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Longitudinal Determinants of Energy Levels in Knowledge Workers

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Abstract

Objective—Increasingly, workers in the service, welfare, and health care sectors suffer adverse effects (ie, depression, burnout, etc) of "low-energy syndromes." Less is known about energy-based outcomes among knowledge workers. This study aimed to identify determinants of self-rated energy in knowledge workers and examine how these determinants change over time.

Methods—In collaboration with a large union and employer federation, 317 knowledge workers in Sweden responded to the health and productivity survey three times.

Results—At each assessment, worry, satisfaction with eating habits, and work-effectiveness were predictive of energy levels; however, only work-effectiveness covaried with energy over time.

Conclusions—This study suggests that perceived work-effectiveness is an important factor in preventing knowledge workers from experiencing "low-energy syndromes." Lifestyle factors also play a role. Therefore, multifaceted interventions for increasing energy are needed.

Working life is rapidly being transformed from an industrial and postindustrial economy to a service- and knowledge-based economy, where innovation and creativity are critical for the well-being of employees, organizations, and society at large.[1,2] To function effectively and remain in such an environment, employees' cognitive functions, skills, flexibility, motivation, and drive become increasingly critical resources.[3] Specifically, drive or energy is important in transforming cognitive skills and ideas into actions. At the same time, numerous reports suggest that knowledge and service workers are at an apparently increased risk to suffer from mood disorders and "low-energy syndrome," severely hampering their

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capacity to function effectively in a knowledge-based economy.[3–9] Indeed, low energy levels can severely hamper conscious decision-making processes,[10] reduce productivity,[11] and exhausts motivation.[12] Such effects lead also to a severe financial burden for employers.[11] Given the negative effects of low energy levels, it is important to examine the causal determinants of energy levels so that interventions aimed at increasing energy can be developed.

A review of the fatigue literature has shown that between 7% and 46% of the general population suffers from fatigue or low energy levels, with most of the variation because of the case definitions of fatigue.[13] Our own assessments indicate that anywhere between 25% and 40% of the population, dependent on type of profession and organization, suffers from "low-energy syndromes."[14] Nevertheless, an overwhelming proportion of studies in the field of stress, energy, "low-energy syndromes," and employee health and performance has focused on low- to mid-level skilled service workers, without representing the social welfare and health care sectors, which limits the applicability to the employees residing in the global and highly competitive knowledge-based society.[15–19] Moreover, most studies are cross-sectional, further limiting the reliability of proposed models as compared with studies observing participants over time.

In this study, we modeled the relationships of individual and work-related factors with employee energy over time in a group of knowledge workers. We tested the reproducibility of the proposed model by applying it to data collected from the group at three different periods of time over a 1-year period. Moreover, we verified the predictive validity of the model by studying the dynamic relationship between independent factors and energy over the 1-year follow-up period. Our main objective was to examine the determinants of change in energy over time.

METHODS

Setting

The target population for the study was *knowledge workers*, defined as those workers whose jobs consist mostly of generating and/or transforming knowledge into new products, for example, software or media products. We focused specifically on workers within the information and technology sectors, including media. These sectors are in the middle of an intense technological, structural, financial, and end-user behavior transformation. Moreover, they are increasingly feeling the pressure from globalization.

Participants

This study was conducted in collaboration with a large Swedish white-collar union (Unionen, formerly known as Sif) and the Swedish Employers' Association (Almega), who identified companies that were willing to offer the research team access to their employees. Potential participants in the study were identified by approaching member companies of Alecta, a Swedish occupational pension plan company, in their member subcategories of information technology and media. Alecta has a total of 33,000 member companies; however, far from all of these companies represent the information technologies and media

sectors. As can be seen in Fig. 1, the management teams of 10 information technology and media companies were asked whether they were interested in participating in the study. If affirmative, within each company, two to four departments were chosen for the study, and all employees in those departments were offered the opportunity to learn more about the study and, if interested, invited to participate in the study. These interested individuals were told about the purpose of the study, design issues, protection of the confidentiality of personal information, and what kind of aggregate would be reported to outside groups. They were also told that they could withdraw from further participation without any further explanation or any consequences for their job prospects. The study was approved by the institutional review board of Uppsala University, Uppsala, Sweden.

