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The Relationship of Person-Specific Eveningness Chronotype, Greater Seasonality, and Less Rhythmicity to Suicidal Behavior: A Literature Review

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Abstract

Background—Epidemiological data have demonstrated seasonal and circadian patterns of suicidal deaths. Several reviews and meta-analyses have confirmed the relationship between sleep disturbance and suicidality. However, these reviews/meta-analyses have not focused on seasonal and circadian dysfunction in relation to suicidality, despite the common presence of this dysfunction in patients with mood disorders. Thus, the current literature review analyzed studies investigating person-specific chronotype, seasonality, and rhythmicity in relation to suicidal thoughts and behaviors.

Methods—Study authors reviewed articles related to individual-level chronotype, seasonality, and rhythmicity and suicidality that were written in English and not case reports or reviews.

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Contributors

Drs. Rumble, Dickson, and Benca were responsible for identifying articles for review along with the initial analysis and interpretation of findings and writing of this review manuscript. All other authors contributed additionally to the analysis and interpretation of the findings and writing of this review manuscript.

Conflicts of Interests

The other authors report no financial relationships with commercial interests.

Results—This review supports a relationship between an eveningness chronotype, greater seasonality, and decreased rhythmicity with suicidal thoughts and behaviors in those with unipolar depression, as well as in other psychiatric disorders and in children/adolescents.

Limitations—These findings need to be explored more fully in mood disordered populations and other psychiatric populations, in both adults and children, with objective measurement such as actigraphy, and with chronotype, seasonality, and rhythmicity as well as broader sleep disturbance measurement all included so the construct(s) most strongly linked to suicidality can be best identified.

Conclusions—Eveningness, greater seasonality, and less rhythmicity should be considered in individuals who may be at risk for suicidal thoughts and behaviors and may be helpful in further tailoring assessment and treatment to improve patient outcome.

Keywords

Eveningness; Chronotype; Seasonality; Rhythmicity; Suicidal Thoughts and Behaviors

Introduction

A number of epidemiological studies have demonstrated seasonal patterns in suicide with a higher rate of suicidal deaths in the spring and early summer compared to fall and winter (Ajdacic-Gross et al., 2010; Christodoulou et al., 2012). More recent data suggest that this pattern of suicide seasonality is diminishing in Western countries, although studies that have divided suicides into violent and non-violent subtypes have found that violent suicides continue to demonstrate a more seasonal pattern than non-violent suicides (Ajdacic-Gross et al., 2010). Suicide also appears to follow a circadian pattern. For example, epidemiological studies have demonstrated a higher peak of suicidal deaths in the morning roughly between 8:30am and 12:30pm (Altamura et al., 1999). However, when examining age differences in circadian patterns of suicide, those ages 45–64 years old and 65+ years old have a clear peak of suicide in the morning (i.e., between 8–11am), whereas suicide is most frequent in the afternoon (between 4–7 pm) in younger individuals (ages 25–44) (Preti and Miotto, 2001). Fewer studies have examined whether person-specific vulnerability to an eveningness chronotype (i.e., a preference to remain active longer into the night), seasonality (i.e., changes in behavior based on season including sleep, social activity, mood, weight, appetite and energy level), and less rhythmicity in day-to-day patterns (i.e., less lifestyle regularity including more inconsistent bedtimes, waking times, times for meals, and work start times) are associated with suicidal death, or, more broadly, suicidal thoughts and behaviors.

There is a substantial literature demonstrating a relationship between suicidal thoughts and behaviors and various types of sleep disturbance (Bernert and Joiner, 2007; Malik et al., 2014; Pigeon et al., 2012). More specifically, a recent meta-analysis found a strong relationship between sleep disturbance and suicidality (including ideation, attempts, and deaths) in those with depression (OR = 3.1, 95% CI 2.1–4.5), post-traumatic stress disorder (PTSD) (OR = 2.5, 95% CI 1.9–3.4), panic disorder (OR = 3.2, 95% CI 1.1–9.5), and schizophrenia (OR = 12.7, 95% CI 1.4–114.4) (Malik et al., 2014). When examining specific type of sleep disturbance related to suicidal thoughts and behaviors across studies in this

meta-analysis, greater insomnia, parasomnia behavior, and sleep-related breathing disorders were significantly related to suicidality. The majority of studies included in this meta-analysis were cross-sectional and assessed sleep disturbance and suicidality through self-report or clinician-rated measures.

Another meta-analysis examined the relationship of mostly self-reported or clinician-rated sleep disturbance (insomnia, nightmares, and other sleep disturbances (e.g., sleep disordered breathing, short sleep duration)) and suicidality while also importantly considering whether studies adjusted for depressive symptoms, anxiety, age, ethnicity, and sex when investigating this relationship (Pigeon et al., 2012). Results from this meta-analysis demonstrated a relationship between greater sleep disturbance and suicidality (ideation, attempts, and deaths) even in adjusted studies (unadjusted studies' risk ratio = 2.8 (95% CI 2.4–3.2) versus adjusted studies' risk ratio = 1.9 (95% CI 1.6–2.2)). However, literature reviews and meta-analyses on this topic have not specifically evaluated the effects of chronotype, degree of seasonality, or rhythmicity on suicidal thoughts, attempts, and deaths.

