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Feeling Good When Sleeping In? Day-To-Day Associations Between Sleep Duration and Affective Well-Being Differ From Youth to Old Age

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The current study investigated how night-to-night variations in sleep duration relate to affective well-being the next morning as well as how the relationship varies for people of different ages. Using an Experience Sampling approach, 397 participants aged 12 to 88 years reported their sleep duration and their momentary affect on nine mornings, on average. Associations between sleep duration during the previous night and morning affect differed depending on the participants' age. For adolescents, for example, affective well-being in the morning was worse the shorter participants had slept the previous night. For adults aged over 20 years, however, affective well-being was worse following nights with shorter or longer than average sleep duration. This effect was more pronounced the older the participants were. The findings demonstrate that the importance of sleep duration for daily affective well-being is better understood when considering the age of the sleeper. In adults, but not adolescents, not only sleeping less but also sleeping more than one's average can be associated with lower affective well-being.

Keywords: sleep, affective well-being, within-person, Experience Sampling, lifespan

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It is undisputed that sleep fulfills important functions, such as allowing physical repair processes or facilitating memory processes (Diekelmann & Born, 2010; Mignot, 2008). Less is known about the role of sleep for people's affective well-being. So far, effects of sleep on affective functioning have mainly been examined in sleep deprivation or clinical studies. These studies reliably show that sleep deprivation decreases affective well-being (Haack & Mullington, 2005; Talbot, McGlinchey, Kaplan, Dahl, & Harvey, 2010). Clinical studies add that sleep disturbances, for example, insufficient (insomnia) or excessive (hypersomnia) sleep, are especially common among affective disorders, such as depression (Peterson & Benca, 2008). Both lines of research focus on extremes—severe sleep deprivation or pathological affect—rather than on normal ranges of sleep and affect. Our aim was to investigate how *naturally occurring day-to-day variations* in *the person's* sleep duration relate to daily affect.

Walker and van der Helm (2009) proposed that sleep facilitates affective well-being, amongst others by restoring the connectivity between the limbic system of the brain—an area associated with emotion generation—and parts of the prefrontal cortex—an area associated with emotion regulation. Presumably, this ensures that a night's sleep enables the then rested brain to handle affective experiences effectively and to maintain an affective balance as a result. Indirect support stems from experiments showing that sleep deprivation decreases affective well-being and increases reactivity to stress (Dinges et al, 1997; Minkel et al., 2012). Research on the effects of excessive sleep is scarce. Worse general affective well-being and depressive symptoms have been reported together with habitual excessive sleeping (Globus, 1969; Kaplan & Harvey, 2009). It remains unclear, however, whether sleeping especially long during a single night is also associated with affective well-being the next morning, and, if so, what the underlying mechanisms could be.

The association between short sleep duration and low affective well-being is puzzling when we look at the age differences: Average sleep duration becomes shorter with higher age (Krueger & Friedman, 2009; Ohayon, Carskadon, Guilleminault, & Vitiello, 2004), but affective well-being becomes higher (see review by Riediger & Rauers, in press)—not lower as one would expect from findings on consequences of short sleep duration in experimental or clinical studies. Although not undisputed (Vitiello, 2009), it has been argued that, in comparison to younger individuals, for at least some older people shorter average sleep duration can be linked to a reduced need for sleep and altered daily routines, as well as to age-related increases in health problems and sleep disturbances (Monk, 2005; Vitiello, 2009). In part, age-related changes in affective well-being are assumed to result from motivational changes—for example, an increasing focus on maintaining affective well-being—and from changes in handling daily life and the accompanying emotional states—for example, an increasing preference for interpersonal conflict avoidance (e.g., Charles & Carstensen, 2010; Riediger, Schmiedek, Wagner, & Lindenberger, 2009). The prominent theoretical position that the ability to regulate one's own emotions improves with age (e.g., Charles & Carstensen, 2010) is disputed (Isaacowitz & Blanchard-Fields, 2012), but has also found some first empirical support (e.g., Charles, Piazza, Luong, & Almeida, 2009; Larcom & Isaacowitz, 2009). The above-mentioned factors could also affect the *association* between sleep duration and affective well-being: If older people indeed need less sleep and are indeed better at handling their emotions than younger people are, it is possible that they are better able to tolerate shorter-than-average sleep durations, whereby their affective well-being would also be less affected.

Previous empirical evidence on such age differences is inconclusive. Brendel and colleagues (1990) observed a stronger increase of negative affect after total sleep deprivation among 20-year-olds compared to 80-year-olds. Neither Talbot and colleagues (2010) nor Oginska and Pokorski (2006) found significant age differences in the association between average sleep duration and mood. These studies, however, addressed associations *between* people, which can be dissimilar to associations *within* persons *over time* (Molenaar, 2004).

