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The Association of Optimism with Sleep Duration and Quality: Findings from the Coronary Artery Risk and Development in Young Adults (CARDIA) Study

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Abstract

Optimism is associated with better health outcomes with hypothesized effects due in part to optimism's association with restorative health processes. Limited work has examined whether optimism is associated with better quality sleep, a major restorative process. We test the hypothesis that greater optimism is associated with more favorable sleep quality and duration. Main analyses included adults aged 32–51 who participated in the Coronary Artery Risk Development in Young Adults (**CARDIA**) study (n=3,548) during the fifth (Year 15: 2000–2001) and sixth (Year 20: 2005–2006) follow-up visits. Optimism was assessed using the revised Life-Orientation Test. Self-report measures of sleep quality and duration were obtained twice 5 years apart. A subset of CARDIA participants (2003–2005) additionally provided actigraphic data and completed the Pittsburgh Sleep Quality Index (**PSQI**) and Epworth Sleepiness Scale (**ESS**). Multivariate regression analyses were used to examine associations of optimism and sleep indicators. In cross-sectional analyses of 3,548 participants, each standard deviation (SD) higher optimism score resulted in 78% higher odds of self-reporting *very good* sleep quality. Prospectively, a 1-SD higher

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Compliance with Ethical Standards

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

The authors declare that they have no conflict of interest.

optimism score was related to higher odds of reporting persistently good sleep quality across 5-years relative to those with persistently poor sleep [OR=1.31; 95%CI:1.10,1.56]. In participant with supplementary data, each SD higher optimism score was marginally associated with 22% greater odds of favorable sleep quality [OR=1.22; 95%CI:1.00,1.49] as measured by the PSQI, with possible mediation by depressive symptoms. Optimism was unrelated to objective actigraphic sleep data. Findings support a positive cross-sectional and prospective association between optimism and self-reported sleep behavior.

Keywords

positive affect; psychological well-being; optimism; sleep quality and duration; sleep disruptions; insomnia

INTRODUCTION

A paradigm shift in public health and medicine has broadened the field from a singular focus on the ill effects of psychopathology to an expanded view that examines protective psychological assets that may promote improved physical health and longevity.[1] Dispositional optimism--characterized by the cognitive appraisal that positive things will occur in the future--has emerged as a psychological asset of particular salience for disease-free survival and superior health. Independent of major cardiovascular disease (**CVD**) risk factors and psychological distress, optimism seems to protect against development of CVD, and has been demonstrated to be independently associated with lower rates of hospital readmission after coronary artery bypass graft surgery, reduced all-cause and cardiac-related mortality, and reduced odds for incident heart disease.[1,2]

Although health behaviors are plausible mechanisms linking optimism and cardiovascular health,[3] few studies have considered associations with the key restorative behavior of sleep.[1] Identification of antecedents to healthful sleep is of public health importance in its own right, as lack of healthy sleep is associated with multiple adverse health outcomes including greater odds of obesity,[4] hypertension,[5] CVD,[6] and elevated risk for all-cause mortality.[7,8] Identifying factors that promote healthy sleep could provide new targets for prevention and intervention efforts for improving health more generally. More specifically, research is needed to elucidate whether optimism holds promise as a novel therapeutic target for enhanced sleep duration and quality.

In the limited available cross-sectional reports that include U.S. samples of young children and older adults, higher levels of optimism are consistently associated with more favorable sleep profiles, even after adjustment for sociodemographic characteristics and psychological distress.[9,10] For instance, in a cross-sectional study of African American and Hispanic/Latino grandmothers, Conway et al. (2008) found that those with greater levels of optimism had lower prevalence of sleep disorders as measured using a self-report scale (i.e., Comprehensive Assessment and Referral Evaluation (CARE) instrument).[9] Multiple pathways are proposed in the literature detailing the mechanisms through which optimism may directly and indirectly influence sleep patterns. Potential pathways include: (a) promotion of problem-focused coping and resilience toward stressors, (b) enhanced

neurobiological processing, and (c) promotion of health-related behaviors, such as exercise and nutrient-rich dietary intake.[1,2] There is some empirical evidence supporting the likelihood that these pathways are operating as documented in adult populations using cross-sectional, prospective, and experimental research designs,[11] but none have been specifically investigated in relation to sleep characteristics. More recently, research supports the hypothesis that depression conceivably mediates the relationship between optimism and healthful behaviors, as informed by multiple psychological frameworks, e.g., the Broaden-and-Build Theory[12] where positive emotions broaden an individual's repertoire in dealing with stress. These models consider the evidence that links depressive symptoms to greater sleep disruption and symptoms of insomnia[13] and—additionally, the impact that psychological attributes or traits exert on risk for depression and suicide ideation.[14,15]

Emerging science is moving in the direction of developing interventions to boost psychological well-being domains, including optimism, to promote better health practices. Although heritability or genetic determinism is involved when characterizing facets of psychological well-being, twin and adoption studies support malleability where 40% of observed variance in well-being is accounted for by intentional behavioral practices that are alterable and teachable[16]. If intervention development is to be pursued, however, more robust evidence of the link between optimism and sleep from prospective studies are needed (as few exist);[17,18] in addition, such studies will benefit from inclusion of more diverse samples and objective markers of sleep quality and duration. Clear shortcomings exist within this emerging body of work as the link between optimism and sleep remains relatively ambiguous given attributable scarcity and overreliance on cross-sectional designs and self-reported measures. Using data from the Coronary Artery Risk Development in Young Adults (**CARDIA**) study, a large multi-center cohort study in the U.S., we examined the cross-sectional and prospective association of optimism with self-reported ratings and objective measures of sleep quality and duration—with exploration of plausible mediation via depressive symptoms. We hypothesized that persons with higher optimism levels would be more likely to have favorable sleep patterns independently of socio-demographic factors, self-reported physical health status, and depressive symptoms.

