Université de Montréal

Changements développementaux dans la survenue d'épisodes de somnambulisme chez les patients somnambules adultes

Par

Narges Kalantari

Département de psychologie, Faculté des arts et des sciences

Mémoire présenté en vue de l'obtention du grade de maîtrise en psychologie

Décembre 2020

Université de Montréal

Département de psychologie, Faculté des arts et des sciences

Ce mémoire intitulé

Changements développementaux dans la survenue d'épisodes de somnambulisme chez les patients somnambules adultes

Présenté par

Narges Kalantari

A été évalué par un jury composé des personnes suivantes

Christopher M. Earls
Président-rapporteur

Antonio Zadra
Directeur de recherche

Marie-Hélène Pennestri
Membre du jury

Résumé

Loin d'être bénins, les épisodes somnambuliques peuvent être fréquents et/ou graves et comporter un risque élevé de blessures. Une amnésie rétrograde variable peut également accompagner les épisodes. Ce mémoire a examiné l'évolution des épisodes de somnambulisme a trois différentes phases de la vie, un sujet qui reste peu étudié. Des somnambules adultes ayant reçu un diagnostic de somnambulisme primaire, et qui ont été somnambules dès leur enfance (n = 113), ont été évalués pour la fréquence de leurs épisodes, le rappel des contenus mentaux liés à leurs épisodes et l'occurrence d'épisodes agressifs pendant l'enfance, l'adolescence et l'âge adulte. Également, les somnambules qui font des terreurs nocturnes (une parasomnie de sommeil lent souvent observés chez les somnambules) depuis leur enfance (n = 52) ont été évalués pour les changements développementaux dans leurs terreurs nocturnes. Les résultats démontrent que les épisodes de somnambulisme sont demeurés stables pendant l'enfance et l'adolescence de nos somnambules, mais ont augmenté à l'âge adulte. Une tendance opposée a été observée quant à la fréquence des terreurs nocturnes. Le rappel des contenus mentaux associé au somnambulisme et les épisodes agressifs ont augmenté progressivement de l'enfance à l'âge adulte. En contrepartie, le rappel des contenus mentaux associé aux terreurs nocturnes est demeuré stable. De plus, une fréquence plus élevée d'épisodes de somnambulisme agressif c'est avérée un prédicteur d'une fréquence plus élevée d'un rappel de contenu mental lié au somnambulisme. Ces résultats sont comparables entre les hommes et les femmes. Dans l'ensemble, cette recherche démontre que chez les somnambules chroniques, le contenu mental associé aux épisodes somnambuliques augmente et que la fréquence et la sévérité des épisodes s'aggravent entre l'enfance et l'âge adulte.

Mots-clés : somnambulisme, fréquence des épisodes, contenu mental lié à l'épisode, rappel de l'épisode, épisodes agressifs, terreurs nocturnes

Abstract

Far from being benign, somnambulistic episodes can be frequent and/or severe and with high risk of injury. Episodes may also be accompanied by sleep mentation with variable degrees of retrograde amnesia. The present thesis investigated how somnambulistic episodes unfold over time, a topic that remains understudied. Adult sleepwalkers with a diagnosis of primary somnambulism and a childhood onset of the disorder (n = 113) were assessed for changes in frequency of their episodes, recall of episode-related sleep mentation and aggressive episodes during childhood, adolescence and adulthood. Additionally, sleepwalkers (n= 52) with childhood-onset of sleep terrors (a NREM parasomnia commonly experienced by sleepwalkers) were assessed for developmental changes in sleep terror frequency. The frequency of somnambulistic episodes remained unchanged during childhood and adolescence before increasing into adulthood. An opposite trend was observed for the frequency of sleep terrors. The frequency of aggressive somnambulistic episodes and of sleep mentation associated with somnambulism increased from childhood to adolescence and into adulthood. By contrast, the recall of sleep mentation associated with sleep terrors did not change over time. Additionally, a higher frequency of aggressive somnambulistic episodes predicted a higher frequency of sleep mentation associated with somnambulism. These findings were similar between men and women. In conclusion, our study demonstrates that in chronic sleepwalkers, sleep mentation associated with somnambulistic episodes increases with age while episodes worsen in frequency and severity from childhood to adulthood.

Keywords: somnambulism, episode frequency, episode-related sleep mentation, episode recall, aggressive episodes, sleep terrors

Table of Contents

List of Tables

List of Abbreviations

ANOVA: analysis of variance

EEG: electroencephalography

EMG: electromyography

EOG: electro-oculography

Hz: hertz

ICSD-II: International Classification of Sleep Disorders, 2nd edition

LMM: linear mixed model

NREM: non-rapid eye movement

PSG: polysomnography

REM: rapid eye movement

Acknowledgments

First and foremost, I would like to thank my supervisor, Antonio, whose knowledge, guidance and support allowed me to accomplish this master's thesis. It was reading about your fascinating research projects that made me interested in pursuing graduate studies in psychology, and I cannot emphasize how glad I am to have made this decision. Thank you so much for giving me the autonomy to choose a project that fit my interests, despite all the complications that the pandemic brought along. Thank you so much for always being present when I needed your support and for meticulously revising my writings. It was an honour to be your graduate student and learn from you.

Special thanks to Pierre for his invaluable help with statistical analysis and for patiently answering my numerous emails and questions. I would also like to thank my lab colleagues, specially Cloé and Mira for all their advice during my first semester of graduate studies. I always enjoyed the time we spent together at the lab, and I wish it did not have to change due to the lockdown.

Accomplishing my thesis would have not been possible without the encouragement from my family and close friends. Thank you so much for your love, patience and for being incredibly supportive through thick and thin.

Chapter 1 – Introduction

1.1 Overview

Somnambulism**,** or sleepwalking, is a non-rapid eye movement (NREM) sleep disorder comprised of unwanted movements, such as walking about, that occur during incomplete arousals from stage N3, the deeper slow-wave stage of sleep (Arnulf, 2018). Behaviours associated with somnambulistic episodes can range from simple movements, such as sitting up in bed, to more complex actions, such as leaving one's house or running away from a perceived threat (Avidan, 2017). Although somnambulism is most common during childhood, it can also continue into or develop during adulthood (Hublin, Kaprio, Partinen, Heikkila, & Koskenvuo, 1997; Kales, Soldatos, Caldwell, et al., 1980). In children, somnambulism is usually benign with non-violent and relatively harmless behaviours. However, in certain cases and particularly in adults, behavioural episodes can be violent or highly agitated and result in injury to the sleepwalker or others (Zadra, Desautels, Petit, & Montplaisir, 2013). The frequency of somnambulistic episodes can vary from more than one episode per night to once every few weeks or months (Avidan, 2017). Moreover, somnambulistic episodes can be associated with mental activity accompanied by confusion, perceptions of threat, variable degrees of retrograde amnesia, as well as altered perception of and responsiveness to the external environment (Zadra & Montplaisir, 2010).

Despite the existence of frequent and/or severe forms of somnambulism with an elevated risk of injury and accompanying psychological distress, there is a paucity of information on how somnambulistic episodes evolve over time. To our knowledge, no study has investigated how clinical and phenomenological dimensions of somnambulism unfold within the same individual from childhood to adolescence and into adulthood. This master's research aims to partially fill this gap by studying the changes in the frequency of somnambulistic episodes, aggressive episodes and recall of mental content associated with somnambulistic events across these developmental stages. It also aims to investigate whether the recall of mental content or sleep-related mentation associated with somnambulism is related to the frequency of aggressive

episodes across these broad developmental stages. Finally, this master's research also assesses the developmental changes in the occurrence of sleep terrors, a NREM parasomnia closely associated with somnambulism and commonly experienced by sleepwalkers.

1.2 Sleep and Sleep Architecture

A simplified definition of sleep describes it as a combination of physiological and behavioural processes that produce a reversible state of unresponsiveness to the external environment and perceptual disconnection from it (Carskadon & Dement, 2017). Far from being a homogenous state, sleep is composed of different stages, each with its unique characteristics. The American Academy of Sleep Medicine (2014) divides sleep into two distinct states: non-rapid eye movement (NREM) and rapid eye movement (REM) sleep. NREM sleep is further subdivided into three stages of N1 (formerly stage 1), N2 (formerly stage 2) and N3 (formerly stages 3 and 4), also known as the slow-wave or deep sleep (Carskadon & Dement, 2017).

As will be detailed below, different stages of sleep are categorized based on electroencephalography (EEG), electro-oculography (EOG) and electromyography (EMG) recordings during polysomnographic (PSG) assessments. The EEG continuously records the electrical activity of the brain as waveforms that are displayed as graphs of voltage over time (Britton, Frey, & Hopp, 2016). Different sleep stages are associated with broadly different EEG patterns. The EOG is used to record the frequency, strength and direction of eye movements. This allows for distinguishing slow, rolling eye movements that characterize much of NREM sleep from the rapid eye movements observed during REM sleep, and consequently helps differentiate these sleep stages (Chaudhary, 2007). The EMG is used to measure muscle tonicity, typically through electrodes placed near the chin as well as on the anterior tibialis muscles of the legs. EMG from the chin muscles allows for differentiating REM sleep, a state with greatly reduced muscle tonicity (also known as muscle atonia), from NREM sleep where this degree of muscle atonia is not observed. Moreover, EMG from the anterior tibialis muscles can be used to identify specific sleep disorders, such as periodic limb movements (Chaudhary, 2007), a condition characterized by recurrent and involuntary leg movements during sleep.

1.2.1 Sleep Stages

The EEG during relaxed wakefulness, with eyes closed, is characterized by alpha activity with a frequency of 8–13 hertz (Hz; cycles per second). The sleep onset starts with the stage N1, or transitional NREM sleep, which is identified by the presence of theta rhythms (4–8 Hz), and slow, rolling eye movements (Malhotra & Avidan, 2014). The stage N2, or intermediate NREM sleep, is also comprised of theta rhythms but is distinguishable from stage N1 due to the occasional presence of sleep spindles and K complexes. Sleep spindles are bursts of 11–16 Hz neural activity that last for 0.5 to 1.5 seconds. K complexes are waveforms composed of a sharply upward deflection immediately followed by a smaller downward deflection, which last at least 0.5 seconds in total (Malhotra & Avidan, 2014). Stage N3, also known as slow-wave sleep or deep sleep, is characterized by presence of slow waves, a variation of delta activity (0.5–4 Hz) with an amplitude (peak voltage) of at least 75 mV (Malhotra & Avidan, 2014). Lastly, REM sleep is characterized by desynchronized low amplitude waves of different frequencies, sawtooth waves (2–6 Hz), which are the notched and evenly shaped variation of theta activity, as well as rapid eye movements and muscle atonia (Malhotra & Avidan, 2014).

1.2.2 Sleep Cycle

A sleep cycle typically consists of a sequence of NREM sleep stages (N1, N2 and N3 sleep) followed by a period of REM sleep with a full cycle taking about 90 minutes. In a young healthy adult, the first sleep cycle begins with stage N1 lasting about 1 to 7 minutes, followed by stage N2 lasting approximately 10 to 25 minutes and then stage N3 for about 20 to 40 minutes. Next, a short transition from stage N3 to N2 precedes the progression of the sleep cycle into REM sleep. During the first sleep cycle, REM sleep typically lasts less than 10 minutes but becomes longer in duration as the sleep period progresses across the night (Carskadon & Dement, 2017).

In the first third of the night, stage N3 predominates NREM sleep but as the sleep period progresses, stage N3 may completely disappear while the proportion of stage N2 increases and will typically constitute the majority of NREM sleep in later sleep cycles. Additionally, brief transitions from sleep stages to wakefulness may occur, especially in later sleep cycles, although

the sleeper may have no recall of these micro arousals or transitions to wakefulness (Carskadon & Dement, 2017).

Sleep architecture also shows variations as a function of age and sex. A metanalysis of 65 studies (Ohayon, Carskadon, Guilleminault, & Vitiello, 2004) revealed that on average, sleep in men contains a higher percentage of stage N3 and of REM sleep, while sleep in women contains a higher percentage of stage N2. The percentage of N1 during sleep is similar between men and women. Furthermore, the percentage of stage N1 remains stable from childhood (assessed from age of 5 years) until adolescence and begins to increase thereafter across adulthood until about the age of 70 years. While the percentage of stage N2 increases consistently from childhood to old age (70 years old), the percentage of stage N3 follows an opposite trend. Lastly, the percentage of REM sleep increases from childhood to adolescence and decreases subsequently with aging. Based on this metanalysis, the duration of sleep stages remains relatively unchanged after the age of 70 years (Ohayon et al., 2004).

1.3 Parasomnias

The term “parasomnia” is derived from “para”, meaning beside or beyond in Greek and “somnus”, meaning sleep in Latin (Colman, 2014). According to the American Academy of Sleep Medicine (2014), parasomnias are defined as “undesirable physical events or sensory experiences that occur with entry into, during, or arousing from sleep”. Parasomnias are generally grouped according to the sleep stages in which they occur and include the broad categories of REM sleep-related parasomnias, NREM sleep-related parasomnias and other parasomnias. Somnambulism, sleep terrors and confusional arousals are NREM parasomnias that are also known as disorders of arousal due to their characteristic, sudden but incomplete arousals (or transitions to wakefulness), usually from N3 sleep (American Academy of Sleep Medicine, 2014). Disorders of arousal can occur across different age groups but are more prevalent during childhood as compared to adulthood (Castelnovo, Lopez, Proserpio, Nobili, & Dauvilliers, 2018).

1.4 Somnambulism

Also known as sleepwalking, somnambulism is a NREM sleep-related parasomnia defined as "a series of complex behaviours that are usually initiated during arousals from slow-wave sleep and culminate in walking around with an altered state of consciousness and impaired judgment" (American Academy of Sleep Medicine, 2014). Somnambulism is characterized by: 1) incomplete arousals during NREM sleep; 2) mental content; 3) simple or complex movements associated with mental content; 4) diminished perception of the surroundings; and 5) diminished judgement and decision-making ability (Stallman, 2017). Somnambulism occurs mostly during the first third of the sleep period, when stage N3 sleep is the most prevalent. However, episodes can also occur out of stage N2 sleep (Zadra et al., 2013). The epidemiology, genetics and behavioural manifestations of somnambulism as well as the mental activity associated with the episodes are discussed in greater detail in subsequent sections.

