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ORIGINAL PAPER

Basic psychological need frustration and health: Prospective associations with sleep quality and cholesterol

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Abstract

In the present study we examined whether basic psychological need frustration is related to poor sleep quality and risky cholesterol levels using National Survey of Midlife Development in the United States (MIDUS) data sets. We first constructed autonomy, competence and relatedness frustration scales from the items used in the MIDUS survey and validated its factor structure in a pilot study (N = 287). An exploratory factor analysis showed that the selected items loaded on to the respective need frustration subscales of basic psychological need satisfaction and frustration scale. Next, a confirmatory factor analysis with MIDUS II data (N = 3929) provided further evidence for construct validity with a clear three factor structure. After creating the scale, we used MIDUS II and the follow-up Biomarkers study data (N = 996) to examine whether frustration of basic needs prospectively predicts poor sleep quality and risky cholesterol levels. Path analyses indicated that frustration of basic needs predicted poor subjective sleep quality after 2 years, controlling for age, gender, ethnicity, income level, suspected or confirmed heart disease, and Body Mass Index (BMI). However, data from participants who also provided objective sleep quality measures via actigraphy (N = 269) showed no direct effect of need frustration on objective sleep quality. Mediation analyses indicated that frustration of basic needs predicted poor subjective and objective sleep quality after 2 years, via anxious arousal. Regarding cholesterol outcomes, logistic regression analyses indicated that frustration of basic needs increased the odds of having risky high-density lipoprotein (HDL) levels, after controlling for age, gender, ethnicity, income level, suspected or confirmed heart disease, and Body Mass Index (BMI).

Keywords Self-determination theory · Basic psychological needs · Sleep · Cholesterol · MIDUS

Developing a healthy lifestyle is essential for well-being. Daily routines and activities such as exercising (Berger and Motl 2000), engaging in hobbies (Newman et al. 2014), healthy eating (Boehm et al. 2018), and good sleep quality (Pilcher et al. 1997) are closely associated with both physical and psychological health. For instance, sleep, a vital part of our everyday lives, is essential for well-being (e.g., Reid et al. 2006). However, sleep deprivation is a common problem, with more than 40% of the public sleeping less than 6 h on average (Ford et al. 2015), 30% reporting signs of insomnia, with an estimated insomnia prevalence rate of 7% to 10% (Roth 2007). Similarly, another prevalent consequence of unhealthy lifestyle is developing risky cholesterol levels. Living with risky cholesterol levels is one of the main antecedents of cardiovascular disease (Stone et al. 2014), which is comorbid with poor sleep quality (Shahar et al. 2001), and also a leading cause of mortality worldwide (Moran et al. 2014).

Psychological factors play an important role in sleep quality and cholesterol levels. For instance, emotion regulation, anxiety and depression are closely associated with sleep

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quality (Alvaro et al. 2013; Palmer and Alfano 2017), and unhealthy cholesterol levels (Boehm et al. 2013; Manfredini et al. 2000; Papakostas et al. 2004). Although the literature shows various psychological antecedents of sleep quality and cholesterol, a theoretical approach would further our understanding by providing a more unifying and concise perspective. Moreover, it would also help practitioners by identifying the key overarching psychological constructs that can be targeted in interventions. Self-determination theory (SDT; Ryan and Deci 2017) provides such a perspective, as the theory identifies three basic psychological needs that are essential for well-being. The theory also received robust support in various applied contexts, including health contexts (Ng et al. 2012). Thus, in the present study we examined the psychological antecedents of sleep quality and health, from a self-determination theory perspective.

We investigated whether frustration of basic psychological needs (Vansteenkiste and Ryan 2013) were associated with poor sleep quality and risky cholesterol levels in a nationwide sample, using the publicly available National Survey of Midlife Development in the United States (MIDUS) datasets. To test these associations, we first created and validated a scale that captures the frustration of basic needs using items from different scales that were administered in the MIDUS project. MIDUS is a longitudinal project that spans over 20 years, and investigates the role of behavioral, psychological, and social factors in physical and psychological health of a nationwide sample of Americans aged between 25 and 74 (all data and documentation can be found at http://midus.wisc.edu/). In brief, we tested whether psychological need frustration predicts poor sleep quality and risky cholesterol levels prospectively, by creating a need frustration scale from items found on MIDUS datasets.

Basic Psychological Need Theory, a mini theory within SDT (Ryan and Deci 2017) posits that there are three basic psychological needs that are essential for well-being; namely, autonomy, competence, and relatedness. Autonomy refers to engaging in fully endorsed actions that are in accord with one's true self. Competence refers to feeling effective, capable, and optimally challenged. Relatedness refers to having a sense of belongingness and feeling genuinely connected to others. A great number of studies in various contexts consistently show that satisfaction of these needs is associated with greater well-being and positive outcomes such as life satisfaction, positive affect, and vitality (DeHaan et al. 2016; Ryan and Deci 2017; Yu et al. 2018).

Recently, researchers also suggested that a lack of psychological need satisfaction is different from need frustration that involves an active undermining of basic needs (Bartholomew et al. 2011; Vansteenkiste and Ryan 2013). Frustration of autonomy, competence, and relatedness refer to feeling controlled by external or self-imposed pressures, feelings of failure and doubts about own capabilities, and feelings of exclusion and loneliness, respectively (Chen et al. 2015). Studies showed that low need satisfaction is a stronger predictor of undermined positive outcomes related to well-being, whereas need frustration is a stronger predictor of negative outcomes related to ill-being (Costa et al. 2016; Ryan and Deci 2017). For example, basic need satisfaction was found to be more strongly linked with life satisfaction, positive affect and vitality, whereas basic need frustration was found to be more strongly linked with depressive symptoms, negative affect and physical symptoms (Unanue et al. 2014). Therefore, basic psychological need frustration may be more relevant for understanding poor sleep quality and risky cholesterol levels.

Although the association between basic needs and well-being is well-established, research using indicators of physical health are less common, compared to studies that use self-report measures of subjective well-being. Early studies assessing biological indicators focused on how autonomy support, which involves supportive behaviors that promote the satisfaction of basic needs, and perceived competence are related to blood glucose levels in diabetes patients using both longitudinal and intervention methods (e.g., Williams et al. 1998). More recently, researchers started to examine the associations between basic needs and other health indicators, such as diastolic blood pressure (Weinstein et al. 2016), cortisol reactivity (Reeve and Tseng 2011; Quested et al. 2011), sleep quality (Campbell et al. 2015) and cholesterol levels (Williams et al. 2017). In order to contribute to the relatively scarce literature, we examined whether need frustration was associated with two health indicators, poor sleep quality and risky cholesterol levels. Moreover, we tested these associations prospectively across a 2-year span, using a nationwide (US) sample.

Sleep quality and basic psychological needs

Sleep quality refers to a combination of subjective and objective aspects of sleep (Buysse et al. 1989). Subjective aspects of sleep quality are most commonly assessed with retrospective self-report questionnaires that include several indicators of sleep, such as perceived sleep quality (e.g. Buysse et al. 1989). Objective aspects of sleep quality, such as objective sleep duration, involve the use of devices such as polysomnography or actigraphy that record objective information on sleep. Subjective measures generally focus on qualitative aspects of sleep (e.g. perceived sleep quality, daytime functioning), whereas objective measures focus more on quantitative aspects of sleep (e.g. wake after sleep onset, number of awakenings). Objective sleep measures are moderately associated with subjective sleep measures, suggesting differences between individuals' perceptions of sleep quality and actual

sleep (Campbell et al. 2018b). Although objective measures of sleep quality may provide a more accurate measure of sleep quantity, they have limitations such as low ecological validity, because participants sleep with several sensors attached to their bodies (Creti et al. 2010). Moreover, these devices occasionally fail to distinguish between sleeping and lying very still while being awake (Sadeh and Acebo 2002). Given the limitations of both approaches, previous research suggests that assessing both subjective and objective aspects are important (Creti et al. 2010; Krystal and Edinger 2008). Therefore, in the present study we examined both subjective and objective measures of sleep quality.