METHODS

Study Population and Data Source

The CARDIA investigation is a multi-center cohort study that explores development and progression of cardiovascular disease risk factors in a U.S. sample of non-Hispanic White and African American adults. Details of the CARDIA recruitment and study protocol have been previously published.[19] Briefly, original study enrollment occurred from 1985–1986 across four U.S. regions (Birmingham, Alabama; Minneapolis, Minnesota; Chicago, Illinois; and Oakland, California), with inclusion of a total of 5,115 adult men and women between the ages of 18 and 30. Those with a previous history of symptomatic/clinical CVD were excluded during initial study enrollment (1985–1986). A balanced racial/ethnic composition was achieved with inclusion of 48.5% non-Hispanic White participants and 51.5% of African American descent in the original cohort. Over a 25-year period, CARDIA

participants have completed seven follow-up clinical exams. Approval for the study was obtained from Institutional Review Boards across all participating institutions.

Optimism was assessed in CARDIA participants once during the fifth follow-up assessment (Year 15 clinical exam: 2000–2001), herein identified as *baseline*. Socio-demographic factors and self-report measures of sleep quality and duration were obtained at baseline (Year 15 clinical exam: 2000–2001) and again at the sixth follow-up visit, i.e., 5 years later (Year 20 clinical exam: 2005–2006), herein identified as *follow-up*. Main analyses for the current study included 3,548 participants with complete data across main variables of interest—i.e., available optimism scores at *baseline* (Year 15) and subjective sleep markers at both *baseline* and *follow-up* (Year 20). Specifically, of the 3,672 participants who attended the Year 15 clinical exam, 16 were missing scores for optimism, 107 had incomplete information for covariates, and one participant withdrew consent, resulting in our final sample of 3,548 individuals. When considering the full sample of the original CARDIA study and participants included in our final analytic sample, participants excluded were more likely to be African American, younger in age, male, and to have lower levels of education.

A subset (n = 669) of CARDIA participants additionally provided actigraphic data at a supplemental assessment period—2 to 5 years post-baseline. More specifically, these objective sleep-related measures were obtained as part of an ancillary to the original CARDIA study.[20] Non-pregnant Chicago-site participants were recruited from among individuals who took part in the Year 15 clinical exam. The 669 participants who consented to take part in the Chicago-based ancillary study provided actigraphy data as well as more comprehensive survey data on sleep quality (assessed with the Pittsburgh Sleep Quality Index [**PSQI**]) and daytime sleepiness (assessed with the Epworth Sleepiness Scale [**ESS**]). Gathered between 2003 and 2005, these additional sleep measures were assessed on two separate occasions for each individual within a 1-year time frame (across participants, the mean interval between the two measures was 340 ± 73 days). Of the 3,548 participants in the main analysis, 650 participated in the Chicago-based ancillary study.

Measurements

Optimism—Optimism was measured using the revised Life Orientation Test-Revised (**LOT-R**), which was completed only at study baseline. The LOT-R is a validated 10-item self-administered questionnaire with possible scores ranging from 6 (*least optimistic*) to 30 (*most optimistic*).[21] The scale includes 3 positively worded items (e.g., I'm always optimistic about my future), 3 negatively worded items (e.g., I hardly expect things to go my way), and 4 filler items that are not considered in the overall score. All items are rated on a 5-point Likert scale with response options ranging from *strongly agree* to *strongly disagree*; note, CARDIA omitted filler items of the original scale as developed by Scheier et al. (1994).[22] Responses for the negatively worded items were reverse-coded to calculate a composite score, with higher scores indicative of greater optimism. As optimism is characterized by endorsement and rejection of positively and negatively worded items, we followed recommendations to treat the LOT-R as a one-factor unidimensional scale.[23] Analyses treated the LOT-R as either a continuous or a categorical variable (i.e., quartiles based on the distribution of scores in the analytic sample).

Outcome Measures of Sleep Quality and Duration—Sleep parameters were assessed using subjective self-report measures and actigraph devices.