A total of 317 employees representing either information technology or media volunteered to participate in this study. Of them, 14 dropped out before the start of the study. The final sample thus consisted of 303 persons. During the 1-year study, a total of 26 participants were lost to follow-up. Respondents were asked to respond to a comprehensive, Web-based health and productivity survey at baseline and after 6 and 12 months. Results are based on the three sampling periods, as well as dynamic changes over the 1-year follow-up period. Descriptive statistics for the sample at each time point can be seen in Tables 1 and 2.

Survey

Participants responded to the health and productivity survey at three separate time points (baseline, 6 months, and 12 months), using a personalized and highly secured Web-based system. Survey questions included socioeconomics, professional experiences, stress and resilience factors at work, leadership and team/coworker interaction characteristics, lifestyle (eg, smoking, alcohol, exercise, and nutrition), as well as sleep and recovery strategies. Most survey questions used a 100-mm visual analog scale response system with anchors that indicated very low and very high agreement with the statement or question. Visual analog scale has been shown to be comparable to Likert scale when the Likert scale is composed of a single item or is measuring a unidimensional construct.[20]

Outcome Variable

Our main outcome variable, employee overall energy, consisted of the average of three visual analog scale items—self-rated energy, ability to concentrate, and overall quality of sleep. These three items have been shown to represent a single component with adequate internal consistency.[21] The measure has also been validated against “gold standards,” that is, through use of objective biological data as well as through prospective and controlled studies assessing the effects of antifatigue intervention on energy.[21]

Statistical Analysis

We conducted a series of hierarchical linear regression analyses predicting energy for each of the measurement time points, separately. For each time point, demographic variables were entered into the regression, followed by blocks of variables that represented eating habits, stimulant use, activity level, rest and reflection, work-related variables, and stress (see Tables 3 to 5). The regressions for each time point were then examined to determine which of these predictors of energy were consistently significant over the three time points.

This resulted in four consistent predictors of energy as follows: satisfaction with eating habits, work-effectiveness, overall stress, and tendency to worry.

On the basis of the regression analyses, two linear latent growth models[22] of the final subset of variables were examined using structural equation modeling with maximum likelihood estimation in LISREL 8.80.[23] The first model was a baseline model estimating growth in each of the predictors as well as the outcome (energy). This model was examined to evaluate overall growth in each of the constructs as well as to provide a baseline model for comparative purposes. When examining latent growth models, there are two latent constructs for each variable of interest. The first is the intercept, which indicates the average for that construct at a given point in time,[24] thus providing us with a baseline for comparison when examining change. The second is the slope, which indicates the rate of change over time for that construct.[24] For each latent construct, we must set the loading values. In this study, the intercept loadings were set to a value of 1 to show equivalence of measurement at each time point, and the slope loadings were set to indicate linear change (ie, 0, 1, and 2). The second model (Fig. 2) assessed the relationship between growth over time in the predictors and growth over time in the outcome. As in the previous model, intercept loadings were set to a value of 1, and slope loadings were set to model linear growth. Therefore, the only difference between the two models was that predictive relationships were estimated in the second model.

RESULTS

The results of the hierarchical regression analyses predicting energy can be seen in Tables 3 to 5. The final model for each of these regressions accounted for a substantial portion of the variance in energy ($R^2_{\text{Time 1}} = 0.44$; $R^2_{\text{Adjusted}} = 0.39$; $F_{23,236} = 8.19$; $P < 0.001$; and $R^2_{\text{Time 2}} = 0.51$, $R^2_{\text{Adjusted}} = 0.46$; $F_{23,234} = 10.68$; $P < 0.001$; and $R^2_{\text{Time 3}} = 0.53$; $R^2_{\text{Adjusted}} = 0.48$; $F_{23,229} = 10.99$; $P < 0.001$). As can seen in these tables, only satisfaction with eating habits, work-effectiveness, overall stress, and tendency to worry remained significant predictors across all three time points, suggesting that these variables are the most stable predictors of energy. Furthermore, these predictors uniquely accounted for more variance in energy than did the demographic variables at each time point, as can be seen by the squared semipartial correlations (r^2) in the Tables.