It is well established that sleep quality plays an important role in daily functioning and well-being. Low quality sleep is associated with diminished cognitive functioning (Curcio et al. 2006), fatigue (Shahid et al. 2010), as well as, poor physical health (Reid et al. 2006). Sleep problems are even linked with increased risk for mortality (Kripke et al. 2002; Dew et al. 2003).

From an SDT perspective, frustration of basic needs would be associated with low sleep quality, as basic need satisfaction is essential for psychological constructs that predict sleep quality. For instance, both stress and anxiety predict sleep problems (Alvaro et al. 2013; Okun et al. 2018). Research also shows that need satisfaction is associated negatively with stress and anxiety (e.g., Lundqvist and Raglin 2015; Weinstein and Ryan 2011), and need frustration is positively linked with stress and anxiety (Inguglia et al. 2018; Li et al. 2019; Olafsen et al. 2017). Thus, basic psychological needs could be an upstream variable that predicts sleep quality. Indeed, a recent line of research provided evidence for the link between basic psychological needs and sleep quality.

In a first study on this topic, researchers found that overall need satisfaction was negatively related to self-reported poor sleep quality, and positively related to self-reported sleep duration and sleep efficiency in adults (Campbell et al. 2015). Similarly, studies with clinical samples showed that frustration of basic needs was associated with poor subjective sleep quality (Campbell et al. 2019), and poor objective sleep quantity (Campbell et al. 2018b). A short-term longitudinal study on university students also found that daily changes in need satisfaction predicts sleep quality, daytime dysfunction, and sleep quantity (Campbell et al. 2018a, c). In brief, recent research shows that basic need satisfaction is associated with poor sleep quality and quantity. The present research extends this line of work in two ways: (1) by testing these associations in a longer time frame with a nationwide sample, and (2) exploring the unique contribution of each need on different aspects of sleep. Although two of these studies examined the unique contribution of each need (Campbell et al. 2015, 2018b); the findings were mixed, and more research is needed. Following prior work, we hypothesized that frustration of basic needs would prospectively predict lower subjective and objective sleep quality (H1).

Although some studies showed zero-order correlations between basic needs and sleep quality (Campbell et al. 2015, 2019), others demonstrated only indirect effect of basic needs on sleep quality via mediator variables that were more proximal to autonomic nervous system (Campbell et al. 2018b). In fact, anxiety is one such psychological variable that predicts sleep problems (Alvaro et al. 2013), but is also a short-term (Quested et al. 2011) and a long-term outcome of thwarted basic needs (Uysal et al. 2017). According to SDT, need satisfaction leads to more effective regulation of anxiety, and acts as a buffer for the negative outcomes of stressful experiences (see Weinstein and Ryan 2011, for a review). Consequently, researchers proposed anxiety and stress as a potential mediator of the link between basic needs and sleep quality (Campbell et al. 2015, 2018b). Stress and anxiety are associated in a way that one type of anxiety, anxious arousal, tends to increase when people are confronted with stressful events (Nitschke et al. 1999). Also referred to as somatic anxiety (e.g., Lehrer and Woolfolk 1982), anxious arousal involves physiological symptoms and responses to stressful events. Therefore, we additionally tested whether need frustration would prospectively predict lower subjective and objective sleep quality via anxious arousal.

Poor sleep quality has high comorbidity with cardiovascular diseases. For instance, sleep problems such as sleep-disordered breathing is linked to heart failure, stroke, and coronary heart disease (Shahar et al. 2001). Similarly, sleep deprivation is associated with increases in blood pressure, sympathetic nervous system activity (Lusardi et al. 1996), and hypertension (Gangwisch et al. 2006). As poor sleep quality is comorbid with cardiovascular health, we also examined whether frustration of basic needs is related to a key predictor of coronary heart disease, risky cholesterol levels (e.g., Barter et al. 2007).

Cholesterol and basic psychological needs

Similar to sleep quality, cholesterol level is another indicator of daily health. Prospective studies suggest that psychological ill-being is an important antecedent of coronary health problems (e.g., Ganster and Rosen 2013; Rugulies 2002). In a more recent study, consistently high psychological well-being predicted healthier blood lipid levels (Radler et al. 2018). Therefore, basic psychological needs that are essential for psychological well-being may also provide a concise approach to examine the psychological antecedents of coronary health. In fact, there is some empirical evidence showing that basic need satisfaction is associated with healthy cholesterol levels.

In one of the early studies on this topic with tobacco users, the findings showed that autonomy support intervention, which involves providing choices and rationale to the participant, understanding and acknowledging the patient's perspective, was associated with greater improvements in low-density lipoprotein (LDL) cholesterol. Furthermore, this effect was mediated via increases in perceived competence for quitting smoking, a construct that can be considered as context specific competence satisfaction (Williams et al. 2006). In another intervention study with diabetes patients, the findings again showed that autonomy support increased perceived competence for managing diabetes, which was then linked to healthier blood lipid levels (Williams et al. 2007). Similarly, in a longitudinal study with a clinical sample, need support was found to be associated with decreases in bad cholesterol levels after 9 months (Block et al. 2016). The associations between perceived competence and healthier cholesterol levels were replicated in two more recent studies that used a virtual intervention for cholesterol management (Williams et al. 2017), and a physical activity intervention at a work setting (Pedersen et al. 2018).

Nevertheless, these studies focused on whether need-supportive interventions affected participants' motivation, with an emphasis on the mediating role of perceived competence for intervention related processes, rather than examining the role of each need in predicting cholesterol levels per se. Consequently, we are not aware of any studies that examined the associations between basic need frustration and risky cholesterol levels. Therefore, we hypothesized that frustration of basic needs would prospectively predict having risky blood lipid levels, after controlling for age, gender, ethnicity, income level, suspected or confirmed heart disease and BMI (H2). It is also important to examine these associations in more representative samples, because past studies that focused on SDT based cholesterol interventions mainly used patient samples. The present research also addresses this gap by testing the hypothesis in a nationwide sample.

Frustration of basic psychological needs could be associated with risky cholesterol levels in various ways. For instance, people may engage in unhealthy eating behaviors to cope with their frustrated needs (Froreich et al. 2017), which could lead to risky cholesterol levels (Brunner et al. 1997). Indeed, recent research shows that psychological need frustration is linked to unhealthy eating behaviors (e.g., Boone et al. 2014; Campbell et al. 2018a, c; Froreich et al. 2017). Further, basic need frustration was found to be linked with binge-eating symptoms (Verstuyf et al. 2013), which may lead to risky cholesterol levels. Another pathway could be via exercising. For example, basic psychological need satisfaction prospectively predicts physical activity levels (Barbeau et al. 2009), while basic need frustration is associated with negative emotional responses to exercise (Teixeira et al. 2018). Both of these variables, diet regulation and exercise, predict cholesterol levels (Leon and Sanchez 2001).

Anxious arousal could be one other potential mechanism for explaining the association among frustration of basic psychological needs and risky cholesterol levels. Prior research shows that anxiety is closely related with risky cholesterol levels (Rosmond and Björntorp 1998). Moreover, anxiety disorder patients' cholesterol levels were found to be riskier compared to healthy individuals' (Peter et al. 2002). Moreover, in a study with general anxiety disorder and comorbid major depression patients, significantly higher cholesterol levels were observed in general anxiety disorder patients (Kuczmierczyk et al. 1996). Frustration of basic psychological needs may build more stress, consequently anxious arousal, in individuals' lives, which may lead to unhealthy cholesterol levels. Therefore, we additionally tested whether need frustration would prospectively predict riskier cholesterol levels via anxious arousal.