Self-Report Measures.: Brief self-report measures of sleep quality and duration were completed at the study baseline and during follow-up CARDIA assessment periods by all CARDIA participants. Using a 5-point Likert scale, participants were asked to rate their overall sleep quality during the past month; "During the past month, how would you rate your sleep quality overall?" This single-item measure was treated as an ordinal variable with categories of '4 = very good,' '3 = fairly good,' '2 = good,' '1 = fairly bad,' and '0 = very bad.' In longitudinal analyses requiring binary metrics, sleep quality was further categorized as *good* (≥2) versus *bad* (<2). Symptoms of insomnia were assessed using three binary (yes/no) items inquiring of difficulty in falling asleep, untimely awakenings during the night, and premature early risings, with the resultant total score ranging from no symptoms to presence of all three. The following open-ended item assessed sleep duration: "During the past month, how many hours of actual sleep did you get at night?" Sleep duration was categorized as short- (< 6 hrs.), sufficient (6 to < 9 hrs.), and long-sleep (≥ 9 hrs.). Categorization was informed by previous studies documenting ill effects of both insufficient (i.e., short) and excessive (i.e., long) sleep duration[6]. As before, longitudinal analyses required a dichotomous measure that resulted in duration being further categorized as *good* (sufficient sleep: 6 to < 9 hrs.) versus *bad* (insufficient or excessive sleep: < 6 or ≥ 9 hrs.). Assessment of subjective sleep using single-item measures is common in large epidemiologic cohorts.[5,24] Other work has demonstrated evidence of their predictive capacity across multiple health outcomes,[5,25,26] and prior research in the CARDIA cohort has reported the single-item measures are also moderately but significantly correlated with actigraphic data.[24] Taken together this work suggests single-item markers can provide valid information about sleep patterns.

More comprehensive sleep quality and daytime sleepiness measures were collected for the subset of CARDIA participants who were part of the Chicago-based ancillary study with actigraphic assessment and completion of the PSQI[27] and the ESS[28]. The PSQI is a 19-item self-administered questionnaire used to derive a global sleep quality score ranging from 0 to 21, with higher scores indicative of poorer quality sleep.[27] Multiple domains are captured by the PSQI and includes items tapping into self-rated sleep quality, duration of sleep, sleep disturbances, sleep latency and efficiency, daytime dysfunction, and use of sleep inducing medication. Documented as having adequate diagnostic sensitivity (89.6%) and specificity (86.5%), a 5-point PSQI score cutoff (>5) is used to identify those with poor sleep quality.[27] The ESS uses a 4-point Likert Scale (0—would *never* doze or sleep to 3—*high* chance of dozing or sleeping) to probe the likelihood of dozing off or falling asleep in 8 different situations to estimate levels of daytime sleepiness; possible scores range from 0 to 24, with scores ≥10 indicative of excessive or above average daytime sleepiness.[28] Both measures have undergone psychometric testing and show adequate validity and reliability.[27,28]

Actigraphy Data.: The subset of participants in the Chicago-based sleep ancillary study also wore an Actiwatch16™ activity monitor (Mini-Mitter Inc, Bend, OR) on their wrist on two occasions approximately 1 year apart. Activity monitors were worn for 3 consecutive

days that included at least 2 weeknights and 1 weekend night. Given their minimalist design, wrist actigraphy devices do not display “first night effects” as they infrequently alter or disrupt sleep behavior.[20] Given the stability of actigraphy readings across the two assessments, mean scores across all available actigraphy recordings were considered;[29] 6 days of actigraphy data were available for 92% of participants, and 3 to 5 days for the remaining 8%. Three metrics were derived using actigraphic data: sleep duration, sleep efficiency (percent of time spent asleep during the sleep period, as defined by the ratio of sleep duration/time in bed), and sleep fragmentation (proportion of time experienced in restlessness). Dichotomization of sleep markers of the Chicago-based subsample mimics previous work that captures clinically relevant cutoffs indicative of disordered sleep.[24]

Covariates.: Covariates included baseline age, sex (male; or female), race/ethnicity (non-Hispanic White; or African American), marital status (married; never married; or other [widowed, divorced, or separated]), education (total years of formal schooling), income (seven-level ordinal variable ranging from <$16,000 to ≥$100,000), health insurance status (insured; or not-insured), and status of employment (employed; or unemployed). Socio-demographic information was gathered via self-report using standardized questionnaires completed in-person at study baseline (Year 15 clinical exam). We additionally considered self-perceived physical health measured using the Physical Health Composite Scale of the 12-item Short Form Health Survey (SF-12),[30] prevalent CVD event (coronary heart disease, stroke, and heart failure) at baseline as adjudicated from medical records through the Year 15 clinical exam, and depressive symptoms captured with the Center for Epidemiologic Studies Depression Scale (CES-D).[31] It is general practice to adjust for depressive symptoms when testing the association of positive psychological assets with behavioral and physical health outcomes to isolate independent effects and to rule out that one is simply capturing absence of ill-being.[2] There remains controversy, however, as to whether this constitutes over adjustment. Some researchers have suggested that depression may instead mediate the relationship between optimism and sleep,[18] and as such, we tested this plausible indirect effect for comprehensive subjective sleep measures.

Statistical Analyses

All data analyses were conducted using statistical software (SAS 9.4 for Windows; SAS, Inc, Cary, North Carolina). The continuous score for optimism was used to create quartiles across the full range of observed scores in the analytic sample for descriptive analyses. Group differences in participant characteristics across optimism quartiles were examined using an F-test (continuous variables) or χ^2-test (categorical variables) as appropriate. For inferential analyses, optimism’s association with sleep quality and duration were examined using binary and multinomial logistic regression procedures. Baseline optimism was treated as a continuous measure with results reported as an increase equivalent to one standard deviation (**1-SD**).