Suicidal thoughts and behavior are commonly seen in the context of psychiatric disorders, often mood disorders. Mood disorders are also associated with abnormalities in seasonal and circadian rhythms, including an evening chronotype, greater seasonal changes in a variety of behaviors and mood, and decreased rhythmicity of daily behaviors. For example, there is a growing literature demonstrating that individuals with either bipolar or unipolar depression are more likely to endorse an evening chronotype (i.e., a preference to remain active longer into the night) than healthy controls (Hasler et al., 2010; Kitamura et al., 2010; Robillard et al., 2013), and those with bipolar disorder have even greater eveningness tendencies than those with unipolar depression (Robillard et al., 2013). An evening chronotype was associated with higher levels of depressive symptoms as well as a greater likelihood of nonremission of depression, even when controlling for insomnia severity, in several studies (Chan et al., 2014; Gaspar-Barba et al., 2009). Individuals with unipolar and bipolar depression also report significantly more seasonality than healthy controls, and those with bipolar depression report significantly higher levels of seasonality than those with unipolar depression (Shin et al., 2005). Additionally, studies have demonstrated that those with bipolar and unipolar depression had significantly less lifestyle regularity or more unstable social rhythmicity than healthy controls (Ashman et al., 1999; Haynes et al., 2005) and more unstable social rhythmicity predicted onset of depressive, hypomanic, and manic episodes in undergraduates diagnosed with cyclothymia, bipolar II disorder, and in those with no affective disorder at baseline (Shen et al., 2008). Finally, there is a literature supporting the positive impact of regulating rhythmicity and seasonality on mood symptoms through treatments such as Interpersonal and Social Rhythm Therapy (IPSRT) for bipolar disorder (Frank et al., 2005) and light therapy for unipolar seasonal and non-seasonal depression (Lam et al., 2016; Westrin and Lam, 2007).

As chronotype, seasonality, and rhythmicity are each considered in relation to psychiatric disorders and suicidal thoughts and behaviors, it is important to note the intercorrelation these constructs have with each other. For example, evening types had significantly higher seasonality scores than morning types, even when measured prospectively over time (Murray et al., 2003; Tonetti et al., 2012). Similarly, healthy participants endorsing an

evening chronotype had significantly less rhythmicity than those endorsing an intermediate or morning chronotype (Monk et al., 2004).

Given the epidemiological data demonstrating seasonal and circadian patterns of suicidal deaths, the presence of differences in chronotype, seasonality, and rhythmicity in patients with mood disorders, and the intercorrelations between chronotype, seasonality, and rhythmicity, it would be of clinical importance to understand whether individuals with particular seasonal and/or circadian phenotypes are at greater risk for suicide. The current literature review analyzed studies investigating person-specific chronotype, seasonality, and rhythmicity in relation to suicidal thoughts and behaviors.

Methods

Study abstraction

Study authors completed separate reviews using Pubmed and Google scholar with the following search terms: suicid* and morningness, eveningness, chronotype, circadian rhythm, seasonality, seasonal affective disorder, rhythmicity, actigraphy, and accelerometer. Articles were retained if they were: (1) related to individual-level chronotype, seasonality, and/or rhythmicity and suicidality; (2) written in English; and (3) not case reports or reviews. Both pediatric and adult studies were included. All articles are detailed in Table 1.

Results

Chronotype

An individual's preference and/or biological predisposition for the timing of rest and activity is referred to as their chronotype (Roenneberg et al., 2007). Those with an evening chronotype engage in activity later in the day, including a later bedtime and wake-up time, whereas those with a morningness preference engage in activity earlier in the day, preferring earlier bedtimes and wake-up times. Chronotype is commonly measured through questionnaires, and the most widely used questionnaire is the Morningness-Eveningness Questionnaire (MEQ) (Horne and Ostberg, 1976). The MEQ consists of 19 questions assessing individuals' timing preferences for bedtime and wake-up time and physical and mental performance. Items are totaled for a possible score ranging from 16–86 with scores between 16–41 indicating an evening type, 42–58 indicating an intermediate type, and 59–86 indicating a morning type. A review of self-report chronotype measures found this measure reliable in some ways (reliability coefficient range of 0.77–0.86 and test-retest reliability range of 0.84–0.95), although with a low homogeneity range (0.20–0.40), which indicates that the scale may contain more than one dimension and not be appropriately used as a single item score as it is often used (Di Milia et al., 2013). However, this review also concluded that the MEQ is a valid measure of chronotype and correlates with timing of body temperature, cortisol, and melatonin (Di Milia et al., 2013).

Seven of the reviewed studies examined chronotype in relation to suicidal thoughts and behaviors (Bahk et al., 2014; Chan et al., 2014; Gaspar-Barba et al., 2009; Gau et al., 2007; Lester, 2015; Selvi et al., 2011; Selvi et al., 2010). The majority of these studies examined this relationship within patient populations consisting mostly of those with Major

Depressive Disorder (MDD). In one study (Chan et al., 2014), 253 patients with MDD from a larger naturalistic follow-up study of patients with depression completed the MEQ and questions regarding suicidal thoughts and past attempts (i.e., yes/no to “Over the past month (1) Have you wished you were dead? (2) Have you wanted to harm yourself? (3) Have you thought about committing suicide? (4) Have you had any plan of suicide?” and yes/no to “In your lifetime, have you ever attempted suicide?”). Individuals classified as evening types endorsed significantly greater suicidal thoughts in the last month (35% versus 18% for both morning and intermediate types) and the highest prevalence of lifetime suicide attempts (49% versus 32% for morning types and 29% for intermediate types). Insomnia severity was also assessed in this study, and results revealed that eveningness chronotype independently predicted non-remission of depression, independent of insomnia severity. However, this study did not control for depression severity or broader sleep disturbance when examining the relationship between chronotype and suicidal thoughts and behaviors. Similarly, in another study (Gaspar-Barba et al., 2009), 100 participants (mostly outpatients) with MDD completed the MEQ and the Hamilton Rating Scale for Depression (HRSD) (Hamilton, 1960). Evening types reported greater suicidality as measured by the suicide item on the HRSD in comparison to morning types, controlling for age, sex, and non-depression psychiatric comorbidities (but not depression severity or sleep disturbance otherwise).

Bahk et al. (2014) examined these same relationships between chronotype and suicidal behavior in 120 outpatients with MDD, but used a more comprehensive measure of suicidality, the Beck Scale for Suicide Ideation (SSI) (Beck et al., 1979). The SSI is a 19-item scale that evaluates active and passive suicidal desire, as well as specific plans for suicide. Chronotype was assessed using a 13-item morningness-eveningness composite scale developed by Smith et al. (1989). As in the other studies, evening types reported higher suicidality than morning types even when controlling for age and education (but not depression severity or sleep disturbance).