To contribute new insights into these questions, we therefore assessed sleep duration and momentary affect, after getting up, on several days in people's daily life. We assumed that affective well-being the next morning would be lower when sleep duration is shorter than the person's individual average, and at higher ages, people would be less affected when sleeping less than usual. This hypothesis is consistent with the theoretical proposal that emotion regulation may improve across adulthood, which would allow older adults to handle the affective consequences of inadequate sleep duration better than their younger counterparts (Charles & Carstensen, 2010). Another possibility could also be that older adults, irrespective of their affect-regulation ability, react less strongly to most negative affect-eliciting events (Charles & Carstensen, 2010), such as reduced sleep might be. In this case, we would also expect that reduced sleep would have less aversive consequences the older the persons are. Further, we explored potential age-related differences in the association between sleeping longer than usual and affective well-being the next morning.

Method

Participants

A fieldwork agency recruited 400 participants aged 12 to 88 years, who were approximately stratified by gender (48% women) and age group (*M* =39.86 yrs, *SD* = 20.48; 12–17 yrs, *n* = 79; 18–29 yrs, *n* = 82; 30–39 yrs, *n* = 50; 40–49 yrs, *n* = 55; 50–59 yrs, *n* = 46; 60–69 yrs, *n* = 55; 70–88 yrs, *n* = 33). Twenty-three percent of the 320 participants who had already completed school held a university degree. The final sample comprised 397 participants due to drop out.

Experience Sampling Procedure

Mobile phones (Nokia E50) prompted participants six times a day for at least nine days to answer a short questionnaire displayed on the phone. The six assessments occurred in approximate 2-hr intervals—the exact timing being randomized so that participants were unaware when the next assessment was to occur. Participants chose, between 6 am and 12 am, when the first assessment should occur (for details, see Riediger et al., 2009). The present analyses used information obtained during the first morning's and the last evening's assessment per day. Participants gave informed consent. The Ethics Committee of the Max Planck Institute for Human Development approved the study.

Experience Sampling Measures

Sleep duration was measured at the first assessment of each day with one of seven answer options: *< 5 hrs*, *5 to <6 hrs*, *6 to <7 hrs*, *7 to <8 hrs*, *8 to <9 hrs*, *9 to <10 hrs*, and *> 10 hrs*. Assuming approximate equidistance between response options, we assigned the values 4.5 and 10.5 to the scale end points, and category means (e. g., 5.5, 6.5) to all other response options for further analyses. This transformation provided an approximation of sleep duration.

Affect balance: At each assessment, participants reported how they currently felt by rating six positive (e. g., happy, enthusiastic, energetic, even-tempered, content, relaxed; $\alpha_{\text{average across days}}$ = .88) and six negative (e. g., tense, angry, nervous, tired, downcast, disappointed; $\alpha_{\text{average across days}}$ = .79) affect adjectives on a scale from 0 (not at all) to 6 (very much). We computed the difference between the average positive and negative affects as an indicator of affect balance. Higher values indicated better mood.

Control variables: At each assessment, participants also reported their current activity (e.g., work, chores, leisure activity) and persons present (e.g., nobody, family, colleagues). The date and time of the assessment were also recorded. Before commencing the Experience Sampling period, participants answered several questionnaires where they also rated their overall health (1 = very good to 5 = poor) and the severity of five broad health complaints: fatigue, sleep disturbances, heavy perspiration, heart trouble, muscle/joint problems (1 = no complaint to 5 = very strong complaint). These six questions were averaged to serve as one indicator of general health (α = .74) and revealed a generally high health status (M = 4.2, SD = 0.6). As an indicator of dysphoria we assessed three face-valid items (Sometimes my life barely seems worth living anymore; I'm now experiencing the most dismal period of my life; I've given up a lot of my interests and activities, from Life Evaluation Scale, Ferring, Filipp, & Schmidt, 1996). The items were rated on a scale 1 = does not apply to 7 = applies totally and averaged (M = 2.0, SD = 1.2, α = .70).

Results

Age Differences in Sleep Duration and Affect Balance

Participants reported their sleep duration for 8.6 nights on average (SD = 1.4). The chosen median category was 6 to <7 hrs. The average sleep duration was estimated at 6.8 hrs (SD of person means = 0.9, within-person range of sleep duration M = 2.5 hrs, SD = 1.3). Age differences in average sleep duration followed a U-shaped curve as indicated by the significant linear $\beta_{age} = -.23$, $p < .001$ and quadratic age effects $\beta_{age^2} = .20$, $p < .001$. Computed average sleep duration for three selected ages illustrate this nonlinear effect: 7.3 hrs for 12- to 17-year-olds, 6.5 hrs for 40- to 49-year-olds, and 6.8 hrs for 60- to 88-year-olds. As in previous studies, participants reported a better mood the older they were: average affect balance in the mornings M = 1.49, SD = 1.29, $r_{age} = .32$, $p < .001$; average affect balance in the evenings M = 1.80, SD = 1.33, $r_{age} = .22$, $p < .001$. There were no significant quadratic age effects.

