A Transdiagnostic Sleep and Circadian Intervention for Adolescents: 6-month Follow-up of a Randomized Controlled Trial

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Eveningness increases and peaks during adolescence and remains stable until early adulthood (Randler, 2011; Roenneberg et al., 2004). Adolescents who exhibit evening circadian chronotype, compared to those with morning circadian chronotype, follow a delayed sleep schedule, with later bedtime and wakeup time and increased activities later in the day. Eveningness has been associated with greater sleep problems in adolescents, most notably sleep deprivation and greater weekday-weekend variability in sleep or “social jetlag” (Crowley, Acebo, & Carskadon, 2007; Gradisar et al., 2013; Wittmann, Dinich, Merrow, & Roenneberg, 2006), as well as a wide range of psychological and physical problems in adolescents, including depression, anxiety, substance use, and lack of physical exercise (Adan et al., 2012; Schaal, Peter, & Randler, 2010; Schlarb, Sopp, Ambiel, & Grünwald, 2014). Mounting evidence suggests that sleep deprivation and social jetlag are prevalent during adolescence (e.g., Crowley et al., 2007; Gradisar, Gardner, & Dohnt, 2011), which confer more risk for psychopathology and other health problems (e.g., Dagys et al., 2012; Owens, Adolescent Sleep Working Group, & Committee on Adolescence, 2014; Talbot, McGlinchey, Kaplan, Dahl, & Harvey, 2010). In light of these evidence, a trans-diagnostic sleep and circadian intervention (TranS-C) was developed to target modifiable psychosocial, cognitive and behavioral factors associated with eveningness (Harvey, 2016).

In a randomized controlled trial for which the 6-month follow-up data are reported in the current study, we tested whether TranS-C modifies eveningness, improves sleep, and reduces risk in health-related domains from pre- to post-treatment. Relative to psychoeducation (PE), TranS-C was associated with shifting away from extreme eveningness, earlier endogenous circadian phase, less weeknight-weekend discrepancy in total sleep time and wakeup time, less daytime sleepiness, and better self- and parent-reported sleep. TranS-C was not directly associated with primary and secondary outcomes in health-related domains relative to PE, except for parent-reported risk in the cognitive domain (Harvey et al., in press). However, mediation analysis suggests that TranS-C exerts indirect effects, relative to PE, on reducing risk in multiple mental and physical health domains through improving sleep and circadian problems from pre- to post-treatment (Dong, Gumport, Martinez, & Harvey, 2018). Although these pre- to post-treatment effects of TranS-C are promising, long-term effects and treatment moderators have not been examined.

The goal of the current study is to investigate the long-term effects of a 6-week TranS-C treatment targeting eveningness and sleep problems in adolescents relative to psychoeducation (PE) in a randomized controlled trial. The first aim was to examine the effect of TranS-C, compared to PE, on sleep and circadian outcomes from baseline and posttreatment to 6-month follow-up. The second aim was to examine the effect of TranS-C, compared to PE, on risks in five health domains from baseline and posttreatment to 6-month follow-up. We hypothesized that TranS-C would demonstrate greater improvements than PE from baseline to 6-month follow-up. The third aim was to explore potential moderators of TranS-C for primary and secondary outcomes, including age, sex, and the number of risk categories presented at baseline.

**Methods**

**Participants and Procedures**

Participants were recruited from January, 2013 to February, 2016 through advertisements and clinician referrals. Participants and parents or guardians were first screened via phone for eligibility, and potentially eligible individuals completed in-person assessment to determine eligibility. Parents or guardians of all participants provided informed consent and participants provided informed assent. Detailed description of the study procedure is reported elsewhere (Harvey et al., in press). Participant flow is illustrated in *Figure 1*.

Inclusion criteria were: (a) were between 10 and 18 years old, living with a parent or guardian, and attending a class/job by 9am at least 3 days per week; (b) were fluent in English; (c) were able and willing to give informed assent; (d) reported eveningness as demonstrated by scoring within the lowest quartile of the Children’s Morningness-Eveningness Preferences Scale (CMEP; 27 or lower) (Dagys et al., 2012) and had a 7-day sleep diary showing a sleep onset time of 10:40pm or later for 10-13 year olds, 11pm or later for 14-16 year olds, and 11:20pm or later for 17-18 year olds at least 3 nights per week for the last 3 months; and e) participants must fall into an ‘at risk’ range on measures of at least one of the five health domains (see Table 1).

Exclusion criteria were: (a) an active, progressive physical illness or neurological degenerative disease directly related to the onset and course of the sleep disturbance; (b) evidence of obstructive sleep apnea, restless legs syndrome, or periodic limb movement disorder (those presented with provisional diagnoses of these disorders were referred for a polysomnography evaluation at the parent’s discretion and were enrolled only if the diagnosis was disconfirmed); (c) significantly impairing pervasive developmental disorder; (d) bipolar disorder, schizophrenia, or another current Axis I disorder if there was a risk of harm if treatment was delayed. Participants ceased taking medications that alter sleep (e.g., hypnotics) 4 weeks prior to the assessment (2 weeks for melatonin) or were excluded; and e) history of substance dependence in the past six months or current suicide risk sufficient to preclude treatment on an outpatient basis was exclusionary.

**Treatment Conditions**

Both treatments involved 6 individual, weekly 50-minute sessions delivered during the school year by doctoral or master-level therapists. Both treatments. A key difference between treatment conditions is that TranS-C promotes behavior change whereas PE only provides information without facilitating behavior change, and this treatment differentiation has been confirmed by coding. Full details about the treatment conditions are reported elsewhere (Harvey et al., 2017).

**Transdiagnostic Sleep and Circadian Intervention for Youth (TranS-C)**.As documented elsewhere (Harvey, 2016; Harvey & Buysse, 2017), TranS-C was developed based on sleep and circadian principles and the transdiagnostic approach. There are four sources for TranS-C: Cognitive Behavior Therapy for Insomnia (Morin et al., 2006; Morin & Espie, 2003; Perlis, Aloia, & Kuhn, 2011), Interpersonal and Social Rhythm Therapy (Frank et al., 2005), Chronotherapy (Wirz-Justice, Benedetti, & Terman, 2009), and Motivational interviewing (Miller & Rollnick, 2002). TranS-C targets psychosocial, behavioral, and cognitive processes that maintain sleep and circadian problems in youth. TranS-C includes 4 cross-cutting modules (functional analysis, goal setting, motivational interviewing, education), 4 core modules (behavioral components, daytime impairment, unhelpful beliefs, relapse prevention), and 7 optional modules (e.g., bedtime worry).