Selvi et al. (2010) examined chronotype, sleep quality, suicidality, and depressive symptoms in 80 patients with a first major depressive episode as well as 80 healthy controls. This study also used a comprehensive assessment of suicidality, the Suicide Ideation Scale (SIS) (Levine et al., 1989), which is a 17-item scale assessing the severity of suicidal ideation. Chronotype was assessed with the MEQ, sleep quality was assessed with the Pittsburgh Sleep Quality Index (Buysse et al., 1989), and depressive symptoms were measured by the Beck Depression Inventory (BDI) (Beck et al., 1961). At a univariate level, evening types and those with poorer sleep quality were found to have greater suicidal ideation than morning types for both depressed patients and healthy controls. At a multivariate level, chronotype and sleep quality were not found as significant predictors for suicidal ideation once accounting for depressive symptomatology. However, it should be noted that the BDI has both suicide and sleep items, and it appears that these items were not dropped from the scale, so these differing results may be explained by confounding relationships between measures. Another possibility is that there are differences in the relationship between chronotype and suicidal ideation in those experiencing their first episode of depression compared to those with recurrent depression.

The same group also investigated the relationship between chronotype and violent versus nonviolent suicide attempts in 89 individuals who had attempted suicide and were admitted to the emergency department (Selvi et al., 2011). The sample was unique in that participants were suicide attempters without psychiatric diagnoses impacting suicidality, including depression. This sample is challenging to imagine given the strong relationship between suicide attempts and psychopathology. Nevertheless, results support the relationship between eveningness and suicidality in this distinct sample in that the largest proportion of violent suicide attempts were likely to have occurred for evening types versus morning or intermediate types, with the caveat that this study did not control for sleep disturbance.

Two studies have explored these relationships in general populations of adolescents and young adults, respectively (Gau et al., 2007; Lester, 2015). In the study of adolescents (ages 12 to 13) (Gau et al., 2007), 1332 students randomly selected from Taiwanese schools and their mothers both completed the Child Morningness/Eveningness Scale (Carskadon et al., 1993), items assessing suicidality (“I think about killing myself” and “I deliberately try to hurt or kill myself” for the adolescents and “talks about killing self” and “deliberately harms self or attempts suicide” for the mothers), and other scales assessing pubertal development, substance use, and behavioral/emotional problems. Suicidality was considered positive if reported by the adolescent or mother. Results revealed that evening types were at an increased risk for suicidality versus morning or intermediate types after controlling for sex, pubertal stage, father’s education level, sleep disturbance, daytime napping, and internalizing/externalizing problems.

In a study of young adults, 194 psychology students from a rural United States college completed the MEQ, BDI, questionnaires assessing the constructs of entrapment, defeat, and hopelessness, and questions about past (versus current) suicidality (“I have had thoughts of killing myself in the past” and “In the past, I have attempted suicide”) (Lester, 2015). Multivariate analyses were conducted to examine how depressive symptoms, eveningness, entrapment, defeat, and hopelessness contributed to past suicidal ideation and attempts without any adjustment for broader sleep disturbance. Results revealed that only depressive symptoms, not eveningness and other studied constructs, contributed to suicidal ideation and attempts. However, similar to Selvi et al. (2010), the suicide and sleep items were not removed from the depressive symptom scale in these analyses. Therefore, these results must be considered in the context of confounding measures (e.g., the predictor contained an item that directly measured suicidal ideation when predicting past suicidality). Another possibility is that the larger adolescent population-based sample (Gau et al., 2007) was more adequately powered to include enough symptomatic children to detect relationships between chronotype (i.e., the evening group had 180 participants, the intermediate group had 740 participants, and the morning group had 412 participants) and suicidal thoughts and behaviors. In contrast, only 194 participants from a rural college sample (Lester, 2015) with likely a much smaller percentage of symptomatic individuals suffering from mood disorders were spread thinly across groups varying in their degrees of morningness and eveningness, leading to less power to detect relationships between eveningness and suicidality.

Summary—This collection of studies examined the relationship between chronotype and suicidal behavior in those mostly with MDD as well as in a sample of individuals who

attempted suicide without diagnosed psychiatric disorders, a population-based sample of adolescents, and a sample of rural college-aged individuals. Overall, these studies point to eveningness as an important characteristic to consider in the context of suicidal behavior in both adults and adolescents. These studies are limited in that chronotype was assessed by a self-report measure, although standardized measures of chronotype were used in each of the studies reviewed. Some of these studies used more comprehensive measures of suicidal behavior (Bahk et al., 2014; Selvi et al., 2010), whereas others measured suicidal behavior with only 1 to 4 questions (Chan et al., 2014; Gaspar-Barba et al., 2009; Gau et al., 2007; Lester, 2015; Selvi et al., 2011). Studies that examined this relationship in populations with MDD used standardized interviews to confirm the diagnosis (Bahk et al., 2014; Chan et al., 2014; Gaspar-Barba et al., 2009; Selvi et al., 2010).

Many of these studies controlled for relevant covariates (e.g., age, sex, non-depression psychiatric co-morbidity, education level) or explored this relationship at a multivariate level (Bahk et al., 2014; Gaspar-Barba et al., 2009; Gau et al., 2007; Selvi et al., 2010). However, important variables to consider in the relationship between chronotype and suicidal thoughts and behaviors are depression severity and sleep disturbance. Only one study (Gau et al., 2007) appropriately controlled for such symptoms by considering internalizing and externalizing issues and sleep disturbance as covariates. One other study (Lester, 2015) attempted to control for depression severity and another attempted to control for depression severity and sleep disturbance (Selvi et al., 2010), but, unfortunately, neither study considered removing the suicidal or sleep items from the depression severity scales so that potential confounding issues between measures likely remained. Additionally, all of these studies were cross-sectional, so causal relationships cannot be inferred. Finally, only MDD psychiatric populations were studied; individuals with bipolar disorder, who show increased tendencies not only for eveningness, but also for suicidality, have not been investigated to see if eveningness is associated with suicidal behaviors.