Age Differences in the Association Between Sleep Duration and Affect Balance

As measurements of sleep duration and affect on specific days (Level 1) were nested within persons (Level 2), we specified random coefficient models in HLM 6.00 (Raudenbush, Bryk, & Congdon, 2004), using full information maximum likelihood and robust standard error estimation (cf. Raudenbush & Bryk, 2002). The dependent variable of affect balance at the first measurement in the morning was predicted by linear and squared sleep duration and affect balance from the previous night (Level 1). Sleep duration was centered at each individual's mean to control for age differences in average sleep duration (Ohayon et al., 2004). The age of participants (centered on the sample mean) was used as continuous linear and squared Level-2 predictors of affect balance and the association with sleep duration. We initially included all interactions between sleep duration, affect, and age, and then omitted nonsignificant effects from the model in the interest of parsimony.

The results summarized in Table 1 show that affect balance in the morning was related nonlinearly to the duration of the previous night's sleep and that this relationship differed by age. Figure 1 illustrates this age moderation exemplarily for three selected ages, namely, 12 years of age (adolescence), 40 years of age (middle adulthood), and 70 years of age (older adulthood). When sleeping shorter than their individual average, people reported lower affect balance in the morning. This linear effect differed with age and was most pronounced for adolescents and older adults, but significant across the entire studied age range—as confirmed by region of significance analysis (Preacher, Curran, & Bauer, 2006). Comparing the estimated differences in affective well-being on mornings after nights with average sleep duration and nights with 1-hr less sleep than average illustrates the size of the respective age moderation. Affective well-being was 0.3 standard units lower for adolescents, 0.2 lower for middle-aged adults, and 0.5 lower for older adults.

Interestingly, people also reported lower affect balance in the morning when their sleep duration was longer than their individual average—as indicated by the quadratic effect of sleep duration (Table 1). The region of significance analyses (Preacher et al., 2006) showed that this quadratic effect of sleep duration was significant for participants older than 20.7 years and more pronounced with higher age (see Figure 1). To illustrate the size of the effect, we now chose a value that corresponds to sleeping: When people slept 3 hrs more than average (i.e., about 10 hrs), adolescents' affective well-being was 0.6 standard units **higher** than after average sleep duration, whereas middle-aged and older adults' well-being were each 0.3 standard units **lower**; the latter effect sizes were similar due to age differences in standard deviations used for computing effect sizes (see Figure 1 for effects of 1- and 2-hrs additional sleep). Effects of sleep duration on affect balance in the morning and the accompanying age effects were robust when controlling for evening affect, current activities, present persons, average sleep duration, self-rated health, and dysphoria (see online supplementary material Table S1 for results from these control analyses). Also, the effects of sleep duration on the summary measure of affect balance remained when analyzing positive and negative affects separately (see online supplementary material Figure S1 and S2).

Finally, we reversed the order of prediction, but found that affect balance for the previous night did not significantly predict the amount of sleep during the following night (b = 0.01, SE = 0.02, p = .66). There were no significant linear or quadratic age effects.

Predictors of the Age-Differential Effect of Longer-Than-Average Sleep Duration

In a next step, we probed possible explanations for the observed age-differential effect on affective well-being when sleeping longer than usual. First, we addressed differences in assessment times. Age was not significantly associated with the time window for the first assessment chosen by each participant individually (M = 8:50 am, SD = 1:24, r_{age} = –.03, p = .30) or with the actual times of the first assessment (M = 9:27 am, SD = 1:24, r_{age} = –.03, p = .27). Also, the reported age differences in effects of sleep duration on affect balance were robust when controlling for individual assessment commencement or actual time of assessments.

Second, we explored the role of health impairments and dysphoria for sleeping longer than an average. That people sleep more when they are not feeling well, physically or mentally, could explain the observed age-differential effects of sleeping longer than usual on affective well-being. As expected, with higher age, participants reported lower self-reported general health (r = –.38, p < .001), but age was not significantly related to self-reported dysphoria (r = .01, p = .42). Self-reported health was not significantly related to the occurrence of sleeping 2 hrs or more in addition to one's average sleep duration (b = –0.13, SE = 0.23, p = .58, OR = 0.88; b_{age} = 0.02, SE = 0.01, p = .09, OR = 1.02). For people older than 38.1 years, higher self-reported dysphoria predicted more frequent occurrences of sleeping 2 hrs or more in addition to one's average sleep duration (b = 0.20, SE = 0.09, p = .03, OR = 1.22; b_{age} = 0.01, SE = 0.005, p = .02, OR = 1.01). Neither health nor dysphoria, however, predicted the association between sleep duration and affective well-being in the morning. Also, the previously reported age effects on the association between sleep and well-being remained robust (see online supplementary material Table S1).

