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# Subjective age and sleep in middle-aged and older adults

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***Objective***: Chronological age is commonly used to explain change in sleep. The present study examines whether subjective age is associated with change in sleep difficulties across middle adulthood and old age.
***Design***: Participants were drawn from the second (2004–2005) and third (2013–2014) waves of the Midlife in the United States Survey (MIDUS, $N = 2350$; Mean Age: 55.54 years), the 2008 and 2014 waves of the Health and Retirement Study (HRS, $N = 4066$; Mean Age: 67.59 years) and the first (2011) and fourth (2014) waves of the National Health and Aging Trends Survey (NHATS, $N = 3541$; Mean Age: 76.46). In each sample, subjective age, sleep difficulties, depressive symptoms, anxiety and chronic conditions were assessed at baseline. Sleep difficulties was assessed again at follow-up.
***Main outcome measures*:** Sleep difficulties.
***Results*:** An older subjective age at baseline was related to an increase in sleep difficulties over time in the three samples, and was mediated, in part, through more depressive symptoms, anxiety and chronic conditions. Feeling older was associated with an increased likelihood of major sleeping difficulties at follow-up in the three samples.
***Conclusion*:** Subjective age is a salient marker of individuals' at risk for poor sleep quality, beyond chronological age.

**Keywords:** subjective age; sleep; depressive symptoms; anxiety; chronic conditions

Poor sleep and insomnia are highly prevalent complaints in the general population. Approximately one-third of all adults report difficulties with sleep and symptoms of insomnia, including trouble falling asleep, difficulty in staying asleep, awakening early in the morning and experiencing non-restorative sleep (Ancoli-Israel & Roth, 1999; Morin, LeBlanc, Daley, Gregoire, & Merette, 2006; Ohayon, 1996). These complaints are very common among older individuals with prevalence estimates that may be as high as 70% in the oldest old (Jaussent et al., 2011; Reid et al., 2006). Poor sleep in old age is related to a spectrum of mental health problems, most notably depression and anxiety (Potvin, Lorrain, Belleville, Grenier, & Préville, 2014), as well as cognitive disturbances (Fortier-Brochu, Beaulieu-Bonneau, Ivers, & Morin, 2012), neuroendocrine and cardiovascular diseases (Fernandez-Mendoza & Vgontzas, 2013; Palagini et al.,

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2013), greater health service use (Kaufmann et al., 2013) and higher mortality risk (Parthasarathy et al., 2015). Chronological age is commonly used to index and explain changes in sleep quality (Jaussent et al., 2011; Knutson, Van Cauter, Zee, Liu, & Lauderdale, 2011; Soldatos, Allaert, Ohta, & Dikeos, 2005) and has been found to predict severe insomnia (Kaufmann et al., 2016). However, epidemiological studies have suggested that the ageing process per se is not responsible for the higher prevalence of sleeping difficulties in the elderly but rather the comorbidities associated with ageing (Ohayon, Zulley, Guilleminault, Smirne, & Priest, 2001; Stewart et al., 2006). Furthermore, there is significant variability in the rate of ageing, which is partly captured by subjective evaluation of age (Kotter-Grühn, Kornadt, & Stephan, 2016). The present study examines whether subjective age, that is how old or young individuals feel relative to chronological age is associated with sleep across middle adulthood and old age.

Subjective age has received growing attention recently as a biopsychosocial marker of ageing that is associated with a range of outcomes among older adults (Kotter-Grühn et al., 2016). Beyond chronological age, an older subjective age is a risk factor of poor mental and physical health (Choi & DiNitto, 2014; Demakakos, Gjonca, & Nazroo, 2007), poor cognitive status (Stephan, Caudroit, Jaconelli, & Terracciano, 2014) and higher risk of hospitalisation (Stephan, Sutin, & Terracciano, 2016) and mortality (Kotter-Grühn, Kleinspehn-Ammerlahn, Gerstorf, & Smith, 2009). Given the association between subjective age and these health-related factors, subjective age may also be associated with risk of sleep difficulties over time. The identification of such a relation could highlight a new pathway (e.g. sleep disturbance) that explains why individuals who feel subjectively older are at greater risk of deleterious health-related outcomes over time.