Seasonality

Seasonality is a term used to refer to an individual's seasonal variation in mood, physiology, and behavior. Seasonality has commonly been measured with the Seasonal Pattern Assessment Questionnaire (SPAQ) (Rosenthal et al., 1987), and, more specifically with the Global Seasonality Score (GSS) contained within the SPAQ. The GSS assesses seasonal fluctuations across the domains of sleep, appetite, weight, mood, energy, and social activity, with higher scores indicating greater seasonality. Overall, the measure has generally good internal consistency (α ranging from 0.74–0.82) and reliability (test-retest reliability ranging from 0.62–0.87) (Young et al., 2003).

Two of the reviewed studies utilized the GSS to examine the relationship between seasonality in mood-disordered populations (Bahk et al., 2014; Kim et al., 2015). In addition to morningness-eveningness analyses detailed in the chronotype section of this review, Bahk, Han, & Lee (2014) categorized their sample of 120 MDD patients who completed the SPAQ and SSI into seasonal (n = 30, 25% of sample) and non-seasonal participants (n = 90, 75% of sample) based on the GSS. Results revealed that those considered as seasonal also reported higher levels of suicidal ideation than those considered non-seasonal without

adjustment for depression severity and sleep disturbance. These authors did not examine the differential effect of chronotype and seasonality on suicidality.

Kim et al. (2015) examined the relationship between seasonality as measured by the GSS and number of suicide attempts in patients with either bipolar I disorder (n = 204) or bipolar II disorder (n = 308) from a mood disorders clinic in Korea. Both groups demonstrated seasonality with bipolar II disorder patients reporting significantly greater seasonality than patients with bipolar I disorder (i.e., 72% of bipolar II disordered patients considered seasonal versus 58% of bipolar I disordered patients). Similarly, from the calculations of these authors based on numbers provided within this article, those with bipolar II disorder were more likely to report a past suicide attempt (28%) versus those with bipolar I disorder (17%; $\chi^2 = 7.9$, $p = 0.01$). In those with bipolar I disorder, the seasonal group reported more suicide attempts than the non-seasonal group, whereas this seasonal/non-seasonal difference in past suicide attempts was not seen in those with bipolar II disorder. In bipolar II disorder subjects, those who were female, had depressive predominance, or met criteria for premenstrual dysphoric disorder (PMDD) were significantly more likely to be seasonal than non-seasonal. When examining only females with bipolar II disorder in a multivariate analysis, PMDD was a significant predictor of greater seasonality, whereas depressive predominance became only a trend level predictor. Thus, seasonality may relate differentially to various clinical correlates, such as suicidal thoughts and behavior, depending on how a mood disordered population is defined.

Summary—Despite numerous studies showing seasonal patterns of suicidal behavior, we found only two studies that have examined seasonality in relation to suicidal thoughts and behavior. Nevertheless, these studies revealed a relationship between greater seasonality and suicidal thoughts and behavior in both those with MDD (Bahk et al., 2014) and bipolar I disorder (Kim et al., 2015). The relationship between seasonality and suicidality was not observed in those with bipolar II disorder potentially due to other factors, such as PMDD in females with bipolar II disorder, relating to seasonality more strongly. The authors note that PMDD may be another indicator of a cyclical disorder, particularly in females (Kim et al., 2015). Thus, seasonality may be a risk factor for suicidal thoughts and behavior for certain mood disordered populations, but future research needs to explore these relationships more fully in mood-disordered patients to clarify whether there are differing relationships. Similar to chronotype assessments, the use of self-report measures to assess seasonality and the cross-sectional nature of these studies present notable limitations. Additionally, these studies did not control for depression severity or broader sleep disturbance, which parallels the majority of studies examining the relationship between chronotype and suicidality. Finally, while standardized suicidal behavior measures were used, one study (Bahk et al., 2014) used a full questionnaire, whereas the other (Kim et al., 2015) only assessed self-reported number of past suicide attempts. Strengths of these studies are also similar in that psychiatric populations are well defined within each study and multivariate approaches were used to examine the relationship of seasonality to suicidal behavior. Unfortunately, these two studies have only examined this relationship in adults with mood disorders, so it is unknown if such relationships exist for adolescents and other psychiatric populations.

Rhythmicity

Rhythmicity refers to the degree an individual engages in consistent daily social patterns and routines, and lower rhythmicity values indicate more irregular circadian patterns. That is, individuals with higher rhythmicity demonstrate more consistent bedtimes, waking times, times for meals, and work start times, whereas individuals with lower rhythmicity demonstrate less consistency with such daily patterns and routines. A key self-report measure in this area is the Social Rhythm Metric (SRM), which contains 17 items in its original form (SRM-17) (Monk et al., 1990) and 5 items in a shortened and revised form (SRM-5) (Monk et al., 2002). The SRM-5 uses a daily diary form to assess timing of getting out of bed for the day; first contact with another person; start of work, housework, or volunteer activities; and dinner over the course of days and then yields a numerical index of lifestyle regularity with higher numbers indicating greater rhythmicity. The SRM has been applied in mood disordered populations, demonstrating lower rhythmicity being related to greater likelihood of unipolar depression (Haynes et al., 2005) as well as greater likelihood of affective episode onset and recurrence in those with bipolar spectrum disorders (Alloy et al., 2015; Shen et al., 2008). Additionally, those with bipolar disorder who demonstrated higher SRM scores (i.e., greater rhythmicity) in treatment were more likely to have a longer time to affective episode recurrence in a 2-year follow-up period in comparison to those with lower SRM scores (Frank et al., 2005). Unfortunately, the SRM has not been used to explore the relationship between rhythmicity and suicidal behavior, but has promise in helping further understand this relationship with future studies.