**Psychoeducation (PE).** PE is an active control associated with sleep improvement (Harvey et al., 2015). PE sessions focus on providing information about the interplay between sleep, stress, diet, health, exercise, accidents, and mood. Participants sample through mediation, yoga, and/or outdoor appreciation activities.

**Measures**

All measures described below were collected at baseline, posttreatment, and 6-month follow-up assessment.

**Sleep and Circadian Outcomes**

***Sleep Diary.*** 7-days sleep diary was collected every morning via phoneby trained research assistants for the week leading up to the treatment, the week after treatment, and the week leading up to the 6-month follow-up assessment. Standardized sleep diary was used (Carney et al., 2012). The following variables are derived using sleep diary: 1) weeknight total sleep time (TST), calculated as time in bed - sleep onset latency - wake after sleep onset - terminal wakefulness; 2) weeknight bedtime, using response to “time getting into bed”; 3) weeknight-weekend discrepancy in TST; 4) weeknight-weekend discrepancy in bedtime; and 5) weeknight-weekend discrepancy in wakeup time (time of final awakening). Weeknight TST and bedtime are primary outcomes.

***Children’s Morningness-Eveningness Preference Scale (CMEP; Carskadon et al., 1993).*** CMEP is a self-report measure of the degree of eveningness. The scores range from 10 (Extreme evening preference) to 43 (Extreme Morning Preference). CMEP score is a primary outcome.

***Sleepiness Scale.*** The sleepiness scalecontains ten items from the School Sleep Habits Survey comprising the Sleepiness Scale (Wolfson & Carskadon, 1998). Items were rated on a 4-point scale (0 = *No*, 1 = *Struggled to Stay Awake*, 2 = *Fallen Asleep*, 3 = Both *Struggled to Stay Awake* and *Fallen Asleep*).

***Pittsburgh Sleep Quality Index (PSQI).*** The PSQI consists of 19 self-reported items on a 4-point scale assessing sleep in the past month (Buysse et al., 1989). Score ranges from 0 to 21 with higher scores indicating greater problems.

***CBCL Sleep Composite.*** A CBCL sleep composite was derived based on seven items on the parent-report CBCL (Achenbach & Rescorla, 2001) that measure sleep functioning (Becker, Ramsey, & Byars, 2015). Items were rated on a 3-point scale (0 =   
*Not True*, 1 = *Somewhat/Sometimes True*, 2 = *Very True/Often True*).

**Functioning in Five Health Domains.**

Two sets of composite scores were used to indicate functioning or risk in five health domains, namely youth self-reported composite risk scores and parent-reported composite risk scores. Both sets of composite scores was composed of measures of emotional, cognitive, behavioral, social, and physical health.

**Youth Self-Report Composite Risk Score.** Five composite scores, each composed of measures of emotional, cognitive, behavioral, social, and physical health, were used to indicate functioning in five health domains. The composite scores were calculated for each of the five health domains by taking the mean of standardized summary scores for specific measures within that domain. Summary scores for specific measures were reverse coded when necessary so that all scores of specific measures within a domain would have the same direction. Specific measures for each domain are listed below:

***Emotional domain***. Emotional domain was assessed by a composite of depressive and anxiety symptoms as measured by the Children’s Depression Rating Scale (CDRS; Poznanski et al., 1984) and the Multidimensional Anxiety Scale for Children (MASC; March, Sullivan, & Parker, 1999) respectively. The CDRS is 17-item rating scale with possible scores ranging from 17 to 113, and higher scores indicating depression. The MASC is a 39-item scale with possible scores ranging from 0 to 117, and higher scores indicating more anxiety.

***Cognitive domain***. Cognitive domain was assessed by a composite of the Attention Control Scale (ACS; Derryberry & Reed, 2002) and pertinent school-related items found in the

Youth Social Adjustment Scale – Self Report (YSAS; Weissman, Orvaschel, & Padian, 1980). The ACS is a 20-item questionnaire, whose scores range from 4 to 80, with higher scores demarcating better attention control. To keep the directionality of the present study we reverse coded the ACS so higher scores meant greater risk in the cognitive composite. We used 6 items from the YSAS, where higher scores indicated more cognitive and school problems.

***Behavioral domain***. Behavioral domain was measured by a composite of the Brief Sensation Seeking Scale (BSSS; Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002) and theAlcohol and Substance Use Questionnaire (Johnston, Malley, Bachman, & Schulenberg, 2009). The BSSS is an 8-item questionnaire designed to assess the thrill and sensation seeking, with higher scores indication higher sensation seeking. TheAlcohol and Substance Use Questionnaire assess the use alcohol, caffeine, and recreational drugs in the past 30 days; moreover, we added extra questions on caffeine and energy drinks in this study. This measure used a 7-point rating scale with higher scores indicating more frequent use of the aforementioned substances. Greater risk in the behavioral domain is indicated by higher scores.

***Social domain***. Social domain was assessed by taking the average of the Youth Social Adjustment Scale – Self-Report (Weissman et al., 1980) subscales on friends, family, and romantic relationships. Higher scores in the social domain indicate more social impairment.

***Physical domain***. Physical domain was assessed by deriving a composite of the Physical Health Questionnaire-15 (PHQ-15; Kroenke, Spitzer, & Williams, 2002) and the Modifiable Activity Questionnaire for Adolescents (MAQ; Aaron & Kriska, 1997). The PHQ-15 is a 15-item questionnaire with scores ranging from 0 to 30, more physical complaints are indicated by a higher score. MAQ is questionnaire designed to assess activity levels, with scores indicating number of hours active or exercising in a week. A higher score was indicative of a more active and exercise rich life. To maintain directionality of risk in the physical domain the PHQ-15 was reverse coded to combine with MAQ to generate a composite score. Thereafter, the composite was reverse coded as to have higher scores indicate higher risk in the physical domain.