In this study, we tested the hypothesis that feeling older is associated with worse sleep because subjective age is related to a range of factors associated with insomnia symptoms and sleep quality in past research. Specifically, an older subjective age is related to a higher propensity to experience negative affect and anxiety (Stephan, Sutin, & Terracciano, 2015a), amplifies individuals' vulnerability to stress (Shrira, Palgi, Ben-Ezra, Hoffman, & Bodner, 2016), and is associated with more depressive symptoms (Choi & DiNitto, 2014). Anxiety and depression are common among older adults with sleep disturbances (Spira, Stone, Beaudreau, Ancoli-Israel, & Yaffe, 2009) and with insomnia (Fok, Stewart, Besset, Ritchie, & Prince, 2010). Individuals with an older subjective age are more likely to suffer from chronic conditions (Demakakos et al., 2007), which increase the severity of insomnia (Jaussent et al., 2011; Knutson et al., 2011).

The present study examined the relation between subjective age and sleep quality in three longitudinal cohorts. It was hypothesised that an older subjective age would be associated with worsening of sleep quality over time. In addition, the extent to which this association was accounted for by depressive symptoms, anxiety and disease burden was tested.

## Method

### *Participants*

The present study used data from the Midlife in the United States Survey (MIDUS), the Health and Retirement Study (HRS) and the National Health and Aging Trends Study

(NHATS). In all three samples, participants with complete data on subjective age, sleep, demographic and health-related covariates at baseline and sleep at follow-up were included. Data from outliers on subjective age were removed in the three samples (see Measures). All participants provided informed consent.

The MIDUS is a longitudinal study of US adults. The second (2004–2005, MIDUS II) and third waves (2013–2014, MIDUS III) were used in the present study. MIDUS II and III are supported by a grant from the National Institute on Aging (P01-AG020166). Complete data were obtained from 2350 participants (55% female, Mean Age = 55.54, SD = 11.20, age range = 30–84 years). The HRS is a national longitudinal study of Americans older than 50 years and their spouses, conducted by the University of Michigan (grant number NIA U01AG009740). Baseline sleep data were obtained from the 2006 wave, subjective age was first assessed in 2008, and follow-up measure was obtained from the 2014 wave; this HRS sample included 4066 individuals aged 50–95 years old (61% female, Mean Age = 67.59, SD = 8.79). The NHATS is a prospective cohort study of Medicare enrollees aged 65 years and older (grant number NIA U01AG032947), and conducted by the Johns Hopkins Bloomberg School of Public Health. Data from the 2011 and 2014 waves were analysed. The sample was composed of 3541 participants (59% female, Mean Age = 76.46, SD = 7.35, age range = 65–102) who provided complete data on the measures of interest. Attrition analyses are presented in Supplementary Material.

### *Measures*

#### *Subjective age*

Participants in all three samples were asked to report, in years, how old they felt. Following past studies (Brothers, Miche, Wahl, & Diehl, in press; Rubin & Berntsen, 2006), proportional discrepancy scores were calculated by subtracting chronological age from felt age and then divided by chronological age. A negative score indicated a younger subjective age, whereas a positive score represented an older subjective age. Values three standard deviations above the mean were considered outliers and excluded ($n$ = 35 in MIDUS, $n$ = 64 in HRS, and $n$ = 70 in NHATS).

### *Sleep*

Sleep quality was assessed at baseline and follow-up in each sample. In the MIDUS, participants answered four questions about how often they had trouble falling asleep, trouble with waking up during the night, trouble with waking up too early, and how often they feel unrested in the morning. The first three questions were the same in the HRS, except that the fourth one was formulated to indicate how often they felt rested. Based on prior studies (Canham, Kaufmann, Mauro, Mojtabai, & Spira, 2015; Kaufmann et al., 2013), answers were recorded so that individuals were considered as experiencing sleeping difficulties if they answered ‘almost always’, ‘often’ or ‘sometimes’ to the four questions in the MIDUS, and ‘most of the time’ or ‘sometimes’ to the first three questions and ‘sometimes’ or ‘rarely or never’ felt rested to the fourth item in HRS. In the NHATS, participants were asked to indicate how frequently over the last month, they took more than 30 min to fall asleep and the frequency of difficulty

returning to sleep when waking earlier than desired. Based on recent research (Spira et al., 2014), participants were considered as experiencing sleeping difficulties when they answered 'every night', 'most nights' or 'some nights'. In the three samples, the number of symptoms was summed to give an overall index of sleep quality, ranging from 0 to 4 in the MIDUS and the HRS, and from 0 to 2 in the NHATS.