1.4.1 Epidemiology

Based on a meta-analysis of 51 studies on somnambulism, the lifetime prevalence of the disorder is 6.9% while its prevalence over 12 months is estimated to be 5% in children and 1.5% in adults (Stallman & Kohler, 2016). The overall childhood prevalence of sleepwalking can be as high as 29% with a peak of 13% between the ages of 10 to 13 years (Petit et al., 2015). During adolescence, the prevalence of somnambulism decreases gradually and reaches below 10% by the age of 16 (Klackenberg, 1982). On average, about 20% of childhood sleepwalkers continue to sleepwalk in adulthood, while about 0.6% of adults start to sleepwalk de novo (Hublin et al., 1997). Altogether, about 2% to 4% of adults experience episodes of somnambulism with varying degrees of frequency (Hublin et al., 1997; Plazzi, Vetrugno, Provini, & Montagna, 2005).

Studies of sex differences in the prevalence of somnambulism have yielded inconsistent results. While many studies have reported no sex differences in the prevalence of somnambulism (Klackenberg, 1982; Laberge, Tremblay, Vitaro, & Montplaisir, 2000; Mume C.O., 2010; Ohayon, Guilleminault, & Priest, 1999; Ohayon, Mahowald, Dauvilliers, Krystal, & Leger, 2012; Petit et al., 2015), some investigations have found a higher prevalence of childhood somnambulism in boys as compared to girls (Petit, Touchette, Tremblay, Boivin, & Montplaisir, 2007; Shang, Gau, &

Soong, 2006). That said, a study by Hublin et al. (1997) found that childhood somnambulism is significantly more common in girls, while being more common in men than in women during adulthood. Differences in assessment periods and methods, definitions of "childhood" and whether or not a diagnosis of primary somnambulism was received by participants prior to their participation in these investigations may partially account for these inconsistencies.

1.4.2 Genetics

The familial occurrence of somnambulism is well documented, occurring in approximately 70% of sleepwalkers (Kales, Soldatos, Bixler, et al., 1980). This observation indicates a role of genetic factors in the development of the disorder (Abe, Amatomi, & Oda, 1984; Abe & Shimakawa, 1966; Kales, Soldatos, Bixler, et al., 1980). More recently, a study found that the likelihood of sleepwalking in children with both parents reporting a history of somnambulism was 2.4 times higher than in children with only one parent reporting a history of the disorder and 7.3 times higher than in children with no parental history of somnambulism (Petit et al., 2015).

Twin studies also support the presence of a genetic predisposition to somnambulism. Bakwin (1970) conducted the first twin study of somnambulism and found that monozygotic pairs were 6 times more likely to be concordant for sleepwalking when compared to pairs of dizygotic twins. Similarly, a subsequent study of 1045 monozygotic and 1899 dizygotic twins found that the concordance rate for somnambulism during childhood was about 1.6 times higher for monozygotic twins as compared to dizygotic twins, while the concordance rate for adult somnambulism was about 5.3 times higher for monozygotic twins as compared to dizygotic twins (Hublin et al., 1997). Finally, a genotype study suggested a link between somnambulism and the HLA-DQB1*05:01 and *04:02 subtypes of the HLA-DQB1 gene (Lecendreux et al., 2003). Additionally, a more recent genotype study of adult patients with somnambulism, sleep terrors, confusional arousals or a combination of these disorders showed that the HLA-DQB1*05:01 variant was highly prevalent in people with all forms of NREM parasomnias, suggesting a common genetic component for all these disorders of arousal (Heidbreder et al., 2016).

1.4.3 Episode Frequency

Epidemiological studies have mainly investigated the overall prevalence of somnambulism, particularly during childhood, and less often have reported the frequency of somnambulistic episodes, i.e. the number of episodes experienced by sleepwalkers as a function of time (for a review of epidemiological studies, see Stallman & Kohler, 2016). Moreover, based on a review of the literature, no study has yet investigated developmental changes in the frequency of somnambulistic episodes from childhood to adulthood.

Only one study of 140 adult sleepwalkers compared the self-reported frequency of somnambulistic episodes at the age of the disorder's onset (median age of onset = 9 years; ranging from 3–49 years) with the frequency of episodes at the time of study (Lopez et al., 2013). The authors found a decrease in the self-reported frequency of episodes in 23% of sleepwalkers, no change in 53% and an increase in the frequency in 24% of sleepwalkers. The study also found that sleepwalkers with a late onset of somnambulism (after age of 9 years) are about 6 times more likely to report an increase in the frequency of the episodes over time as compared to sleepwalkers with an early onset (before age of 9 years). Additionally, the authors found that sleepwalkers who reported less than one episode per week were about 6 times more likely to experience a decrease in the frequency of episodes over time than sleepwalkers who reported one or more episodes per week.

Another study examined the association between the frequency of childhood sleepwalking and the "likelihood" of sleepwalking during adulthood (Hublin et al., 1997). The authors of this study found that, on average, about 21% of adults who reported sleepwalking "often" or "sometimes" in their childhood had at least one sleepwalking episode in adulthood. They also found that, on average, 87% of participants who experienced episodes of sleepwalking in adulthood reported having sleepwalked at least a few times during their childhood. This study, however, did not investigate changes in the frequency of somnambulism from childhood to adulthood.

Table 1 provides a comprehensive list of studies on the frequency of somnambulistic episodes. The table provides information on the type of assessment (i.e. questionnaire-based,

clinical and/or polysomnographic), the average frequency of episodes, as well as sex differences in the frequency of episodes in children, adolescents and adults. A general trend shows that children and adolescents with a history of somnambulism usually experience episodes infrequently (i.e. “few times” or “sometimes” rather than “often” or “always”). While studies involving adults sampled from the general population follow the same general trend, studies of adults with a diagnosis of somnambulism include a higher proportion of sleepwalkers who report experiencing episodes frequently. It is important to note that adult sleepwalkers referred to a sleep clinic for assessment and/or treatment may not be representative of adult sleepwalkers in the general population as they may experience particularly frequent and/or severe episodes (Lopez et al., 2013; Moldofsky, Gilbert, Lue, & MacLean, 1995). This may also account for some of the differences observed in Table 1.

Studies on the frequency of somnambulistic episodes are also subject to key limitations. First, episode frequency is most often measured through self-report or by questioning parents and without any complimentary clinical or PSG investigations. Only 3 studies (16%) in Table 1 performed a clinical and video-PSG assessment, all 3 of which investigated the frequency of episodes in adults. Clinical and video-PSG assessments are invaluable to rule out the presence of other sleep disorders which can be mistaken for somnambulism (e.g., nightmares, nocturnal epilepsy, REM behaviour disorder; (Ralls & Grigg-Damberger, 2013), as well as the use of medications that may induce somnambulism (e.g., Z drugs; see Stallman, Kohler, & White, 2018 for a review). Second, many of the studies presented in Table 1 measure the frequency of episodes in broad and subjective terms, such as through 3 to 5-point Likert scales with choices ranging from “always” to “never”. These scales are not easily comparable with findings from epidemiological studies and are likely to be interpreted differently by different participants. Third, the assessment period in these studies ranges from one month to lifetime, which further complicates comparisons between studies. Fourth, some studies assess different types of parasomnias together, such as disorders of arousal or use a more general term, such as nocturnal wandering (Ohayon et al., 2012) that includes several potential underlying causes and neurological conditions for the observed behaviour. Lastly, none of these studies assessed the changes in the frequency of episodes across different stages of life within the same subjects.

Hence, these studies cannot be used to establish reliable developmental trajectories in self-reported frequencies of somnambulistic episodes.

Given that over one-fifth of children with somnambulism continue to experience sleepwalking as they attain adulthood (Hublin et al., 1997), empirical investigations that include PSG and clinical assessments are needed for a clearer and potentially unbiased understanding of developmental changes in episode frequency in the same group of individuals. Understanding how episode frequency changes over time can add to our limited knowledge on the evolution of the clinical characteristics of somnambulism across the lifespan.

Table 1. Studies on the Frequency of Somnambulistic Episodes

Study	Sample	Sleep Disorder	Assessed Period	Assessment	Average Episode Frequency (%)					Sex Differences in Episode Frequency	Subjects Assessed for > 1 Period?
					Never	Few times	Sometimes	Often	Always		
Childhood											
Klackenberg (1982)	**sleepwalkers** 44 M, 31 F 6–16 y/o rec. from a Swedish urban pop.	SW	lifetime	parent-report	N/A	53.3	sometimes/often = 46.7		-	no	no
Fisher and Wilson (1987)	354 **sleepwalkers** 5–18 y/o rec. from 11 schools in Canada	SW	1 y.	parent-report	N/A	1–3/y. = 60	4–8/y. = 23	≥ 9/y. = 17	-	not reported	no
Saarenpää-heikkilä et al. (1995)	23 M, 33 F 7–9 y/o rec. from 1 school in Finland	SW	present	parent-report	91	-	9	0	0	no	no
Blader et al. (1997)	972 children 5–12 y/o rec. from 6 school districts in Nassau, New York	SW	6 mos.	parent-report	90.2	< 1/mo. = 8.7	1–2/w = 0.6	> 3/w = 0.4	-	not reported	no
Hublin et al. (1997)	5116 M, 6104 F 33–60 y/o twins rec. from Finnish gen. pop.	SW	childhood	self-report	73.8	17.4	6.4	2.4	-	F > M (p = .004)	adulthood

Study	Sample	Sleep Disorder	Assessed Period	Assessment	Average Episode Frequency (%)					Sex Differences in Episode Frequency	Subjects Assessed for > 1 Period?
					Never	Few times	Sometimes	Often	Always		
Smedje et al. (1999)	951 M, 893 F 5–7 y/o rec. from Swedish gen. pop.	SW	6 mos.	parent-report	91.7	occasional = 7.6	1–2/w = .3	3–4/w = 0.1	5–7/w = 0.2	not reported	no
Nevéus et al. (2001)	697 M, 716 F 6–11 y/o rec. from various schools (n.s.) in Sweden	SW	present	self-report	92.8	-	6.3	0.7	0.3	not reported	no
Lehmkuhl et al. (2008)	712 M, 676 F mean age = 5.5 y/o rec. from various schools (n.s.) in Germany	SW	present	Parent-report	96.7	≤ 1/w = 3.2		> 1/w = 0.1		not reported	no
Wiechers et al. (2011)	585 M, 559 F mean age = 9.6 y/o rec. from 27 schools in Germany	SW	present	self-report	0–1/w = 88.3		2–4/w = 7.4	5–7/ w = 1.4		no	no
				parent-report		= 93.6	= 4.1		= .5		
Adolescence											
Saarenpää-heikkilä et al. (1995)	251 M, 262 F 9–17 y/o rec. from 2 schools in Finland	SW	present	self-report	72.5	-	24.5	2.5	0.49	no	no

Study	Sample	Sleep Disorder	Assessed Period	Assessment	Average Episode Frequency (%)					Sex Differences in Episode Frequency	Subjects Assessed for > 1 Period?
					Never	Few times	Sometimes	Often	Always		
Abdel-Khalek (2001)	1309 M, 1265 F 14–18 y/o rec. from various schools (n.s.) in Kuwait	SW	1 mo.	self-report	89.9	5.0	2.2	1.3	very much = 1.5	M > F (p = .001)	no
Ipsiroglu, et al. (2002)	146 M, 186 F 11–15 y/o rec. from 2 schools in Vienna	SW	lifetime	self-report	84.9	occasionally = 14.2		very often = 0.9		not reported	no
Itani et al. (2013)	47 981 M, 49 418 F 12–17 y/o rec. from 244 schools in Japan	DOA	1 mo.	self-report	60.6	14.9	17.1	4.8.	2.6	F > M (p <.001)	no
Stallman et al. (2016)	348 M, 184 F 16–18 y/o rec. from 1814 schools in Australia	SW	1 mo.	self-report	79.7	< 1/w = 1.88	1–2 /w = 0.2	≥ 3/ w = 0.8	-	not reported	no
Adulthood											
Hublin et al. (1997)	5116 M, 6104 F 33–60 y/o. twins rec. from Finnish gen. pop.	SW	present	self-report	96.6	< than monthly = 2.9	monthly = .2	weekly = 0.4	-	M > F (P = .048)	childhood
Ohayon et al. (2012)	7755 M, 8174 F 18–102 y/o from US gen. pop.	NW	lifetime	structured interview	96.4	≤ 12/y. = 2.6	2 –3/ mo. = 0.8	≥ 1/w = 0.2	-	no	no

Study	Sample	Sleep Disorder	Assessed Period	Assessment	Average Episode Frequency (%)					Sex Differences in Episode Frequency	Subjects Assessed for > 1 Period?
					Never	Few times	Sometimes	Often	Always		
Lopez et al. (2013)	**Sleepwalkers** 55 M, 45 F 18–58 y/o rec. from a clinical pop. in France	SW	present	clinical assessment and v-PSG	N/A	< than monthly = 16.3	monthly = 17.4	weekly = 43.5	22.8	not reported	no
Bušková et al. (2015)	**Sleepwalkers** 28 M, 24 F 19–63 y/o rec. from a clinical pop. in Czech Republic	SW	present	clinical assessment and v-PSG	N/A	sporadically = 9.6	1/w to 1/mo. = 28.8	> 1/w = 61.5	-	not reported	no
Bargiotas et al. (2017)	**Sleepwalkers** 41 M, 22 F 18–80 y/o rec. from a clinical pop. in Switzerland	SW	lifetime	clinical assessment and v-PSG	N/A	≤ 1/mo. 22	≥ 1/mo. 45	weekly = 29	≥ 2/w 4	not reported	no

Note. M = male; F = female; rec. = recruited; gen. pop. = general population; n.s. = not specified; SW = sleepwalking; DOA = disorders of arousal; NW = nocturnal wandering; v-PSG = video-polysomnography; y/o = years old; y. = year; mo. = month; mos. = months; w = week

1.4.4 Sleep Mentation

Perceptions, thoughts, bodily feelings and emotions experienced during sleep are collectively referred to as sleep mentation. For many researchers, sleep mentation refers to the remembrance of *any mental activity* having occurred just prior to waking up (see Nielsen 2000 for a review) and is sometimes conceptualized as being synonymous with dreaming. While there exists no consensual definition of the term dreaming (Pagel, Blagrove, Levin, Stickgold, & White, 2001), many researchers view dreams as a more complex form of sleep mentation that usually involves a setting, one or more social interactions and a narrative structure (e.g., Domhoff, 1996; Domhoff, 2019). While these more immersive forms of sleep mentation more closely resemble the kinds of "dream reports" typically collected out of REM sleep (Kales et al., 1967), sleep mentation remains an important and useful term to describe the range of mental activities and experiential events that can occur across sleep stages as a whole (Stickgold, 2017). The mental contents associated with somnambulistic episodes are also referred to as forms of sleep mentation, which will be discussed in greater detail later in this section.