**Parent-Reported Composite Risk Score via the Child Behavior Checklist (CBCL).** Parents were given the 113-item CBCL ( Achenbach & Rescorla, 2001)questionnaire to rate the behavioral and psychological functioning of their adolescent. Each item of the CBCL was on 3-point scale (0 = not true, 1 = somewhat/sometimes true, 2 = very true/often true), with higher scores signaling more problematic behaviors. The parent-reported composite risk score was derived using seven of the CBCL subscales. Anxious/Depressed and Withdrawn/Depressed subscales comprised the *Emotional Domain*. Thought and Attention subscales comprised the *Cognitive Domain*. Rule-Breaking and Aggressive Behavior subscales comprised the *Behavioral Domain*. Social Problems and Somatic Complaints subscales comprised the *Social and Physical Domains* respectively.

**Data Analysis**

A priori power analysis yielded 69 participants per condition to achieve at least 80% power, assuming an average effect size *d* = 0.48 and two-sided significance of 0.05. The recruitment allowed for at least 20% more for potential attrition. The final sample size for the analysis was 176.

Data analysis was conducted in Stata 15 (StataCorp., 2017). All analyses were adjusted by age and sex, which were the stratification factors used during the randomization. Intent-to-treat method was used. Multilevel modeling with maximum likelihood estimation with the assumption of missing at random was used to examine all continuous variables. Missing at random was assumed. The fixed component of the model included stratification factors (age and sex), an indicator of time period (Pre = 0, Post = 1), an indicator for treatment condition (TranS-C = 1, PE = 0), and a Time by Treatment interaction term. The random part of the model included a subject-specific random intercept and a subject-specific error term. The significance of treatment moderator was examined using three-way interaction between treatment condition, time, and the moderator. Multiplicity was corrected using Hochberg’s (1988) procedure for the confirmatory analyses of the primary outcomes in Aims 1 and 2, and for the exploratory analyses concerning treatment moderators in Aim 3.

**Results**

**Demographic and Descriptive statistics**

Figure 1 summarizes the flow of participants from baseline through 6-month follow-up. The attrition rate was X during treatment and at the 6-month follow-up. Attrition was not significantly different across treatment groups at posttreatment (TranS-C: XX, PE: XX, *p* = ) or at 6-month follow-up (TranS-C: XX, PE: XX, *p* =) [to be updated]. Table 2 presents demographic variables. Table 3 presents the descriptive statistics of all outcome variables.

**Sleep and Circadian Outcomes (Aim 1)**

The primary sleep and circadian outcomes are weeknight TST and BT as well as CMEP. Relative to PE, TranS-C was associated with greater reduction in eveningness as indexed by greater increase in CMEP score from baseline through 6-month follow-up (*b* = 1.84, *p* = 0.006), and there was no significant difference between treatment conditions on CMEP from posttreatment to 6-month follow-up (*b* = -0.16, *p* = 0.83). There was no significant difference between treatment conditions on weeknight TST or BT from baseline to posttreatment or 6-month follow-up.

The secondary sleep and circadian outcomes are weeknight-weekend discrepancy in TST, BT and wakeup, and sleepiness, PSQI, and CBCL Sleep Composite. Wakeup time weeknight-weekend discrepancy, sleepiness, PSQI, and CBCL Sleep Composite all showed significant improvement for TranS-C relative to PE from baseline to posttreatment. The additional treatment gains associated with TranS-C relative to PE were maintained from baseline through 6-month follow-up for wakeup time weeknight-weekend (*b* = 0.72, *p* = 0.01) and PSQI (*b* = -1.09, *p* = 0.02), and there was no significant difference between treatment conditions from posttreatment to 6-month follow-up on these two measures. For sleepiness, both TranS-C and PE exhibited significant decrease from post to follow-up, so there was no advantage of TranS-C over PE by 6-month follow-up. For CBCL Sleep Composite, there was an increase for TranS-C and a decrease for PE from post to 6-month follow-up and thus at 6-month follow-up TranS-C no long had an advantage over PE.

**Five Health Risk Domains (Aim 2)**

The primary health outcomes are the five youth self-report composite risk scores. None of the five youth self-report composite risk scores was significantly different between treatment conditions in terms of their changes from baseline to posttreatment and to 6-month follow-up. We have also presented exploratory analyses using specific measures within each health domain. TranS-C did not produce additional changes above and beyond PE on these measures. For the Attention Control Scale (ACS), there was a significant treatment by time interaction from posttreatment to 6-month follow-up (*b* = 0.79, *p* = 0.02) in favor of PE, such that PE had significantly greater improvement in attention control (as indicated by an increase in ACS score) than TranS-C during this period. However, none of the changes from baseline to posttreatment or 6-month follow-up were significant for TranS-C or PE (all *p*s> 0.05) [not sure we need to add this/how to interpret this].

The secondary health outcomes are the parent-reported composite risk scores. None of the five parent-report composite risk scores was significantly different between treatment conditions from baseline to posttreatment or 6-month follow-up. There was a significant treatment by time interaction in the behavioral health domain from posttreatment to 6-month follow-up in favor of PE, such that there was significantly more reduction in the parent-report composite scores in the behavioral domain for PE over TranS-C during that period, although there was no significant difference between treatment condition for the changes from baseline to 6-month follow-up. We also presented specific subscales within each domain. For the CBCL thought problem subscale, there was a significant advantage of TranS-C relative to PE from pre to post. However, by 6-month follow-up, this advantage has diminished. At 6-month follow-up, both TranS-C and PE exhibited a significant decrease of thought problems compared to pre (both *p*s < 0.002). TranS-C maintained the treatment gain for this outcome, but PE caught up from posttreatment to follow-up. For CBCL rule breaking behavior, there was a significant difference in the slopes of TranS-C vs. PE from post to 6-month follow-up. However, the changes from pre to post or follow-up were not significant for both TranS-C and PE (all *p*s > .05)

**Treatment Moderators (Aim 3)**

Three moderators were tested: sex, age, and the number of risk domains present at baseline (participants met between one to five risk domains as part of the eligibility and inclusion criteria at baseline, shown in Table 1).Tests ofthe treatment by time by moderator interaction for all outcome variables are presented in Table X.

Sex did not moderate the treatment effects from baseline to post or 6-month follow-up for any of the sleep and circadian outcomes, youth self-reported composite risk scores, or parent-reported composite risk scores.

For age, there was a significant 3-way interaction between treatment conditions, time period, and age for weeknight bedtime, *χ2*(2, *N* = 172) = 15.19, *p* = 0.0005. Specifically, the slope of age for TranS-C relative to PE was significantly steeper at 6-month follow-up versus baseline for weekday bedtime (*b* = 0.21, *p* = 0.016), suggesting that treatment effect was better maintained for younger rather than older adolescents from posttreatment to 6-month follow-up (TranS-C vs. PE contrast: *b* = 0.34, *SE* = 0.09, *p* < 0.001).