### *Covariates*

Basic demographic factors and sleep medication were included as covariates. Demographic factors included age (in years), sex (coded as 1 for male and 0 for female) and race (coded as 1 for white and 0 for other). Educational level was reported in years in the HRS, whereas it was assessed using a scale that ranged from 1 'no grade school' to 12 'doctoral level degree' in the MIDUS and from 1 'No schooling completed' to 9 'Master's, professional or doctoral degree' in the NHATS. In the MIDUS, sleep medication was assessed by asking participants to report whether they ever used sedatives, including either barbiturates or sleeping pills (e.g. seconal, halcion, methaqualone) on their own during the past 12 months. In the HRS, individuals were asked whether they took any medications or used other treatments to help them sleep in the past two weeks. In the NHATS, they were asked how often in the last month they took medication to help them sleep, from every night (coded as 1) to never (5).

Depressive symptoms, anxiety and chronic conditions were included in additional analysis to examine whether they accounted for the link between subjective age and sleep over time. Depressive symptoms and anxiety were assessed with the Composite International Diagnostic Interview Short Form scales (Kessler, Andrews, Mroczek, Ustun, & Wittchen, 1998) in the MIDUS. In the HRS, depressive symptoms were assessed using an 8-item version of the Centers for Epidemiologic Study Depression, and anxiety symptoms were assessed using a 5-item version of the Beck Anxiety Inventory scale (Smith et al., 2013). In the NHATS, the Patient Health Questionnaire-2 (Kroenke, Spitzer, & Williams, 2003) and the Generalized Anxiety Disorder-2 (Kroenke, Spitzer, Williams, Monahan, & Löwe, 2007) were used to measure depressive symptoms and anxiety, respectively. In the three samples, the measure of chronic condition was the sum of diagnosed diseases and conditions, such as high blood pressure, diabetes, cancer, lung disease, heart condition, stroke, osteoporosis or arthritis.

## ***Data analysis***

In each sample, partial correlations were used to examine the association between subjective age and sleep at baseline, controlling for demographic factors, sleep medications, depressive symptoms, anxiety and chronic conditions. For the main analysis, multiple regression was used to predict sleep difficulties at follow-up from baseline subjective age, controlling for age, sex, education, race, and baseline sleep difficulties. In addition, a bootstrapping method (Preacher & Hayes, 2008) was used to estimate whether depressive symptoms, anxiety and chronic conditions mediated the relation between subjective age and sleep, controlling for the demographic factors and sleep medication. The statistical significance of these indirect effects was tested using 5000 bootstrapped samples and 95% bias-corrected confidence intervals. Confidence intervals that do not include zero indicated a statistically significant indirect effect (Preacher & Hayes, 2008).

Additional logistic regressions were conducted in each sample to examine whether subjective age was related to the likelihood of suffering from major sleep difficulties at follow-up. Major sleep difficulties were defined as the experience of all four sleep difficulties in both the MIDUS and the HRS (i.e. score = 4) (Kaufmann et al., 2016) and of the two difficulties in the NHATS (Spira et al., 2014). The basic model controlled for demographic factors, sleep medication and baseline symptoms. Depressive symptoms, anxiety and chronic conditions were included in an additional step.

## Results

Descriptive statistics for the three samples are presented in Table 1. The partial correlations indicated that an older subjective age was related to poorer sleep at baseline in the MIDUS ($r = .06$, $p < .01$), in the HRS ($r = .06$, $p < .001$) and in the NHATS ($r = .07$, $p < .001$) controlling for demographics, sleep medication, depressive symptoms, anxiety and chronic conditions.