Multinomial logistic regression procedures were used for both cross-sectional analyses and those examining change in sleep patterns over time. In cross-sectional analyses with the single-item measure of self-perceived sleep quality, we estimated the odds for sleep quality characterized as higher-grade, i.e., ‘very good’ to ‘fairly bad,’ when compared to the

reference group endorsing 'very bad' sleep quality. Multinomial logistic regression was used when aseesing the cross-sectional relationship between optimism and self-reported sleep duration as well, with impaired sleep (short- <6 or long- ≥9 hrs.) serving as the reference group when modeling odds for sufficient sleep duration (6 to <9 hrs.). Multinomial logistic regression was also used when examining the odds of reporting no difficulties falling asleep or remaining asleep over night and early morning, 1 or 2 of these insomnia symptoms, compared to experiencing all symptoms (reference group). For each outcome, two sets of models were constructed. Model 1 was minimally adjusted for age, sex, and race/ethnicity. Model 2 additionally adjusted for marital status, education, income, health insurance status, status of employment, self-perceived physical health (i.e., SF-12), prevalent CVD, and study site. Model 3 additionally considered depressive symptoms as a covariate. In exploratory analyses we tested for mediation by depressive symptoms on effects of optimism on comprehensive subjective sleep measures using the SAS macro of Valeri and VanderWeele.[32]

Changes in sleep patterns over time were examined using the single-item dichotomized measures of quality and duration across time points categorized as four distinct states—persistently poor [bad➔bad; ref], improved [bad➔good], worsened [good➔bad], or persistently good [good➔good]—based on variations experienced from baseline (Year 15) to follow-up (Year 20).

Binary logistic regression was used when examining the association of optimism with the ESS, PSQI, and actigraphy data in the subset of participants for whom these data were available. In separate models, we assessed the odds for normal range daytime sleepiness (normal [ESS<10]/excessive), favorable sleep quality (yes [PSQI≤5]/no), and objectively-measured duration (sufficient [≥6 hrs.]/inappropriate), efficiency (TOP 25th percentile), and fragmentation (BOTTOM 25th percentile). Moreover, we conducted additional sensitivity analyses with the ancillary study measures—ESS, PSQI, and actigraphic data—to explore potential linear associations by treating dispositional optimism and sleep measures as continuous scores. As before, minimally-adjusted and multivariable-adjusted models were fitted. For all models, fit indices were reported, whereby lower values for Akaike information criterion (AIC) and Schwarz criterion would indicate a better fit to the data.

RESULTS

Characteristics of the Study Sample

Participants ranged in age from 32 to 51 years (M = 40.2, SD = 3.6), with a slightly greater number of women, i.e., 55.8% (n = 1,978). A balanced representation by race/ethnicity was evident, consisting of 53.7% (n = 1,906) non-Hispanic White and 46.3% (n = 1,642) African American. A large proportion reported household income exceeding $50,000 per year (n=2,088, 58.9%) and 88.8% reported having some form of health insurance coverage. Table 1 provides participant characteristics according to levels of optimism. Participants categorized as most optimistic tended to be women, non-Hispanic White, married, and of higher socioeconomic status. Lower levels of depressive symptoms were evident for those reporting the highest levels of optimism when compared to least optimistic counterparts.

Finally, lower rates of CVD events (i.e., coronary heart disease, stroke, and heart failure) were apparent for participants within the highest strata of optimism.

Multivariate Association of Optimism with Sleep Quality and Duration

Subjective Sleep Measures—Table 2 presents odds ratios across sleep quality categories according to a 1-SD higher optimism score, using cross-sectional data. In the minimally adjusted Model 1, where participants reporting 'very bad' sleep quality served as the reference group, the odds for higher-grade sleep quality were higher with each SD higher optimism score, i.e., fairly bad [OR = 1.57: 95% CI = 1.23, 2.00]; good [OR = 1.88: 95% CI = 1.49, 2.38]; fairly good [OR = 2.45: 95% CI = 1.93, 3.11]; and very good [OR = 3.58: 95% CI = 2.80, 4.59]. These cross-sectional associations were slightly attenuated, although still statistically significant, after additional adjustment for education, income, insurance status, employment, physical health (SF-12), prevalent CVD, depressive symptoms, and study site (**Model 3**). A 25% greater odds for sufficient sleep (6 to < 9 hrs.) was evident with each SD higher optimism score in multivariate models, although this association was non-significant statistically after adjusting for depressive symptoms. Table 2 additionally presents odds of having fewer insomnia symptoms for every SD higher optimism score. In models adjusted for age, sex, and race/ethnicity, a 1-SD higher optimism score resulted in 97% greater odds of having no symptoms of insomnia, compared to experiencing all insomnia symptoms. These results were attenuated after inclusion of relevant covariates, particularly when depressive symptoms were added to the model.

Table 3 presents the prospective association of optimism and self-reported sleep patterns across the 5-year interval, i.e., persistently poor, improved, worsened, and persistently good. In the multivariable adjusted model, 1-SD higher optimism score was associated with 31% higher odds of being in the subgroup of participants reporting good sleep quality at both clinical exam periods [OR = 1.31: 95% CI = 1.10, 1.56], compared to those reporting persistently poor sleep. Optimism was also positively associated with the sleep pattern classified as improved [OR = 1.32: 95% CI = 1.07, 1.62]. While optimism scores were significantly or marginally associated with 5-year change in sleep duration in the multivariate models, relations were no longer statistically significant after adjusting for depressive symptoms.