1.4.4.1 Sleep Mentation During NREM Sleep

The association between REM sleep and dreaming was established in the mid-1950s, shortly after the discovery by Aserinsky and Kleitman (1953) of regularly occurring rapid eye movement during sleep. At first, it was believed that REM sleep and dreaming were respectively the physiological and psychological representations of the same state (Stickgold, Malia, Fosse, Propper, & Hobson, 2001). However, later studies showed that dreaming was not exclusive to REM sleep and that about 40% to 70% of the awakenings from NREM sleep were accompanied by a recall of different forms of sleep mentation, some of which were indistinguishable from typical dream reports from REM sleep (Foulkes, 1962; Nielsen, 2000; Stickgold et al., 2001). Furthermore, Oudiette et al. (2012) showed that the recall of sleep mentation can occur in any sleep stage, even when REM sleep is suppressed, suggesting that the occurrence of sleep mentation does not depend on specific underlying sleep stages.

When compared to typical dream reports from REM sleep, sleep mentation from NREM sleep has been found to be shorter in duration and in the number of words needed to describe

the experience, as well as less complex and more thought-like (Cicogna, Natale, Occhionero, & Bosinelli, 2000; Kales et al., 1967). However, Foulkes and Schmidt (1983) found that controlling for the length of sleep mentation reports significantly reduces the qualitative differences between REM and NREM sleep mentation. Consistent with this observation, one study found that sleep mentation was reported in 65% of awakenings from slow-wave-sleep as compared to 89% of awakenings from REM sleep, and mentation reports from slow-wave-sleep were significantly shorter than those collected following awakenings from REM sleep (Cavallero, Cicogna, Natale, Occhionero, & Zito, 1992). That said, the authors of the study also found that many of the slow-wave-sleep mentation reports contained content dimensions similar to REM sleep mentation reports, such as references to the self, bodily feelings and settings (Cavallero et al., 1992).

1.4.4.2 Sleep Mentation During Somnambulism

The presence of sleep mentation during somnambulistic episodes has been reported in several studies and the idea famously explored in Shakespeare's Macbeth. Examples of sleep mentation associated with somnambulistic episodes include believing a bomb is nearby (Oswald & Evans, 1985), thinking that an intruder is trying to attack the sleepwalker or attempting to strangle their bedpartner (Schenck & Mahowald, 1995a), seeing a train approaching via a narrow tunnel or a snake tightly squeezing the sleepwalker (Szűcs et al., 2014). The core characteristics of sleep mentation associated with episodes of somnambulism and/or sleep terrors have been detailed by Oudiette et al. (2009) in a study of 43 adult subjects with severe somnambulism and/or sleep terrors. Specifically, this study found that 95% of episode-related sleep mentation reports were short, comprised a single scene (e.g., an intruder in the room), lacked a coherent content and did not resemble real life situations. The study also found that 80% of sleep mentation reports were negatively toned, involving aggressions or misfortunes. In all instances of sleep mentation involving aggression, patients perceived themselves as the victim of the aggression. Moreover, fear and apprehension were the most frequently reported emotions (84% of the episodes with sleep mentation). Finally, only 11% of the sleep mentation associated with somnambulistic or sleep terror episodes contained friendly social interactions, and none were accompanied by feelings of happiness.

1.4.4.3 Amnesia for Somnambulistic Episodes

Partial or complete amnesia for the mental contents and behaviours associated with somnambulistic episodes has been regarded as one of the key characteristics of the disorders of arousal (American Academy of Sleep Medicine, 2014; Kales & Kales, 1974). Although complete amnesia of somnambulistic episodes has been reported in the literature (for examples, see Pressman, 2007), many investigations based on patients' self-reports obtained in clinical settings have revealed a relatively high degree of recall of episode-related sleep mentation over the patients' lifetime. For example, in a study of 63 adult sleepwalkers by Bargiotas et al. (2017), 54% of the sleepwalkers reported a partial recall of their episodes. Another study found that 71% of 38 adults with somnambulism, sleep terrors or both recalled at least one sleep mentation experienced during an episode (Oudiette et al., 2009). Similarly, Zadra et al. (2013) reported that 80% of 94 adult sleepwalkers referred to a sleep disorders clinic reported recalling various elements of their episodes (e.g., thoughts, perceptions, behaviors, emotions) upon awakening at least some of the time. Taken together, the results from these studies show that, at least in adults, amnesia during somnambulistic episodes is more the exception than the rule. Contrary to what is observed in adult sleepwalkers, and possibly as a result of higher arousal thresholds (Busby, Mercier, & Pivik, 1994) and maturational factors (Foulkes, 1982), complete amnesia for sleepwalking episodes appears to be more frequently experienced by children (Zadra et al., 2013).

Based on the review of literature, neither the developmental changes nor the sex differences in the recall frequency of sleep mentation associated with somnambulism have been extensively studied, if at all. Empirical studies on this subject are thus needed to examine how the phenomenology of somnambulism evolves in men and women across the lifespan.

1.4.5 Behavioural Manifestation

Table 2 presents examples of behaviours and associated sleep mentation experienced during somnambulistic episodes. As illustrated by these examples, behaviours evinced during somnambulistic episodes appear to be congruent with reported sleep mentation from the same episodes. This synchrony between manifested behaviours and episode-related sleep mentation is suggestive of a "mind-behaviour isomorphism" (Oudiette et al., 2009). Furthermore, as shown

in Table 2, many of the behaviours during the episodes appear to be motivated by a sense of inherent logic or urgency and generally represent a response to a troubling or menacing situation that requires immediate attention (Zadra & Montplaisir, 2010). Consistent with this observation, one study of 29 subjects with nocturnal wandering showed that violence and injury during sleep seems to occur as a response to a perceived threat (Guilleminault, Moscovitch, & Leger, 1995). Altogether, these findings point to the important role played by sleep mentation in shaping the behaviours associated with somnambulistic episodes.

Table 2. Examples of Somnambulistic Behaviour and Episode-related Sleep Mentation

Study	Subject	Behaviour During the Episode	Recalled Sleep Mentation
Oswald and Evans (1985)	10 y/o M	Rushed to throw the butter dish out of the window	The object was a bomb and he had to save his family from it
Pilon et al. (2008)	Adult F, age ns	Looked at the ceiling with fear and pointed at it with her hand. Then, anxiously tried to remove the electrodes	Heard someone telling her to take off the electrodes. Heard that electrodes were connected to the ceiling and she was going to suffocate because of that
Pillmann (2009)	26 y/o M	Tied his infant to clothesline in the attic and covered her mouth	Officials from child welfare were at the door to take his infant away
Oudiette et al. (2009)	32 y/o F	Ran out of bed and rubbed her hair	Cockroaches were falling on her bed and hair from a crack on the wall containing dead flesh
Oudiette et al. (2009)	11 y/o M	Climbed to the roof of the house	His brother and he were being followed by people. He didn't let his younger brother climb the roof, but he climbed himself and collected shining balls on the way
Bhat et al. (2012)	27 y/o M	Stood up suddenly and raised his arm	He was trying to stop the roof from collapsing
Uguccioni et al. (2013)	32 y/o F	Hit the partner and verbally confronted him	Saw partner kissing another woman
Szűcs et al. (2014)	28 y/o M	Ran out through the window from the second floor causing a bone fracture in the cervical vertebra	Walls were falling on him
Szűcs et al. (2014)	26 y/o F	Broke the window to scape. Injured herself with broken glass	She was locked up in a room with bars

Note. M = male; F = female; y/o = year old; ns = not specified

1.4.5.1 Violence and Injuries During Somnambulism

Violence during sleep is regarded as any behaviour towards self, others and/or objects that may result in serious or even life-threatening consequences (Ohayon & Schenck, 2010). Violence during sleep can occur due to various conditions such as REM sleep behaviour disorder, nocturnal seizures or disorders of arousal (Ohayon & Schenck, 2010). In a study of 20 000 European participants aged 15 years and older, 1.6% of participants reported violent behaviours during their sleep (Ohayon & Schenck, 2010). Of these, 23% reported sleep-related violent behaviours several times a week, 8% once a week, 14% several times a month and 56% once a month. Additionally, when compared to participants without violent behaviours during sleep, those with violent sleep-related behaviours were 9 times more likely to report a history of somnambulism or sleep terrors.

While childhood somnambulism is usually benign, a range of violent behaviours have been described in relation to adult somnambulism, sometimes with important medico-legal and forensic implications (Cartwright, 2004; Siclari et al., 2010). Examples of injurious behaviours in adult sleepwalkers include running into or smashing a glass door, falling from a height (Rauch & Stern, 1986), strangling a bedpartner (Szűcs et al., 2014), climbing out of a window (Oswald & Evans, 1985) and even homicide and attempted homicide (Broughton et al., 1994). Cases of violent somnambulism have been also reported in adolescents (for examples, see Oswald & Evans, 1985; Schenck & Mahowald, 1995b).

Moreover, a PSG investigation of 64 adults with somnambulism or sleep terrors found that 19% of the patients reported a history of harmful behaviour that did not result in serious injury or damage, while 41% of the patients had manifested serious violence involving dangerous or life-threatening actions towards the self, others, or important damage to property (Moldofsky et al., 1995). Only 16% of the 25 women in this study reported having a history of serious sleep-related violence, which was never described as being directed towards others. By contrast, 56% of the 39 men in this study reported a history of serious violence. Among these men with a history of serious seep-related violence, 41% reported that the violent behaviours were exhibited towards others.

A subsequent PSG study of 50 adult sleepwalkers found that 30% of the patients reported a history of at least one injurious episode (Guilleminault et al., 2005). Similarly, Bargiotas et al. (2017) reported that 40% of 63 adult sleepwalkers manifested violent behaviours during their somnambulistic episodes and that 42% had injured themselves during an episode. The authors also found that violence during somnambulistic episodes was more frequent in men than in women, an observation consistent with the findings of Moldofsky et al. (1995) and Guilleminault et al. (1995).

Despite the risk of injurious behaviors during somnambulistic episodes and the gravity of potential consequences, questions regarding the frequency of aggressive episodes and how it changes over time within the same individuals remain largely unanswered. Furthermore, since the majority of the reported episode-related sleep mentation contain themes of threat and aggression (Oudiette et al., 2009; Uguccioni et al., 2013), it is important to investigate whether episode-related sleep mentation recall is related to aggressive and/or violent behaviour in somnambulistic episodes. A study of how violent and non-violent somnambulistic episodes evolve from childhood to adulthood in the same subjects may help clarify this relationship while ensuring that other important variables, such as sex and family history of somnambulism, remain constant. Such research could help pinpoint factors associated with the changes in the frequency of aggressive episodes from childhood to adulthood and may allow clinicians to better predict the likelihood of somnambulistic episodes in a given subject progressing into a more violent type.

1.5 Significance of Sleep Terrors in the Study of Somnambulism

Sleep terrors are a NREM parasomnia characterized by piercing cries or loud vocalizations, strong autonomic nervous system activation (e.g., elevated heart rate and rapid breathing), unresponsiveness to external stimuli, extreme fear and agitated motor activity which can be aggressive and result in injury to self or others (Castelnovo et al., 2018; Mahowald, Borneman, & Schenck, 2004). The prevalence of sleep terrors is reported to be 34% in 1 ½-year-old children and to decrease significantly to about 5% by adolescence (Petit et al., 2015). Although more common in children, sleep terrors can continue into adulthood and have a prevalence of approximately 2% in the general adult population (Ohayon et al., 1999).

Numerous studies have documented the co-occurrence of somnambulism and sleep terrors in the same individuals. Petit et al. (2015) found that about one-third of children suffering from sleep terrors in early childhood (age of 1½–3½ years) started to sleepwalk after the age of 5. Additionally, the authors found that a parental history of somnambulism was associated with the presence of sleep terror episodes in children as well as the persistence of sleep terror episodes beyond early childhood (past the age of 5 years). Similarly, Kales, Soldatos, Bixler, et al. (1980) showed that 80% of 25 sleepwalkers and 96% of 27 individuals who reported experiencing sleep terrors had at least one family member with somnambulism, sleep terrors or both parasomnias. Not only can sleep terrors and somnambulism co-occur in the same individual, but they can also be experienced within the same episode with, for example, a sleep terror followed by agitated sleepwalking (Siclari et al., 2010). Thus, while the main goal of the present study is to investigate developmental changes in somnambulistic episodes, it also includes an analysis of developmental changes in sleep terrors.

Chapter 2 – Research Objectives and Hypotheses

Given the lack of empirical data on how somnambulistic episodes evolve over time, the present study aims to investigate changes in the clinical and phenomenological characteristics of somnambulism across different developmental stages, from childhood to adulthood.

Specifically, the objectives of this study are to examine developmental changes during childhood, adolescence and adulthood as well as sex differences in: 1) the frequency of somnambulistic episodes; 2) the recall of sleep mentation associated with somnambulistic episodes; 3) the frequency of aggressive behaviour during episodes; and 4) the impact of aggressive episodes on recall frequency of episode-related sleep mentation. Additionally, the developmental changes and sex differences in the frequency of sleep terrors and recall of sleep mentation associated with this NREM sleep parasomnia will be investigated.