For the number of risk domains present at baseline, there was a significant treatment by time by risk domains interaction for youth self-report composite risk in behavioral health domain, *χ2*(2) = 15.19, *p* = 0.0022. Specifically, the difference in the effects of risk domains at baseline on behavioral risk was significant comparing TranS-C versus PE during treatment phase (*b* = -0.21, *p* = 0.01) and through 6-month follow-up (*b* = -0.28, *p* = 0.001). As shown in *Figure X*, adolescents who met criteria in 3 or more risk domains had significant greater reduction in behavioral risk from pretreatment to posttreatment (TranS-C vs. PE contrast: *b* = -0.41, *SE* = 0.20, *p* = 0.04) and from pretreatment to 6-month follow-up (TranS-C vs. PE contrast: *b* = -0.57, *SE* = 0.20, *p* < 0.001). We also explored the specific measures within the behavioral domain. The difference in the effects of risk domains at baseline on self-reported substance use comparing TranS-C versus PE was significant during treatment phase (*b* = -1.49, *p* = 0.045) and through 6-month follow-up (*b* = -2.80, *p* < 0.001).

**Discussion**

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Table 1.

*Inclusion Criteria Operationalizing ‘At Risk’ for the Five Health Domains*

|  |  |
| --- | --- |
| Risk Domain | Criteria for Inclusion |
| Emotional | ≥ 4 on any of the following items on the CDRS: Difficulty Having Fun, Social Withdrawal, Irritability, Depressed Feelings, Excessive Weeping, *or* a T-score of 61 orabove on the MASC-10, based on age group (10-11 years, 12-15 year, 16-19 years) using the MASC-10 Profile. |
| Behavioral | A SSS score greater than 3.93 for males aged 10-13, greater than 3.19 for females aged 10-13, greater than 4.07 for males aged 14-18, or greater than 3.19 for females aged 14-18 *or* taking ADHD medication or the KSADS indicating a diagnosis of ADHD *or* current alcohol or substance abuse assessed with the KSADS. |
| Social | A parent rating their child as "worse" than others the participants age on one or more of the social behavior items (Section VI) from the CBCL. |
| Cognitive | A parent rating their child as “failing” in one or more academic class from CBCL Section VII. |
| Physical | A score of 4 or above on the PHQ-15, six or more days of school absences, or a BMI above the 85th percentile for the participant's sex and age. |

*Note.* CDRS = Child Depression Rating Scale (Poznanski et al., 1984), the cutoff is commensurate with “clinical symptoms.” MASC-10 = Multidimensional Anxiety Scale for Children, the cutoff T-score was selected to capture the ‘slightly elevated’ through to the ‘very elevated’ range (March et al., 1999). SSS = Sensation Seeking Scale (Russo et al., 1993), the cutoff correspond to at or above one standard deviation over the normative average (Stephenson, Hoyle, Palmgreen, & Slater, 2003). K-SADS = Schedule for Affective Disorders and Schizophrenia for School-Age Children (Kaufman et al., 1997). CBCL = Child Behavior Checklist (Becker et al., 2015), which asks the parent if their child does "worse", "average", or "better" than other teens their age or if the teen is "failing", "below average", " average" or "above average". PHQ-15 = Physical Health Questionnaire-15, the cutoff corresponds to ‘minimal somatic symptom severity’ through to the ‘high somatic symptom severity’ range (Kroenke et al., 2002). BMI = Body Mass Index, the cutoff corresponds to 1 standard deviation above the mean.

Table 2.

*Demographic Variables and Sample Characteristics.*

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristic | Whole Sample (*N*=176) | TranS-C  (*N*=89) | PE  (*N*=87) |
|  | *N (%)* | *N (%)* | *N (%)* |
| Female | 102 (58) | 49(55) | 53(61) |
| Hispanic/Latino | 27(15) | 14(16) | 13(15) |
| Race |  |  |  |
| Caucasian | 114 (65) | 58 (65) | 56 (64) |
| African American/Black | 12 (7) | 4 (4) | 8 (9) |
| American Indian or Alaska Native | 0 (0) | 0 (0) | 0 (0) |
| Asian | 18 (10) | 11 (12) | 7 (8) |
| Native Hawaiian/Other Pacific Islander | 2 (1) | 2 (2) | 0 |
| Refused to answer | 0 (0) | 0 (0) | 0 (0) |
| Unknown | 0 (0) | 0 (0) | 0 (0) |
| Mixed Race | 30 (17) | 14 (16) | 16 (18) |
| Family annual income |  |  |  |
| < 20,000 | 6 (3) | 2 (2) | 4(5) |
| 20,001 – 50,000 | 21 (12) | 11 (12) | 10 (11) |
| 50,001 – 100,000 | 42 (24) | 26 (29) | 16 (18) |
| 100,000+ | 102 (58) | 47 (53) | 55 (63) |
| Refused to answer/missing | 5 (3) | 3 (3) | 2 (2) |
| Current grade at pretreatment |  |  |  |
| 5 | 5 (3) | 4 (4) | 1 (1) |
| 6 | 7 (4) | 4 (4) | 3 (3) |
| 7 | 14 (8) | 6 (7) | 8 (9) |
| 8 | 25 (14) | 11 (12) | 14 (16) |
| 9 | 28 (16) | 16 (18) | 12 (14) |
| 10 | 46 (26) | 22 (25) | 24 (28) |
| 11 | 25 (14) | 13 (15) | 12 (14) |
| 12 | 25 (14) | 12 (13) | 13 (15) |
| College | 1 (1) | 1 (1) |  |
| Any current K-SADS Dx (teen report) | 63/171 (37%) | 34/87 (39%) | 29/84 (35%) |
| Any past K-SADS Dx (teen report) | 77/171 (45) | 40/86 (47) | 37/85 (44) |
| Any current K-SADS Dx (parent report) | 49/168 (29) | 21/85 (25) | 28/83 (34) |
| Any past K-SADS Dx (parent report) | 55/168 (33) | 24/84 (29) | 31/84 (37) |
|  |  |  |  |
|  | *M (SD)* | *M (SD)* | *M (SD)* |
| Age | 14.77 (1.84) | 14.76 (1.94) | 14.78 (1.74) |

*Note. M* = Mean. *SD* = Standard Deviation. K-SADS = Schedule for Affective Disorders and Schizophrenia for School-Age Children. Dx = diagnosis.