The present research

The first goal of this research is to create a scale that captures the frustration of autonomy, competence, and relatedness needs in MIDUS datasets. Although MIDUS project generated more than 1000 publications with its publicly available data, self-determination theory research using these datasets are lacking. Consequently, the present study aims to lay the groundwork for basic needs theory researchers to use these rich datasets that spans over 20 years, by creating a scale that captures basic need frustration. A second goal is to extend the previous literature on basic needs and sleep by testing these associations in a longer term and a large, nationwide sample. A third goal is to test whether basic need frustration predicts risky cholesterol levels prospectively and extend the past research that only focused on perceived competence and cholesterol link in intervention contexts.

Therefore, we first constructed a scale that captures autonomy, competence and relatedness frustration scales from the items used in the MIDUS survey. After creating the MIDUS Basic Need Frustration scale, we used three different MIDUS datasets to test whether frustration of basic psychological needs is prospectively associated with subjective and objective sleep quality (H1), and whether need frustration prospectively predicts risky cholesterol levels (H2), across 2-years.

Pilot study: validation of the MIDUS basic need frustration scale

We first conducted a pilot study to construct autonomy, competence and relatedness frustration scales using items from the different scales administered in MIDUS survey. We initially

reviewed the items of the MIDUS II survey and used our expertise to identify five to six items for each need that would capture frustration of autonomy, competence, and relatedness needs. These initial items were chosen from Psychological Well-Being Scale (Ryff and Keyes 1995), Sense of Control Scale (Lachman and Weaver 1998), and Self-Esteem Scale (Rosenberg 1965).

Next, MTurk participants (N = 287) completed the Basic Psychological Need Satisfaction and Frustration scale (Chen et al. 2015) and the MIDUS scales mentioned above. We conducted exploratory factor analyses to test whether the selected items from MIDUS load on to the relevant need frustration dimensions of the Basic Psychological Need Satisfaction and Frustration scale. We followed a data-driven, iterative process that provided a clean three factor structure for each need. This approach resulted in a 9-item scale, with three items for frustration of each need. Finally, we conducted confirmatory factor analysis using MIDUS II (N = 3929) data to confirm the validity of the three-factor structure of the chosen items.

Method

Participants and procedure

The study was approved by the university Institutional Review Board prior to data collection. Participants were recruited through announcements on Amazon's Mechanical Turk (MTurk) platform. Previous research showed that MTurk data are at least as reliable as those obtained via traditional methods, and MTurk participants are demographically more diverse than college students or standard Internet samples typically recruited in research (Buhrmester et al. 2011). The survey was posted as an academic survey about psychological well-being, and only participants from U.S. were eligible. In order to improve the validity of the data, the study was only visible to MTurk users with a minimum 95% approval rate, meaning that they completed at least 95% of their previous tasks satisfactorily, and had at least 1000 approved tasks. Finally, all of the items included in the survey were presented in a randomized order. Participants received monetary compensation for completing the study.

We recruited 300 MTurkers for the pilot study, and 287 participants (167 female, 119 male) provided complete data. Participants were aged between 20 and 81 (M = 39.56, SD = 12.67), 84.3% were White, 79.7% had a college or higher degree.

Measures

Demographics

Participants were asked to report their age, sex, education level, and ethnicity.

Basic psychological need satisfaction and frustration

Participants completed the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS; Chen et al. 2015), which consisted of 24 items measuring both need satisfaction and frustration. The scale included equal numbers of (a) autonomy satisfaction (e.g., "I feel that my decisions reflect what I really want"), (b) competence satisfaction (e.g., "I feel capable at what I do"), (c) relatedness satisfaction (e.g., "I feel close and connected with other people who are important to me"), (d) autonomy frustration (e.g., "I feel pressured to do too many things"), (e) competence frustration (e.g., "I feel like a failure because of the mistakes I make"), and (f) relatedness frustration (e.g., "I feel the relationships I have are just superficial") items. Participants rated the extent to which they agreed with the items on a scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*). Reliabilities for autonomy satisfaction, competence satisfaction, relatedness satisfaction, autonomy frustration, competence frustration, and relatedness frustration subscales were .79, .89, .86, .87, .91 and .91, respectively. Overall basic need satisfaction had a reliability of .92, and overall basic need frustration had a reliability of .95.

MIDUS items

Participants completed the 42-item short psychological well-being scale (PWB; Ryff and Keyes 1995); 12-item Sense of Control Scale (Lachman and Weaver 1998) and 10 items from the Rosenberg Self-esteem Scale (Rosenberg 1965). All items were coded in a way that higher scores reflected higher standing on items ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*). We initially started with approximately 20 items from these scales that could potentially capture satisfaction and frustration of different needs. We conducted several data-driven factor analyses until we obtained an acceptable factor structure. We selected 9 items from the initial items to conduct validity analyses (Table 1).

Results and brief discussion

We first conducted an exploratory factor analysis to test whether the selected 9 items would load on to the respective need frustration dimension of the BPNSFS. Thus, we ran a factor analysis with 21 items, with 7 items for each need frustration. Four of these items were from the respective need frustration subscale of BPNSFS, and 3 of these items were the items we selected from MIDUS. An exploratory factor analysis with maximum likelihood estimation and promax rotation using MTurk data (N = 287) showed 3-factors with eigenvalues greater than 1. These three factors explained 67% of the total variance. The items and their

Table 1 Basic need frustration and MIDUS items factor loadings

	Relatedness	Competence	Autonomy
I feel that people who are important to me are cold and distant towards me	**0.86**	0.02	−0.06
I have the impression that people I spend time with dislike me	**0.80**	0.13	−0.03
I have not experienced many warm and trusting relationships with others[a]	**0.76**	0.08	−0.05
I feel the relationships I have are just superficial	**0.71**	−0.05	0.20
Maintaining close relationships has been difficult and frustrating for me[a]	**0.66**	0.01	0.17
I feel excluded from the group I want to belong to	**0.65**	0.16	0.09
I do not fit very well with the people and the community around me[b]	**0.54**	0.09	0.13
I feel insecure about my abilities	−0.08	**0.88**	0.08
I certainly feel useless at times[c]	0.07	**0.80**	−0.04
At times I feel that I am no good at all[c]	0.11	**0.76**	−0.02
I feel disappointed with many of my performance	0.10	**0.75**	0.00
I have serious doubts about whether I can do things well	0.07	**0.67**	0.16
I feel like a failure because of the mistakes I make	0.29	**0.64**	−0.04
When I think about it, I haven't really improved much as a person over the years[d]	0.21	**0.49**	0.15
Most of the things I do feel like "I have to"	−0.02	−0.03	**0.84**
There are many things that interfere with what I want to do[e]	0.17	−0.18	**0.77**
My daily activities feel like a chain of obligations	−0.10	0.19	**0.74**
I feel forced to do many things I wouldn't choose to do	0.09	0.06	**0.72**
I sometimes feel I am being pushed around in my life[e]	0.16	0.08	**0.61**
I often feel overwhelmed by my responsibilities[b]	−0.08	0.37	**0.53**
I feel pressured to do too many things	0.04	0.27	**0.47**

Items with superscripts are from [a]Positive relations with others (PWB); [b]Environmental mastery (PWB); [c]Self-esteem (Rosenberg); [d]Personal growth (PWB); and [e]Perceived constraints (sense of control) scales. All other items are from Basic Psychological Need Satisfaction and Frustration Scale

factor loadings are provided in Table 1, All 9 items had loadings greater than .49 on the respective BPNSFS subscale. Reliabilities for the three-item autonomy, competence, and relatedness frustration subscales were .83, .86, and .84, respectively. The overall 9-item MIDUS Basic Need Frustration scale had a reliability of .92.