Third, we analyzed sleep duration on previous nights. In two separate multilevel logistic regressions, person-mean centered sleep duration one or two nights ago, respectively, was used to predict the occurrence of sleeping 2 hrs or more than the average (1 = yes, 0 = no) in a given night. The shorter people slept one night ago, the more likely they were to sleep two or more hours longer than their average (b = –0.95, SE = 0.20, p < .001, OR = 0.39). This effect was more pronounced with age (b = –0.02, SE = 0.01, p = .03, OR = 0.98), and effects were similar for sleep duration two nights ago (b = –1.63, SE = 0.33, p < .001, OR = 0.20; b_{age} = –0.03, SE = 0.01, p = .03, OR = 0.97). The deviations from the average sleep duration one or two nights ago were not significantly related (b = –0.003, SE = 0.03, p = .93). If older people do not "recover" from sleep deprivation during just one night of extended sleep and continue not to feel well, this could be one of the reasons for the observed association between sleeping longer than usual and lower affective well-being especially among adults, but not adolescents. Including sleep deprivation/surplus during previous nights (deviation in sleep duration from the average either one or two nights ago) in the model presented in Table 1, however, neither changed the association between sleeping longer than usual, lower affective well-being, and age, nor proved to be a significant predictor of affective well-being ($b_{\text{last night}}$ < 0.001, SE = 0.04, p = .99; $b_{\text{two nights ago}}$ = 0.002, SE = 0.05, p = .97; no significant age moderations).

Discussion

The current results extend previous findings that experimentally induced sleep deprivation impairs affective well-being (Brendel et al., 1990; Dinges et al., 1997) in important ways: (a) Naturally occurring variations in sleep duration across on average 9 days were significantly related to people's affect the next morning. This is especially important because long sleep duration is difficult to induce experimentally without medication that also influences affect. (b) Age differences in the association between sleep duration and well-being were multifaceted: Sleeping **shorter** than average was more strongly related to lower affective well-being among adolescents and older people than among middle-aged adults. This is partly consistent with our assumption that, compared to adolescents, adults are better able to tolerate sleep deficits perhaps because their sleep need is lower and their emotion regulation is more pronounced. Unexpectedly, there seemed to be an upper age limit because shorter-than-average sleep duration among older adults' was more strongly related to lower well-being compared to middle-aged adults. Perhaps decreased flexibility in dealing with variations in sleep duration (Monk, 2005) contributes to this effect.

Sleeping **longer** than average was more strongly related to lower affective well-being among older people than among middle-aged adults and was even related to higher affective well-being among adolescents. For adolescents, perhaps the observed sleep duration—on average 7.3 hrs—is not fully sufficient for this age group to feel rested. Although their need for sleep remains high (8– 9 hrs per night; cf. Carskadon, 2011; Loessl et al., 2008), sleep duration shortens during adolescence due to changes in life style, for example, staying up late to go out despite having to keep early school hours. Thus, when adolescents sleep longer, for example, 9 or 10 hrs, they then actually satisfy their sleep need and feel rested and well the next morning. To understand why older adults' affective well-being is lower with longer-than-average sleep compared to younger adults, we tested the role of health impairments (Vitiello, 2009) and sleep duration on previous nights. Although higher dysphoria among adults and shorter sleep duration on the previous nights both predicted higher occurrences of sleeping longer than average, we found no indication that these factors account for the age differences in the association between longer sleep duration and affective well-being. A possible reason could be that the current sample was drawn from the general population and quite healthy. Perhaps in clinical samples, the mental health status partly accounts for the association between sleep duration and affective well-being. Other possible explanations for the observed age effects could be that sleeping longer is related differently to participants' affective well-being because of the accompanying sleep quality or appraisals: Perhaps older adults are more likely to sleep longer when sleep quality is low, which in turn influences affective well-being in the morning, or they appraise longer-than-average sleep more negatively than younger people and are dissatisfied with the "wasted" time. In the current study, we did not assess sleep quality or appraisals regarding sleep and were therefore not able to probe these interpretations empirically.

In addition to obtaining information on the age-differential processes on how longer-than-average sleep relates to well-being next morning, assessing mental health and medication more thoroughly in future studies is important because both potentially influence sleep and well-being. Also, the chosen range for measuring sleep duration limits the possible conclusions. For practical reasons, we applied a scale with ranges as scale endpoints. Hence, we cannot distinguish between 10 hrs of sleep, which might be excessive for adults, but not for adolescents, and 13 or 14 hrs of sleep. Nonetheless, we provide first evidence that naturally occuring longer-than-average sleep relates to lower affective well-being, which so far has only been shown for sleep deprivation, with this effect possibly being more pronounced in late adulthood.