Table 3.

*Descriptive Statistics of Outcome Variables*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TranS-C | | | | | | PE | | | | |
|  | Baseline | Post-treatment | | | 6-month follow-up | | Baseline | Post-treatment | | 6-month follow-up | |
| Outcome | *Mean (SD)* | *Mean (SD)* | *d* | | *Mean (SD)* | *d* | *Mean (SD)* | *Mean (SD)* | *d* | *Mean (SD)* | *d* |
| Sleep and Circadian Outcomes | | | | | | | | | | | |
| TST weeknights\* | 459.06 (64.92) | 482.76 (82.55) | 0.37 | | 436.63 (58.15) | -0.35 | 454.96 (61.51) | 464.81 (76.01) | 0.16 | 430.57 (60.63) | -0.40 |
| BT weeknights\* | 22.87 (1.07) | 22.85 (0.98) | -0.03 | | 22.98 (1.16) | 0.10 | 22.99 (1.05) | 23.04 (1.12) | 0.04 | 22.94 (0.94) | -0.05 |
| TST weeknight-weekend discrepancy | -70.39 (113.10) | -31.16 (115.19) | 0.35 | | -74.21 (70.71) | -0.03 | -48.91 (89.28) | -56.46 (106.25) | -0.08 | -70.98 (133.91) | -0.25 |
| BT weeknight-weekend discrepancy | -0.79 (1.23) | -0.68 (1.41) | 0.09 | | -0.39 (0.98) | 0.32 | -0.58 (1.13) | -0.51 (1.09) | 0.06 | -0.55 (1.89) | 0.03 |
| WUP weeknight-weekend discrepancy | -1.91 (1.36) | -1.13 (1.29) | 0.58 | | -1.55 (1.19) | 0.26 | -1.42 (1.28) | -1.32 (1.55) | 0.08 | -1.78 (1.38) | -0.28 |
| Sleepiness | 6.20 (4.52) | 4.67 (3.98) | -0.34 | | 3.56 (4.02) | -0.58 | 6.15 (4.01) | 6.37 (4.71) | 0.06 | 4.80 (4.84) | -0.34 |
| PSQI | 7.58 (2.99) | 5.85 (2.56) | -0.58 | | 4.88 (3.03) | -0.90 | 7.58 (3.03) | 6.75 (3.48) | -0.28 | 6.00 (3.97) | -0.52 |
| CBCL Sleep Composite | 3.32 (2.03) | 1.84 (1.86) | -0.73 | | 2.10 (2.14) | -0.60 | 3.24 (2.13) | 2.54 (1.92) | -0.33 | 2.11 (1.95) | -0.53 |
| CMEP\* | 21.09 (3.76) | 25.08 (4.86) | 1.06 | | 25.33 (4.77) | 1.13 | 21.52 (3.86) | 23.44 (4.82) | 0.49 | 23.93 (4.32) | 0.62 |
|  |  |  |  | |  |  |  |  |  |  |  |
| Youth Self-Report Composite Risk Score\* | | | | | | | | | | | |
| *Emotional health* |  |  |  | |  |  |  |  |  |  |  |
| CDRS | 33.90 (9.34) | 27.01 (8.72) | -0.74 | | 25.87 (7.68) | -0.86 | 33.08 (9.90) | 27.00 (8.16) | -0.61 | 26.63 (10.08) | -0.65 |
| MASC | 46.51 (17.73) | 45.45 (17.10) | -0.06 | | 42.28 (20.28) | -0.24 | 45.98 (15.99) | 44.74 (18.03) | -0.08 | 40.63 (18.18) | -0.33 |
| Composite | 0.36 (0.90) | -0.07 (0.79) | -0.48 | | -0.24 (0.82) | -0.66 | 0.28 (0.81) | -0.11 (0.79) | -0.47 | -0.25 (0.89) | -0.65 |
| *Cognitive health* |  |  |  | |  |  |  |  |  |  |  |
| ACS | 50.56 (8.23) | 52.18 (8.09) | 0.20 | | 51.25 (8.67) | 0.08 | 51.24 (7.22) | 51.29 (7.77) | 0.01 | 52.70 (10.10) | 0.20 |
| YSAS (school/cognitive) | 11.68 (2.95) | 11.69 (3.14) | 0.00 | | 10.21 (3.65) | -0.50 | 11.90 (2.83) | 12.49 (2.94) | 0.21 | 10.68 (3.72) | -0.43 |
| Composite | 0.10 (0.79) | -0.001 (0.82) | -0.13 | | -0.18 (0.75) | -0.36 | 0.07 (0.65) | 0.17 (0.80) | 0.14 | -0.19 (1.00) | -0.40 |
| *Behavioral health* |  |  |  | |  |  |  |  |  |  |  |
| Sensation Seeking Scale | 27.28 (5.97) | 27.35 (6.61) | 0.01 | | 26.50 (6.45) | -0.13 | 26.36 (6.22) | 27.51 (7.04) | 0.18 | 25.96 (6.65) | -0.06 |
| Alcohol and Substance Use | 5.76 (8.24) | 5.51 (8.10) | -0.03 | | 5.60 (7.93) | -0.02 | 5.67 (6.62) | 6.26 (8.37) | 0.09 | 5.46 (7.68) | -0.03 |
| Composite | 0.03 (0.80) | 0.02 (0.83) | -0.02 | | -0.03 (0.79) | -0.08 | -0.04 (0.77) | 0.09 (0.92) | 0.16 | -0.08 (0.85) | -0.06 |