As hypothesised, baseline subjective age was related to change in sleep difficulties in all three samples. Specifically, the linear regressions revealed that an older subjective age at baseline was related to an increase in sleep difficulties over time, controlling for the demographic factors (see Table 2, Model 1). This relation was independent of chronological age. Of note, the size of the association between subjective age and change in sleep difficulties was stronger or comparable to those of the demographic factors. The relation between subjective age and change in sleep was still significant in the MIDUS and the NHATS when depressive symptoms, anxiety and chronic conditions were included simultaneously in the regression model (see Table 2, Model 2). Bootstrap analysis revealed that the association between an older subjective age and more sleep difficulties at follow-up was partially mediated by higher chronic conditions in the MIDUS (point estimate = .04, 95% CI = .01, .09) and more anxiety in the NHATS (point estimate = .03, 95% CI = .01, .05). Higher depressive symptoms (point

Table 1. Characteristics of the samples.

| | MIDUS | | HRS | | NHATS | |
|---|---|---|---|---|---|---|
| Variables | *M*/% | SD | *M*/% | SD | *M*/% | SD |
| Age (Years) | 55.54 | 11.20 | 67.59 | 8.79 | 76.46 | 7.35 |
| Sex (% female) | 55% | – | 61% | – | 59% | – |
| Race (% white) | 95% | – | 85% | – | 73% | – |
| Education | 7.56 | 2.50 | 12.88 | 2.96 | 5.32 | 2.25 |
| Subjective age | −.18 | .15 | −.17 | .15 | −.16 | .16 |
| Depressive symptoms | .53 | 1.60 | 1.20 | 1.83 | 1.44 | .65 |
| Anxiety | .09 | .74 | 1.53 | .56 | 1.42 | .66 |
| Disease Burden | 2.22 | 2.29 | 1.95 | 1.28 | 2.49 | 1.53 |
| Sleep medication | 3% | – | 21% | – | 4.24 | 1.36 |
| Baseline sleep quality | 1.73 | 1.41 | 1.85 | 1.36 | .87 | .83 |
| Follow-up sleep quality | 1.82 | 1.45 | 2.02 | 1.37 | .90 | .84 |

Notes: MIDUS: $N = 2350$; HRS: $N = 4066$; NHATS: $N = 3541$.
Education, depression, anxiety, disease burden, sleep medication, and sleep were assessed using different methods in the three samples (see Method).

Table 2. Summary of regression analysis predicting follow-up sleep quality from baseline subjective age.

| | MIDUS | | HRS | | NHATS | |
|---|---|---|---|---|---|---|
| Predictor | Model 1 | Model 2 | Model 1 | Model 2 | Model 1 | Model 2 |
| Age | .00 | −.00 | −.00 | −.01 | −.00 | −.00 |
| Sex | −.05* | −.04* | −.03* | −.02 | −.04* | −.03* |
| Education | −.03 | −.02 | −.08*** | −.05*** | −.07*** | −.06*** |
| Race | .01 | .01 | −.02 | −.01 | −.02 | −.02 |
| Sleep medication | .01 | .01 | .06*** | .05*** | −.04** | −.04* |
| Baseline sleep quality | .52*** | .50*** | .47*** | .44*** | .46*** | .45*** |
| Subjective age | .04* | .04* | .05*** | .02 | .05*** | .04** |
| Depressive symptoms | | .03 | | .08*** | | .00 |
| Anxiety | | .02 | | .07*** | | .06*** |
| Chronic conditions | | .04* | | .03* | | −.01 |
| Adjusted $R^2$ | .29 | .30 | .27 | .29 | .26 | .26 |

Note. MIDUS: $N = 2350$; HRS: $N = 4066$; NHATS: $N = 3541$.
*$p < .05$, **$p < .01$; ***$p < .001$.

estimate = .11, 95% CI = .07, .17), anxiety (point estimate = .10, 95% CI = .06, .15) and chronic conditions (point estimate = .03, 95% CI = .005, .07) were mediators in the HRS. In separate regression models that included depressive symptoms, anxiety or chronic conditions, the association of subjective age with change in the quality of sleep was reduced but remained significant in the three samples (see Supplementary Material Table 1). Overall, this pattern suggested that the association between feeling older and an increase in sleep difficulties over time was mediated in part by higher depressive symptoms, anxiety and more chronic conditions.

Finally, the logistic regressions indicated that an older subjective age was associated with an increased likelihood of major sleep difficulties in the three samples, controlling for demographic and baseline sleep (Table 3). More precisely, a 1SD older subjective age[1] was related to a 13–21% higher risk of suffering from the maximum number of sleep difficulties assessed in each study at follow-up. When depressive symptoms, anxiety and chronic conditions were simultaneously added, the association between subjective age and the severity of sleep difficulties remained significant in the MIDUS and the NHATS but was reduced to non-significance in the HRS (see Table 3). This relation was slightly attenuated by the separate inclusion of these variables in the three samples (see Supplementary Material Table 2). Across samples, higher depressive symptoms and anxiety were the covariates with the largest impact on the association between an older subjective age and severe sleep difficulties.