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Table 1

Affect Balance in the Morning Predicted From Sleep Duration and Age (Unstandardized Multilevel Regression Coefficients)

	Morning affective balance	
	b	(SE)
Intercept	1.172**	(0.096)
Age [a]	0.009*	(0.004)
Age^2 [a]	-0.0003*	(0.0001)
Sleep duration [b]	0.147**	(0.058)
Sleep duration [b] × Age [a]	0.002	(0.002)
Sleep duration [b] × Age^2 [a]	0.0003*	(0.0001)
Sleep $duration^2$ [b]	–0.103**	(0.028)
Sleep $duration^2$ [b] × Age [a]	–0.003*	(0.001)
Evening affective balance	0.262**	(0.024)
Evening affective balance × Age [a]	0.005**	(0.001)

Note. Nonsignificant quadratic age effects were omitted from the model, see Results section. SE in brackets.

[a] Grand-mean centered (deviations from sample mean).

[b] Group-mean centered (deviations from individual's mean).

* $p < .05$, ** $p < .01$.

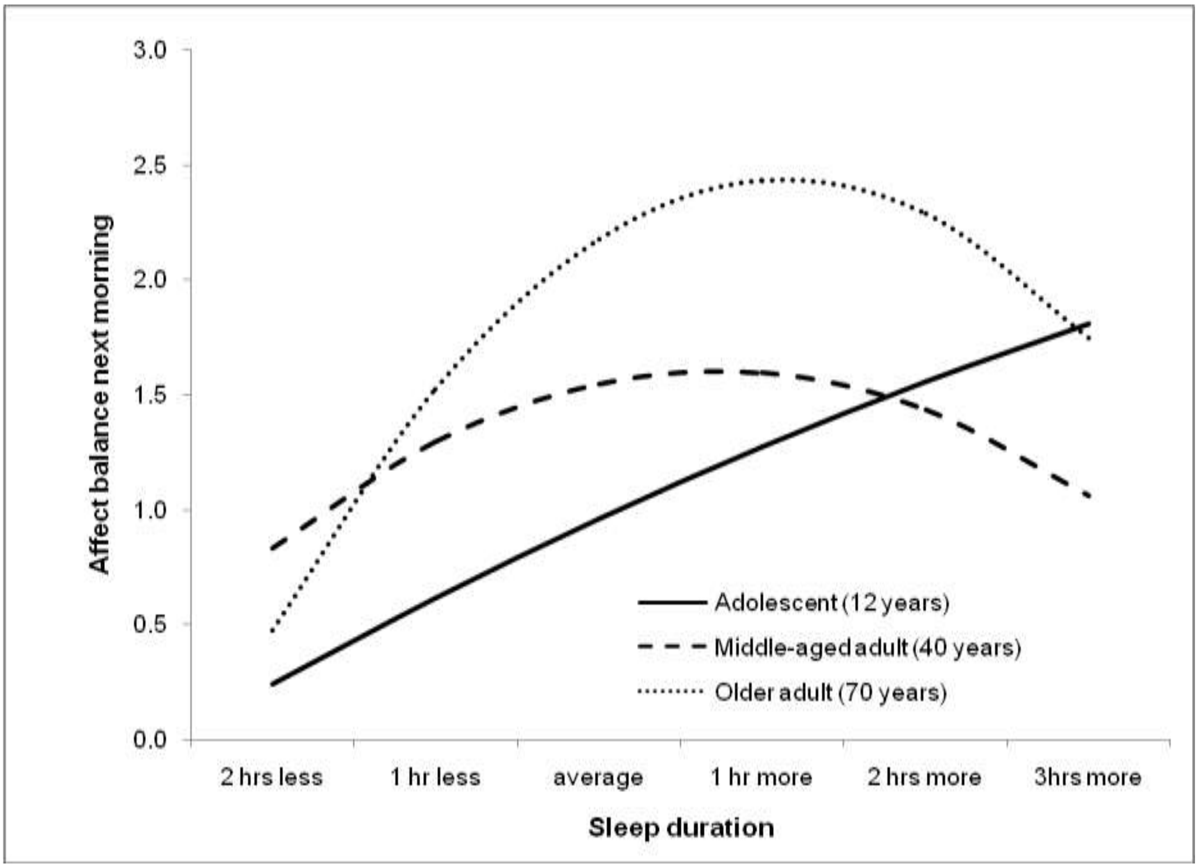

Figure 1. Model-predicted affect balance the next morning related to differences in sleep duration for three example age groups: adolescents, middle-aged adults (sample mean age), and older adults.