The correlations between the scales are presented in Table S1 in Supplementary. MIDUS autonomy frustration and relatedness frustration subscales showed the highest correlations with the respective subscales of the BPNSFS. However, MIDUS competence frustration subscale showed the highest correlation with the competence satisfaction subscale of the BPNSFS.

Next, we conducted a confirmatory factor analysis using MIDUS II data (N = 3929) to confirm the factor structure of the 9 items obtained in the MTurk data. We used the maximum likelihood estimation method in Mplus software (Muthen and Muthén 2010) to estimate the parameters. CFI and TLI values above .90, RMSEA and SRMR values below .08 indicate acceptable fit (Kline 2005). A confirmatory factor analysis with three latent variables for each need showed a good fit (χ^2 (24) = 385.77, $p < .001$, CFI = .97, TLI = .95, RMSEA = .06, SRMR = .035). Finally, we also tested a single factor structure to examine whether it provided a better fit. A single factor measurement model did not provide an acceptable fit to the data (χ^2 (27) = 1245, $p < .001$, CFI = .89, TLI = .85, RMSEA = .11, SRMR = .05).

These results show that MIDUS Basic Need Frustration scale we constructed provide an acceptable measure of basic need frustration. In the exploratory factor analysis all the items were in line with the respective need frustration subscale of the BPNSFS, showing moderate to high loadings. The items showed good reliability, and the three-factor structure was confirmed with the larger MIDUS sample.

Main study: need frustration, sleep quality, and cholesterol

In the main study, we used the MIDUS Basic Need Frustration scale created in the pilot study to test whether frustration of basic psychological needs is prospectively associated with subjective and objective sleep quality (H1), and whether need frustration prospectively predicts risky cholesterol levels (H2) in the MIDUS datasets.

Method

Sample

Data for the current study were drawn from MIDUS II self-administered survey (N = 4963; age range = 32–84), and the follow-up Biomarkers data (Love et al. 2010). MIDUS is a nationwide longitudinal project on psychological and biological changes in midlife. All MIDUS data collection process is reviewed and approved by the Education and Social/Behavioral Sciences and the Health Sciences IRBs at the University of Wisconsin-Madison. The first wave of data, MIDUS I, was collected between 1995 and 1996 through phone interviews and self-administered surveys with 7108 participants. The second wave of data, MIDUS II phone interviews and self-administered surveys, were collected between 2004 and 2006. There were several separate research projects in MIDUS II in addition to the self-administered survey. Biomarkers data were collected on average 2 years after the completion of MIDUS II survey, and it involves a subset of MIDUS II respondents (N = 1255; age range = 34–84). This dataset includes several well-being biomarker assessments including subjective sleep quality and blood lipid levels, collected at one of three General Clinical Research Centers around the country. This subsample involves more educated, but otherwise similar respondents compared to MIDUS II sample (Love et al. 2010). Furthermore, 445 of these participants (268 female, 177 male; mean age = 54.03, range = 34–83), also completed a separate 7 day long, daily actigraphy study that measured daily objective and subjective sleep quality, also on average 2 years after the completion of MIDUS II survey.

Sample: subjective sleep quality and cholesterol

The analysis sample included 996 individuals (547 female, 449 male; mean age = 55.20, range = 34–84) who completed the need frustration items on MIDUS II self-administered survey, as well as the subjective sleep quality and cholesterol measures on the Biomarkers Project (on average 2 years after completing MIDUS II self-administered survey). Participants with missing data on these variables were not included in the sample. Among these participants, 93.1% were White and 6.9% were from other racial backgrounds; 75.1% had a college education or more and 24.7% had a high school degree or less, and 0.2% had missing education information.

Sample: objective sleep quality

The analysis sample consisted of 269 individuals (147 female, 122 male; mean age = 53.99, range = 34–83), who completed the need frustration items on MIDUS II self-administered survey, and the objective sleep quality measures on the Biomarkers Project (on average 2 years after completing MIDUS II self-administered survey). Participants with missing data on these variables were not included in the analytical sample. We also included the one-item measure of daily subjective sleep quality in the analyses. Among these participants, 95.5% were White and 4.5% from other racial backgrounds; 72.1% had a college education or more and 27.9% had a high school degree or less.

Measures

Basic need frustration

Basic psychological need frustration was assessed with the MIDUS Basic Need Frustration scale constructed in the pilot study. Reliabilities for autonomy, competence, and relatedness frustration in the Biomarkers sample were .76, .68, and .79, respectively. The overall scale had a reliability of .84.

Subjective sleep quality

Subjective sleep quality was assessed at the beginning of the Biomarkers study (see Fig. 1) using the Pittsburgh Sleep Quality Index (PSQI; Buysse et al. 1989). PSQI is a 19-item scale that has seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency (i.e., what percentage of time spent in bed was the person asleep), sleep disturbances, use of sleeping medication, daytime dysfunction. These components can be analyzed separately or combined to obtain a global score ranging from 0 to 21. Participants rated their sleep quality for the past month, using items such as "Could not get to sleep within 30 min" and "Woke up in the middle of the night or early in the morning" on a 0 (*not during the past month*) to 3 (*three or more times a week*) scale, and higher scores reflect worse sleep quality. A global sleep quality score for PSQI was computed by summing the score of each component.

Daily subjective sleep quality

Daily subjective sleep quality was assessed with one item ("Overall quality of your sleep last night") during the sleep diary part of the project. Participants rated the item on a scale ranging from 1 (*very good*) to 5 (*very poor*) for 7 days within 10 min after waking up. Higher scores represent poor sleep quality. We used the mean score across 7 days as the outcome.

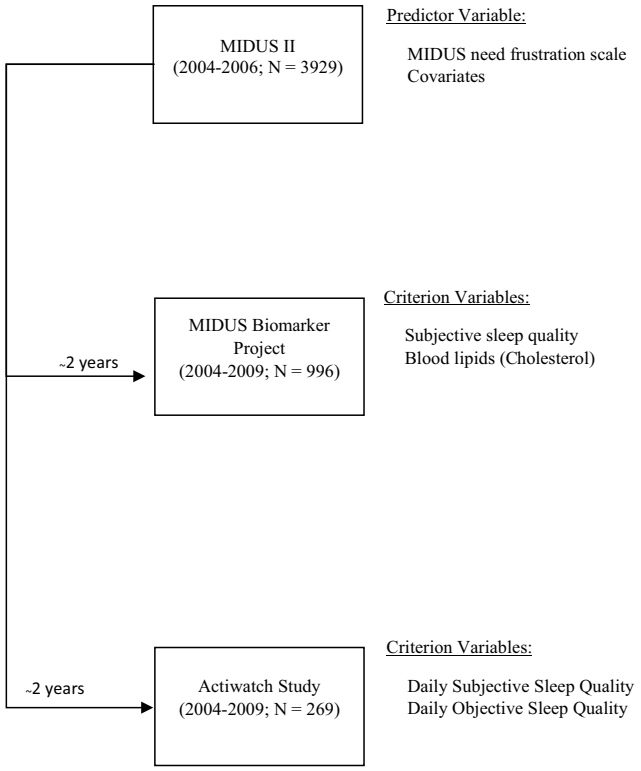

Fig. 1 Overview of timeline and data used in the study

Daily objective sleep quality

Daily objective sleep quality was assessed with actigraphy data using the Mini Mitter Actiwatch®-64 activity monitor. Participants wore the devices on their non-dominant wrist for seven consecutive days and nights, starting on a Tuesday morning 7:00 a.m. and ending on the next Tuesday morning. Participants recorded their bedtime and risetime in the daily diaries to determine the start and end times of actigraphy records. In 28 cases, daily diary records of participants were missing, and event markers on the device was used to determine those participants' bed and rise times. Sleep statistics of participants were estimated with activity counts within 30 s epochs. Participants' sleep status (i.e., whether they were asleep or awake) was determined by comparing activity counts of each epoch and immediate surrounding epochs to a predetermined threshold value. To analyze the actigraphy data, Actiware 5 software (Philips Respironics) was used (Ancoli-Israel et al. 2003). Actiware 5 software has the capacity to generate statistics about sleep and activity, and we used four summary statistics generated by the software as actigraphy sleep indices: sleep efficiency (the percentage of total sleep time to total spent time in bed), sleep onset latency (the time required for the onset of sleep after first attempting to get to sleep), wake after sleep onset (total time of awakenings during the night after falling asleep), and time dozing before rising (the time between waking up and getting out of bed) by taking the mean of each score across 7 days.