## Discussion

In three large longitudinal samples of older adults, the present study examined the relation between subjective age and sleep. The results supported our hypothesis that an older subjective age is related to worse sleep over time, independent of chronological age and other demographic factors. In addition, feeling older was a significant predictor of major sleep difficulties at follow-ups that ranged from 3 to 10 years later. The results

Table 3. Logistic regression predicting severity of sleeping difficulties at follow-up from baseline subjective age.

| | MIDUS[a] | | HRS[a] | | NHATS[a] | |
|---|---|---|---|---|---|---|
| Predictor | Model 1 Odds ratios (95% CI) | Model 2 Odds ratios (95% CI) | Model 1 Odds ratios (95% CI) | Model 2 Odds ratios (95% CI) | Model 1 Odds ratios (95% CI) | Model 2 Odds ratios (95% CI) |
| Age | 1.00 (.99–1.02) | 1.01 (1.00–1.02) | 1.00 (.99–1.01) | 1.00 (.99–1.01) | 1.00 (.99–1.01) | 1.00 (.99–1.01) |
| Sex | .87 (.68–1.10) | .94 (.74–1.20) | .80 (.66-.96)* | .81 (.67-.98)* | .84 (.71–1.00)* | .86 (.73–1.02) |
| Education | .89 (.79–1.00) | .91 (.81–1.02) | .94(.91-.97)*** | .96(.93-.99)* | .84(.77-.92)*** | .86(.79-.94)*** |
| Race | .86 (.52–1.44) | .86 (.52–1.44) | .70(.55-.88)** | .77(.61-.98)* | .76(.63-.91)** | .76(.64-.92)** |
| Sleep medication | .99 (.47–2.10) | .95(.54–1.67) | 1.25(1.03–1.52)* | 1.14(.94–1.40) | .91(.85-.99)* | .93(.86–1.01) |
| Baseline sleep quality | 3.00(2.63–3.42)*** | 2.82(2.47–3.22)*** | 2.62(2.37–2.90)*** | 2.44(2.20–2.70)*** | 2.64(2.42–2.88)*** | 2.59(2.37- 2.82)*** |
| Subjective Age | 1.22 (1.09–1.37)** | 1.20 (1.07–1.34)** | 1.15 (1.05–1.25)** | 1.07 (.98–1.17) | 1.12 (1.03–1.22)** | 1.11 (1.02–1.21)* |
| Depressive symptoms | | 1.16 (1.04–1.28)** | | 1.16(1.06–1.27)*** | | 1.00 (.90–1.10) |
| Anxiety | | 1.10 (1.00–1.22) | | 1.17(1.06–1.28)** | | 1.17(1.06–1.28)** |
| Disease Burden | | 1.04 (.99–1.10) | | 1.07 (1.00–1.15) | | .98 (.93–1.04) |

Note: MIDUS: $N = 2350$; HRS: $N = 4066$; NHATS: $N = 3541$.

[a]Major sleeping difficulties was defined as the experience of the maximum number of difficulties assessed in each samples, from two in the NHATS ($N = 1083$) to four difficulties in both the MIDUS ($N = 445$) and the HRS ($N = 745$).

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

were consistent across the three samples from middle age to older adulthood. These findings provide robust evidence that subjective age is a salient marker of individuals' risk of poor sleep quality.