Supplementary material to

"Feeling good when sleeping in? Day-to-day associations between sleep duration and affective well-being differ from youth to old age" ***Wrzus, Wagner, & Riediger***

The main findings of the manuscript were that for adolescents, affective well-being in the morning was worse the shorter participants had slept the previous night. For adults aged over 20 years, however, affective well-being was worse following nights with shorter or longer than average sleep duration. This effect was more pronounced the older participants were. The supplementary material covers three topics:

(1) For the main analyses presented in Table 1 of the manuscript, where affect balance in the morning was predicted by sleep duration the previous night, we provide Table S1 with results from the control analysis including all covariates, such as current activity and present persons in the morning, average sleep duration, and subjective health. The result that our main findings were robust to controlling of these covariates was summarized in the manuscript.

(2) In addition to affect balance in the morning predicted by sleep duration, we summarized in the manuscript that the pattern of sleep duration and age effects therein were similar when positive affect and negative affect were analyzed separately. We provide Figures S1-S3 for positive and negative affect as well as sadness, which was of interest to one of the reviewers.

(3) In the manuscript we summarized that the effects of sleep duration on affect balance in the morning were similar for weeknights and weekend nights. Here we provide the detailed results in Table S2. In addition, people reported on average somewhat longer sleep durations on weekends (M = 7.0 h, SD = 1.3) compared to weeknights (M = 6.7, SD = 0.9, $t(390) = 5.16$, $p < .001$).

1. Full table for Table 1 in manuscript including all control variables:

Supplementary Table S1

Affect Balance in the Morning Predicted from Sleep Duration and Age (Unstandardized Multilevel Regression Coefficients)

	Morning affective balance	
	b	(SE)
Intercept	1.290**	(0.174)
Age [a]	0.014**	(0.004)
Age^2 [a]	-0.0004**	(0.0001)
Sleep duration [b]	0.144*	(0.057)
Sleep duration [b] × Age [a]	0.001	(0.002)
Sleep duration [b] × Age^2 [a]	0.0003*	(0.0001)
Sleep $duration^2$ [b]	-0.086**	(0.028)
Sleep $duration^2$ [b] × Age [a]	-0.003*	(0.001)
Evening affective balance	0.241**	(0.024)
Evening affective balance × Age [a]	0.004**	(0.001)
Control variables		
Average sleep duration	0.194**	(0.053)
General health	0.175	(0.107)
Dysphoria [a]	-0.267**	(0.048)
Sleep duration [b] × Health [a]	-0.013	(0.071)
Sleep duration [b] × Dysphoria [a]	0.005	(0.034)
Sleep $duration^2$ [b] × Health [a]	0.002	(0.039)
Sleep $duration^2$ [b] × Dysphoria [a]	0.027	(0.021)
Person present: nobody [c]	-0.108	(0.149)
Person present: private acquaintance [c]	0.027	(0.146)
Person present: non-private acquaintance [c]	0.149	(0.162)

Table continued

Supplementary Table S1 continued

	Morning affective balance	
	b	(SE)
Activity: work [c]	-0.031	(0.128)
Activity: chores [c]	0.162	(0.118)
Activity: leisure [c]	0.514**	(0.135)
Activity: TV [c]	-0.392**	(0.111)
Activity: enjoying company [c]	0.103	(0.180)

Note. [a] Grand-mean centered (deviations from sample mean). [b] Group-mean centered (deviations from individual's mean). [c] Dummy-coded (1=yes, 0=no). * $p < .05$, ** $p < .01$.