In the subsample of participants who underwent additional sleep assessments, optimism was significantly associated with both sleep quality [OR=1.64, 95% CI= 1.37, 1.96] and day-time sleepiness [OR=1.23, 95% CI= 1.01, 1.48] as assessed by the PSQI and the ESS respectively in cross-sectional multivariate logistic regression models (see **Model 2** of Table 4). However, after inclusion of depressive symptoms as a covariate, only a trend toward significance was evident when modeling the odds for a favorable PSQI score, i.e., ≤ 5 points. Specifically, in models adjusting for socio-demographic, physical health indicators, and depressive symptoms, a 1-SD higher optimism score was associated with 22% higher odds for favorable PSQI sleep quality [95% CI = 1.00, 1.49; $p = 0.054$]. Analogous multivariable analyses (i.e., without depressive symptoms) replicated findings in sensitivity analyses modeling continuous scores for PSQI ($\beta=-0.50$, SE=0.11, $p<0.01$) and ESS ($\beta=-0.44$, SE=0.16, $p<0.01$) measures. Note, for all models using self-reported sleep measures, the

AIC and the Schwarz criterion generally favored the multivariate model that further adjusted for depressive symptoms (Model 3).

Finally, mediational testing using the SAS macro by Valeri and VanderWeele (2013)[32] suggested depressive symptoms may significantly mediate effects of optimism on comprehensive subjective sleep measures for both PSQI (OR=1.22, 95% CI=1.15, 1.30, 73.4% mediation) and ESS (OR=1.04, 95% CI=1.01, 1.07, 92.2% mediation) measures.

Objective Sleep Measures

In the CARDIA ancillary subsample, no association was seen between optimism and objective sleep markers as shown in Table 4 across multivariable adjusted models. Specifically, optimism was not associated with the odds for sufficient sleep duration [OR = 0.98: 95% CI = 0.80, 1.20], efficiency [OR = 1.08: 95% CI = 0.87, 1.36], or fragmentation [OR = 0.98: 95% CI = 0.79, 1.21]. Although a positive association was seen for optimism and sleep efficiency when adjusting for age, sex, and race/ethnicity [OR = 1.22: 95% CI=1.01, 1.47], this association was not maintained when additional covariates were considered. Null findings were replicated when treating actigraphic sleep measures as continuous scores and when exploring linear associations. When using objective sleep measures, the AIC more often favored Model 3 whereas Schwarz criterion tended to favor Model 1.

DISCUSSION

Results from this study revealed significant associations between optimism and various characteristics of self-reported sleep in both cross-sectional and prospective analyses, after adjusting for a wide array of covariates. Specifically, higher levels of optimism at baseline were associated with more favorable profiles of sleep quality when assessed concurrently and also across time when measured over a 5-year period. These associations remained significant even after adjustment for socio-demographic characteristics, comorbid physical health conditions, and depressive symptoms. Individuals with greater optimism levels were also more likely to report sufficient sleep duration (6 to < 9 hrs.) and fewer insomnia symptoms in multivariate models, although these associations were attenuated after further adjustment for depressive symptoms. In the subset of participants who were part of the Chicago-based ancillary sleep study, optimism was also significantly associated with better sleep quality as assessed with the 19-item PSQI and less day-time sleepiness as per items of the ESS. While objective sleep markers were not robustly related to dispositional optimism, minimally adjusted models suggested greater sleep efficiency with each SD higher optimism score.

Our observational study offers supporting evidence for a cross-sectional and prospective link between optimism and self-reported sleep patterns in a large heterogeneous sample of young and middle-aged U.S. adults. Though it remains unclear as to the mechanisms through which optimism influences sleep patterns, a multifactorial biopsychosocial and behavioral process is hypothesized to underlie the relationship. One hypothesis is that optimism can buffer the effects of stress by facilitating adaptive coping. Optimist are more likely to engage in active problem-focused coping and positive reinterpretation of stress evoking events

which may diminish vulnerability to worry and ruminative thoughts when initiating sleep and throughout the sleep cycle.[33–35] Corroborating this mechanistic pathway, we saw suggestive evidence in CARDIA of mediation via depressive symptoms, suggesting we treat depression not as a covariate but as a potential mechanism linking optimism to sleep behavior. The effects of optimism on physiological processes may also more directly influence sleep patterns. Prior work suggests that optimism has protective biological effects such as improved hormonal balance via regulation of released epinephrine and norepinephrine, lowering of cortisol output, and reduction of cardiovascular arousal.[29,36] In turn, better regulation of the endocrine and cardiac systems may have a direct positive impact on restorative sleep processes.[37]

Findings of the current study are consistent with limited prior research examining the link between optimism and subjective sleep patterns in which a significant and healthful positive association is evident, with similar medium-sized effects (d≈0.50). For instance, among 115 older women with 10-years of follow-up data, Phelan et al. (2010) reported lower odds for persistently disrupted sleep (as per the PSQI) among those displaying greater scores across multiple psychological well-being domains.[38] In a sample of 987 Chinese adults followed over a 19-month period, Lau et al. (2015) found optimism to be significantly associated with more favorable sleep quality as measured using the PSQI. Although the current CARDIA study is observational in nature, a significant prospective association between optimism and 5-year patterns of sleep quality makes reverse causality less of a concern.[17] Nonetheless, cautious interpretation is warranted as a positive future-oriented outlook on life may over-accentuate self-appraisal of adherence to restorative health behaviors. This then remains a major scientific gap in the field and suggests the necessity for use of more objective sleep markers and randomized trials that incorporate a control arm.