Cholesterol

In the Biomarker Project, participants visited one of three general clinical research centers (University of California, Los Angeles, University of Wisconsin, Georgetown University) for 2 days. On the second morning of the visit, fasting blood samples of the participants were collected for cholesterol measures. Additional information regarding the collection process can be found in previous research (Love et al. 2010). Cholesterol was assessed with four different measures: high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides, and total cholesterol levels. These cholesterol measures are among the most common biomarker measures in clinical medicine (Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults 2001). HDL is considered as the "good" cholesterol, and it is negatively associated with risk of heart disease (Prospective Studies Collaboration 2007). While an HDL level above 60 mg/dL is desirable, a level of 40 mg/dL is considered as a major risk factor for heart disease (Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults 2001). On the other hand, LDL is considered as the "bad" cholesterol, and it is positively associated with risk of heart disease (Prospective Studies Collaboration 2007). An LDL level below 100 mg/dL is desirable, levels above 160 are seen as high (Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults 2001). Triglycerides are also positively associated with risk of heart disease and triglycerides levels above 200 mg/dL are considered as high (Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults 2001). For total cholesterol, levels above 240 mg/dL are considered as high (Expert Panel on Detection, Evaluation and Treatment of High Cholesterol in Adults 2001). To determine participants' HDL, triglycerides, and total cholesterol levels, enzymatic colorimetric assays were used. To determine participants' LDL levels, Friedewald formula (Friedewald et al. 1972) was used. Mean values were 185.76 mg/dL (SD = 38.48, range = 91–326) for total cholesterol, 126.51 mg/dL (SD = 72.50, range = 25–507) for triglycerides, 55.34 mg/dL (SD = 17.97, range = 19–121) for HDL, and 105.11 mg/dL (SD = 34.65, range = 6–231) for LDL.

Anxious arousal

Anxious arousal was measured using 17 items from the anxious arousal subscale of the Mood and Symptom Questionnaire (Clark and Watson 1991) in the MIDUS Biomarkers Study. Participants were asked to report how much they felt

or experienced anxiety symptoms (e.g., "hands were shaky"; "heart was racing or pounding") during the past week on a scale from 1 (not at all) to 5 (extremely). Ratings of items were summed to make an overall anxious arousal score and the reliability was .84.

Covariates

Covariates for both outcomes included age, gender, ethnicity, education level, income level, suspected or confirmed cancer, suspected or confirmed heart disease, family history of heart disease and Body Mass Index (BMI). Family history of heart disease was measured with one item "Has anyone in your immediate family (blood relatives only) had heart disease?", suspected or confirmed cancer was measured with one item "Have you ever had cancer?", suspected or confirmed heart disease was measured with one item "Have you ever had heart disease?" with yes and no answers. Family history of heart disease was coded such that a score of 1 indicated "no" and 2 indicated "yes". Suspected or confirmed cancer and suspected or confirmed heart disease were coded such that a score of 0 indicated "no" and 1 indicated "yes".

Analysis plan

In all analyses, we used MIDUS Basic Need Frustration Scale to prospectively predict sleep and cholesterol outcomes that were measured after 2-years on average, after controlling for potential demographic confounds. We also conducted MANCOVA analyses to remove non-significant potential confounds. We were not able to conduct longitudinal analyses, because the Biomarker Project did not include need frustration items from MIDUS II.

For subjective sleep quality analyses, we used MIDUS II and the 2-year follow-up Biomarker Project (N = 996) to examine prospective associations between basic need frustration and subjective sleep quality (H1). We conducted prospective path analyses to test the regression model, controlling for potential demographic confounds. For objective sleep quality analyses, we used the outcomes from sleep study data, a sub-sample of Biomarker Project (N = 269), which measured daily subjective and daily objective sleep quality (actigraphy) for 7 days. We used the average scores across 7 days for sleep quality as outcomes.

For cholesterol analyses, we dichotomized four different blood-lipids measurements to represent risky versus healthy cholesterol levels, based on past research guidelines (Grundy 2001), because clinical significance of cholesterol levels is not necessarily linear. Then, we conducted logistic regression analyses to test whether need frustration increases the odds of having risky cholesterol levels (H2). The study samples and the related measurements are summarized in Fig. 1.

Results

Results for sleep outcomes

Correlations, means and standard deviations are provided in Table 2. In general, need frustration subscales showed small significant correlations with subjective sleep quality outcomes in the expected direction. We conducted two path analyses to test whether basic need frustration is prospectively associated with lower subjective global sleep quality. All of the covariates, age, gender, ethnicity, education level, income level, suspected or confirmed cancer, suspected or confirmed heart disease, family history of heart disease and BMI, showed significant effects in MANCOVA analyses. Therefore, we controlled for all of the variables in path analyses (see coefficients in Table S2 in the Supplementary). The findings showed that overall need frustration is significantly associated with poor subjective sleep quality ($\beta = .19$, $p < .001$), subjective sleep latency ($\beta = .13$, $p < .001$), subjective sleep duration ($\beta = .07$, $p = .040$), subjective sleep disturbances ($\beta = .19$, $p < .001$), and subjective daytime dysfunction ($\beta = .32$, $p < .001$), but not with subjective habitual sleep efficiency ($\beta = .06$, $p = .060$) and subjective use of sleeping medication ($\beta = .04$, $p = .256$), after controlling for all covariates.

Next, we tested the effect of each need frustration simultaneously in a second path analysis. The findings showed that autonomy frustration was prospectively associated with subjective habitual sleep efficiency ($\beta = -.10$, $p = .001$), subjective sleep disturbances ($\beta = .08$, $p = .036$), and subjective daytime dysfunction ($\beta = .16$, $p < .001$). There were also significant associations between competence frustration and poor subjective sleep quality ($\beta = .10$, $p = .012$), subjective sleep latency ($\beta = .14$, $p < .001$), subjective habitual sleep efficiency ($\beta = .14$, $p = .001$), subjective sleep disturbances ($\beta = .14$, $p = .001$), and subjective daytime dysfunction ($\beta = .08$, $p = .033$). Finally, relatedness frustration was prospectively associated with poor subjective sleep quality ($\beta = .11$, $p = .004$), subjective sleep duration ($\beta = .12$, $p = .001$), and subjective daytime dysfunction ($\beta = .15$, $p < .001$).