2. Positive affect, negative affect, and downcastness in the morning predicted by sleep duration the previous night

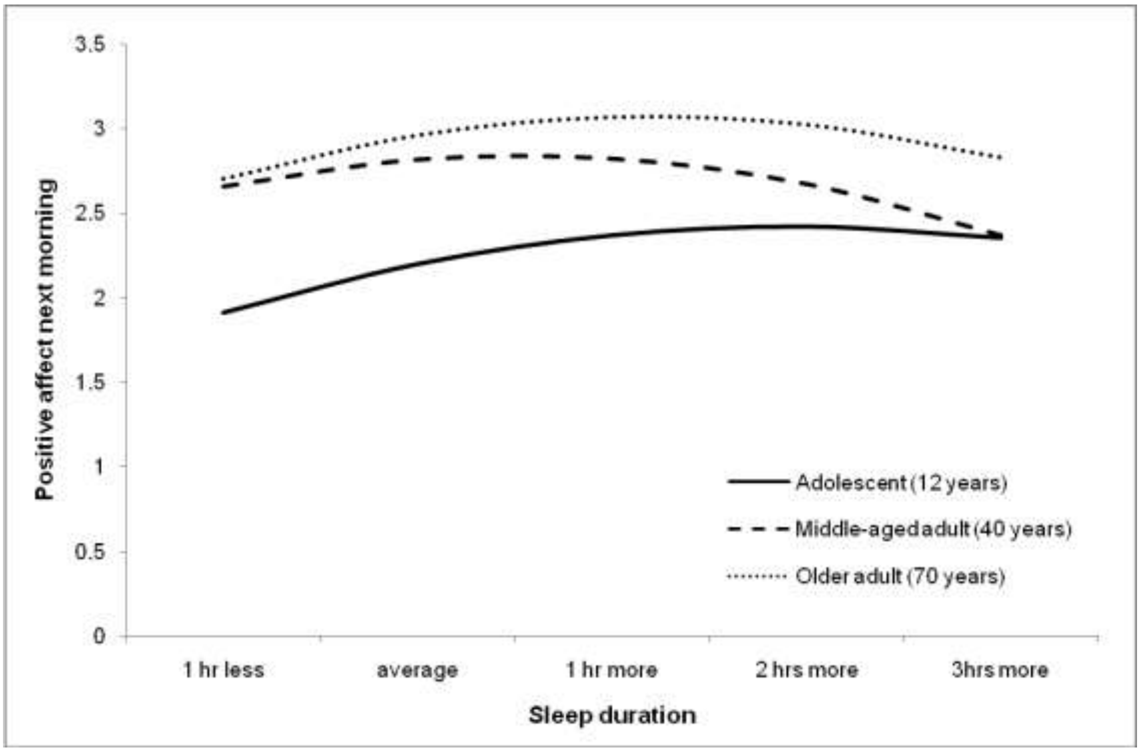

Figure S1. Model-predicted positive affect the next morning related to differences in sleep duration for three example age groups: adolescents, middle-aged adults, and older adults.

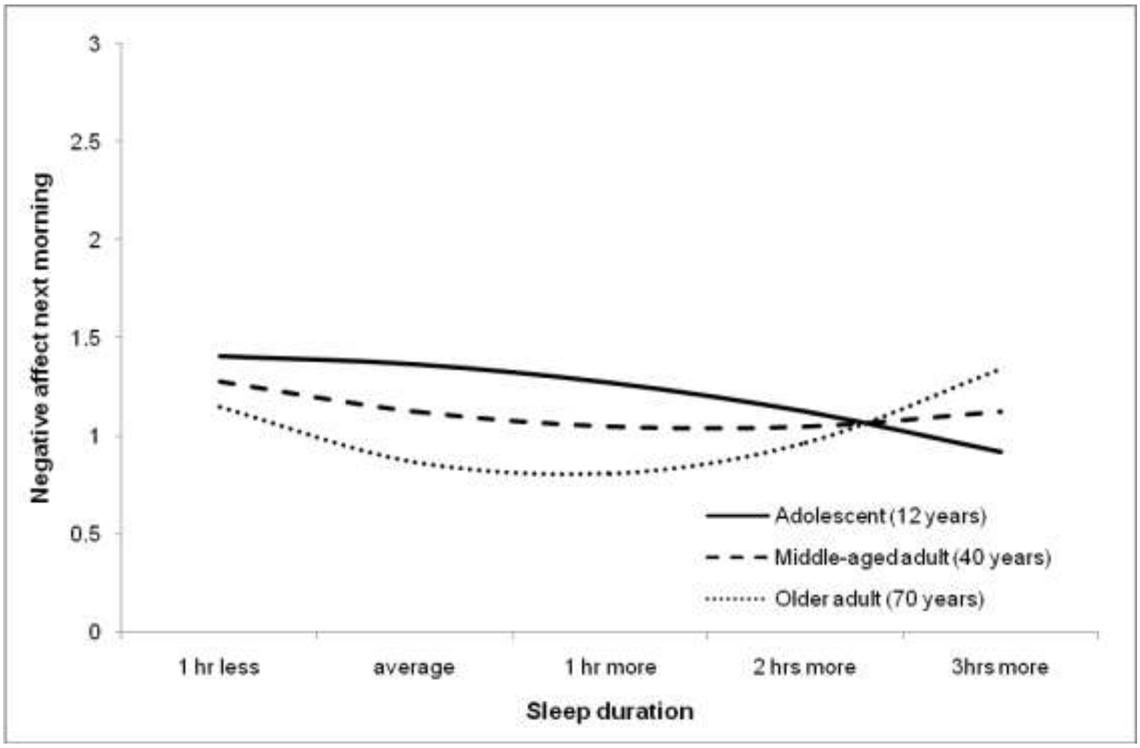

Figure S2. Model-predicted negative affect the next morning related to differences in sleep duration for three example age groups: adolescents, middle-aged adults, and older adults.