In contrast to findings using self-report data, triangulation of results was not evident when using objective actigraphy data. One is then left to grapple with the notion of whether optimism truly influences sleep behavior or whether it simply colors an individual's subjective rating of sleep. Jackowska et al.[39] offers evidence suggesting that optimism or other aspects of psychological well-being may result in under- or over-reporting of sleep difficulties and may be an important source of self-report bias to consider. This may in turn contribute to the discrepancy seen when self-report values are compared to those objectively collected via actigraphy.[40] We must also acknowledge, however, the significant difference in sample size for self-report measures included in the original parent study versus actigraphy data collected from the Chicago-based ancillary, i.e., 3,548 vs. 650, which may also influence discordant findings. When testing the influence of optimism on actigraphy output, we cannot rule out the possibility of power insufficiency or that phenotypic differences in Chicago-based participants, contrasted to the full sample, markedly influenced findings; self-selection bias based on sleep profiles at the Year 15 clinical exam was not evident, however, for the ancillary subsample.[24]

Another possible explanation for dissimilar findings may be a function of distinct methodologies for data acquisition leading to poor convergence or correlation. It is not uncommon for objective and subjective measures of sleep to diverge and for discrepancies to surface. Indeed, Lauderdale et al. (2008) reports a moderate correlation between self-report

and objectively measured sleep duration in the CARDIA cohort (r = 0.45).[24] The question then remains whether subjective and objective measures of sleep are equivalent or whether they are capturing distinct processes with divergent antecedents. There remains an urgent need for future studies assessing the impact of psychological factors and sleep to include dual methodologies to capture sleep profiles.

Notwithstanding recorded discrepancies across sleep measures, there is epidemiologic evidence documenting protective health effects even when using subjective reports for sleep duration and quality; and, many diagnostic tools to identify sleep disorders continue to rely heavily on self-report measures of sleep. For example, higher levels of self-reported sleep quality and duration are linked with more favorable cardiovascular health risk profiles,[41] lower accumulation of coronary artery calcification,[42] and reduced morbidity and mortality.[43] Thus, subjective measures of sleep provide valuable evidence, and if supplemented by qualitative inquiry, can offer insight as to whether favorable sleep is linked to greater self-perceived restfulness and overall vigor.

Inclusion of depressive symptoms, but not other covariates, attenuated the observed association between dispositional optimism and self-reported sleep measures of sleep duration, insomnia, and excessive day-time sleepiness; however, effect estimates for cross-sectional associations and longitudinal changes in sleep quality as measured by a single-item and PSQI scores were less altered. Nonetheless, in models adjusted for age, sex, and race/ethnicity, optimism was robustly associated with sleep, even when measured using distinct measurement methodologies. Over-adjustment bias is possible if intermediate factors involved in the pathway linking optimism and sleep are included as covariates in regression models; this may be particularly true when adjusting for depressive symptoms. Future studies will want to thoroughly explore factors (e.g., physiologic biomarkers, health behaviors, etc.) that may modify the relationship or lie on the pathway between optimism and sleep as this may elucidate subgroups for which this phenomenon is of most salience.

The present study has multiple strengths. As mentioned earlier, it is the first to examine the prospective association of dispositional optimism and sleep patterns using both objective and subjective measures in a large sample of young and middle-aged men and women (n=3,549), with substantial representation of persons from an underserved minority subgroup. A well-validated instrument was used to assess dispositional optimism and standardized approaches were used to obtain objective measures of sleep quality and duration. However, study limitations include having a short 1-year follow-up for the ancillary subsample with objective measures of sleep with a substantially smaller sample than in the primary study. Optimism was only measured once at baseline and more recurrent assessments of sleep behavior would have optimized investigation of mediation patterns. Future prospective studies with longer follow-up of time and a combination of both objective and subjective sleep measurements are needed to determine more conclusively whether optimism is an important determinant of sleep characteristics, as sufficient sleep quantity and greater sleep quality may also lead to higher levels of optimism.

CONCLUSIONS

Research is needed to more fully elucidate the relationship between optimism and sleep patterns with particular emphasis on potential psychosocial, behavioral, and biological pathways, and identification of factors that may mediate and moderate the observed effects. A more complex link is also possible with dispositional optimism and sleep related in a bidirectional fashion such that improvements in either leads to dual cyclical improvements—i.e., greater optimism improves sleep duration and quality, which in turn causes improved optimism as a consequence of feeling fully rested and restored. Nonetheless, our findings suggesting that optimism does increase likelihood of self-reporting favorable sleep patterns set the stage for future studies to explore factors that may serve as mediators and/or moderators, e.g., lifestyle patterns and cognitive coping styles. Our findings additionally indicate that the prospective association between optimism and self-reported sleep is partly independent, with indirect mediation via depressive symptoms. This may suggest the importance of going beyond focusing on reducing psychopathology and instead moving upstream toward cultivating psychological assets that can produce positive sequela.

In addition, more studies with longitudinal designs and randomized trials are needed. Such studies would allow more conclusive inferences about causality, with exploration to determine whether improvements in optimism (or perhaps other positive psychological assets) translate to improved sleep duration and quality. This has significant public health implications as psychosocial interventions leading to improved sleep duration and quality may directly and indirectly lead to increased health-adjusted life expectancy and longevity.