Due to the paucity of data on developmental changes in the frequency and content of somnambulistic episodes, this study is mainly exploratory. However, based on the existing literature, it is hypothesized that: 1) aggressive somnambulistic episodes occur more frequently during adulthood than in childhood, including within the same patient; 2) aggressive somnambulistic episodes occur more frequently in men than in women; and 3) the recall of sleep mentation associated with somnambulistic episodes in life-long sleepwalkers is more frequent in adulthood than in childhood.

Chapter 3 – Material and Methods

3.1 Participants

Participants were chosen among 188 francophone sleepwalkers (74 men, 114 women) between the ages of 18 to 68 years (*M* = 32.6, *SD* = 10.1) who were referred to l'Hôpital du Sacré-Cœur de Montréal's sleep disorders clinic between 2003 and 2018. Included participants all underwent a thorough clinical assessment, which included at least one night of video-PSG and received a final diagnosis of primary sleepwalking (ICSD-II; American Academy of Sleep Medicine, 2005). As part of their assessment, participants also completed an extensive questionnaire focusing on the patient's history of parasomnias, overall sleep quality, and dream recall. This questionnaire, along with the clinical assessment and video-PSG screening, were part of a larger study on the assessment and pathophysiology of adult somnambulism, which was approved by l'Hôpital du Sacré-Cœur de Montréal's ethics committee. All participants provided signed informed consent for this larger study under which the present data was collected.

3.1.1 Inclusion and Exclusion Criteria

Only patients with a primary diagnosis of somnambulism according to the 2nd edition of *the International Classification of Sleep Disorders* (ICSD-II; American Academy of Sleep Medicine, 2005) were considered for the study. A clinical assessment and an overnight video-PSG screening were used to exclude participants with any of the following conditions: 1) presence of a neurological disorder; 2) the presence of a comorbid sleep disorder, except for sleep terrors; 3) an apnea index of ≥ 5 per hour of sleep or an index of > 15 for respiratory events (apneas and hypopneas) or an index ≥ 10 for periodic leg movements associated with microarousals; 4) the use of medications that could alter sleep EEG, sleep architecture, motor activity during sleep, or daytime vigilance; 5) transmeridian travel or night work in the 3 months prior to the PSG screening; and 6) the presence of any major psychiatric disorder.

3.2 Material

3.2.1 Questionnaire on Somnambulism, Sleep and Dreams

The questionnaire on Somnambulism, Sleep and Dreams (originally in French), which has been utilized in other studies by our team (Labelle, Desautels, Montplaisir, & Zadra, 2013; Zadra A, Trudeau S, Hebert L, & Montplaisir J., 2018; Zadra, Hébert-Tremblay, Trudeau, Desautels, & Montplaisir, 2018), was developed over a 2-year period by our research team based on studies and case reports reported in the literature in combination with material collected from sleepwalkers assessed in our sleep disorders clinic. This questionnaire, which consists of 9 sections and a total of 102 items, assesses sleep quality, the occurrence of somnambulism, sleep terrors and the presence of a family history of these disorders, precipitating factors associated with these parasomnias, history of sleep-related injurious behaviours, as well as the patient's recall of dreams, nightmares, bad dreams and recurrent dreams. Except for a few open-ended questions requiring descriptive responses, the questions are multiple-choice and mostly based on a 5-point Likert-like scale with the following options: "never" (1), "rarely" (2), "sometimes" (3), "often" (4) and "always" (5).

3.3 Measures

3.3.1 Frequency of Somnambulistic and Sleep Terror Episodes

Participants were asked about the average frequency of somnambulistic episodes (3 items) and the average frequency of sleep terror episodes (3 items) during childhood (before the age of 12 years), adolescence (between 12 and 18 years of age) and adulthood (after the age of 18 years). All items included the following 9 choices: "more than one episode per night" (1), "six or 7 per week" (2), "four or 5 per week" (3), "two or 3 per week" (4), "one or 2 per week" (5), "one every two weeks" (6), "one per month" (7), "less than one per month" (8), and "does not apply (not a sleepwalker during the period)" (9).

3.3.2 Recall of Sleep Mentation Associated with Somnambulistic and Sleep Terror Episodes

Mental content (also known as sleep mentation) associated with somnambulism was described in the questionnaire as the presence of images, sensations, thoughts or emotions during the episodes or the presence of more elaborated scenarios that resemble dreams or nightmares that is recalled upon awakening. It was also explained that it was possible for elements from the patient's environment to be incorporated into their recall of sleep mentation associated with their episodes. Additionally, two examples of sleep mentation reports were provided to ensure that participants understood the provided description. Sleepwalkers were then asked to report how often their sleepwalking episodes were accompanied by recall of sleep mentation during childhood, adolescence and adulthood. Analogous questions were asked for sleep terror episodes. All 6 items included 6 response choices: a 5-point scale from "never" (1) to "always" (5) and "not applicable" (6).

3.3.3 Frequency of Aggressive Behaviour During Somnambulistic Episodes

Participants were required to indicate how often their sleepwalking episodes contained physical and/or verbally aggressive or violent behaviour during each of the 3 broad developmental stages. The response choice ranged from "never" (1) to "always" (5) and "not applicable" (6). The frequency of aggressive behaviour associated with sleep terror episodes was not investigated as patients typically remain in their bed and have limited if any behavioral interactions with others during such episodes. Lastly, how the frequency of aggressive episodes impacts the recall of episode-related sleep mentation was investigated based on the responses to the items described above.

3.4 Statistical Analysis

All statistical analyses were performed with SPSS statistics, version 25 (IBM Corp., 2017). The variables "frequency of somnambulistic episodes" and "frequency of sleep terror episodes" were re-coded to obtain response choices with an ascending order of frequency. Descriptive statistics were calculated for all study variables (Table 3). A linear mixed model (LMM) procedure

was conducted for each repeated measure analysis. LMM is a flexible and powerful statistical model used for studies with clustered, longitudinal or repeated measures data. As opposed to repeated measures analysis of variance (ANOVA), LMM does not require an equal number of observations per participant nor does it exclude participants with missing data entirely from the analysis. Additionally, LMM allows for choosing the best-fitting covariance structure to improve the quality of the model (West, Welch, & Galecki, 2014).

The MIXED procedure in SPSS was used to compute mixed models for each of the study variables, with developmental period (in 3 categories: childhood, adolescence and adulthood) as a fixed within-subject and sex as a fixed between-subject factor. The frequency of aggressive somnambulistic episodes was added as an additional fixed factor to a model aiming to predict the frequency of recall of episode-related sleep mentation. The maximum likelihood method was used to estimate the unknown parameters in LMM. Full maximum likelihood was chosen over restricted maximum likelihood as it is generally believed to provide a more accurate estimate of fixed regression parameters (Twisk, 2019). In all models, compound symmetry was chosen as the best-fitting covariance structure as it yielded a smaller Schwarz's Bayesian Criterion. Interactions between time and sex were not statistically significant and did not improve the quality of the models. Thus, interactions were dropped to obtain simpler final models with fewer analysis parameters. Effect sizes (Cohen's d) for statistically significant findings were evaluated based on criteria established by J. Cohen (1988). The critical value was set at .05 for all comparisons.

Chapter 4 – Results

4.1 Descriptive Statistics

Among the 188 sleepwalkers who were referred to our sleep disorders clinic, 113 (60%) reported somnambulism with a childhood onset (i.e. before the age of 12 years). One-hundred forty sleepwalkers (74%) also reported a history of sleep terror episodes, among whom 52 individuals (37%) reported sleep terrors with a childhood onset. Overall, 44 sleepwalkers (23%) reported a childhood onset for both sleep terrors and somnambulism.

To compare changes in somnambulistic episodes from childhood to adolescence as well as to adulthood, only the 113 participants (M = 48, F = 65; M_{age} = 30.8, *SD* = 8.5) with a childhood onset of somnambulistic episodes were included in the analyses. Similarly, to compare the developmental changes in sleep terror episodes, only the 52 sleepwalkers who reported a childhood onset of sleep terrors were considered in the analyses (M = 19, F = 33; M_{age} = 31, *SD* =.9).

Table 3 provides the mean, standard deviation and the range of study variables for two subsets of our sample: frequency of somnambulistic episodes, episode-related sleep mentation and aggressive somnambulistic episodes for sleepwalkers with childhood-onset somnambulism, as well as frequency of sleep terror episodes and sleep mentation associated with it for sleepwalkers with childhood-onset sleep terrors. Finally, Table 4 provides the frequencies for each of the study variables as reported in childhood, adolescence and adulthood.

Table 3. Descriptive Statistics of Outcome Variables

Period	*N*	*M* (*SD*)	*Min-Max* [c, d, e]
Frequency of Somnambulistic Episodes [a]			
Childhood	107	5.2 (2.0)	2–9
Adolescence	101	5.2 (2.0)	2–9
Adulthood	109	5.9 (1.9)	2–9
Frequency of Sleep Terror Episodes [b]			
Childhood	46	5.3 (2.1)	2–9
Adolescence	43	4.4 (1.9)	2–9
Adulthood	43	4.6 (1.9)	2–9
Frequency of Sleep Mentation Associated with Somnambulism			
Childhood	96	2.7 (1.3)	1–5
Adolescence	95	3.1 (1.2)	1–5
Adulthood	101	3.7 (1.0)	1–5
Frequency of Sleep Mentation Associated with Sleep Terrors			
Childhood	42	3.2 (1.3)	1–5
Adolescence	36	3.3 (1.2)	1–5
Adulthood	35	3.5 (1.1)	1–5
Frequency of Aggressive Somnambulistic Episodes			
Childhood	98	1.6 (1.0)	1–5
Adolescence	96	1.9 (1.1)	1–5
Adulthood	101	2.5 (1.2)	1–5

Note. N = number of responses; *M* = mean; *SD* = standard deviation

a & b. These variables are re-coded to obtain response choices with an ascending order of frequency.

c. “Not applicable” (N/A) response choices were not included in the calculation of mean and standard deviation.

d. 1–9 re-coded scores range from 1= N/A, 2= less than one per month, 3= one per month, 4= one every two weeks, 5= one or 2 per week, 6= two or 3 per week, 7= four or 5 per week, 8= six or 7 per week and 9= more than one episode per night.

e. 1–6 coded scores range from 1= never, 2= rarely, 3= sometimes, 4= often, 5= always and 6 = N/A.

Table 4. Frequencies of Outcome Variables

Period/Frequency (%)	N/A	< 1/mo.	1/mo.	1/ 2 w.	1–2/w.	2–3/w.	4–5/w.	6–7/w.	> 1/night
Frequency of Somnambulistic Episodes									
Childhood	0	12.1	15.0	6.5	17.8	24.3	9.3	8.4	6.5
Adolescence	4.7	12.3	10.4	11.3	16.0	22.6	9.4	6.6	6.6
Adulthood	0.9	5.5	8.2	12.7	7.3	24.5	23.6	6.4	10.9
Frequency of Sleep Terror Episodes									
Childhood	4.2	10.4	10.4	14.6	20.8	14.6	6.3	8.3	10.4
Adolescence	15.7	17.6	9.8	17.6	15.7	11.8	7.8	0	3.9
Adulthood	17.3	19.2	7.7	11.5	15.4	17.3	5.8	3.8	1.9

Period/Frequency (%)	Never	Rarely	Sometimes	Often	Always	N/A
Frequency of Sleep Mentation Associated with Somnambulism						
Childhood	18.6	25.5	20.6	20.6	8.8	5.9
Adolescence	9.6	18.3	25.0	29.8	8.7	8.7
Adulthood	2.8	9.4	18.9	42.5	21.7	4.7
Frequency of Sleep Mentation Associated with Sleep Terrors						
Childhood	15.2	10.9	23.9	26.1	15.2	8.7
Adolescence	8.7	6.5	28.3	23.9	10.9	21.7
Adulthood	6.5	4.3	21.7	30.4	13.0	23.9
Frequency of Aggressive Somnambulistic Episodes						
Childhood	57.4	16.7	12.0	2.8	1.9	9.3
Adolescence	45.4	15.7	19.4	7.4	0.9	11.1
Adulthood	28.2	18.2	20.9	22.7	1.8	8.2

Note. N/A = not applicable; mo. = month; w. = week

4.2 Linear Mixed-Model Analyses of Study Variables

This section describes the main findings obtained from the linear mixed-model analyses. The unstandardized regression coefficients derived from mixed models are estimated in relation to reference groups (adulthood period and female group) and are provided in Table 5.

4.2.1 Episode Frequency

A significant main effect was found for changes in the frequency of somnambulistic episodes across the 3 main developmental periods (F (2, 210.1) = 9.89, p < .001) but not between men and women (F (1,112.9) = 0.064, p = .80). Based on pairwise comparisons, the frequency of somnambulistic episodes in adulthood was significantly higher than in adolescence (p < .001; d = 0.36, small to medium effect) and in childhood (p < .001; d = 0.37). However, no statistically significant difference was found between the frequency of somnambulistic episodes in childhood and in adolescence (p = .98).

An opposite trend was observed for the frequency of sleep terror episodes in sleepwalkers. A significant main effect was found for the changes in the frequency of sleep terror episodes across the 3 developmental stages (F (2, 81.3) = 6.012, p = .004). However, the frequency of sleep terror episodes was significantly higher in childhood in comparison to adolescence (p = .002, d = 0.46, medium effect) and to adulthood (p = .011; d = 0.37, small to medium effect). Furthermore, no statistically significant difference was found between the frequency of sleep terrors during adolescence and adulthood (p = .52). There was no statistically significant difference in the frequency of sleep terror episodes between men and women (F (1, 47.4) = 0.23, p = .63).