We also conducted two additional path analyses to test whether basic need frustration would predict anxious arousal, which in turn, would predict lower global sleep quality. We controlled for all covariates, age, gender, ethnicity, education level, income level, suspected or confirmed cancer, suspected or confirmed heart disease, family history of heart disease and BMI. The findings showed that overall need frustration significantly predicted poor sleep quality via anxious arousal, after controlling for all covariates, $\chi^2\ (9) = 64.90$, $p < .001$, CFI = 0.97, RMSEA = .08, SRMR = .02 (see Fig. S1 in

Table 2 Prospective correlations between MIDUS Basic Need Frustration scale and subjective and objective sleep quality outcomes after 2 years

Variables	Overall need frustration	Autonomy frustration	Competence frustration	Relatedness frustration
Overall need frustration	–			
Autonomy frustration	.83***	–		
Competence frustration	.85***	.58***	–	
Relatedness frustration	.82***	.47***	.53***	–
Subjective sleep quality outcomes				
Global sleep quality	.24***	.18***	.23***	.20***
Subjective sleep quality	.22***	.16***	.20***	.20***
Sleep latency	.16***	.12***	.18***	.10**
Sleep duration	.12***	.06	.10**	.14***
Habitual sleep efficiency	.09**	.02	.12***	.08*
Sleep disturbances	.21***	.20***	.21***	.14***
Use of sleeping medicine	.05	.05	.04	.04
Daytime dysfunction	.36***	.32***	.29***	.29***
Daily assessed subjective sleep quality outcomes				
Daily subjective sleep quality	.19**	.17***	.18**	.12*
Objective sleep quality outcomes				
Sleep efficiency	− .08	− .03	− .09	− .08
Sleep onset latency	.07	.02	.09	.07
Wake after sleep onset	.06	.04	.05	.07
Time dozing before rising	.02	− .01	.04	.01
M	2.52	2.99	2.15	2.44
SD	1.13	1.40	1.27	1.40

Higher scores reflect poor sleep quality

*$p < .05$; **$p < .01$; ***$p < .001$

Supplementary). The indirect effects of overall need frustration on subjective poor sleep quality ($\beta = .03$, $p < .001$), sleep latency ($\beta = .06$, $p < .001$), sleep duration ($\beta = .02$, $p = .005$), sleep disturbances ($\beta = .10$, $p < .001$), use of sleeping medication ($\beta = .07$, $p < .001$), and daytime dysfunction ($\beta = .05$, $p < .001$) through anxious arousal were significant, but the indirect effect on habitual sleep efficiency was not ($\beta = .01$, $p = .295$).

Then, we tested each need separately. The findings showed that frustration of each need significantly predicted poor sleep quality via anxious arousal χ^2 (9) = 62.55, $p < .001$, CFI = .97, RMSEA = .08, SRMR = .02 (see Fig. S2 in Supplementary). All indirect effects of basic needs frustration through anxious arousal on sleep quality outcomes were significant, except for habitual sleep efficiency ($\beta = .01$, $p = .211$ for autonomy frustration, $\beta = .01$, $p = .215$ for competence frustration, $\beta = .01$, $p = .252$ for relatedness frustration).

We followed similar procedures for objective sleep quality outcomes and subjective sleep quality. There were no significant associations between need frustration and objective sleep quality outcomes. We conducted two path analyses to test whether basic need frustration would predict lower objective and daily subjective sleep quality. Overall need frustration did not predict objective sleep efficiency ($\beta = -.05$, $p = .357$), objective sleep onset latency ($\beta = .05$, $p = .415$), objective time dozing before rising ($\beta = .02$, $p = .685$), and objective wake after sleep onset ($\beta = .02$, $p = .769$). However, the findings showed that overall need frustration significantly predicted poor daily subjective sleep quality ($\beta = .15$, $p = .010$), after controlling for all covariates (see coefficients in Table S3 in the Supplementary). Next, we tested each need simultaneously, however, the findings showed no significant unique effects.

We also conducted two additional path analyses to test whether basic need frustration would predict anxious arousal, which in turn, would predict lower objective and subjective sleep quality. The findings showed that overall need frustration significantly predicted, sleep efficiency, wake after sleep onset, and poor subjective sleep quality via anxious arousal, after controlling for all covariates χ^2 (9) = 23.80, $p = .005$, CFI = .98, RMSEA = .08, SRMR = .03 (see Figure S3 in supplementary). The indirect effects of overall need frustration through anxious arousal on sleep efficiency ($\beta = -.08$, $p = .003$), wake after sleep onset ($\beta = .09$, $p = .001$), and poor daily subjective sleep quality

($\beta = .09$, $p = .001$) were significant, but the indirect effects on sleep onset latency ($\beta = .05$, $p = .079$) and time dozing before rising ($\beta = .04$, $p = .131$) were not.

Then, we tested each need separately. The findings, showed that autonomy and competence frustration significantly predicted sleep efficiency, wake after sleep onset, and poor daily subjective sleep quality via anxious arousal, after controlling for all covariates, whereas relatedness frustration did not χ^2 (9) = 23.24, $p = .005$, CFI = .98, RMSEA = .07, SRMR = .02 (see Figure S4 in supplementary). The indirect effects of autonomy frustration through anxious arousal on sleep efficiency ($\beta = -.04$, $p = .023$), wake after sleep onset ($\beta = .05$, $p = .013$), and poor subjective sleep quality ($\beta = .05$, $p = .016$), the indirect effects of competence frustration through anxious arousal on sleep efficiency ($\beta = -.04$, $p = .036$), wake after sleep onset ($\beta = .05$, $p = .024$), and poor subjective sleep quality ($\beta = .04$, $p = .028$) were significant, the other indirect effects were not.

Results for cholesterol outcomes

Correlations, means and standard deviations are provided in Table 3. First, we performed a MANCOVA to examine the effect of age, gender, ethnicity, education level, income level, suspected or confirmed cancer, suspected or confirmed heart disease, family history of heart disease and BMI on study measures. Education level, suspected or confirmed cancer and family history of heart disease had no significant effects, whereas age, $F(8,960) = 11.33$, $p < .001$, gender, $F(8,960) = 27.27$, $p < .001$, ethnicity, $F(8,960) = 3.25$, $p = .001$, income level, $F(8,960) = 4.94$, $p < .001$, suspected or confirmed heart disease, $F(8,960) = 4.24$, $p < .001$, and BMI, $F(8,960) = 8.28$, $p < .001$, had significant multivariate effects on cholesterol measures and need frustration. In the following analyses, all of the significant covariates are controlled.

To examine whether basic need frustration prospectively predicts the likelihood of having risky cholesterol levels compared to healthy levels (H2), we binary coded each cholesterol measure. A score of 1 represented the risky level for each index (LDL > 159 mg/dL, HDL < 41 mg/dL, Triglycerides > 199 mg/dL, Total cholesterol > 239 mg/dL) and a score of 0 represented healthy cholesterol levels. We then conducted logistic regression analyses to test whether frustration of basic needs increases the odds of having risky cholesterol levels, after controlling for age, gender, ethnicity, income level, suspected or confirmed heart disease and BMI.

Logistic regression analyses showed that participants whose needs were more frustrated were more likely to have risky HDL levels ($OR = 1.17$, $p = .041$), but there was no significant effect on LDL ($OR = 1.10$, $p = .357$). The effects on triglycerides ($OR = 1.16$, $p = .068$) and total cholesterol ($OR = 1.16$, $p = .099$) also did not reach significance (Table 4). When we examined the role of each need, however, autonomy predicted the likelihood of having risky triglycerides levels ($OR = 1.36$, $p < .001$), but it did not significantly predict HDL ($OR = 1.51$, $p = .070$), LDL ($OR = 1.18$, $p = .111$), and total cholesterol ($OR = 1.18$, $p = .068$), competence frustration did not significantly predict risky triglycerides levels ($OR = .84$, $p = .061$), HDL ($OR = .97$, $p = .710$), LDL ($OR = .87$, $p = .222$), and total cholesterol ($OR = .86$, $p = .141$). Finally, relatedness frustration did not predict risky triglycerides levels ($OR = 1.02$, $p = .805$) HDL ($OR = 1.05$, $p = .503$), LDL ($OR = 1.06$, $p = .535$) and total cholesterol ($OR = 1.13$, $p = .158$), after controlling for all covariates. The findings are summarized in Table 5.