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Acronyms:

CARDIA	Coronary Artery Risk Development in Young Adults
CVD	cardiovascular disease
PSQI	Pittsburgh Sleep Quality Index
LOT-R	Life Orientation Test-Revised

SD	standard deviation
ESS	Epworth Sleepiness Scale
CES-D	Center for Epidemiologic Studies Depression Scale
OR	Odds Ratio
CI	Confidence Interval

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Table 1.

Characteristics of the Study Sample According to Quartiles of Optimism: CARDIA Study (N=3,548)

Quartile of LOT-R Score (Optimism)	Total Sample	Optimism Quartile				
		Least Optimistic	Mid-Low Optimistic	Mid-High Optimistic	Most Optimistic	
	N = 3,548	n=777	n=1,113	n=875	n=783	p†
Socio-demographic Measures						
Age, *M* (SD)	40.2 (3.6)	40.2 (3.7)	40.3 (3.7)	40.3 (3.5)	40.0 (3.6)	0.23
Women, n (%)	1978 (55.8)	426 (54.8)	582 (52.3)	489 (55.9)	481 (61.4)	0.001
Race/ethnicity, n (%)						
non-Hispanic White	1906 (53.7)	383 (49.3)	589 (52.9)	514 (58.7)	420 (53.6)	0.002
African American	1642 (46.3)	394 (50.7)	524 (47.1)	361 (41.3)	363 (46.4)	
Marital Status, n (%)						
Married	2154 (60.7)	391 (50.3)	670 (60.2)	569 (65.0)	524 (67.0)	<0.001
Never married	767 (21.6)	231 (29.7)	230 (20.7)	179 (20.5)	127 (16.2)	
Other *	626 (17.7)	155 (20.0)	213 (19.1)	127 (14.5)	131 (16.8)	
Annual Income $, n (%)						
<25,000	563 (15.9)	218 (28.1)	178 (16.0)	100 (11.4)	67 (8.6)	<0.001
25,000–49,999	897 (25.3)	212 (27.3)	315 (28.3)	198 (22.6)	172 (22.0)	
≥ 50,000	2088 (58.9)	347 (44.7)	620 (55.7)	577 (65.9)	544 (69.5)	
Years of Education, *M* (SD)	14.9 (2.5)	14.4 (2.7)	14.7 (2.5)	15.2 (2.5)	15.6 (2.4)	<0.001
Health Insurance Status, n (%)						
Has health insurance	3152 (88.8)	654 (84.2)	970 (87.2)	806 (92.1)	722 (92.2)	<0.001
Does not have health insurance	396 (11.2)	123 (15.8)	143 (12.9)	69 (7.9)	61 (7.8)	
Employed, n (%)	3233 (91.1)	677 (87.1)	1006 (90.4)	819 (93.6)	731 (93.4)	<0.001
Health Status						
Depressive Symptoms (CES-D), *M* (SD)	9.1 (7.8)	15.3 (9.5)	9.3 (6.7)	7.0 (5.9)	5.1 (5.0)	<0.001
Physical Health (SF-12), *M* (SD)	51.8 (7.5)	50.1 (8.9)	51.5 (7.6)	52.4 (6.7)	53.0 (6.6)	<0.001
Cardiovascular Disease Event, n (%)	32 (0.9)	14 (1.8)	8 (0.7)	8 (0.9)	2 (0.3)	0.010

* Includes those reporting being widowed, divorced, or separated.

† P-value examining overall group differences using χ^2 or F tests as appropriate.

Table 2.

Odds ratios (ORs) and 95% confidence intervals (CIs) for the cross-sectional association of one standard deviation (SD) higher optimism score with sleep quality, duration, and insomnia: Self-report measures

Self-reported Sleep in 2000–2001 (n=3,548)						
	M1: Minimally adjusted		**M2: Multivariable adjusted**		**M3: Multivariable adjusted with psychological distress**	
Sleep Measures	**OR (95 % CI)**		**OR (95 % CI)**		**OR (95 % CI)**	
Sleep Quality						
Very good	**3.58 (2.80, 4.59)**		**3.40 (2.62, 4.41)**		**1.78 (1.32, 2.39)**	
Fairly good	**2.45 (1.93, 3.11)**		**2.32 (1.80, 2.97)**		**1.42 (1.07, 1.88)**	
Good	**1.88 (1.49, 2.38)**		**1.81 (1.41, 2.31)**		1.17 (0.89, 1.56)	
Fairly bad	**1.57 (1.23, 2.00)**		**1.53 (1.19, 1.97)**		1.33 (1.00, 1.77)	
Very bad [ref]	1.0 (ref)		1.0 (ref)		1.0 (ref)	
Model fit	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion
	9636.58	9760.07	9565.44	9911.01	9263.98	9634.24
Sleep Duration						
Sufficient Sleep (6 to <9 hrs.)	**1.31 (1.21, 1.42)**		**1.25 (1.15, 1.37)**		1.02 (0.92, 1.13)	
vs.						
Short-sleep (<6 hrs.) or Long-sleep (≥9 hrs.) [ref]	1.0 (ref)		1.0 (ref)		1.0 (ref)	
Model fit	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion
	3424.56	3455.44	3368.87	3455.26	3292.76	3385.32
Insomnia						
No insomnia symptoms	**1.97 (1.73, 2.25)**		**1.74 (1.51, 2.00)**		1.09 (0.92, 1.28)	
1 symptom endorsed	**1.53 (1.34, 1.75)**		**1.37 (1.19, 1.58)**		0.97 (0.82, 1.14)	
2 symptoms endorsed	**1.17 (1.01, 1.34)**		1.09 (0.94, 1.27)		0.91 (0.77, 1.07)	
3 symptoms endorsed [ref]	1.0 (ref)		1.0 (ref)		1.0 (ref)	
Model fit	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion
	8429.41	8522.02	8277.56	8536.75	8060.77	8338.47

M1: Adjusted for age, sex, and race/ethnicity.