4.2.2 Frequency of Episode-Related Sleep Mentation

The frequency of recall of sleep mentation associated with somnambulistic episodes differed across developmental periods (F (2, 193.8) = 50.35, p < .001) but not between men and women (F (1, 104.4) = 3.53, p = .063). The frequency of recall of episode-related sleep mentation was higher in adulthood than in adolescence (p < .001; d = 0.65, medium to large effect) and in childhood (p < .001; d = 0.97, large effect). Additionally, the frequency of recall was higher in

adolescence as compared to childhood (p = .001; d = 0.32, small to medium effect). As opposed to what was found for somnambulism, the frequency of recall of sleep mentation associated with sleep terrors was not statistically significant across the 3 developmental periods (F (2, 69.2) = 0.93, p =.40). Similarly, the difference between men and women was not statistically significant (F (1, 42.5) = 1.86, p = .18).

4.2.3 Frequency of Aggressive Somnambulistic Episodes

The frequency of aggressive somnambulistic episodes was different across the 3 developmental periods (F (2, 192.9) = 41.30, p < .001) but not between men and women (F (1, 101.3) = 2.55, p = .11). The frequency of aggressive episodes was higher in adulthood as compared to adolescence (p < .001; d = 0.59, medium to large effect) and childhood (p < .001; d = 0.87, large effect). Additionally, the frequency of aggressive episodes was higher in adolescence than in childhood (p = .004; d =0.29, small to medium effect).

4.2.4 Aggressive Somnambulistic Episodes as a Predictor of Episode-Related Sleep Mentation Recall

The frequency of aggressive somnambulistic episodes was included as an additional fixed factor to the model assessing the developmental changes in the frequency of episode-related sleep mentation. The interaction between the frequency of aggressive somnambulistic episodes and sleep mentation was not significant (F (2, 192.91) = 0.54, p = .59). Thus, the interaction term was dropped from the final model. As expected, a main effect was found for developmental changes in the frequency of sleep mentation associated with somnambulism across the 3 developmental periods (F (2, 194.4) = 23.25, p < .001). The main effect for the frequency of aggressive somnambulistic episodes was also statistically significant (F (1, 264.6) = 5.09, p = .025; d = 0.23, small effect). The positive value of the estimate of fixed effect for aggressive somnambulistic episodes (Table 5) indicates that a higher frequency of aggressive episodes predicts a higher recall frequency of sleep mentation, b = 0.15, t (264.6) = 2.26, p = .025. The differences in the frequency of episode-related sleep mentation were lower in men as compared to women, but the difference was only marginally statistically significant (F (1, 97.6) = 3.98, p = .049).

Table 5. Estimates of Fixed Effects Derived from Linear Mixed-Model Analyses

Parameter	*b*	*SE*	*df*	*t*	*sig.*	*95% CI*
DV: Frequency of Somnambulistic Episodes						
Childhood	−0.70	0.18	210.6	−3.87	.000	[−1.05, −0.34]
Adolescence	−0.69	0.18	209.5	−3.80	.000	[−1.05, −0.33]
Adulthood	0	0	-	-	-	-
Male	−0.081	0.32	112.9	−0.25	.80	[−0.72, 0.56]
Female	0	0	-	–	-	-
DV: Frequency of Sleep Terror Episodes						
Childhood	0.68	0.26	82.7	2.62	.011	[0.16, 1.20]
Adolescence	−0.17	0.26	79.5	−0.65	.52	[−0.68, 0.35]
Adulthood	0	0	-	-	-	-
Male	0.26	0.53	47.4	0.48	.63	[−0.81, 1.32]
Female	0	0	-	-	-	-
DV: Frequency of Sleep Mentation Associated with Somnambulism						
Childhood	−1.00	0.10	194.9	−9.83	.000	[−1.20, −0.80]
Adolescence	−0.66	0.10	193.4	−6.56	.000	[−0.86, −0.46]
Adulthood	0	0	-	-	-	-
Male	−0.37	0.20	104.4	−1.88	.063	[−0.76, 0.02]
Female	0	0	-	-	-	-
DV: Frequency of Sleep Mentation Associated with Sleep Terrors						
Childhood	− 0.14	0.13	70.1	−1.081	.28	[−0.39, 0.12]
Adolescence	−0.16	0.13	68.5	−1.28	.21	[−0.42, 0.92]
Adulthood	0	0	-	-	-	-
Male	−0.51	0.37	42.5	−1.36	.18	[−1.26, 0.24]
Female	0	0	-	-	-	-
DV: Frequency of Aggressive Somnambulistic Episodes						
Childhood	−0.83	0.09	193.4	−8.91	.000	[−1.02, −0.65]
Adolescence	−0.56	0.09	193.0	−5.96	.000	[−0.74, −0.37]
Adulthood	0	0	-	-	-	-
Male	0.30	0.19	101.3	1.60	.11	[−0.07, 0.68]
Female	0	0	-	-	-	-

	DV: Frequency of Sleep Mentation Associated with Somnambulism (Frequency of Aggressive Episodes Added to the Model as a Predictor)					
Childhood	−0.81	0.12	215.2	−6.72	.000	[− 1.04, −0.57]
Adolescence	−0.53	0.11	196.1	−4.74	.000	[−0.75, −0.31]
Adulthood	0	0	-	-	-	-
Male	−0.40	0.20	97.6	−2.00	.049	[−0.81, 0.00]
Female	0	0	-	-	-	-
Aggression	0.15	0.07	264.6	2.26	.025	[0.02, 0.27]

Note. DV = dependant variable; *b* = unstandardized regression coefficient; *SE* = standard error; *df* = degrees of freedom; *sig*. = significant value; *CI* = confidence interval

Chapter 5 – Discussion

5.1 Discussion of Main Findings

This is the first study to assess clinical and phenomenological changes in somnambulism within the same individuals across childhood, adolescence and adulthood. The primary objectives of this thesis were to assess the changes in the frequency of somnambulistic episodes, episode-related sleep mentation and aggressive somnambulistic episodes in adult sleepwalkers with a childhood onset of the disorder. Furthermore, the present study investigated whether the frequency of aggressive somnambulistic episodes could predict the recall of episode-related sleep mentation. As a secondary objective, this thesis assessed the frequency of sleep terrors and sleep mentation associated with such episodes in a subsample of sleepwalkers with a childhood onset of sleep terrors. In this section, the findings (summarized in Table 6) will be discussed in relation to the literature on somnambulism, sleep terrors and dreams. Finally, a discussion of the limitations and strengths of the present study as well as future research directions will be presented.

Table 6. Summary of Findings

Study Variable	Childhood → Adolescence	Adolescence → Adulthood
Frequency of Somnambulistic Episodes	≈	↑
Frequency of Sleep Terror Episodes	↓	≈
Frequency of Recall of Sleep Mentation Associated with Somnambulism	↑	↑
Frequency of Recall of Sleep Mentation Associated with Sleep Terrors	≈	≈
Frequency of Aggressive Somnambulistic Episodes	↑	↑

Note. Statistically insignificant difference is depicted by ≈, while statistically significant increase and decrease in mean frequency is depicted by ↑ and ↓, respectively.

5.1.1 Episodes Frequency

Based on our analyses, the frequency of somnambulistic episodes in sleepwalkers with a childhood onset of the disorder remained unchanged from childhood to adolescence but

increased during adulthood. Because no other empirical study has investigated developmental changes in the frequency of somnambulistic episodes from childhood to adulthood, it is not possible to compare the present findings to the literature. Nonetheless, possible explanations for the observed changes in episode frequency are detailed below.

A variable degree of amnesia has been regarded as one of the characteristics of somnambulistic episodes (American Academy of Sleep Medicine, 2014). As will be discussed in the subsequent section, our study shows a lower frequency of sleep mentation associated with somnambulism during childhood and adolescence as compared to adulthood. Similarly, the lower frequency of somnambulistic episodes reported during childhood and adolescence could be due to a lower frequency of "recall" of the episodes (e.g., if the parents or other household members are not present to witness given episodes), rather than a less frequent occurrence of episodes *per se* during these earlier developmental stages as compared to adulthood. Specifically, sleepwalkers in our study may have been more amnesic for somnambulistic episodes during childhood and adolescence, leading to an underestimation of episode frequency in these stages as compared to adulthood. Finally, it is possible that the adult sleepwalkers included in our study, which were referred to our sleep disorders clinic for suspected somnambulism, consulted their doctors due to a worsening of their somnambulistic episodes. This may partially explain the higher episode frequency observed during our patients' adulthood as compared to their childhood and adolescence.

The present study did not find a statistically significant difference in the frequency of somnambulistic episodes between men and women. This finding is similar to the findings of several other studies of sex differences in the frequency of somnambulistic episodes (Klackenberg, 1982; Ohayon et al., 2012; Saarenpää-heikkilä et al., 1995; Wiechers et al., 2011). Contrary to these findings, one study reported a higher frequency of episodes in women than in men during childhood (assessed up to age 15), but a higher frequency of episodes in men than in women during adulthood (Hublin et al., 1997). A higher frequency of somnambulistic episodes in men than in women sleepwalkers during adolescence was also reported in another study (Abdel-Khalek, 2001). The disparity between these reports and our finding may be partially due to differences in samples and assessment methods for somnambulistic episodes.

Lastly, our analysis of the frequency of sleep terror episodes showed a decrease in the frequency of sleep terrors from childhood to adolescence, after which the frequency of sleep terror episodes remained stable. This is in contrast with our finding of the developmental changes in the frequency of somnambulistic episodes. How and why these two NREM sleep parasomnias show different frequency patterns as a function of aging remains to be determined.

5.1.2 Recall Frequency of Sleep Mentation

Our results confirmed the hypothesis that sleepwalkers recall more sleep mentation associated with somnambulism during adulthood as compared to childhood. More specifically, the recall of sleep mentation associated with somnambulism gradually increased from childhood to adolescence and adulthood. In addition, the difference in recall frequency of episode-related sleep mentation between adulthood and childhood stages was very robust (d = 0.97), indicating the importance of this effect.

Due to the lack of empirical studies on developmental changes in the frequency of episode-related sleep mentation, our findings are compared to studies of sleep mentation in non-sleepwalker samples (referred to as “dreams” in this section to avoid confusion). Our findings of recall frequency of sleep mentation associated with somnambulism are comparable with several studies on dream recall (Foulkes, 1982; Nielsen, 2000, 2012; Strauch, 2005). For example, a longitudinal study of children aged 3 or 4 years and 9 or 10 years reported a significant increase in recall frequency of dreams from pre-school years to pre-adolescent years (Foulkes, 1982): The median recall frequency of dreams from REM awakenings changed from 15% at age 3–5 years to 79% at age 9–11 years while the median recall frequency of dreams from NREM awakenings increased from 0% to 33% between these age groups. However, no significant difference in dream recall frequency was found between the ages of 9 to 15 years (Foulkes, 1982). Nevertheless, a second longitudinal study reported a higher frequency of dream recall at age 16 as compared to age 13 (Nielsen et al., 2000). Finally, a cross-sectional study reported a higher frequency of REM dream recall in adults aged 20–29 years as compared to children and adolescents aged 10–19 years (Nielsen, 2012). That said, this observed increase in dream recall frequency is not supported by other studies. For instance, one investigation found no significant

difference in dream recall frequency in younger (4–5 years) and older children (8–10 years; Resnick, Stickgold, Rittenhouse, & Hobson, 1994) while a longitudinal investigation reported a decrease in dream recall frequency in girls from age 10–11 years to 12–13 years (Soffer-Dudek & Sadeh, 2013). The disparity between these findings is possibly due to differences in sample composition, varying definitions or conceptualizations of what constitutes a dream, and differences in the methods used to measure dream recall and to collect dream reports.

It has been suggested that the production and development of dreams in children is a gradual, step-like process associated with children's broader cognitive development: Dreams in children become progressively more complex and lengthier (e.g., in terms of word count) while dream recall frequency increases as children's cognitive abilities improve and develop (Foulkes, 1982). The longitudinal study by Foulkes (1982) described earlier in this section assessed several cognitive skills in children, including working memory, verbal expression and visuospatial skills, and showed that visuospatial skill development was the best predictor of REM dream recall in these children.

Foulkes (1982) suggested that the lower dream recall in children is associated with lack of cognitive processes necessary for creating dream imagery, rather than the inability to recall or describe dreams. The association between the score on the Wechsler Block Design subtest (Wechsler, 1949), which was used to assess visuospatial skill development in this study, and the frequency of REM dream recall is confirmed by other in-lab sleep studies (Butler & Watson, 1985; Foulkes, Hollifield, Sullivan, Bradley, & Terry, 1990). Similar to dream recall, the recall of episode-related sleep mentation could be associated with cognitive development, namely the visuospatial skills associated with the creation of dreams. This may explain the increase in the frequency of sleep mentation associated with somnambulism from childhood to adolescence and adulthood, although longitudinal investigations using a sample of sleepwalkers are needed to support this proposition.

In addition to cognitive development, the gradual decrease in sleep-related arousal thresholds from childhood to adolescence and adulthood (Busby et al., 1994) may explain the increase in frequency of sleep mentation recalled in association with somnambulism from

childhood to adulthood. The association between arousal threshold and sleep mentation is supported by a study in which non-sleepwalker adults with relatively low arousal thresholds recalled dreams from NREM awakenings over 3 times more frequently than adults with a high arousal threshold (Zimmerman, 1970).

The present study did not find any significant sex differences in the recall frequency of sleep mentation associated with somnambulism. To our knowledge, no other study has ever investigated differences between male and female sleepwalkers in their recall of episode-related sleep mentation.

As a secondary objective, this thesis investigated changes in the frequency of sleep mentation associated with sleep terrors. The recall frequency of sleep mentation associated with sleep terror episodes was neither different between the 3 developmental stages investigated nor between men and women. This finding shows that, as compared to somnambulism, sleep mentation associated with sleep terrors remains fairly stable over time.

It is notable that a remarkable percentage of our adult sleepwalkers reported experiencing recall of episode-related sleep mentation across the 3 developmental stages investigated (see Table 4). Specifically, about 29% of participants with childhood-onset somnambulism recalled episode-related sleep mentation “often” or “always” during childhood, 39% during adolescence and 64% in adulthood. For the subset of our sample with childhood onset of sleep terrors, the comparable figures were 41% during childhood, 35% during adolescence and 43% in adulthood. These frequencies indicate that amnesia is not a common characteristic of somnambulistic and sleep terror episodes.