There are several potential explanations that account for the relation between subjective age and sleep quality. Subjective age is a biopsychosocial marker of ageing (Stephan, Sutin, & Terracciano, 2015b) that captures and predicts a range of emotional, physical and biological processes manifested in sleep quality. In particular, individuals with an older subjective age have emotional profiles that may amplify their risk of poor sleep and its chronicity, such as higher depressive symptoms (Choi & DiNitto, 2014), vulnerability to stress (Shrira et al., 2016) and propensity to experience anxiety and negative emotions (Stephan et al., 2015b). Depressive symptoms, anxiety and stress are involved in insomnia and sleep disturbances (Fok et al., 2010; Spira et al., 2009). Furthermore, feeling older is related to suffering from chronic conditions (Demakakos et al., 2007), which is also related to severe sleep difficulties (Kaufmann et al., 2016). Additional bootstrap analysis supported these assumptions and suggested that higher depressive symptoms, anxiety and chronic conditions mediated part of the link between feeling older and poor sleep quality in the present study. Indeed, the association between subjective age and sleep quality was still significant even when these variables were included as mediators. In addition, some of these factors were not significant mediators. Thus, these findings suggest that additional mechanisms may operate in the association between subjective age and sleep-related factors. Social factors are also likely to explain part of this relation. Individual with an older subjective age are exposed to age discrimination, which is the perception of being treated unfairly because of one's age (Stephan et al., 2015b), and such discriminatory experiences are associated with worse sleep quality (Slopen & Williams, 2014; Vaghela & Sutin, 2016). In addition, the age an individual feels is related to physiological processes that are associated with changes in sleep over time. For example, an older subjective age reflects poor respiratory function (Stephan et al., 2015b), which is related to worsening sleep quality (Ezzie, Parsons, & Mastronarde, 2008). Finally, behavioural pathways may also operate in the association between subjective age and sleep. In particular, feeling older is related to lower participation in physical activity (Wienert, Gellert, & Lippke, 2017), which is likely to result into worse sleep (Chen, Steptoe, Chen, Ku, & Lin, 2017).

The results of this study suggest that sleep quality is a potential mechanism that links subjective age to a range of cognitive and health-related outcomes. Indeed, an older subjective age has been related to higher risk of hospitalisation (Stephan et al., 2016), inflammation (Stephan, Sutin, & Terracciano, 2015c), cognitive decline (Stephan et al., 2016), and mortality (Kotter-Grühn et al., 2009). It is likely that declines in sleep quality over time may partly explain the relation between feeling older and these outcomes.

This study has several strengths, including the replication of the association between subjective age and sleep in three large, independent longitudinal samples. The findings were robust despite differences in age, time of assessment and measure of sleep. In addition, several risk factors of poor sleep were included as covariates. However, several limitations need to be considered. The first limitation of our study arises from the fact that the survey-based assessment of sleep difficulties did not permit a diagnosis of chronic insomnia following standard international criteria. In addition, this study focused on subjective age as a predictor of changes in sleep. However, it is also likely

that poor sleep may impact subjective age. The longitudinal samples were characterised by positive selection, which limits the generalisability of the findings. Given that participants without follow-up measures were feeling older at baseline, the association between subjective age and sleep quality observed in the present study may be underestimated. Although the association of subjective age was stronger or comparable to those of demographic factors, the effect sizes were relatively small. However, sleep quality is complex and likely the result of a large number of factors, spanning from genetics to social influences. Therefore, each factor, including subjective age, is likely to have a limited association.

Despite these limitations, the present study identifies a new association between a biopsychosocial marker of ageing and sleep. This association was consistent across the three longitudinal samples of older adults over periods ranging from 3 to 10 years. In addition, the present study revealed that the subjective experience of age is stronger than chronological age as a predictor of sleep difficulties. This study has potential clinical implications for interventions. Indeed, subjective age may help identify individuals at higher risk of poor sleep and insomnia, which may be targeted by intervention efforts. In particular, stress-management interventions, such as mindfulness, may prove useful among individuals with an older subjective age, to reduce their anxiety and stress and ultimately their risk of impaired sleep and insomnia. In addition to identifying individuals at higher risk of insomnia, the present findings suggest that changing subjective age may help improve sleep quality. Future research may test whether standard interventions, such as physical activity programme or cognitive behavioural interventions, promote a younger subjective age, and whether such change may lead to lower stress, improved health and better sleep over time.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Supplemental data

Supplemental data for this article can be accessed here: https://doi.org/10.1080/08870446.2017.1324971.

## Note

1. A 1 SD difference in subjective age corresponds to an about 8-year difference in the MIDUS (the youngest sample), a 10-year difference in the HRS, and a 12-year difference in the NHATS (the oldest sample). For example, given two 70 years old HRS participants, the 1 SD difference would correspond to roughly one feeling 65 years old and one feeling 75 years old.

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