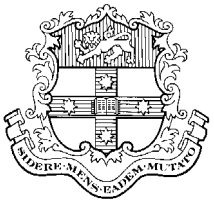

Studies Investigating the Influence of Macronutrient Intake on Sleep

By

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As the doctoral thesis supervisor of Ahmad Afaghi, I certify that I consider his thesis **'Studies investigating the influence of macronutrient intake on sleep'** to be suitable for examination.

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Abstract

Several studies have documented the direct effect of macronutrient intake on sleep. A general picture that has emerged indicates that a low carbohydrate diet with a total energy between 13-47% and high fat content with a total energy between 47-77% shows increases in slow wave sleep and may decrease rapid-eye movement sleep. However, previous studies investigating the association between carbohydrate meals and sleep have not explored the effects of the glycemic index (GI) of carbohydrate on sleep. This thesis investigated the affect of GI on the sleep pattern. In a cross-over, repeated measures design, we explored both the effect of GI and the timing of these meals on sleep in good sleepers. The effects of high and low GI carbohydrate-based meals given 4 h before the subjects' usual bedtime on their sleep quality were examined in Chapter 3. Also evaluated was the effect of high GI meal timing (4 h vs. 1 h) on sleep. Twelve healthy men (18-35y, BMI 18.5-25 kgm^{-2}) were administered a standard, isocaloric meal of low GI = 50 or high GI=109 in a cross-over and counter balanced manner, 4 h before their usual bedtime. On another occasion, the high GI meal was given 1 h before bedtime. Following the high or the low GI meal, participants underwent a familiarization sleep night followed by three polysomnographic test nights. The subjects' blood and urine were collected for glucose and 6-sulfatoxymelatonin analysis respectively. Significant differences were found between the area under

the curve (AUC) for blood glucose responses following the high GI meal compared to the responses for the low GI meal. It was shown that a carbohydrate-based high GI meal resulted in a significant shortening of sleep onset latency (SOL) in normal sleepers compared to a low GI meal ($P = 0.009$), and was most effective when consumed 4 h before bedtime ($P = 0.01$). There were no significant changes in other sleep indices.

The Atkins' Diet is a popular dietary therapy that promotes weight loss. This restricted carbohydrate diet with high fat and high protein content has not been evaluated for its effects on sleep, or systematically documented for its effects on mood, fatigue or sleepiness. The short term effect of the Atkins' diet over 48 h on the sleep quality of healthy, non-obese males to a Control mixed diet was compared in Chapter 4. This study employed a repeated measure design where fourteen healthy, non-obese, good sleepers were given isocaloric diets and matching evening test meals (4 h before usual bedtime), which were either mixed (15% protein, 25% fat, 60% carbohydrate) or Atkins' (38% protein, 61% fat, <1% carbohydrate). After a familiarization night with polysomnography, further polysomnographic testing was then performed on the Control night, 4 h after the first Atkins' test meal (Atkins Acute) and 48 h (Atkins Ketosis) following commencement of the Atkins' diet. Objective sleep was recorded using Compumedics S-series Sleep system; Compumedics Ltd, Melbourne, Australia. Urine ketone level was monitored before the evening test meals and at bedtime on

the Control night, during the Atkins Acute and Ketosis phase. Blood glucose level was measured before the evening test meal until 120 min following the meal. Significant differences were found for the AUC for the blood glucose between the Control night and the Atkins Acute and Atkins Ketosis phase ($P < 0.001$). Participants developed mild hypoglycemia and ketosis 48 h following the Atkins' diet. A significant reduction in the proportion of rapid eye movement (%REM) sleep to total sleep time (TST) was observed following the Atkins' Acute and Atkins' Ketosis phase compared to the Control ($P = 0.006$ and 0.05 respectively). The percentage of slow wave sleep (%SWS) to TST significantly increased for both the Atkins' Acute and Ketosis phase compared to the Control meal ($P = 0.02$ for both phases). The sleep changes may be linked to the energy metabolism of fat of the Atkins' diet.

The effects of the Atkins' diet compared to a Control mixed diet on sleepiness, mood, fatigue and dream recall were also investigated (Chapter 5). Participants' overall daytime mood, fatigue intensity, sleepiness and other symptoms were assessed using a visual analogue scale before the evening test meals. The number of subjects with dream recalls was recorded on awakening after each polysomnographic night. The daytime symptoms of fatigue, sleepiness and depressed mood were significantly increased following the Atkins' diet compared to the Control diet. A greater proportion of subjects reported dreams 48 h after the Atkins' diet compared to either the Atkins' Acute phase or the Control condition.

Our findings suggest that mild hypoglycemia resulting from the diet may mediate the subjective responses of daytime sleepiness, depressed mood and intense fatigue. The increased proportion of subjects with dream recall may be related to an increased transient arousals from sleep during which dreams are usually consolidated into memory.

The finding that “high-glycemic-index carbohydrate meals shorten sleep onset” may be relevant to persons with sleep disturbance. These meals may facilitate sleep transition for those with sleep initiation problems. The effect of the Atkins’ diet in SWS promotion and increasing feelings of fatigue and suppressing mood in the short-term may be relevant for patients with sleep apnoea (obesity), who experience low proportion of SWS and significant somnolence. Further studies to explore these effects on a longer term in this group would be worthwhile.

STATEMENT OF THE AUTHOR

I, Ahmad Afaghi, hereby declare that this thesis is my own work and that it contains no material previously published or written by another person except where acknowledged in the text. Nor does it contain material which has been accepted for the award of another degree.

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Signed:

Date:

PUBLISHED WORKS

Parts of this work presented in this thesis have been published in the

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PAPERS SUBMITTED FOR PUBLICATION

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