| *Social health* |  |  |  | |  |  |  |  |  |  |  |
| YSAS: Friends | 18.53 (4.58) | 17.73 (3.69) | -0.18 | | 17.22 (4.21) | -0.29 | 18.81 (4.98) | 18.68 (4.82) | -0.03 | 17.12 (4.94) | -0.34 |
| YSAS: Family | 11.92 (3.50) | 11.33 (3.56) | -0.17 | | 10.97 (3.29) | -0.27 | 12.34 (3.67) | 11.68 (4.17) | -0.18 | 10.74 (3.70) | -0.44 |
| YSAS: Romantic | 7.34 (2.03) | 7.62 (1.78) | 0.14 | | 6.79 (2.41) | -0.27 | 7.59 (1.69) | 7.62 (1.85) | 0.02 | 6.80 (2.36) | -0.47 |
| Composite | 0.06 (0.59) | -0.0001 (0.60) | -0.10 | | -0.20 (0.62) | -0.43 | 0.18 (0.70) | 0.11 (0.68) | -0.10 | -0.22 (0.72) | -0.58 |
| *Physical health* |  |  |  | |  |  |  |  |  |  |  |
| MAQ | 3.36 (5.35) | 4.20 (8.22) | 0.16 | | 5.31 (8.78) | 0.37 | 2.83 (4.31) | 3.40 (5.11) | 0.13 | 3.58 (3.97) | 0.17 |
| PHQ | 9.30 (5.37) | 7.97 (5.01) | -0.25 | | 6.42 (4.88) | -0.54 | 8.58 (4.40) | 7.01 (4.33) | -0.36 | 6.00 (5.09) | -0.59 |
| Composite | 0.20 (0.68) | 0.01 (0.87) | -0.27 | | -0.25 (0.93) | -0.67 | 0.18 (0.58) | -0.02 (0.57) | -0.34 | -0.15 (0.63) | -0.56 |
|  |  |  |  | |  |  |  |  |  |  |  |
| Parent-Reported Composite Risk Score | | | | | | | | | | | |
| *Emotional Health* |  |  |  |  | |  |  |  |  |  |  |
| Anxious/Depressed | 3.13 (3.48) | 2.61 (2.97) | -0.15 | 2.79 (3.22) | | -0.10 | 4.11 (3.78) | 3.61 (3.56) | -0.13 | 3.36 (2.88) | -0.20 |
| Withdrawn/Depressed | 2.83 (2.84) | 2.49 (2.54) | -0.12 | 2.57 (2.88) | | -0.09 | 3.14 (2.77) | 2.99 (2.72) | -0.06 | 3.09 (2.68) | -0.02 |
| Composite | -0.03 (0.94) | -0.17 (0.80) | -0.15 | -0.13 (0.92) | | -0.10 | 0.17 (0.93) | 0.07 (0.89) | -0.11 | 0.05 (0.83) | -0.13 |
| *Cognitive Health* |  |  |  |  | |  |  |  |  |  |  |
| Thought problems | 3.56 (2.59) | 2.38 (2.31) | -0.46 | 2.57 (2.78) | | -0.38 | 3.75 (2.73) | 3.60 (2.90) | -0.05 | 2.92 (2.63) | -0.30 |
| Attention problems | 4.23 (3.61) | 4.01 (3.85) | -0.06 | 4.03 (3.86) | | -0.05 | 4.17 (4.13) | 4.33 (4.30) | 0.04 | 4.07 (4.26) | -0.02 |
| Composite | 0.08 (0.80) | -0.16 (0.81) | -0.30 | -0.12 (0.90) | | -0.26 | 0.11 (0.89) | 0.10 (0.96) | -0.01 | -0.05 (0.91) | -0.19 |
| *Behavioral Health* |  |  |  |  | |  |  |  |  |  |  |
| Rule-Breaking Behavior | 1.91 (2.31) | 1.39 (1.87) | -0.22 | 1.97 (2.31) | | 0.03 | 1.98 (2.16) | 2.31 (2.61) | 0.16 | 1.85 (2.33) | -0.06 |
| Aggressive Behavior | 3.84 (4.02) | 3.62 (4.22) | -0.05 | 3.84 (4.32) | | 0.00 | 4.54 (4.52) | 3.76 (3.73) | -0.17 | 3.69 (3.85) | -0.19 |
| Composite | -0.005 (0.91) | -0.14 (0.86) | -0.15 | 0.01 (0.96) | | 0.01 | 0.09 (0.88) | 0.07 (0.92) | -0.02 | -0.03 (0.87) | -0.15 |
| *Social Health* |  |  |  |  | |  |  |  |  |  |  |
| Social Problems | 1.36 (1.52) | 1.24 (1.81) | -0.08 | 1.25 (1.72) | | -0.07 | 1.86 (2.15) | 1.83 (2.49) | -0.01 | 1.44 (1.91) | -0.19 |
| Composite | -0.07 (0.77) | -0.13 (0.92) | -0.08 | -0.13 (0.88) | | -0.07 | 0.18 (1.09) | 0.16 (1.27) | -0.01 | -0.03 (0.97) | -0.19 |
| *Physical Health* |  |  |  |  | |  |  |  |  |  |  |
| Somatic Complaints | 2.89 (3.11) | 2.14 (2.75) | -0.24 | 1.94 (2.45) | | -0.30 | 2.49 (2.74) | 2.01 (2.43) | -0.17 | 1.93 (2.12) | -0.20 |
| Composite | 0.24 (1.17) | -0.04 (1.04) | -0.24 | -0.12 (0.93) | | -0.30 | 0.09 (1.04) | -0.09 (0.92) | -0.17 | -0.12 (0.80) | -0.20 |