These findings provided partial support for the hypothesis that frustration of basic needs would be associated with risky blood lipid levels, after controlling for potential risk

Table 3 Prospective correlations between MIDUS Basic Need Frustration scale and cholesterol outcomes after 2 years

Variables	1	2	3	4	5	6	7	8
1. Overall need frustration	–	.82***	.83***	.81***	.05	.05	−.06	.06
2. Autonomy frustration	.83***	–	.55***	.45***	.05	.09**	−.09**	.05
3. Competence frustration	.85***	.58***	–	.53***	.03	.02	−.06	.05
4. Relatedness frustration	.82***	.47***	.55***	–	.03	.01	−.01	.04
5. Total cholesterol	.07*	.07*	.04	.06	–	.34***	.16***	.91***
6. Triglycerides	.09**	.07*	.06	.09**	.34***	–	−.37***	.17***
7. HDL	−.09**	−.07*	−.06*	−.07*	.17***	−.46***	–	−.12***
8. LDL	.08*	.08*	.06	.06	.90***	.18***	−.13***	–
M	2.52	2.99	2.15	2.44	186.59	132.52	55.37	105.53
SD	1.13	1.40	1.27	1.40	40.17	131.82	17.97	35.40

Number below the diagonal shows zero-order correlations; numbers above the diagonal shows partial correlations after controlling for age, gender, ethnicity, education level, income, cancer, suspected or confirmed heart disease, family history of heart disease, and body mass index

*$p < .05$; **$p < .01$; ***$p < .001$

Table 4 Odds ratios for general need frustration prospectively predicting risky cholesterol levels after 2 years

Predictors	Total cholesterol			HDL			LDL			Triglycerides		
	OR	[95% CI]		OR	[95% CI]		OR	[95% CI]		OR	[95% CI]	
Step 1												
Need Frustration	1.16	.98	1.37	**1.17***	1.04	1.33	1.16	.96	1.40	**1.22****	1.06	1.41
Step 2												
Need frustration	1.16	.97	1.39	**1.17***	1.01	1.35	1.10	.90	1.34	1.16	.99	1.36
Age	1.00	.98	1.02	.99	.97	1.00	.99	.97	1.01	.99	.97	1.01
Gender	**1.55***	1.02	2.35	**.17*****	.12	.25	1.17	.73	1.86	**.44*****	.31	.64
Ethnicity	.85	.41	1.74	1.45	.75	2.78	.86	.39	1.91	1.85	.85	4.00
Income level	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Suspected or confirmed HD	.87	.48	1.56	1.38	.90	2.11	1.22	.66	2.28	1.16	.71	1.87
BMI	**1.03***	1.00	1.07	**1.11*****	1.08	1.14	**1.05****	1.02	1.09	**1.10*****	1.07	1.13

Effects of covariates in overall need frustration analyses are not presented for clarity

*$p < .05$; **$p < .01$; ***$p < .001$

factors (H2). There was only a significant effect of composite need frustration on HDL, and a unique effect of autonomy frustration on triglyceride levels, however, the other effects were not significant.

To test whether basic need frustration would predict anxious arousal, which in turn, would predict risky cholesterol levels, we conducted two path analyses. The findings showed that overall need frustration significantly predicted risky HDL and triglycerides levels via anxious arousal, after controlling for all covariates χ^2 (9) = 62.78, $p < .001$, CFI = .99, RMSEA = .08, SRMR = .10 (see Fig. S5 in Supplementary). The indirect effects of overall need frustration through anxious arousal on risky HDL levels ($\beta = .03$, $p = .006$) and risky triglycerides levels ($\beta = .04$, $p = .005$) were significant, but the indirect effects on risky LDL levels ($\beta = .03$, $p = .14$) and risky total cholesterol levels ($\beta = .01$, $p = .38$) were not.

Then, we tested each need separately. The findings showed that autonomy, competence, and relatedness frustration significantly predicted risky HDL and triglycerides levels via anxious arousal after controlling for all covariates χ^2 (9) = 64.50, $p < .005$, CFI = .99, RMSEA = .08, SRMR = .09 (see Fig. S6 in supplementary). The indirect effects of frustration of needs on risky HDL levels ($\beta = .02$, $p = .018$ for autonomy; $\beta = .02$, $p = .016$ for competence; $\beta = .01$, $p = .028$ for relatedness) and risky triglycerides levels ($\beta = .02$, $p = .015$ for autonomy; $\beta = .02$, $p = .014$ for

Table 5 Odds ratios for need frustration prospectively predicting risky cholesterol levels after 2 years

Predictors	Total cholesterol			HDL			LDL			Triglycerides		
	OR	[95% CI]		OR	[95% CI]		OR	[95% CI]		OR	[95% CI]	
Step 1												
Autonomy frustration	**1.23***	1.04	1.46	1.07	.94	1.21	**1.22***	1.00	1.48	**1.27*****	1.10	1.48
Competence frustration	.85	.69	1.04	.99	.85	1.14	.87	.69	1.09	.88	.74	1.05
Relatedness frustration	1.09	.93	1.29	1.11	.98	1.26	1.09	.90	1.31	1.08	.94	1.25
Step 2												
Autonomy frustration	1.18	.99	1.41	1.15	.99	1.34	1.18	.97	1.45	**1.36*****	1.15	1.61
Competence frustration	.86	.70	1.05	.97	.83	1.14	.87	.69	1.09	.84	.70	1.01
Relatedness frustration	1.13	.95	1.34	1.05	.91	1.21	1.06	.88	1.29	1.02	.87	1.19
Age	1.00	.98	1.02	.99	.97	1.00	.99	.97	1.01	.99	.97	1.01
Gender	**1.53***	1.01	2.34	**.17*****	.12	.24	1.14	.71	1.82	**.40*****	.28	.59
Ethnicity	.86	.42	1.76	1.54	.79	3.01	.86	.38	1.90	2.12	.94	4.72
Income level	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Suspected or confirmed HD	0.84	.47	1.53	1.35	.88	2.07	1.20	.65	2.24	1.09	.66	1.07
BMI	**1.04***	1.01	1.07	**1.11*****	1.08	1.14	**1.06****	1.02	1.09	**1.10****	1.07	1.13

Effects of covariates in overall need frustration analyses are not presented for clarity

*$p < .05$; **$p < .01$; ***$p < .001$

competence; $\beta = .02$, $p = .024$ for relatedness) were significant, the other indirect effects were not.

General discussion

In this research, we examined whether frustration of basic needs predicts two biomarkers, sleep quality and cholesterol levels, using prospective data from a nationwide sample. We first created a Basic Need Frustration scale from MIDUS items and showed that these items are in line with the frustration subscales of Basic Need Satisfaction and Frustration scale (Chen et al. 2015). Next, findings from MIDUS II data and the follow-up biomarkers study demonstrated that frustration of basic needs prospectively predicted lower subjective sleep quality, after controlling for potential confounds. Finally, the results also showed that frustration of basic needs increased the odds of having risky HDL levels, after controlling for potential confounds.

This research contributes to the basic psychological needs literature in several ways. First, it provides a measure to capture basic need frustration in MIDUS data sets and paves the way for future studies examining these data sets. We only examined two outcomes using three data sets; however, this project provides publicly available, 20 year-long rich data with several datasets (including neuroscience data and cross-cultural data from Japan) for interested SDT researchers. Second, the findings extend the recent work on the association between basic need frustration and sleep by testing these associations prospectively across 2-years, using a nationwide sample. Third, it also contributes to the literature by demonstrating a context independent prospective association between frustration of basic needs and risky cholesterol levels. In short, the findings show the importance of basic needs for health, by demonstrating the significant associations with health indicators across 2 years, in a large, nationwide sample.

