

# AN EXAMINATION OF THE NATURE OF SLEEP FRAGMENTATION IN CHILDREN WITH UPPER AIRWAY OBSTRUCTION

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## ***i. Abstract***

An examination of the nature of sleep fragmentation in children with upper airway obstruction.

**Introduction** – Sleep related upper airway obstruction (UAO) in children disrupts breathing in sleep, resulting in sleep fragmentation and subsequent neurocognitive and behavioural deficits. Unfortunately the nature of this fragmentation in children is poorly understood and a universally accepted, clinically valid, measure of sleep fragmentation has been elusive. This limits our ability to accurately determine and measure the consequences of sleep fragmentation on a child's development due to UAO, as well as the success of any treatment administered.

**General Aims** - The aim of the current study was to (i) examine the nature of sleep fragmentation in children with upper airway obstruction and (ii) to develop a new sleep fragmentation index for use in paediatric clinical populations with upper airway obstruction. When this study began no such index existed that was widely accepted and utilized. A range of sleep fragmentation measures already trialed in children with upper airway obstruction were reviewed to identify problems and limitations with current and previous methods of measuring sleep fragmentation in these children. An attempt was also made to identify other possible additional factors that mediate sleep fragmentation so as to develop a workable and generally applicable sleep fragmentation index for children with upper airway obstruction.

**Methods** – We performed a series of analyses on sleep and neurocognitive data from children with upper airway obstruction to identify and quantify neural activity associated with sleep fragmentation. We then used these measures and other mediating factors to create a composite measure of sleep fragmentation in children.

**Results** – We found that children with upper airway obstruction had characteristically altered neural activity as measured by electroencephalogram (e.g. changes in sleep spindle density,

decreased alpha and sigma power around spontaneous arousals from sleep). They also had an altered movement distribution in sleep (increased exponential distribution coefficient when sleep runs between movements are modeled on a survival curve), when compared to normal controls. The studies also demonstrated the potential ability of a composite measure of such sleep fragmentation markers and mediating vulnerability factors to more accurately and usefully quantify the negative impacts of upper airway obstruction.

**Conclusions** - Sleep fragmentation is a significant consequence of UAO in children, however the current measure of UAO severity is insufficient for determining the overall impact on a child's development. As this study demonstrates, the impact of sleep fragmentation is dependent on a complicated set of variables including: age, health factors (e.g. BMI), exposure time, disease severity (e.g. AHI), genetics, trait-like factors, social factors (e.g. SES) and family history. The arousals, or disruptions to sleep, are also altered in children with UAO compared to normal controls. We therefore propose a composite measure of these important factors as a more accurate tool for determining the impact of sleep fragmentation and overall severity of UAO in children.



## ***ii. Signed Declaration***

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968. The author acknowledges that copyright of published works contained within this thesis (as listed below) resides with the copyright holders of those works.

Chatburn, A., S. Coussens, K. Lushington, D. Kennedy, M. Baumert, and M. Kohler. (2013) "**Sleep spindle activity and cognitive performance in healthy children.**" *Sleep*, 36(2): pp. 237-243.

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Coussens, S., Baumert, M., Kohler, M., Martin, J., Kennedy, D., Lushington, K., & Pamula, Y. (2014). "**Movement distribution: a new measure of sleep fragmentation in children with upper airway obstruction.**" *Sleep*, 37(12), pp. 2025-2034.

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**v. *Style and Referencing Format of Jointly Authored Papers, Documents and Unpublished Manuscripts***

The manuscript style and referencing format for chapters 1,2,3,5,7 and 8 are that prescribed by the journal Sleep Medicine.

The manuscript style and referencing format for Chapters 4 and 6 are that prescribed by the journal Sleep.

## ***vi. Abbreviations***

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$\alpha$	<i>Alpha Wave Form In EEG (~ 9 – 12 Hz)</i>
ACPT	Auditory Continuous Performance Test
Adolescents	12-18 Years Old
AHI	Apnoea-Hypopnea Index
ANOVA	One Way Analysis Of Variance
Artotl	Total Arousal Index
BMI	Body Mass Index
C	Control
CA	Central Apnoea
CBCCL	Child Behaviour Check-List
Children	4-11 Years Old
CPRS	Conner's Parents Rating Scale
CRS-R	Conner's Rating Scale – Revised (Conners 1997)
DAS	Differential Abilities Scale
DBP	Diastolic Blood Pressure;
DS	Daytime Sleepiness
DTVMI	The Developmental Test Of Visual-Motor Integration
EMG (SM)	Electromyogram (Submental) – Chin Electrode Measuring Local Muscle Activity
ESS	Epworth Sleepiness Scales. A Subjective Measure Of Daytime Sleepiness
GDSVD - s	The Gordon Diagnostic System Vigilance And Distractibility Subtests (Gordon 1983)
Infants	1-3 Year Old
MAP	Mean Arterial Pressure
MDI	Mental Development Index

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ME	Movement Events
MSLT	Multiple Sleep Latency Test. An Objective Measure Of Daytime Sleepiness
nCPAP	Nasal Continuous Positive Airway Pressure
NEPSY	Neuropsychological Developmental Assessment (Korkman 2001)
NIPPV	Nocturnal Non-Invasive Positive Pressure Ventilation
NN	SFI Calculated Using A Neural Network Approach To Complicated To Be Summarized In This Paper
ns	Not Significant
nt	Night Of Study Including Clinical PSG
OA	Obstructive Apnoea
OAI	Obstructive Apnoea Index
OSAS	Obstructive Sleep Apnea Syndrome
OSLER	Oxford Sleep Resistance Test. An Objective Measure Of Daytime Sleepiness
PeS	Esophageal Pressure Monitoring
PLMI	Periodic Limb Movement Index
PS	Primary Snoring
R/K	Remember/Know (R/K) Procedure (Tulving 1985)
RAI	Respiratory Arousal Index
REM	Sleep Stage REM (Rapid Eye Movement)
S1, S2, S3, S4	Sleep Stage 1, 2, 3 And 4 Respectively
SAI	Spontaneous Arousal Index
SaO <sub>2</sub>	Arterial Oxyhaemoglobin Saturation
SBP	Systolic Blood Pressure
SPT	Sleep Period Total
TAC	Thoracoabdominal Asynchrony
TCAoSAS	Subjects From The Tucson Children's Assessment Of Sleep Apnoea Study (Mulvaney 2005)

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TST	Total Sleep Time (In Hours)
TWT	Total Wake Time In Hours
Ua	Unattended In Home PSG
WASI	The Wechsler Abbreviated Scales Of Intelligence
WCST- 64	The Wisconsin Card Sorting Test-64 Card Version
WISC-III	Wechsler Intelligence Scale For Children-Third Edition
wk	Weeks
WPPSI-R	Wechsler Pre-School And Primary Scale Of Intelligence–Revised
WRAML	Wide Range Assessment Of Memory And Learning

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