*Note. d* indicates within-group change from pre- to posttreatment and from pre- to 6-month follow-up (reference group is pretreatment).

Table 4.

*Results from Multilevel Modeling for All Outcome Variables.*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Treatment effect on change during the treatment phase | | | | | | Treatment effect on change from baseline to 6mFU | | | | | | Treatment effect from post to 6-month follow-up | | | | | |
|  | Coef. | | *SE* | | *p* | | Coef. | | *SE* | | *p* | | Coef. | | *SE* | | *p* | |
| Sleep and Circadian Outcomes | |  | |  | |  | |  | |  | |  | |  | |  | |  |
| TST weeknights\* | | 12.98 | | 11.56 | | 0.26 | | -0.75 | | 11.62 | | 0.95 | | -13.73 | | 11.83 | | 0.25 |
| BT weeknights\* | | -0.04 | | 0.16 | | 0.81 | | 0.20 | | 0.16 | | 0.21 | | 0.24 | | 0.16 | | 0.14 |
| CMEP\* | | 2.00 | | 0.65 | | 0.002 | | 1.84 | | 0.67 | | 0.006 | | -0.16 | | 0.69 | | 0.83 |
| TST weeknight-weekend discrepancy | | 48.03 | | 23.45 | | 0.04 | | 18.30 | | 23.47 | | 0.44 | | -29.73 | | 24.00 | | 0.22 |
| BT weeknight-weekend discrepancy | | 0.04 | | 0.29 | | 0.89 | | 0.38 | | 0.29 | | 0.19 | | 0.34 | | 0.29 | | 0.25 |
| WUP weeknight-weekend discrepancy | | 0.70 | | 0.29 | | 0.02 | | 0.72 | | 0.29 | | 0.01 | | 0.02 | | 0.29 | | 0.95 |
| Sleepiness | | -1.69 | | 0.72 | | 0.02 | | -1.08 | | 0.73 | | 0.14 | | 0.61 | | 0.76 | | 0.43 |
| PSQI | | -0.99 | | 0.47 | | 0.04 | | -1.09 | | 0.48 | | 0.02 | | -0.10 | | 0.49 | | 0.84 |
| CBCL Sleep Composite | | -0.76 | | 0.29 | | 0.01 | | -0.06 | | 0.30 | | 0.85 | | 0.70 | | 0.30 | | 0.02 |
|  | | | | | | | | | | | | | | | | | | |
| Youth Self-Report Composite Risk Score\* | | | | | | | | | | | | | | | | | | |
| *Emotional health:* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| CDRS | -0.54 | | 1.35 | | 0.69 | | -1.22 | | 1.36 | | 0.37 | | -0.68 | | 1.38 | | 0.64 | |
| MASC | -0.89 | | 2.13 | | 0.68 | | 1.41 | | 2.18 | | 0.52 | | 2.29 | | 2.20 | | 0.30 | |
| Composite\* | -0.01 | | 0.10 | | 0.90 | | -0.02 | | 0.10 | | 0.82 | | -0.01 | | 0.10 | | 0.92 | |
| *Cognitive health:* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| ACS | 1.28 | | 1.15 | | 0.27 | | -1.31 | | 1.17 | | 0.26 | | -2.59 | | 1.20 | | 0.03 | |
| YSAS (school/cognitive) | -0.55 | | 0.59 | | 0.35 | | -0.27 | | 0.60 | | 0.65 | | 0.28 | | 0.62 | | 0.67 | |
| Composite\* | -0.16 | | 0.12 | | 0.17 | | 0.01 | | 0.12 | | 0.92 | | 0.17 | | 0.13 | | 0.16 | |
| *Behavioral health:* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Sensation Seeking Scale | -0.64 | | 0.69 | | 0.35 | | -0.26 | | 0.70 | | 0.71 | | 0.38 | | 0.72 | | 0.61 | |
| Alcohol and Substance Use | -0.03 | | 0.62 | | 0.96 | | 0.50 | | 0.64 | | 0.43 | | 0.53 | | 0.65 | | 0.42 | |
| Composite\* | -0.06 | | 0.07 | | 0.41 | | 0.01 | | 0.07 | | 0.83 | | 0.07 | | 0.07 | | 0.32 | |
| *Social health:* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| YSAS: Friends | -0.80 | | 0.67 | | 0.24 | | 0.39 | | 0.69 | | 0.57 | | 1.19 | | 0.70 | | 0.09 | |
| YSAS: Family | 0.06 | | 0.55 | | 0.91 | | 0.85 | | 0.56 | | 0.13 | | 0.79 | | 0.57 | | 0.17 | |
| YSAS: Romantic | 0.14 | | 0.39 | | 0.72 | | 0.12 | | 0.40 | | 0.77 | | -0.02 | | 0.40 | | 0.96 | |
| Composite\* | -0.02 | | 0.11 | | 0.87 | | 0.16 | | 0.11 | | 0.15 | | 0.17 | | 0.11 | | 0.11 | |
| *Physical health:* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| MAQ | -0.22 | | 5.67 | | 0.97 | | 4.97 | | 5.85 | | 0.40 | | 5.19 | | 5.99 | | 0.39 | |
| PHQ | 0.26 | | 0.68 | | 0.71 | | -0.09 | | 0.69 | | 0.89 | | -0.26 | | 0.68 | | 0.72 | |
| Composite\* | -0.004 | | 0.11 | | 0.97 | | -0.13 | | 0.11 | | 0.24 | | -0.13 | | 0.11 | | 0.26 | |
|  |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Parent-Reported Composite Risk Score | | | | | | | | | | | | | | | | | | |
| *Emotional Health* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Anxious/Depressed | -0.02 | | 0.43 | | 0.97 | | 0.47 | | 0.44 | | 0.29 | | 0.49 | | 0.45 | | 0.27 | |
| Withdrawn/Depressed | -0.07 | | 0.35 | | 0.83 | | -0.04 | | 0.37 | | 0.92 | | 0.04 | | 0.37 | | 0.92 | |
| Composite | -0.02 | | 0.11 | | 0.89 | | 0.06 | | 0.11 | | 0.57 | | 0.08 | | 0.12 | | 0.50 | |
| *Cognitive Health* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Thought problems | -1.02 | | 0.33 | | 0.002 | | -0.23 | | 0.35 | | 0.51 | | 0.79 | | 0.35 | | 0.02 | |
| Attention problems | -0.36 | | 0.42 | | 0.39 | | 0.01 | | 0.44 | | 0.98 | | 0.37 | | 0.44 | | 0.40 | |
| Composite | -0.23 | | 0.10 | | 0.01 | | -0.04 | | 0.10 | | 0.67 | | 0.19 | | 0.10 | | 0.05 | |
| *Behavioral Health* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Rule-Breaking Behavior | -0.71 | | 0.30 | | 0.02 | | 0.30 | | 0.32 | | 0.34 | | 1.01 | | 0.32 | | 0.002 | |
| Aggressive Behavior | 0.58 | | 0.47 | | 0.22 | | 0.93 | | 0.49 | | 0.06 | | 0.35 | | 0.49 | | 0.49 | |
| Composite | -0.08 | | 0.11 | | 0.45 | | 0.18 | | 0.11 | | 0.10 | | 0.26 | | 0.11 | | 0.02 | |
| *Social Health* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Social Problems | -0.16 | | 0.27 | | 0.55 | | 0.15 | | 0.28 | | 0.58 | | 0.32 | | 0.28 | | 0.26 | |
| Composite | -0.08 | | 0.14 | | 0.55 | | 0.08 | | 0.14 | | 0.58 | | 0.16 | | 0.14 | | 0.26 | |
| *Physical Health* |  | |  | |  | |  | |  | |  | |  | |  | |  | |
| Somatic Complaints | -0.25 | | 0.37 | | 0.50 | | -0.34 | | 0.38 | | 0.37 | | -0.10 | | 0.38 | | 0.81 | |
| Composite | -0.09 | | 0.14 | | 0.50 | | -0.13 | | 0.14 | | 0.37 | | -0.04 | | 0.14 | | 0.81 | |