There are two studies, however, examining rhythmicity used the Mood Spectrum-Self-Report (MOODS-SR) (Dell'Osso et al., 2002), a questionnaire assessing features associated with mood disorders, with the following subscales: (1) manic-hypomanic symptoms; (2) depressive symptoms; (3) rhythmicity defined as changes in mood, energy, and physical well-being according to the weather, season, and phase of the menstrual cycle; and (4) vegetative functions including sleep, appetite, and sexual function. Thus, this measure assesses rhythmicity (e.g., "In the past month, have you had periods of at least 3 days in which you found that your mood, energy, interest, and efficiency improved if you were in a regular routine?"), but also overlaps with other constructs in this review (e.g., seasonality, "Are you the kind of person whose mood, energy, and physical well-being change in a specific season of the year or with the change of seasons?"; and chronotype, "…it was difficult for you to work or be productive in the early morning").

In one study (Balestrieri et al., 2006), the MOODS-SR was completed by patients with a number of psychiatric diagnoses including 77 patients with schizophrenia, 60 with borderline personality disorder, 61 with bipolar disorder, 88 with unipolar depression, 57 with panic disorder, and a comparison group of 102 healthy controls from Italy. Lifetime suicidal behavior was assessed with 6 items on the MOODS-SR (i.e., asking whether a person had experienced 3 days or more when he or she (1) felt like life was not worth living; (2) hoped to die; (3) wanted to die; (4) made suicidal plans; (5) attempted suicide; and (6) needed medical attention after the attempt). Results revealed suicidal ideation and plans were more common in unipolar depression and bipolar disorder than in borderline personality disorder, but borderline personality disorder patients had significantly more

suicide attempts than those with mood disorders. Less rhythmicity and greater vegetative symptoms including sleep disturbance were significantly associated with increased risk of lifetime suicide attempts in those with bipolar disorder and borderline personality disorder, controlling for manic-hypomanic and depressive subscale scores along with age and sex. The same research group also examined the relationship between rhythmicity and suicidal behavior with the MOODS-SR in 65 out- and in-patients with PTSD in Italy (31% also met criteria for MDD) (Dell'Osso et al., 2014). They found a significant association between less rhythmicity and greater suicidal behavior, even when controlling for other subscales related to mood and vegetative symptoms such as sleep disturbance, and this relationship held when looking at only those with PTSD without co-morbid MDD.

Rhythmicity can be measured more objectively and non-invasively through actigraphy. Actigraphy uses a device worn on the wrist containing a highly sensitive accelerometer to assess rest-activity patterns through measurement of activity levels (Ancoli-Israel et al., 2015). These data are collected in epochs (e.g., 1-minute) continuously over a set of days and can be analyzed in a variety of ways to quantify rhythmicity through rest-activity patterns.

Actigraphy has been applied broadly in psychiatric populations due to importance of both rest-activity and sleep-wake patterns in various disorders (Burton et al., 2013; Harvey et al., 2005; Martin et al., 2005). However, only three of the reviewed studies investigated actigraphic measures as they related to suicidal thoughts and behavior (Aronen et al., 2011; Indic et al., 2012; Verkes et al., 1996). Two studies examined actigraphic indices in relation to suicidality in adults. The first of these was conducted within a sample of 59 Dutch patients seeking care in an emergency department due to attempted suicide and reporting at least one other suicide attempt (Verkes et al., 1996). Patients had a mixture of mostly personality, mood, or anxiety diagnoses. Actigraphy (piezoelectric accelerometer, Gaehlwiler Electronic) was collected for 5 to 7 days in the full sample in 30-second epochs and then 40 participants completed actigraphic assessment about 6 months later. Actigraphic analysis included identifying whether participants had a 24-hour peak (i.e., a periodogram was computed for each participant and it was determined whether a distinct single peak was present, demonstrating differentiation of rest-activity patterns in a 24-hour period) as well as the mean activity level while awake and mean immobility index while sleeping (i.e., percentage of time active when awake and still when sleeping, again showing degree of differentiation within the rest-activity pattern). Suicidality was measured with the SSI (Beck et al., 1979) and the suicide item from the BDI (Beck et al., 1961). Results revealed that participants without a 24-hour peak in activity reported more suicidal ideation than those with a discernable 24-hour peak. Also, participants with less activity when awake and less immobility when asleep were significantly more likely to report suicidality. In the subsample that completed two actigraphic assessment periods, those that demonstrated a change from a non-discernable to more discernable 24-peak reported less suicidality, and those that demonstrated a change from a discernable to a non-discernable 24-peak reported greater suicidality. These relationships were significant after controlling for multiple covariates, including the use of antidepressants, benzodiazepines, neuroleptics, and alcohol as well as sex, age, and season. However, there was no control for depression severity or sleep disturbance.

The second study examining actigraphic indices and suicidality was conducted in a sample of 36 Italian outpatients diagnosed with bipolar I disorder, bipolar II disorder, or unipolar depression (n = 12 within each diagnostic category) (Indic et al., 2012). Participants completed 3 days of actigraphy (Mini-Motionlogger®, Ambulatory Monitoring, Inc.) collected in 6-minute epochs as well as a 29-item instrument that contained a question about suicidal ideation (translated as “I felt the wish to die or be dead.”). Wavelet analysis of motility data from actigraphy was used to produce the vulnerability index (VI), which fits an amplitude distribution to a Gamma function up to scales of two hours. Amplitude is the amount of differentiation in a rest-activity pattern, and the VI can be considered similar in construct to the 24-hour peak measure used by Verkes et al. (1996). Furthermore, the VI has positively correlated with higher ratings of mania and negatively correlated with higher ratings of depression (Indic et al., 2011). When examining the relationship between this novel actigraphic index and suicidality, results revealed a lower VI was related to greater reports of wishes to die or be dead, similar to the relationship of the VI to other depressive symptoms. This relationship held even when considering covariates like sex, clinician-rated dysphoria, self-rated depression, vital drive, dysphoria, anxiety, unusual body-perception experiences, and autonomic-neurovegetative symptoms. Sleep disturbance was not included in the covariates.