Basic need frustration and sleep quality

The findings showed significant associations between need frustration and subjective sleep quality outcomes. The findings are consistent with past research that revealed negative associations between need frustration and sleep quality using cross-sectional (e.g., Campbell et al. 2019) and longitudinal studies (Campbell et al. 2018a, c). This study extends the literature by replicating these associations prospectively in the longer term while using a nationwide sample. Although the effect sizes are not large, need frustration still predicts subjective sleep quality after 2 years, and also after controlling for various demographic factors. Additionally, our findings also showed that anxious arousal plays a role in the link between need frustration and subjective sleep quality outcomes except habitual sleep efficiency.

The analyses also showed that basic need frustration did not have significant direct associations with objective sleep outcomes, in contrast to subjective outcomes. One reason could be that the effect of basic needs on objective sleep measures can be captured by mediator variables that are more proximal to autonomic activation, such as anxiety and stress. Research suggests that need satisfaction leads to less stress incursion, as well as, better regulation and coping with stress (Weinstein and Ryan 2011). For instance, basic need satisfaction was associated with positive appraisals (challenge instead of threat), lower cortisol secretion (an indicator of stress), and lower levels of anxiety before a performance (Quested et al. 2011). Similarly, a recent study that examined the link between basic needs and objective sleep outcomes (Campbell et al. 2018b), found an indirect effect of basic needs on objective sleep outcomes via increased stress. In our study, we conducted additional analyses to test anxious arousal as a mediator, and found an indirect effect of need frustration on objective sleep quality outcomes such as sleep efficiency and wake after sleep onset via anxious arousal. Findings from our mediator analyses support the idea that basic need frustration can indirectly affect objective sleep quality via anxiety. Future studies can examine the other potential mediators of the associations between basic needs and sleep quality. For instance, inauthentic behaviors or activities have a detrimental effect on basic need satisfaction (e.g., Uysal et al. 2010, 2012). Behaviors that are not self determined or incongruent with one's true self could be more likely to lead to ruminative thoughts before sleep, leading to poor sleep quality. Nevertheless, more research is needed on the mechanisms of the link between basic needs and objective sleep quality.

When we examined the unique associations between basic needs and subjective sleep outcomes, competence frustration generally predicted subjective sleep outcomes more strongly. However, autonomy frustration was a stronger predictor for daytime dysfunction. This finding is consistent with a past study, which showed that only competence satisfaction significantly predicted subjective sleep quality, and only autonomy satisfaction significantly predicted daytime dysfunction when all three needs are used as predictors (Campbell et al. 2015). It should also be mentioned that autonomy frustration had a positive contribution on habitual sleep efficiency, which deviates from the one observed for overall basic need frustration. We believe that this could be an example of suppressor effect, due to the high correlation among autonomy frustration and competence frustration. Overall, the consistent findings suggest that there might be a pattern on how each need uniquely relates to different sleep outcomes, however, more research is needed before drawing conclusions on this issue.

Basic need frustration and cholesterol

We found that frustration of basic needs increases the odds of having risky HDL levels after 2 years. These findings are in line with past research demonstrating that autonomy supportive interventions are associated with healthier HDL based blood lipid measures in controlled trial studies (e.g., Williams et al. 2007; Pedersen et al. 2018). However, other studies also reported associations with LDL (Williams et al. 2017), in contrast to the findings of the present research. Nevertheless, these studies generally focused on the role of perceived competence in interventions, instead of examining whether basic psychological needs are directly associated with cholesterol. The current study expands this line of work by testing the direct associations between need frustration and cholesterol prospectively, in a nationwide sample without an intervention context, and controlling for various demographic risk factors. Although the effect sizes were small, odds ratios suggest that one point increase in need frustration score, increases the odds of having risky HDL levels by 17%, after 2 years and after controlling for demographic risk factors.

When we examined the unique contribution of each need for cholesterol outcomes, we only found a significant association between autonomy frustration and risky triglyceride levels. Unfortunately, past research on SDT and cholesterol only examined the role of perceived competence; hence, this finding needs to be replicated before drawing conclusions. We also investigated the role of anxious arousal in the link between need frustration and risky cholesterol, and found an indirect effect of basic need frustration on risky HDL and triglycerides levels. Future research may also examine other mechanisms of the link between need frustration and risky cholesterol. For instance, it is well documented that exercising and daily activity has a positive effect on HDL and triglycerides (Trejo-Gutierrez and Fletcher 2007). Similarly, dietary behaviors also play an important role in maintaining healthy blood lipid levels (Leon and Sanchez 2001). Basic need frustration is associated with both unhealthy eating behaviors (e.g., Boone et al. 2014; Froreich et al. 2017) and exercising (Teixeira et al. 2018). Thus, these potential mechanisms could be tested in future studies.

Practical implications

The findings show that need frustration has long-term negative associations with sleep quality and good cholesterol. Although short-term interventions that facilitate need satisfaction are shown to be beneficial for coping with stress (Weinstein et al. 2016), the present findings suggest that long term health consequences of one's general need satisfaction levels should also be taken into consideration. Targeting everyday contexts that strongly influence one's general basic needs, such as work or family, is also important for health interventions. Although, short-term need support could be helpful for temporary situations, controlling work or family environments that continuously frustrate basic needs could still be detrimental to health in the long term.

Limitations

The present study also has some shortcomings. First, it should be noted that the need frustration scale we created is not a direct substitute of Basic Need Frustration scales. Some of the items might not reflect an ideal representation of the constructs, and researchers need to be aware of the limitations when drawing conclusions. For instance, the autonomy frustration item "I often feel overwhelmed by my responsibilities" cross-loads moderately on to competence frustration. People might feel overwhelmed by their responsibilities because they feel they "have to" meet these obligations, leaving no time for things they "want to" do, which would frustrate their autonomy needs. However, they might also feel overwhelmed because of highly challenging responsibilities that are beyond their capacity, which would frustrate their competence needs. Similarly, two of the competence frustration items were items from a self-esteem scale, a construct that is generally considered as an outcome of basic needs in self-determination theory literature. Finally, the competence frustration subscale showed the highest correlation with the competence satisfaction subscale (instead of competence frustration subscale) of the BPNSFS in the negative direction. This finding suggests that the competence frustration subscale could be capturing competence satisfaction in the opposite direction. Nevertheless, the findings of the pilot study suggest that the scale sufficiently captures autonomy, competence, and relatedness frustration with a clean three factor structure. Although we do not suggest that the MIDUS Basic Need Frustration scale we devised is a substitute for basic needs scales, we think that it captures basic need frustration sufficiently such that researchers can use this scale to complement their research with findings from MIDUS datasets.

Second, the subsample who participated in the Biomarker study is more educated than, but otherwise similar to MIDUS participants (Love et al. 2010). Moreover, the MIDUS sample is predominantly white, although the data were collected nationwide across the US. Thus, future studies are needed to examine these associations in different ethnicities, as well as, in different cultures. Third, although we conducted prospective analyses using outcomes measured after 2 years, we were not able to run cross-lagged analyses, because Biomarker data were only available for a single time point. Although there were sleep measures available for multiple days, we were not able to examine how need frustration relates to day-to-day within-person fluctuations

in sleep (Campbell et al. 2018c) because need frustration was not measured during those days. Analyses with multiple time points may reveal a cyclical relationship between sleep and need frustration (Campbell et al. 2017). These analyses could be possible in the future when the data for the second Biomarker study is completed and made available, and if daily measures of both need frustration and sleep are available. Nevertheless, the current findings are correlational, and they do not warrant causality.

Conclusion

In conclusion, these studies present a Basic Need Frustration scale that could facilitate the use of MIDUS data sets by self-determination theory researchers. Moreover, they also provide further evidence for the prospective associations between basic need frustration and two health indicators, using prospective nationwide data. Satisfaction of basic needs is not only essential for psychological well-being, but also for good sleep quality and healthy cholesterol levels.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval 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. Further information about the open data used in this study can be obtained from http://www.midus.wisc.edu/.

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