*Note*. \*indicates primary outcomes of the trial. All models adjusted for age and sex. Treatment effect = TranS-C (coded 1) vs. PE (coded 0)

Table 5

Test for Treatment by Time by Moderator (Sex, Age, or Risk Count at Baseline) 3-Way Interaction

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sex | | |  | Age | | |  | Number of Risk Domains at Baseline | | |
| Outcome | *df* | *χ2* | *p* |  | *df* | *χ2* | *p* |  | *df* | *χ2* | *p* |
| *Sleep and Circadian Outcomes* |  |  |  |  |  |  |  |  |  |  |  |
| TST weeknights\* | 2 | 1.81 | 0.40 |  | 2 | 1.17 | 0.56 |  | 2 | 0.68 | 0.71 |
| BT weeknights\* | 2 | 2.13 | 0.35 |  | 2 | 15.19 | 0.0005\*\* |  | 2 | 0.13 | 0.94 |
| TST weeknight-weekend discrepancy | 2 | 1.49 | 0.47 |  | 2 | 0.05 | 0.98 |  | 2 | 0.90 | 0.64 |
| BT weeknight-weekend discrepancy | 2 | 3.81 | 0.15 |  | 2 | 6.78 | 0.038 |  | 2 | 0.29 | 0.86 |
| WUP weeknight-weekend discrepancy | 2 | 2.01 | 0.37 |  | 2 | 2.47 | 0.29 |  | 2 | 0.86 | 0.65 |
| Sleepiness | 2 | 3.96 | 0.14 |  | 2 | 3.52 | 0.17 |  | 2 | 4.44 | 0.11 |
| PSQI | 2 | 2.66 | 0.26 |  | 2 | 3.28 | 0.19 |  | 2 | 0.09 | 0.96 |
| CBCL Sleep Composite | 2 | 2.73 | 0.26 |  | 2 | 0.34 | 0.84 |  | 2 | 3.02 | 0.22 |
| CMEP\* | 2 | 0.20 | 0.90 |  | 2 | 0.33 | 0.85 |  | 2 | 8.14 | 0.017 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| *Youth Self-Report Composite Risk Scores* |  |  |  |  |  |  |  |  |  |  |  |
| Emotional domain | 2 | 0.08 | 0.96 |  | 2 | 5.95 | 0.051 |  | 2 | 0.85 | 0.65 |
| Cognitive domain | 2 | 3.74 | 0.15 |  | 2 | 1.00 | 0.61 |  | 2 | 3.42 | 0.18 |
| Behavioral domain | 2 | 0.28 | 0.87 |  | 2 | 1.08 | 0.58 |  | 2 | 12.27 | 0.0022\*\* |
| Social domain | 2 | 2.64 | 0.27 |  | 2 | 4.83 | 0.09 |  | 2 | 2.49 | 0.29 |
| Physical domain | 2 | 1.40 | 0.50 |  | 2 | 0.64 | 0.72 |  | 2 | 0.60 | 0.74 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| *Parent-Report Composite Risk Scores* |  |  |  |  |  |  |  |  |  |  |  |
| Emotional domain | 2 | 1.07 | 0.59 |  | 2 | 0.03 | 0.99 |  | 2 | 4.16 | 0.13 |
| Cognitive domain | 2 | 2.01 | 0.37 |  | 2 | 0.84 | 0.66 |  | 2 | 3.02 | 0.22 |
| Behavioral domain | 2 | 1.24 | 0.54 |  | 2 | 0.18 | 0.91 |  | 2 | 3.93 | 0.14 |
| Social domain | 2 | 1.57 | 0.46 |  | 2 | 0.65 | 0.72 |  | 2 | 2.26 | 0.32 |
| Physical domain | 2 | 3.14 | 0.21 |  | 2 | 1.78 | 0.41 |  | 2 | 3.26 | 0.20 |

*Notes.* \*indicates primary outcomes of the RCT. The corrected significance level is 0.0026 based on either Hochberg (1988), Benjamin & Hochberg (1995), or Bonferroni correction for multiple testing within each subset of analysis (testing of moderating effects of sex, age, and risk domains are considered three subsets of analysis). \*\*indicates significant *p*-values after correction for multiplicity.

*Figure 1.* CONSORT Diagram Illustrating the Flow of Participants Through the Study

Lost to follow up (N=4)

**Reason:** 3 teens stopped responding to research staff; 1 teen thought the intervention was not helpful.

Lost to follow up (N=4)

**Reason:** 2 teens thought the intervention was not helpful; 1 teen family too busy to continue; 1 family emergency impeded continuing.

Lost to follow up (N=3)

**Reason:** 2 teens decided the study required a significant time commitment; 1 teen did not complete follow up due to a medical condition.

Discontinued intervention (N=1)

**Reason:** Family decided the study required a significant time commitment.

Lost to follow up (N=1)

**Reason:** Teen thought the intervention was not helpful.

Discontinued intervention (N=5)

**Reason:** 1 family voluntary withdrew from the study without an explanation; 4 teens decided the study required a significant time commitment.

## Enrollment

Excluded (N=220)

Not meeting inclusion criteria (N=154)

Refused to participate (N=66)

## Post Follow-Up

## Allocation

## 6-Month Follow-Up

Allocated to Trans-C (N=89)

Received allocated intervention (N=87)

Did not receive allocated intervention (N=2)

**Reason:** Families decided the study required a significant time commitment.

Allocated to PE (N=87)

Received allocated intervention (N=86)

Did not receive allocated intervention (N=1)

**Reason:** Family stopped responding to research staff.

Randomized (N=176)

Assessed for Eligibility (N=396)

Analyzed (N=89)

Excluded from Analysis (N=0)

Analyzed (N=87)

Excluded from Analysis (N=0)

## Analysis

*Figure 2.*



*Note.* Age moderation of the treatment effect of TranS-C relative to PE on weeknight bedtime.

*Figure 3.*



*Note.* Number of risk categories present at baseline moderated the treatment effect of TranS-C relative to PE on behavioral risk composite.