One study examined actigraphy (Basic Mini-Motionlogger®, Ambulatory Monitoring, Inc.) in the context of suicidality in 22 depressed children ages 8 to 12 years old as well as 22 age-matched controls (Aronen et al., 2011). Actigraphy is often placed differently in children, and for this study, actigraphy was worn around the waist on a belt over a 3-day period and assessed in 1-minute epochs. Actigraphy indices were mean, nocturnal and daytime activity counts as well as a mean, nocturnal, and daytime activity index (the percentage of non-zero epochs). Parents and teachers additionally completed the Child Behavior Checklist (Achenbach & Rescorla, 2001), and children completed the Child Depression Inventory (Kovacs, 1983), which includes a question about suicide (“I think about killing myself but I would not do it”). With age and gender as covariates, depressed children reporting suicidal ideation had less overall and daytime activity counts compared to depressed children without suicidal ideation and healthy controls. Depressed children reporting suicidal ideation also had a lower overall and nocturnal activity index than depressed children without suicidal ideation and healthy controls. Depression severity and sleep disturbance were not controlled for in these analyses.

Summary—Studies examining the relationship between rhythmicity and suicidal thoughts and behaviors have investigated the broadest array of psychiatric populations in comparison to studies examining chronotype and seasonality. Using a self-report measure of rhythmicity (including some elements of chronotype and seasonality in the measure used), less rhythmicity was related to greater suicidality in those with bipolar disorder (Balestrieri et al., 2006), PTSD (with and without MDD) (Dell’Osso et al., 2014), and borderline personality disorder, even when controlling for depression severity (Balestrieri et al., 2006; Dell’Osso et al., 2014) and sleep disturbance (Dell’Osso et al., 2014). The relationship between self-reported rhythmicity and suicidal behavior was not observed in those with unipolar depression, schizophrenia, or panic disorder (Balestrieri et al., 2006). Thus, self-reported

rhythmicity and suicidal behavior may be more strongly linked in certain psychiatric diagnostic subgroups.

Studies using objective actigraphic measurement of rhythmicity revealed somewhat different findings. Unlike self-reported rhythmicity data (Balestrieri et al., 2006), adults with unipolar depression were found to show a significant relationship between reduced rhythmicity and increased suicidality, even when controlling for depression severity (Indic et al., 2012). One of the few studies with children within this review also provided support for lower actigraphic rhythmicity and increased suicidality in children with unipolar depression (Aronen et al., 2011). Similar to self-report findings (Balestrieri et al., 2006), adults with bipolar disorder (type I and II) also demonstrated a relationship between reduced actigraphic rhythmicity and suicidality (Indic et al., 2012). Additionally, in a sample of mixed adult psychiatric patients with mostly personality, mood, or anxiety diagnoses (Verkes et al., 1996), a significant relationship between less rhythmicity and suicidal thoughts and behaviors was demonstrated, which corresponds to findings from self-reported rhythmicity (Balestrieri et al., 2006). In adults, the particular rest-activity patterns shown to be related to greater suicidality were measures that capture a lack of differentiation in the rest-activity pattern (Indic et al., 2012; Verkes et al., 1996). In children, similarly, the particular rest-activity patterns shown to be related to suicidal thoughts and behavior were low levels of activity both during the day and at night (Aronen et al., 2011). None of the actigraphy studies controlled for broader sleep disturbance.

All of the above studies examining rhythmicity have the strengths of having well-defined samples and demonstrate a relationship between suicidality and lower rhythmicity. Importantly, some studies controlled for depression severity (Balestrieri et al., 2006; Dell'Osso et al., 2014; Indic et al., 2012) and sleep disturbance (Dell'Osso et al., 2014), and the relationship between suicidality and both self-report and actigraphic rhythmicity held. Those studies using actigraphy also had the strength of using similar actigraphic devices (Aronen et al., 2011; Verkes et al., 1996). However, as is often the case with actigraphy, a variety of approaches were used to analyze the data resulting in a variety of indices. Although the diversity of approaches is exciting in terms of seeing what type of indices best predict suicidal behavior, further refinement of these approaches and replication is needed. Regardless, the results support further investigation of the relationship between self-reported and actigraphic rhythmicity and suicidality in a variety of psychiatric populations, including at least unipolar depression, bipolar disorder, PTSD, and borderline personality disorder.

Discussion

Overall, this review demonstrates that person-specific eveningness, greater seasonality, and decreased rhythmicity seem to be important sleep-wake constructs to consider in relation to suicidal thoughts and behavior. Much of the seasonality/rhythmicity and suicidality literature has been more epidemiological in nature and focused on the relationship between extrinsic factors (season, light, temperature) and suicidal death (Ajdacic-Gross et al., 2010; Altamura et al., 1999; Christodoulou et al., 2012; Preti and Miotto, 2001). Additionally, meta-analyses and reviews examining the link between sleep disturbance and suicidality have not looked at constructs related to person-specific seasonality or delayed or decreased rhythmicity

(Bernert and Joiner, 2007; Malik et al., 2014; Pigeon et al., 2012). Understanding the relationship between individual vulnerability to suicidal thoughts and behavior based on chronotype, seasonality, and rhythmicity may be helpful in further tailoring assessment and treatment to improve patient outcomes.

There are several caveats to consider in drawing conclusions from the studies included in this review. First, the majority of studies examining the relationship between chronotype, seasonality, and/or rhythmicity and suicidality have been done in patients with mood disorders and many did not control appropriately for depression severity (Aronen et al., 2011; Bahk et al., 2014; Chan et al., 2014; Gaspar-Barba et al., 2009; Indic et al., 2012; Kim et al., 2015; Selvi et al., 2010). Mood-disordered populations are well documented as having a more delayed sleep pattern, greater seasonality, and less rhythmicity (Ashman et al., 1999; Chan et al., 2014; Gaspar-Barba et al., 2009; Hasler et al., 2010; Haynes et al., 2005; Kitamura et al., 2010; Robillard et al., 2013; Shen et al., 2008; Shin et al., 2005). Those with bipolar disorder have been shown to have greater seasonality and eveningness chronotype (Robillard et al., 2013; Shin et al., 2005), but were less frequently researched than those with unipolar depression in the studies meeting criteria for this review. Also, chronotype, seasonality, and rhythmicity were not assessed in all mood disorder groups. For example, there were no studies examining the relationship between eveningness chronotype and suicidality in those with bipolar disorder. In regards to other psychiatric populations, studies within this review provided support for the relationship between less rhythmicity and suicidality in PTSD and borderline personality disorder (Balestrieri et al., 2006; Dell'Osso et al., 2014). Future work examining biological rhythm constructs within unipolar and bipolar disorder as well as other psychiatric disorders is needed to understand the impact of these constructs on suicidal thoughts and behaviors more fully.