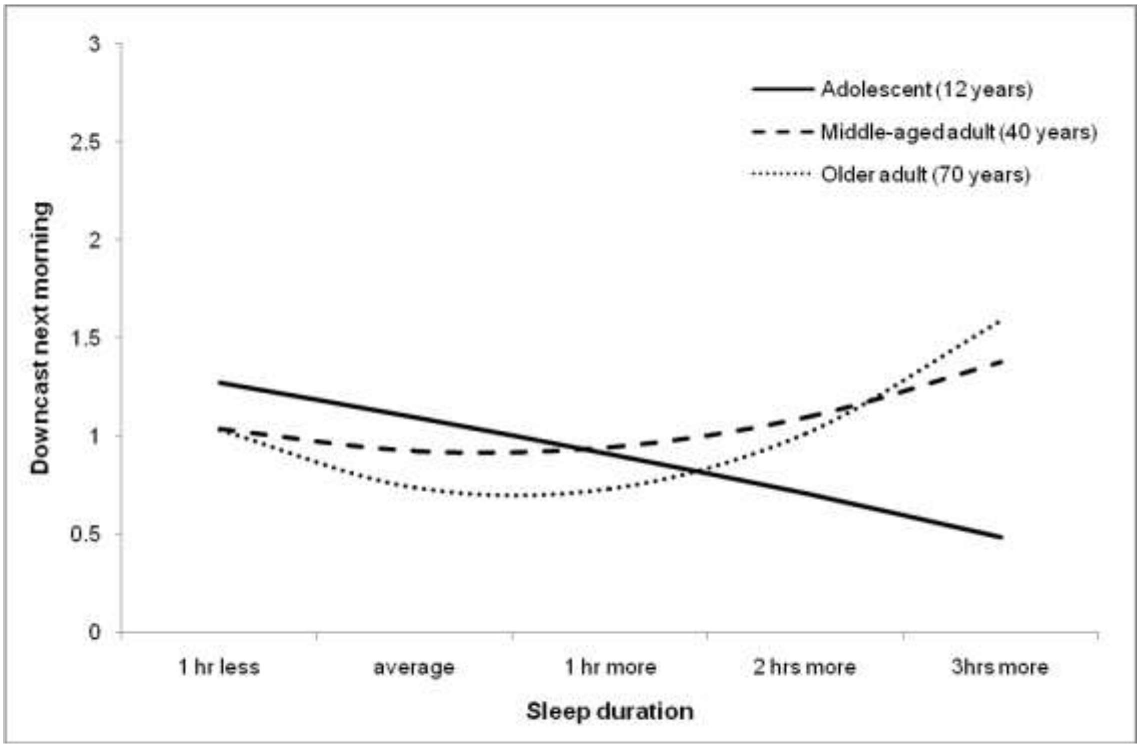

Figure S3. Model-predicted downcastness the next morning related to differences in sleep duration for three example age groups: adolescents, middle-aged adults, and older adults.

3. Effects of sleep duration on affect balance the next morning on weeknight vs. weekend nights

Supplementary Table S2

Affect Balance in the Morning Predicted from Sleep Duration, Weeknight, and Age (Unstandardized Multilevel Regression Coefficients)

	Morning affective balance	
	b	(SE)
Intercept	1.680**	(0.103)
Age [a]	0.022**	(0.003)
Age^2 [a]	-0.0003	(0.0002)
Sleep duration [b]	0.155**	(0.054)
Sleep duration [b] × Age [a]	0.0003	(0.002)
Sleep duration [b] × Age^2 [a]	0.0002*	(0.0001)
Sleep $duration^2$ [b]	-0.103**	(0.036)
Sleep $duration^2$ [b] × Age [a]	-0.003*	(0.001)
Sleep $duration^2$ [b] × Age^2 [a]	<-0.0001	(0.0001)
Weeknight [c]	-0.330	(0.392)
Weeknight [c] × Age [a]	-0.011	(0.013)
Weeknight [c] × Age^2 [a]	-0.0001	(0.001)
Weeknight [c] × Sleep duration [b]	0.061	(0.059)
Weeknight [c] × Sleep duration [b] × Age [a]	0.002	(0.002)
Weeknight [c] × Sleep duration [b] × Age^2 [a]	<-0.0001	(0.0001)
Weeknight [c] × Sleep $duration^2$ [b]	-0.020	(0.039)
Weeknight [c] × Sleep $duration^2$ [b] × Age [a]	-0.0003	(0.001)
Weeknight [c] × Sleep $duration^2$ [b] × Age^2 [a]	0.0001	(0.0001)

Note. [a] Grand-mean centered (deviations from sample mean). [b] Group-mean centered (deviations from individual's mean). [c] Effect-coded (-1=weeknight, 1=weekend night).
* $p < .05$, ** $p < .01$.