Somnambulism is primarily diagnosed based on the patient’s clinical history, yet the inter-observer reliability for diagnosis of adults with somnambulism using ICSD-II criteria has been found to be only “fair”, due to disagreements over “amnesia following an episode” criterion (Vignatelli et al., 2005). That said, recent refinements in diagnostic criteria have increased the inter-observer reliability for diagnosis of somnambulism to “almost perfect”, although disagreements over the “amnesia following an episode” criterion still occur (Loddo et al., 2019).

Accordingly, the findings of the present study support that, at least in adults, retrograde amnesia should not be considered as de defining clinical characteristic of somnambulistic episodes.

5.1.3 Frequency of Aggressive Somnambulistic Episodes

Our findings support the hypothesis that aggressive somnambulistic episodes occur more frequently in adulthood than in childhood. Indeed, our findings show a gradual increase in the frequency of aggressive somnambulistic episodes from childhood to adolescence and into adulthood. The effect size for the difference in the frequency of aggressive somnambulistic episodes between adulthood and childhood was particularly large (*d* = .87), indicating the saliency of the difference in the frequency of aggressive episodes between these developmental stages. Approximately 57% of sleepwalkers included in the present study reported having "never" experienced an aggressive somnambulistic episode during childhood as compared to 45% during adolescence and 28% during adulthood (see Table 4). Although the frequency of aggressive episodes was lower during childhood than during subsequent developmental periods, these percentages indicate that childhood somnambulism is not always benign and in certain cases, it can involve aggressive and/or harmful behaviours. In fact, about 5% of sleepwalkers reported having experienced aggressive somnambulistic episodes "often" or "always" during childhood. In sum, these findings suggest that aggressive somnambulistic episodes are present across the 3 developmental periods investigated in the present study but that they are more likely to be experienced during adulthood.

Contrary to our prediction, we found no significant difference in the frequency of aggressive episodes reported by men versus women. This is in contrast with findings from past studies reporting a higher frequency of sleep-related violent behaviour in men as compared to women (Bargiotas et al., 2017; Guilleminault et al., 1995; Moldofsky et al., 1995). Unlike these studies, which included a higher proportion of men than women, our investigation included a higher proportion of women (n = 65; 58%), which may play a role in the observed differences. Additionally, participants in our study were asked about the frequency of physical and/or "verbally aggressive" or violent behaviour during sleep, while the studies cited above did not explicitly consider verbal aggression in their analysis. Thus, while instances of physical aggression

in somnambulistic episodes may be greater in men than in women, the magnitude of such sex differences may diminish if reports of aggressive somnambulistic episodes also include verbal forms of aggression.

5.1.4 Aggression as a Predictor of Sleep Mentation Recall

This thesis also investigated whether the frequency of aggressive somnambulistic episodes could predict recall frequency of episode-related sleep mentation. Our results indicate that sleepwalkers who report experiencing more aggressive somnambulistic episodes recall more episode-related sleep mentation. However, as compared to our other significant results, the effect size associated with this finding was relatively small (d = 0.23).

Several studies on dreams found a positive correlation between the intensity of dream experiences and dream recall (D. B. Cohen & MacNeilage, 1974; Schonbar, 1961; Schredl & Doll, 1998), supporting the salience hypothesis of dream recall, which states that more salient dreams are more likely to be recalled than are less salient dreams (D. B. Cohen, 1974). Accordingly, the intensity or the salience of episode-related sleep mentation during aggressive somnambulistic episodes may improve its recall in sleepwalkers. As discussed earlier, a study of 38 adults with chronic somnambulism and/or sleep terrors found that 86% of episode-related sleep mentation reports were accompanied by negative emotions, primarily apprehension (Oudiette et al., 2009). Similarly, a study of 94 adult sleepwalkers referred to our sleep disorders clinic found that strong negative emotions, including fear, anger, frustration and helplessness, were reported to “often” or “always” accompany somnambulistic episodes in 75% of the sample (Zadra et al., 2013). Furthermore, a study of 32 adults with somnambulism or sleep terrors reported that 70% of the 74 episode-related reports contained threats, particularly in forms of misfortune, aggression and flight response (Uguccioni et al., 2013). Hence, it is possible that strong negative emotions associated with threats perceived during somnambulistic episodes lead to more frequent recall of episode-related sleep mentation.

Studies of episode-related dream reports in individuals with REM sleep behaviour disorder may provide further support for the hypothesis that strong threat-related emotions are associated with a higher frequency of sleep mentation recall. In an assessment of dream reports

from 24 individuals with REM sleep behaviour disorder, 60% of the 47 dreams recalled by the patients following a RBD episode involved threats. Aggression was the most common threat in the reported dreams, but fleeing, misfortunes and accidents were also reported (Uguccioni et al., 2013). Furthermore, one study comparing the dream content of 49 individuals with REM sleep behaviour disorder with 71 age- and sex- matched control subjects found a higher percentage of dream recall and a higher percentage of aggression in the dream reports of individuals with REM sleep behaviour disorder (Fantini, Corona, Clerici, & Ferini-Strambi, 2005). In this study, about 82% of the individuals with REM sleep behaviour disorder and 49% of healthy controls remembered at least one dream while being assessed in the sleep laboratory. Among the 98 dreams collected from the patients, 66% involved aggression and 86% involved a higher proportion of aggressive to friendly interactions. By contrast, only 15% of the 69 dream reports collected from the control participants contained a theme of aggression and 44% had a higher proportion of aggression to friendliness interactions. Dream reports from individuals with REM sleep behaviour disorder also contained more negative emotions as compared to the dream reports from healthy controls (Fantini et al., 2005). It is possible that individuals with REM sleep behaviour disorder recall more dreams as compared to control subjects due to the strong negative emotions associated with aggressive interactions in their dreams.

Furthermore, as shown in Table 2, many of the enacted sleep mentation associated with aggressive somnambulistic episodes contain bizarre elements. However, whether aggressive somnambulistic episodes are more bizarre than non-aggressive episodes has not been empirically investigated. Given that bizarre dreams are more likely to be recalled than non-bizarre dreams (Cipolli, Bolzani, Comoldi, Beni, & Fagioli, 1993) and that bizarre experiences are more likely to be reported as dreams as compared to consistent and thought-like mental experiences (Goodenough, Shapiro, Holden, & Steinschriber, 1959), it is possible that the degree of bizarreness associated with aggressive somnambulistic episodes also play a role in the recall of episode-related sleep mentation. Similarly, it is possible that sleepwalkers are more likely to recall sleep mentation associated with aggressive episodes as compared to more mundane somnambulistic behaviours.

5.1.5 Clinical Implications of Injurious Behaviour During Somnambulism

Why certain sleepwalkers develop potentially injurious episodes while others experience episodes involving relatively simple and benign movements remains unclear. One study of 105 adult sleepwalkers with a diagnosis of chronic somnambulism investigated the relationship between the presence of psychopathology and frequency of aggressive/injurious somnambulistic episodes as well as recall frequency of episode-related sleep mentation (Labelle et al., 2013). The authors found that the recall frequency of episode-related sleep mentation as well as the frequency of episodes resulting in injuries were similar between sleepwalkers with minimal levels of daytime anxiety or depression and sleepwalkers with moderate to severe daytime levels of anxiety or depression. However, sleepwalkers with moderate to severe levels of anxiety or depression were more likely to engage in risky behaviours during their episodes such as handling a knife or a gun, or leaving their house and walking outdoors (Labelle et al., 2013). This finding has important clinical implications as it suggests that sleepwalkers with relatively higher levels of psychopathology are more likely to put themselves and others in danger during their episodes. Clinicians may use this information to assess the risk of injury in adult sleepwalkers and suggest medical treatments if, despite implementing safety measures in their sleep environment, sleepwalkers still pose a risk to themselves or others (Harris & Grunstein, 2009).

To our knowledge, no study has investigated the relationship between daytime aggression in sleepwalkers and the frequency of their aggressive or injurious episodes. One study of dream content in 32 adult patients with somnambulism/sleep terrors and 24 patients with REM sleep behaviour disorder, reported low levels of daytime aggression, anxiety and depression in both groups, but did not assess whether these factors influenced the frequency of aggressive episode-related sleep mentation observed in these groups (Uguccioni et al., 2013). On the other hand, some earlier studies of adult sleepwalkers reported difficulties in managing day-time aggression in these patients (Crisp, Matthews, Oakey, & Crutchfield, 1990; Kales, Soldatos, Caldwell, et al., 1980). The differences in these findings could be partly due to sample composition as well as differences in how daytime aggression was measured. That said, while a potentially valuable research question, whether the degree of efficiency or difficulty experienced

in handling daytime feelings of aggression is associated with the frequency of aggressive somnambulistic episodes has yet to be investigated.

5.2 Limitations and Strengths

Several limitations must be described when considering the findings of the present study. To begin with, our findings may not be generalizable to sleepwalkers from the general population. Adult sleepwalkers seeking professional help and referred to a sleep disorders clinics may present with a more severe and/or frequent form of the disorder (Lopez et al., 2013) and opt to consult after experiencing injuries during one or more of their episodes (Labelle et al., 2013; Zadra et al., 2013). Furthermore, this study only investigated developmental changes in somnambulistic episodes in adult sleepwalkers with a childhood-onset of the disorder. Hence, our findings may not apply to people with a later or adult onset of sleepwalking.

Several limitations also arise from the assessment tools used in the present study. First, our study variables were assessed across 3 developmental stages through a questionnaire filled out by our sample of adult sleepwalkers. This may have resulted in recall bias and a less accurate reporting, particularly for the childhood period that was further back in time. Second, due to amnesia for or forgetting of childhood and later episodes, the reported episode frequencies may have underestimated the actual frequencies. An alternative method that may reduce this bias is have other household members that may have witnessed such episodes (e.g., parents, siblings, bedpartner) to also provide estimates of episode frequency (Pressman, 2013). In the present study, it would have been informative to obtain and compare witness' reports of episode frequency with those from sleepwalkers' themselves, particularly during the participants' childhood, a time when amnesia for episodes is at its highest.

Another limitation related to our assessment methods was the use of a scale with subjective measures (e.g., never, rarely, sometimes) to categorize the frequency of sleep mentation and aggressive episodes. These scales have been shown to be less reliable than scales that include absolute categories (Schredl, 2007), such as the one used to measure the frequency of somnambulistic episodes in our study.

Despite the limitations discussed above, our study has several strengths. First, the number of sleepwalkers included in the present study (n= 113) represents one of the largest clinical samples of sleepwalkers ever included in a study of somnambulism. Furthermore, the fact that each participant underwent a thorough clinical assessment, including a night of video-PSG, and received a final diagnosis of primary somnambulism prior to their inclusion, also constitutes an important strength of the study. This may have reduced the likelihood of attribution bias (i.e. considering any nocturnal wandering as somnambulism), which is regarded as another issue in research on somnambulism (Pressman, 2013).

More importantly still, to our knowledge, this is the first empirical study to have assessed changes in the frequency of somnambulistic episodes, sleep mentation and aggression associated with somnambulistic episodes across 3 key developmental stages. Our results thus provide preliminary yet intriguing findings on how somnambulism evolves over time in terms of severity and frequency in sleepwalkers presenting with a history of chronic episodes. Moreover, by using a repeated-measure design, we were able to control for within-subject variability by having each subject act as their own control (Salkind, 2010). Thus, variables that may have influenced our results, such as sex, age of onset and family history of the disorder remained constant across time, allowing for more accurate comparisons between the 3 developmental periods under consideration. In addition, by opting for linear mixed-model analysis over repeated-measures ANOVA, we were able to avoid a loss of information from participants with incomplete responses (West et al., 2014).

5.3 Conclusion and Future Directions

The primary objective of this study was to assess how somnambulistic episodes evolve from childhood to adulthood within the same individuals. Based on our analyses, the frequency of somnambulistic episodes remains stable from childhood to adolescence before increasing during adulthood. In addition, the frequency of sleep mentation associated with somnambulism and aggressive somnambulistic episodes increases from childhood to adolescence and adulthood. Furthermore, the overall frequency of aggressive somnambulistic episodes predicts the recall of episode-related sleep mentation in adult sleepwalkers. As a secondary objective, this thesis

investigated developmental changes in sleep terrors. We found that the frequency of sleep terror episodes decreases from childhood to adolescence but that it remains stable thereafter. Also, no change was observed in the recall frequency of sleep mentation associated with sleep terrors from childhood to adulthood.

Future investigations should study factors that may affect how somnambulistic episodes unfold over time. For example, differences in the frequency of episodes have been reported based on age of onset: Late-onset sleepwalkers (after age of 9 years) are more likely to experience an increase in episode frequency over time as compared to early-onset sleepwalkers (before age of 9 years; Lopez et al., 2013). Additionally, another study found a higher frequency of episodes in chronic adult sleepwalkers (Bušková et al., 2015). It would be interesting to conduct similar analyses comparing changes in episode frequency and severity among groups of sleepwalkers with childhood, adolescent or adult onset of the disorder.

The presence or absence of a family history of somnambulism is another factor that may affect how episodes evolve over time. Despite strong evidence for a genetic component in the etiology of sleepwalking (Abe & Shimakawa, 1966; Kales, Soldatos, Bixler, et al., 1980; Petit et al., 2015), no study has investigated how a positive family history for the disorder impacts its developmental trajectory and associated symptoms. For example, one study of the psychopathologic correlates of somnambulism in adults found that the presence of psychopathology was associated with a higher frequency of nightmares, behavioural episodes with an elevated risk of injury and the absence of family history for somnambulism (Labelle et al., 2013). This information can be valuable for clinicians as it potentially allows them to evaluate the risk of injury during somnambulistic episodes in a given sleepwalker based on the presence or development of psychopathology in the absence of a family history of somnambulism.