Second, the majority of the studies within this review were done with adult populations. Although these relationships are important to understand in adults, delayed circadian changes are central to adolescent development and could play a significant role in suicidality with younger individuals (Robillard et al., 2014). Thus, future studies examining the relationship between chronotype, seasonality, and rhythmicity and suicidal thoughts and behaviors in younger individuals are needed.

Third, although some work has been done examining rhythmicity through self-report measures and actigraphy, there are also potential missed opportunities. One well-validated measure, the Social Rhythm Metric (SRM) (Monk et al., 1990; Monk et al., 2002), has not been applied in the investigation of rhythmicity and suicidality. Additionally, actigraphy offers an objective and unique measurement that allows researchers to step into the world of individuals and capture moment-to-moment activity. The studies within this review mostly looked at measurement of rest-activity differentiation through the 24-hour period (Aronen et al., 2011; Indic et al., 2012; Verkes et al., 1996). However, actigraphy can also measure timing of major rest/low activity periods, offering an objective measure of chronotype. This can be achieved by looking at an actual time point of when major rest/low activity periods begin, which is provided through most actigraphy scoring packages accompanying purchased actigraphy devices. Another option is to use a cosinor approach to actigraphic analysis. This approach simultaneously fits 24-hour and 12-hour rhythms to the data and

produces a behavioral acrophase (i.e., the time of day the rest-activity rhythm peaks) (Halberg et al., 1968). These approaches (i.e., clock time of the major rest period and acrophase) have been used in psychiatric populations (e.g.,(Robillard et al., 2014)), but unfortunately have not been applied when investigating suicidality. Actigraphy could also be used simultaneously and longitudinally to measure sleep-wake and rest-activity seasonality in individuals more objectively as this has been done in some studies not investigating suicidality (e.g., (Lehnkering and Siegmund, 2007)). Thus, there are many promising opportunities for utilizing this objective measurement as well as other well-validated questionnaire measures to further elucidate the relationships of interest within this review.

Finally, eveningness, seasonality, and rhythmicity have been shown to relate to one another (Monk et al., 2004; Murray et al., 2003; Tonetti et al., 2012). Given these significant relationships, it would be helpful to assess all of these constructs simultaneously within studies to determine which ones are the most important in terms of predicting suicidal thoughts and behaviors. Additionally, it would be helpful to also consider the contribution of sleep disturbance more broadly whether considering sleep quality, insomnia, or other sleep difficulties to best determine which variables most relate to suicidal thoughts and behaviors.

In summary, this review supports a relationship between eveningness, greater seasonality, and decreased rhythmicity and suicidal thoughts and behavior. Additionally, several important areas for future direction are noted, including (1) investigating this relationship more fully in mood disordered populations and other psychiatric populations with adjustment for depression severity; (2) examining this relationship in both adults and children and utilizing actigraphy as an objective measure of eveningness, seasonality, and rhythmicity; and (3) assessing all of these constructs as well as sleep disturbance more broadly with well-validated measures to see which are most strongly linked to suicidality. These future research directions will allow for more attention to be paid to clinical correlates of suicidality in psychiatric disorders.

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Highlights

- Eveningness, seasonality, and decreased rhythmicity are related to suicidality.
- These relationships are mainly supported in those with unipolar depression.
- Future work includes exploring these relationships more fully as follows:
  - in mood disordered and other psychiatric populations;
  - in both adults and children;
  - with objective measurement such as actigraphy; and
  - with all constructs considered simultaneously.

Table 1

Descriptive Characteristics of 13 Studies Assessing Suicidal Thoughts and Behaviors and Chronotype, Seasonality, and Rhythmicity