M2: M1 + education, income, insurance status, employment status, self-perceived physical health (SF-12), cardiovascular disease, and study site.

M3: M2 + depressive symptoms (CES-D).

Bold font = $p < 0.05$

Table 3.

Odds ratios (ORs) and 95% confidence intervals (CIs) for the association of one standard deviation (SD) higher optimism score and 5-year change in self-reported sleep quality (n=3,548)

	M1: Minimally adjusted		**M2: Multivariable adjusted**		**M3: Multivariable adjusted with psychological distress**	
Change in Self-reported Sleep Quality	**OR (95% CI)**		**OR (95% CI)**		**OR (95% CI)**	
Persistently Poor [Bad, Bad]	1.0 (ref)		1.0 (ref)		1.0 (ref)	
Improved [Bad, Good]	**1.43 (1.20, 1.70)**		**1.41 (1.17, 1.69)**		**1.32 (1.07, 1.62)**	
Worsened [Good, Bad]	**1.63 (1.37, 1.93)**		**1.57 (1.31, 1.88)**		1.21 (0.98, 1.48)	
Persistently Good [Good, Good]	**2.01 (1.74, 2.31)**		**1.94 (1.67, 2.25)**		**1.31 (1.10, 1.56)**	
Model fit	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion
	4868.53	4957.93	4806.20	5056.40	4654.07	4922.14
Change in Self-reported Sleep Duration	**OR (95% CI)**		**OR (95% CI)**		**OR (95% CI)**	
Persistently Poor [Bad, Bad]	1.0 (ref)		1.0 (ref)		1.0 (ref)	
Improved [Bad, Good]	1.13 (0.97, 1.33)		1.15 (0.98, 1.36)		1.17 (0.97, 1.41)	
Worsened [Good, Bad]	**1.22 (1.04, 1.43)**		**1.24 (1.05, 1.47)**		1.04 (0.86, 1.26)	
Persistently Good [Good, Good]	**1.39 (1.23, 1.57)**		**1.32 (1.16, 1.51)**		1.07 (0.92, 1.24)	
Model fit	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion
	5215.42	5304.83	5172.16	5422.37	5113.56	5381.63

M1: Adjusted for age, sex, and race/ethnicity.

M2: M1 + education, income, insurance status, employment status, self-perceived physical health (SF-12), cardiovascular disease, and study site.

M3: M2 + depressive symptoms (CES-D).

Bold font = $p < 0.05$

Table 4.

Odds ratios (ORs) and 95% confidence intervals (CIs) for association of one standard deviation (SD) higher optimism score with sleep quality and duration: Validated self-report measures and actigraphy data

N=641 to 648	Validated Self-report Measures				Actigraphy Data					
	ESS < 10 (normal range daytime sleepiness) vs. ≥ 10		PSQI ≤ 5 (favorable sleep quality) vs. > 5		Sufficient Sleep Duration (≥ 6 hrs)		Sleep Efficiency TOP 25th Percentile		Sleep Fragmentation BOTTOM 25th Percentile	
	OR (95 % CI)		OR (95 % CI)		OR (95 % CI)		OR (95 % CI)		OR (95 % CI)	
LOT-R Continuous Score										
M1: Minimally adjusted	**1.24 (1.04, 1.49)**		**1.73 (1.45, 2.05)**		1.17 (0.99, 1.39)		**1.22 (1.01, 1.47)**		1.08 (0.90, 1.30)	
Model Fit	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion
	705.39	727.76	848.99	871.35	769.86	792.22	671.65	693.97	709.56	731.92
M2: Multivariable adjusted	**1.23 (1.01, 1.48)**		**1.64 (1.37, 1.96)**		1.11 (0.93, 1.33)		1.14 (0.93, 1.39)		0.99 (0.82, 1.20)	
Model Fit	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion
	709.77	758.97	846.03	895.21	766.36	815.54	662.81	711.91	696.98	746.16
M3: Multivariable adjusted with psychological distress	1.06 (0.86, 1.31)		**1.22 (1.00, 1.49)**		0.98 (0.80, 1.20)		1.08 (0.87, 1.36)		0.98 (0.79, 1.21)	
Model Fit	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion	AIC	Schwarz criterion
	701.08	754.75	793.13	846.78	760.74	814.39	663.95	717.50	698.86	752.51

M1: Adjusted for age, sex, and race/ethnicity.

M2: M1 + education, income, insurance status, employment status, self-perceived physical health (SF-12), cardiovascular disease, and study site.

M3: M2 + depressive symptoms (CES-D).

Bold font = $p < 0.05$