In addition, longitudinal studies of children who sleepwalk should investigate whether visuospatial skill development is associated with the recall of episode-related sleep mentation as is the case with general dream recall (Foulkes, 1982; Foulkes et al., 1990). Similarly, given that some recent models of dream function conceptualize dreaming and dream recall on a continuum across different sleep stages (Zadra & Stickgold, 2021), it would be interesting to investigate if

adult sleepwalkers with relatively high levels of recall for sleep mentation associated with their episodes also report high levels of general dream recall.

Furthermore, studies are needed to better understand the role that different factors associated with aggressive somnambulistic episodes, such as bizarreness and emotional salience, may play in the recall of episode-related sleep mentation. Moreover, it would be interesting to compare the frequency of aggressive somnambulistic episodes in men and women based on the type of aggression (verbal versus physical) more often exhibited during their episodes. Finally, future studies should include sleepwalkers recruited from the general population for comparison with clinically-based samples to compare obtained results and thus help increase the generalizability of observed findings.

Bibliographical References

Abdel-Khalek, A. M. (2001). Epidemiologic study of sleep disorders in Kuwaiti adolescents. *Perceptual and Motor Skills, 93*(3), 901-910. https://doi.org/10.2466/pms.2001.93.3.901

Abe, K., Amatomi, M., & Oda, N. (1984). Sleepwalking and recurrent sleeptalking in children of childhood sleepwalkers. *The American journal of psychiatry, 141*(6). https://doi.org/10.1176/ajp.141.6.800

Abe, K., & Shimakawa, M. (1966). Predisposition to sleep-walking. *Psychiatr Neurol (Basel), 152*(5), 306-312. https://doi.org/10.1159/000128256

American Academy of Sleep Medicine. (2005). *ICSD-II: the international classification of sleep disorders: diagnostic and coding manual* (2 ed.). Westchester: American Academy of Sleep Medicine.

American Academy of Sleep Medicine. (2014). *International Classification of Sleep Disorders* In.

Arnulf, I. (2018). Sleepwalking. *Current Biology, 28*(22), R1288-R1289. https://doi.org/10.1016/j.cub.2018.09.062

Aserinsky, E., & Kleitman, N. (1953). Regularly occurring periods of eye motility, and concomitant phenomena, during sleep. *Science, 118*(3062), 273-274. https://doi.org/10.1126/science.118.3062.273

Avidan, A. Y. (2017). Non–Rapid Eye Movement Parasomnias: Clinical Spectrum, Diagnostic Features, and Management. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine* (6 ed., pp. 981-992): Elsevier.

Bakwin, H. (1970). Sleep-walking in twins. *The Lancet, 296*(7670), 446-447. https://doi.org/10.1016/s0140-6736(70)90058-9

Bargiotas, P., Arnet, I., Frei, M., Baumann, C. R., Schindler, K., & Bassetti, C. L. (2017). Demographic, clinical and polysomnographic characteristics of childhood-and adult-onset sleepwalking in adults. *European neurology, 78*(5-6), 307-311. https://doi.org/10.1159/000481685

Bhat, S., Chokroverty, S., Kabak, B., Yang, Q. R., & Rosen, D. (2012). Dream-enacting behavior in non-rapid eye movement sleep. *Sleep medicine, 4*(13), 445-446. https://doi.org/10.1016/j.sleep.2011.10.029

Blader, J. C., Koplewicz, H. S., Abikoff, H., & Foley, C. (1997). Sleep problems of elementary school children: a community survey. *Archives of pediatrics & adolescent medicine, 151*(5), 473-480. https://doi.org/10.1001/archpedi.1997.02170420043007

Britton, J. W., Frey, L. C., & Hopp, J. L. (2016). Introduction. In E. K. St. Louis & L. C. Frey (Eds.), Electroencephalography (EEG): An introductory text and atlas of normal and abnormal findings in adults, children, and infants. Chicago: American Epilepsy Society.

Broughton, R., Billings, R., Cartwright, R., Doucette, D., Edmeads, J., Edwardh, M., . . . Turrell, G. (1994). Homicidal somnambulism: a case report. *Sleep, 17*(3), 253-264. https://doi.org/10.1093/sleep/17.3.253

Busby, K. A., Mercier, L., & Pivik, R. T. (1994). Ontogenetic variations in auditory arousal threshold during sleep. *Psychophysiology, 31*(2), 182-188. https://doi.org/10.1111/j.1469-8986.1994.tb01038.x

Bušková, J., Piško, J., Pastorek, L., & Šonka, K. (2015). The course and character of sleepwalking in adulthood: a clinical and polysomnographic study. *Behavioral sleep medicine, 13*(2), 169-177. https://doi.org/10.1080/15402002.2013.845783

Butler, S. F., & Watson, R. (1985). Individual differences in memory for dreams: the role of cognitive skills. *Perceptual and Motor Skills, 61*(3), 823-828. https://doi.org/10.2466/pms.1985.61.3.823

Carskadon, M. A., & Dement, W. C. (2017). Normal Human Sleep: An Overview. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine* (6 ed., pp. 15-24): Elsevier.

Cartwright, R. (2004). Sleepwalking violence: a sleep disorder, a legal dilemma, and a psychological challenge. *American journal of psychiatry, 161*(7), 1149-1158. https://doi.org/10.1176/appi.ajp.161.7.1149

Castelnovo, A., Lopez, R., Proserpio, P., Nobili, L., & Dauvilliers, Y. (2018). NREM sleep parasomnias as disorders of sleep-state dissociation. *Nature Reviews Neurology, 14*(8), 470-481. https://doi.org/10.1038/s41582-018-0030-y

Cavallero, C., Cicogna, P., Natale, V., Occhionero, M., & Zito, A. (1992). Slow wave sleep dreaming. *Sleep, 15*(6), 562-566. https://doi.org/10.1093/sleep/15.6.562

Chaudhary, B. A. (2007). Introduction to Polysomnography. In J. F. Pagel & S. R. Pandi-Perumal (Eds.), *Primary Care Sleep Medicine. Current Clinical Practice* (pp. 295-304): Humana Press.

Cicogna, P., Natale, V., Occhionero, M., & Bosinelli, M. (2000). Slow wave and REM sleep mentation. *Sleep research online, 3*(2), 67–72.

Cipolli, C., Bolzani, R., Comoldi, C., Beni, R. D., & Fagioli, I. (1993). Bizarreness effect in dream recall. *Sleep, 16*(2), 163-170. https://doi.org/10.1093/sleep/16.2.163

Cohen, D. B. (1974). Toward a theory of dream recall. *Psychological Bulletin, 81*(2), 138–154. https://doi.org/10.1037/h0037616

Cohen, D. B., & MacNeilage, P. F. (1974). A test of the salience hypothesis of dream recall. *Journal of Consulting and Clinical Psychology, 42*(5), 699–703. https://doi.org/10.1037/h0036948

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2 ed.). New York Lawrence Erlbaum Associates.

Colman, A. M. (2014). *A Dictionary of Psychology*. In. Retrieved from https://www.oxfordreference.com/view/10.1093/acref/9780199534067.001.0001/acref-9780199534067

Crisp, A. H., Matthews, B. M., Oakey, M., & Crutchfield, M. (1990). Sleepwalking, night terrors, and consciousness. *British Medical Journal, 300*(6721), 360-362. https://doi.org/10.1136/bmj.300.6721.360

Domhoff, G. W. (1996). *Finding Meaning in Dreams: A Quantitative Approach*. New York: Springer Science & Business Media.

Domhoff, G. W. (2019). The neurocognitive theory of dreams at age 20: An assessment and a comparison with four other theories of dreaming. *Dreaming, 29*(4), 265-302. https://doi.org/10.1037/drm0000119

Fantini, M. L., Corona, A., Clerici, S., & Ferini-Strambi, L. (2005). Aggressive dream content without daytime aggressiveness in REM sleep behavior disorder. *Neurology, 65*(7), 1010-1015. https://doi.org/10.1212/01.wnl.0000179346.39655.e0

Fisher, B. E., & Wilson, A. E. (1987). Selected sleep disturbances in school children reported by parents: prevalence, interrelationships, behavioral correlates and parental attributions. *Perceptual and Motor Skills, 64*(3_suppl), 1147-1157. https://doi.org/10.2466/pms.1987.64.3c.1147

Foulkes, D. (1962). Dream reports from different stages of sleep. *The Journal of Abnormal and Social Psychology, 65*(1), 14–25. https://doi.org/10.1037/h0040431

Foulkes, D. (1982). *Children's dream : longitudinal studies*. New York J. Wiley.

Foulkes, D., Hollifield, M., Sullivan, B., Bradley, L., & Terry, R. (1990). REM dreaming and cognitive skills at ages 5-8: A cross-sectional study. *International Journal of Behavioral Development, 13*(4), 447-465. https://doi.org/10.1177/016502549001300404

Foulkes, D., & Schmidt, M. (1983). Temporal sequence and unit composition in dream reports from different stages of sleep. *Sleep, 6*(3), 265–280. https://doi.org/10.1093/sleep/6.3.265

Goodenough, D. R., Shapiro, A., Holden, M., & Steinschriber, L. (1959). A comparison of" dreamers" and" nondreamers": Eye movements, electroencephalograms, and the recall of dreams. *The Journal of Abnormal and Social Psychology, 59*(3), 295-302. https://doi.org/10.1037/h0040532

Guilleminault, C., Kirisoglu, C., Bao, G., Arias, V., Chan, A., & Li, K. K. (2005). Adult chronic sleepwalking and its treatment based on polysomnography. *Brain, 128*(5), 1062-1069. https://doi.org/10.1093/brain/awh481

Guilleminault, C., Moscovitch, A., & Leger, D. (1995). Forensic sleep medicine: nocturnal wandering and violence. *Sleep, 18*(9), 740-748. https://doi.org/10.1093/sleep/18.9.740

Harris, M., & Grunstein, R. R. (2009). Treatments for somnambulism in adults: assessing the evidence. . *Sleep medicine reviews, 13*(4), 295-297.

Heidbreder, A., Frauscher, B., Mitterling, T., Boentert, M., Schirmacher, A., Hörtnagl, P., . . . Högl, B. (2016). Not only sleepwalking but NREM parasomnia irrespective of the type is associated with HLA DQB1* 05: 01. *Journal of Clinical Sleep Medicine, 12*(4), 565-570. https://doi.org/10.5664/jcsm.5692

Hublin, C., Kaprio, J., Partinen, M., Heikkila, K., & Koskenvuo, M. (1997). Prevalence and genetics of sleepwalking: a population-based twin study. *Neurology, 48*(1), 177-181. https://doi.org/10.1212/wnl.48.1.177

IBM Corp. (2017). IBM SPSS Statistics for Macintosh (Version 25.0). Armonk, NY: IBM Corp. .

Ipsiroglu, O. S., Fatemi, A., Werner, I., Paditz, E., & Schwarz, B. (2002). Self-reported organic and nonorganic sleep problems in schoolchildren aged 11 to 15 years in Vienna *Journal of Adolescent Health, 31*(5), 436-442. https://doi.org/10.1016/S1054-139X(02)00423-8

Itani, O., Kaneita, Y., Ikeda, M., Kondo, S., Yamamoto, R., Osaki, Y., . . . Ohida, T. (2013). Disorders of arousal and sleep-related bruxism among Japanese adolescents: a nationwide representative survey. *Sleep medicine, 14*(6), 532-541. https://doi.org/10.1016/j.sleep.2013.03.005

Kales, A., Hoedemaker, F. S., Jacobson, A., Kales, J. D., Paulson, M. J., & Wilson, T. E. (1967). Mentation during sleep: REM and NREM recall reports. *Perceptual and Motor Skills, 24*(2), 555-560. https://doi.org/10.2466/pms.1967.24.2.555

Kales, A., & Kales, J. D. (1974). Sleep disorders: recent findings in the diagnosis and treatment of disturbed sleep. *New England Journal of Medicine, 290*(9), 487-499. https://doi.org/10.1056/NEJM197402282900905

Kales, A., Soldatos, C. R., Bixler, E. O., Ladda, R. L., Charney, D. S., Weber, G., & Schweitzer, P. K. (1980). Hereditary factors in sleepwalking and night terrors. *The British Journal of Psychiatry, 137*(2), 111-118. https://doi.org/10.1192/bjp.137.2.111

Kales, A., Soldatos, C. R., Caldwell, A. B., Kales, J. D., Humphrey, F. J., Charney, D. S., & Schweitzer, P. K. (1980). Somnambulism: clinical characteristics and personality patterns. *Archives of general psychiatry, 37*(12), 1406-1410. https://doi.org/10.1001/archpsyc.1980.0178025009201

Klackenberg, G. (1982). Somnambulim in Childhood-Prevalence, Course and Behavioural Correlations: A Prospective Longitudinal Study (6-16 years). *Acta Paediatrica, 71*(3), 495-499. https://doi.org/10.1111/j.1651-2227.1982.tb09458.x

Labelle, M. A., Desautels, A., Montplaisir, J., & Zadra, A. (2013). Psychopathologic correlates of adult sleepwalking. *Sleep medicine, 14*(12), 1348-1355. https://doi.org/10.1016/j.sleep.2013.05.023

Laberge, L., Tremblay, R. E., Vitaro, F., & Montplaisir, J. (2000). Development of parasomnias from childhood to early adolescence. *Pediatrics, 106*(1), 67-74. https://doi.org/10.1542/peds.106.1.67

Lecendreux, M., Bassetti, C., Dauvilliers, Y., Mayer, G., Neidhart, E., & Tafti, M. (2003). HLA and genetic susceptibility to sleepwalking. *Molecular psychiatry, 8*(1), 114-117. https://doi.org/10.1038/sj.mp.4001203

Lehmkuhl, G., Wiater, A., Mitschke, A., & Fricke-Oerkermann, L. (2008). Sleep disorders in children beginning school: their causes and effects. *Deutsches Ärzteblatt International, 105*(47), 809-814. https://doi.org/10.3238/arztebl.2008.0809

Loddo, G., Vignatelli, L., Zenesini, C., Lusa, F., Sambati, L., Baldelli, L., . . . Provini, F. (2019). Interobserver reliability of ICSD-3 diagnostic criteria for disorders of arousal in adults. *Sleep and Breathing, 23*, 1309-1314. https://doi.org/10.1007/s11325-019-01937-w