	Citation	Sample Characteristics	Assessment of Suicidal Thoughts and Behaviors	Assessment of Seasonality or Circadian Rhythm	Relevant Findings
Chronotype	Bahk et al. (2014) *	120 outpatients with MDD (*M* age = 42 years old; *SD* =14; 82 % female).	SSI (Beck et al., 1979)	13-item morningness-eveningness composite scale with < 28 for evening and > 41 for morning (Smith et al., 1989)	Evening types (*n* = 37) reported higher suicidality than morning types (*n* = 25), controlling for age and education.
	Chan et al. (2014)	253 outpatients with MDD from university-affiliated regional psychiatric clinic (*M* age = 50 years old; *SD* = 10; 83% female).	Endorsed suicidal thoughts in the last month (Y/N) and history of suicide attempts (Y/N)	MEQ (Horne and Ostberg, 1976)	Evening types (*n* = 49) had greater suicidal thoughts in the past month and the highest prevalence of lifetime suicide attempts compared to morning types (*n* = 62) and intermediate types (*n* = 142).
	Gaspar-Barbara et al. (2009)	98 outpatients and 2 inpatients with HRSD>17 (*M* age = 34 years old; SD = 12; 79% female).	Suicide item from the HRSD (Hamilton, 1960)	MEQ (Horne and Ostberg, 1976)	Evening types (*n* = 18) reported greater suicidal thinking than morning types (*n* = 21) when controlling for age, sex, and non-depression psychiatric co-morbidity.
	Gau et al. (2007)	1332 randomly selected students and their mothers (Ages 12–13; 49% female).	Suicidal behavior endorsement by child or mother	Child Morningness-Eveningness Scale (Carskadon et al., 1993)	Evening types (*n* = 180) had significantly more suicidal behavior endorsement than morning or intermediate types (*n* = 412 and *n* = 740, respectively) even when adjusting for sex, pubertal stage, father's education level, trouble sleeping, daytime napping, and internalizing/externalizing problems.
	Lester (2015)	194 psychology students from rural state college (*M* age = 22 years old; SD = 1; 72% female)	Past suicidal behavior (i.e., I had thoughts; I attempted)	MEQ (Horne and Ostberg, 1976) and 1 item on the MEQ in which individuals indicate whether they are definitely morning, more morning, more evening, or definitely evening types	Using multivariate logistic regression, the MEQ was not a significant predictor of past suicidal behavior, but depressive symptoms (including a suicide item) were a significant predictor of suicidal behavior.
	Selvi et al. (2010)	80 patients with first episode of depression and 80 healthy controls (*M* age = 31 years old; SD = 9; 60% female)	SIS (Levine et al., 1989)	MEQ (Horne and Ostberg, 1976)	Evening (*n* = 11) and intermediate types (*n* = 52) had significantly higher SIS scores than morning types (*n* = 17). MEQ score was significantly related to SIS score at a univariate level; depressive symptoms and sleep quality were also related to SIS score. At a multivariate level, only depressive symptoms (including a suicide item) remained significantly related to SIS score.
	Selvi et al. (2011)	89 suicide attempters consecutively admitted to the emergency department (*M* age = 28 years old; SD = 9; 57.30% female).	Type of attempt (i.e., violent vs. nonviolent)	MEQ (Horne and Ostberg, 1976)	Evening types (*n* = 29) were more likely to have had a violent suicide attempt than morning or intermediate types (*n* = 21 and *n* = 39, respectively).
	Bahk et al. (2014) *	120 total outpatients with MDD (*M* age = 42 years old; SD = 14; 82% female).	SSI (Beck et al., 1979)	GSS from the SPAQ (Rosenthal et al., 1987); seasonal group defined as GSS	Seasonal group (*n* = 30) reported greater suicidality in comparison to the non-seasonal group (*n* = 90).

	Citation	Sample Characteristics	Assessment of Suicidal Thoughts and Behaviors	Assessment of Seasonality or Circadian Rhythm	Relevant Findings
				≥ 10 or GSS ≥ 8 and reporting at least moderate difficulty with seasonal issues	
Seasonality	Kim et al. (2015)	204 bipolar I disorder and 308 bipolar II disorder patients (*M* age = 35 years old; SD = 11; 70% female)	Number of suicide attempts	GSS from the SPAQ (Rosenthal et al., 1987); seasonal group defined as a GSS > 9 and reporting at least moderate difficulty with seasonal changes or GSS > 11 and reporting at least mild difficulty with seasonal changes	Within individuals with bipolar I disorder, the seasonal group reported a higher rate of suicide attempts than the non-seasonal group.
Rhythmicity Self-Report	Balestrieri et al. (2006)	77 patients with schizophrenia, 60 with borderline personality disorder, 61 with bipolar disorder, 88 with unipolar depression, 57 with panic disorder, and comparison group of 102 (*M* age = 34 years old; SD = 10; 60% female)	Suicidality questions from the MOODS-SR (Dell'Osso et al., 2002)	The rhythmicity subscale from the MOODS-SR (Dell'Osso et al., 2002)	Within bipolar disorder and borderline personality disorder individuals, lifetime rhythmicity was associated with increased risk of suicidal attempts, even when controlling for depressive symptoms, manic-hypomanic symptoms, age, and sex.
	Dell'Osso et al. (2014)	65 outpatients and inpatients with PTSD (*M* age = 45 years old; SD = 15; 49% female)	Suicidality questions from the MOODS-SR (Dell'Osso et al., 2002)	The rhythmicity subscale from the MOODS-SR (Dell'Osso et al., 2002)	Lifetime dysregulated rhythmicity was associated with lifetime suicidal ideation and attempts even when excluding those PTSD patients with co-morbid current or past depression and controlling for other sub-scales.
	Aronen et al. (2011)	22 depressed children outpatients and 22 healthy controls volunteers (*M* age = 11 years old; SD = 1; 36% female)	CDI (Kovacs, 1983)	belt-worn actigraphy	Depressed children endorsing suicidal ideation had lower 24h, diurnal, and nocturnal motor activity and nocturnal activity index than depressed children not endorsing suicidal ideation even when adjusting for age and sex.
Rhythmicity Actigraphy	Indic et al. (2012)	36 subjects from Italy (12 each bipolar I, bipolar II, and unipolar; *M* age = 46 years old; SD = 13; 75% female)	Endorsement of item: "I felt the wish to die or be dead"	wrist-worn actigraphy	Lower multi-scale motility amplitude (the vulnerability index as measured by actigraphy) was associated with greater suicidal thinking, even when considering relevant covariates such as depression severity, across all participants.
	Verkes et al. (1996)	59 patients with history of suicide attempts (*M* age = 38 years old; SD = 14; 64% female)	Suicide item from the BDI (Beck et al., 1961) and SSI (Beck et al., 1979)	wrist-worn actigraphy	Patients with non-24 hour periodicities reported greater suicidal ideation than those with 24 hour periodicities even after consideration of medication use, alcohol use, sex, age, and season of the year. Similarly, those with less wakeful activity and greater nighttime activity reported greater suicidaility, even when considering covariates.

Note:

*Duplicate study examining both chronotype and seasonality; BDI = Beck Depression Inventory; CDI = Children's Depression Inventory; GSS = Global Seasonality Score; HRSD = Hamilton Ration Scale for Depression; MDD = Major Depressive Disorder; MEQ = Morningness-Eveningness Questionnaire; MOODS-SR = Mood Spectrum-Self-Report; PTSD = Post-Traumatic Stress Disorder; SIS = Suicide Ideation Scale; SPAQ = Seasonal Pattern Assessment Questionnaire; SSI = Scale for Suicide Ideation