Lopez, R., Jaussent, I., Scholz, S., Bayard, S., Montplaisir, J., & Dauvilliers, Y. (2013). Functional impairment in adult sleepwalkers: a case-control study. *Sleep, 36*(3), 345-351. https://doi.org/10.5665/sleep.2446

Mahowald, M. W., Borneman, M. A. C., & Schenck, C. H. (2004). Parasomnias. *Seminar in Neurology, 24*(3), 283-292. https://doi.org/10.1055/s-2004-835064

Malhotra, R., & Avidan, A. Y. (2014). Sleep Stages and Scoring Technique. In Atlas of Sleep Medicine (pp. 77-99): Elsevier. https://doi.org/10.1016/B978-1-4557-1267-0.00003-5

Moldofsky, H., Gilbert, R., Lue, F. A., & MacLean, A. W. (1995). Sleep-related violence. *Sleep, 18*(9), 731-739. https://doi.org/10.1093/sleep/18.9.731

Mume C.O. (2010). Prevalence of sleepwalking in an adult population. *Libyan journal of medicine, 5*(1). https://doi.org/10.4176/090907

Nevéus, T., Cnattingius, S., Olsson, U., & Hetta, J. (2001). Sleep habits and sleep problems among a community sample of schoolchildren. *Acta Paediatrica, 90*(12), 1450-1455. https://doi.org/10.1111/j.1651-2227.2001.tb01612.x

Nielsen, T. A. (2000). A review of mentation in REM and NREM sleep:"covert" REM sleep as a possible reconciliation of two opposing models. *Behavioral and Brain Sciences, 23*(6), 851-866. https://doi.org/10.1017/S0140525X0000399X

Nielsen, T. A. (2012). Variations in dream recall frequency and dream theme diversity by age and sex. *Frontiers in neurology, 3*(106). https://doi.org/10.3389/fneur.2012.00106

Nielsen, T. A., Laberge, L., Paquet, J., Tremblay, R. E., Vitaro, F., & Montplaisir, J. (2000). Development of disturbing dreams during adolescence and their relation to anxiety symptoms. *Sleep, 23*(6), 1-10.

Ohayon, M. M., Carskadon, M. A., Guilleminault, C., & Vitiello, M. V. (2004). Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep, 27*(7), 1255-1273. https://doi.org/10.1093/sleep/27.7.1255

Ohayon, M. M., Guilleminault, C., & Priest, R. G. (1999). Night terrors, sleepwalking, and confusional arousals in the general population: their frequency and relationship to other sleep and mental disorders. *The Journal of clinical psychiatry, 60*(4), 268-276.

Ohayon, M. M., Mahowald, M. W., Dauvilliers, Y., Krystal, A. D., & Leger, D. (2012). Prevalence and comorbidity of nocturnal wandering in the US adult general population. *Neurology, 78*(20), 1583-1589. https://doi.org/10.1212/WNL.0b013e3182563be5

Ohayon, M. M., & Schenck, C. H. (2010). Violent behavior during sleep: prevalence, comorbidity and consequences. *Sleep medicine, 11*(9), 941-946. https://doi.org/10.1016/j.sleep.2010.02.016

Oswald, I., & Evans, J. (1985). On serious violence during sleep-walking. *The British Journal of Psychiatry, 147*(6), 688-691. https://doi.org/10.1192/bjp.147.6.688

Oudiette, D., Dealberto, M. J., Uguccioni, G., Golmard, J. L., Merino-Andreu, M., Tafti, M., & Arnulf, I. (2012). Dreaming without REM sleep. *Consciousness and cognition, 21*(3), 1129-1140. https://doi.org/10.1016/j.concog.2012.04.010

Oudiette, D., Leu, S., Pottier, M., Buzare, M. A., Brion, A., & Arnulf, I. (2009). Dreamlike mentations during sleepwalking and sleep terrors in adults. . *Sleep, 32*(12), 1621-1627. https://doi.org/10.1093/sleep/32.12.1621

Pagel, J. F., Blagrove, M., Levin, R., Stickgold, B., & White, S. (2001). Definitions of dream: A paradigm for comparing field descriptive specific studies of dream. *Dreaming, 11*(4), 195-202. https://doi.org/10.1023/A:1012240307661

Petit, D., Pennestri, M. H., Paquet, J., Desautels, A., Zadra, A., Vitaro, F., . . . Montplaisir, J. (2015). Childhood sleepwalking and sleep terrors: a longitudinal study of prevalence and familial aggregation. *JAMA pediatrics, 169*, 653-658. https://doi.org/10.1001/jamapediatrics.2015.127

Petit, D., Touchette, É., Tremblay, R. E., Boivin, M., & Montplaisir, J. (2007). Dyssomnias and parasomnias in early childhood. *Pediatrics, 119*(5), e1016-e1025. https://doi.org/10.1542/peds.2006-2132

Pillmann, F. (2009). Complex dream-enacting behavior in sleepwalking. *Psychosomatic medicine, 71*(2), 231-234. https://doi.org/10.1097/PSY.0b013e318190772e

Pilon, M., Montplaisir, J., & Zadra, A. (2008). Precipitating factors of somnambulism: impact of sleep deprivation and forced arousals. *Neurology, 70*(24), 2284-2290. https://doi.org/10.1212/01.wnl.0000304082.49839.86

Plazzi, G., Vetrugno, R., Provini, F., & Montagna, P. (2005). Sleepwalking and other ambulatory behaviours during sleep. *Neurological Sciences, 26*, s193-s198. https://doi.org/10.1007/s10072-005-0486-6

Pressman, M. R. (2007). Factors that predispose, prime and precipitate NREM parasomnias in adults: clinical and forensic implications. *Sleep medicine reviews, 11*(1), 5-30.

Pressman, M. R. (2013). Sleepwalking, amnesia, comorbid conditions and triggers: effects of recall and other methodological biases. *Sleep, 36*(11), 1757-1758. https://doi.org/10.5665/sleep.3144

Ralls, F. M., & Grigg-Damberger, M. M. (2013). Sleepwalking and Its Variants in Adults. In S. V. Kothare & A. Ivanenko (Eds.), *Parasomnias: Clinical Characteristics and Treatment*. New York: Springer.

Rauch, P. K., & Stern, T. A. (1986). Life-threatening injuries resulting from sleepwalking and night terrors. *Psychosomatics, 27*(1), 62-64. https://doi.org/10.1016/S0033-3182(86)72743-6

Resnick, J., Stickgold, R., Rittenhouse, C. D., & Hobson, J. A. (1994). Self-representation and bizarreness in children′ s dream reports collected in the home setting. *Consciousness and cognition, 3*(1), 30-45. https://doi.org/10.1006/ccog.1994.1003

Saarenpää‐heikkilä, O. A., Rintahaka, P. J., Laippala, P. J., & Koivikko, M. J. (1995). Sleep habits and disorders in Finnish schoolchildren. *Journal of Sleep Research, 4*(3), 173-182. https://doi.org/10.1111/j.1365-2869.1995.tb00166.x

Salkind, N. J. (2010). Repeated Measures Design. In *Encyclopedia of research design*. Thousand Oaks, CA: SAGE Publications, Inc.

Schenck, C. H., & Mahowald, M. W. (1995a). A polysomnographically documented case of adult somnambulism with long-distance automobile driving and frequent nocturnal violence:

parasomnia with continuing danger as a noninsane automatism? *Sleep, 18*(9), 765-772. https://doi.org/10.1093/sleep/18.9.765

Schenck, C. H., & Mahowald, M. W. (1995b). Two cases of premenstrual sleep terrors and injurious sleep-walking. *Journal of Psychosomatic Obstetrics & Gynecology,, 16*(2), 79-84. https://doi.org/10.3109/01674829509042782

Schonbar, R. A. (1961). Temporal and emotional factors in the selective recall of dreams. *Journal of Consulting Psychology, 25*(1), 67–73. https://doi.org/10.1037/h0043994

Schredl, M. (2007). Dream recall: Models and empirical data. In D. Barrett & P. McNamara (Eds.), *The new science of dreaming: Vol. 2. Content, recall, and personality correlates* (pp. 79–114). Westport: Praeger Publishers.

Schredl, M., & Doll, E. (1998). Emotions in diary dreams. *Consciousness and cognition, 7*(4), 634-646. https://doi.org/10.1006/ccog.1998.0356

Shang, C., Gau, S. S., & Soong, W. (2006). Association between childhood sleep problems and perinatal factors, parental mental distress and behavioral problems. *Journal of sleep research, 15*(1), 63-73. https://doi.org/10.1111/j.1365-2869.2006.00492.x

Siclari, F., Khatami, R., Urbaniok, F., Nobili, L., Mahowald, M. W., Schenck, C. H., . . . Bassetti, C. L. (2010). Violence in sleep. *Brain, 133*(12), 3494-3509. https://doi.org/10.1093/brain/awq296

Smedje, H., Broman, J. E., & Hetta, J. (1999). Parents' reports of disturbed sleep in 5–7 - year - old Swedish children. *Acta Paediatrica, 88*(8), 858-865. https://doi.org/10.1111/j.1651-2227.1999.tb00062.x

Soffer - Dudek, N., & Sadeh, A. (2013). Dream recall frequency and unusual dream experiences in early adolescence: Longitudinal links to behavior problems. *Journal of Research on Adolescence, 23*(4), 635-651. https://doi.org/10.1111/jora.12007

Stallman, H. M. (2017). Assessment and treatment of sleepwalking in clinical practice. *Australian Family Physician, 46*(8), 590-593.

Stallman, H. M., & Kohler, M. (2016). Prevalence of sleepwalking: a systematic review and meta-analysis. *PLoS One, 11*(11), e0164769. https://doi.org/10.1371/journal.pone.0164769

Stallman, H. M., Kohler, M., & White, J. (2018). Medication induced sleepwalking: a systematic review. *Sleep medicine reviews, 37*, 105-113. https://doi.org/10.1016/j.smrv.2017.01.005

Stallman, H. M., Kohler, M., Wilson, A., Biggs, S., Dollman, J., Martin, J., . . . Lushington, K. (2016). Self-reported sleepwalking in Australian senior secondary school students. *Sleep medicine, 25*, 1-3. https://doi.org/10.1016/j.sleep.2016.06.024

Stickgold, R. (2017). Introduction. In M. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and Practice of Sleep Medicine* (pp. 506-508): Elsevier.

Stickgold, R., Malia, A., Fosse, R., Propper, R., & Hobson, J. A. (2001). Brain-mind states: I. Longitudinal field study of sleep/wake factors influencing mentation report length. *Sleep, 24*(2), 171-179. https://doi.org/10.1093/sleep/24.2.171

Strauch, I. (2005). REM dreaming in the transition from late childhood to adolescence: A longitudinal study. *Dreaming, 15*(3), 155-169. https://doi.org/10.1037/1053-0797.15.3.155

Szűcs, A., Kamondi, A., Zoller, R., Barcs, G., Szabó, P., & Purebl, G. (2014). Violent somnambulism: a parasomnia of young men with stereotyped dream-like experiences. *Medical hypotheses, 83*(1), 47-52. https://doi.org/10.1016/j.mehy.2014.04.012

Twisk, J. W. (2019). *Applied Mixed Model Analysis: A Practical Guide* (2 ed.). New York, NY: Cambridge University Press.

Uguccioni, G., Golmard, J. L., de Fontréaux, A. N.,, Leu-Semenescu, S., Brion, A., & Arnulf, I. (2013). Fight or flight? Dream content during sleepwalking/sleep terrors vs rapid eye movement sleep behavior disorder. *Sleep medicine, 14*(5), 391-398. https://doi.org/10.1016/j.sleep.2013.01.014

Vignatelli, L., Bisulli, F., Zaniboni, A., Naldi, I., Fares, J. E., Provini, F., . . . Montagna, P. (2005). Interobserver reliability of ICSD-R minimal diagnostic criteria for the parasomnias. *Journal of neurology, 252*(6), 712–717. https://doi.org/10.1007/s00415-005-0723-1

Wechsler, D. (1949). *Manual for the Wechsler intelligence scale for children*. New York: The Psychological Corporation.

West, B. T., Welch, K. B., & Galecki, A. T. (2014). *Linear mixed models: a practical guide using statistical software*. In.

Wiechers, S., Schlarb, A. A., Urschitz, M. S., Eggebrecht, E., Schlaud, M., & Poets, C. F. (2011). Sleep problems and poor academic performance in primary school children. *Somnologie-Schlafforschung und Schlafmedizin, 15*(4), 243-248. https://doi.org/10.1007/s11818-011-0535-8

Zadra A, Trudeau S, Hebert L, & Montplaisir J. (2018). *Recall of dreams and nightmares in adult sleepwalkers*. Poster presented at the 30th Association for Psychological Science Annual Convention, San Francisco, CA.

Zadra, A., Desautels, A., Petit, D., & Montplaisir, J. (2013). Somnambulism: clinical aspects and pathophysiological hypotheses. *Lancet Neurol, 12*(3), 285-294. https://doi.org/10.1016/S1474-4422(12)70322-8

Zadra, A., Hébert-Tremblay, L., Trudeau, S., Desautels, A., & Montplaisir, J. (2018). Patients' Self-reported Precipitating Factors For Sleepwalking. *Sleep, 41*, A255-A255. https://doi.org/10.1093/sleep/zsy061.687

Zadra, A., & Montplaisir, J. (2010). Sleepwalking. In M. J. Thorpy & G. Plazzi (Eds.), The Parasomnias and Other Sleep-Related Movement Disorders (pp. 109-118): Cambridge University Press https://doi.org/10.1017/CBO9780511711947.014

Zadra, A., & Stickgold, R. (2021). *When Brains Dream: Exploring the Science and Mystery of Sleep*. New York: W.W. Norton.

Zimmerman, W. B. (1970). Sleep mentation and auditory awakening thresholds. *Psychophysiology, 6*(5), 540-549. https://doi.org/10.1111/j.1469-8986.1970.tb02243.x