On the basis of the results of the regression analyses, we examined two latent growth models of energy and the four significant predictors of energy across time. The first model, a saturated baseline model, examined linear change in each of the variables across the three time points. This model provided a good fit to the data as can be seen by the fit indices in Table 6. Energy ($M_{\text{change}} = 1.94$; $z = 4.23$), satisfaction with eating habits ($M_{\text{change}} = 2.65$; $z = 3.75$), and worry ($M_{\text{change}} = –0.05$; $z = –3.19$) each showed significant change over time, whereas work-effectiveness ($M_{\text{change}} = 1.04$; $z = 1.79$) and overall stress ($M_{\text{change}} = –1.26$; $z = –1.82$) did not, Thus, energy and satisfaction with eating habits increased over time, worry decreased over time, and work-effectiveness and stress did not change significantly over time.

The predictive latent growth model also represented a good fit to the data (Table 6). The two models were compared using the chi-squared difference test. The predictive model fit the data significantly worse than the baseline model ($\Delta\chi^2 = 87.58$ greater than χ^2 critical = 43.77); however, the chi-squared difference test has been shown to be biased toward rejecting the null hypothesis.[25] Therefore, we also examined changes in practical fit, which are conceptualized as Root Mean Square Error of Approximation and CFI changes greater than 0.01.[26] The degree of practical change was very little (see Table 6), thus the predictive model was retained. As can be seen in Fig. 2, baseline levels of stress were not predictive of energy, whereas baseline levels of worry, satisfaction with eating habits, and work-effectiveness significantly predicted baseline energy levels. These relationships indicate that at each time point, there is a relationship between these variables and energy. In addition, the slope of work-effectiveness was predictive of the slope of energy. This indicates that change in work-effectiveness over time was predictive of change in energy over time, such that increases in work-effectiveness yielded increases in energy levels.

DISCUSSION

This study identifies consistent and reproducible predictors of employee energy—an important indicator of total employee health and productivity in knowledge-based professions. Knowledge workers make up a rapidly growing proportion of the workforce.[2,27] Nevertheless, apart from studies of physicians and nurses, there has been a relative void of studies of advanced knowledge workers, especially using prospective methods where the relationship of individual and workplace factors with health and productivity are modeled dynamically.[3,14] Considering the growing importance of this group of workers for society at large, as well as the group's relevance for enhancing our understanding of determinants of and effects from cognitive stress in advanced workers, there is a need for more research targeting this group of workers.

Both baseline and subsequent longitudinal data reveal that individual lifestyle and personality factors, such as tendency to worry, and work factors are associated with employee energy. Because the baseline model was reproduced at two separate time points, 6 months apart, the validity of the model is strengthened. The model suggests the importance of addressing lifestyle habits, tendency to worry, work stress, and work-effectiveness when addressing employees suffering from “low-energy syndromes.” It is increasingly recognized that both proper nutritional habits and exercise are effective anti-stress measures, results that the current study supports as well.[28–32] Tendency to worry is a marker of anxiety, which is a well-recognized risk factor for the susceptibility of a person to suffer adverse effects from acute and chronic stress.[33]

The study also revealed that employees’ ratings of worry, eating habits, and energy changed significantly over time, while ratings of work-effectiveness and overall stress did not. This indicates a need to more carefully look at stress as a causal factor in terms of predicting changes in energy over time.

The last step of the study concerned prospectively validating the model, using longitudinal methods that examine change over time in the model variables. This is a more robust means

of testing the model. We found that only changes in work-effectiveness predicted changes in energy. That is, knowledge workers who rate their work processes as becoming more effective over time also rated their energy as increasing over time. We believe that this is reflective of the fact that given a set amount of energy that one has to put into the process, those with effective work processes gets more out of energy dispersed. This finding is supported by our prior work, indicating that organizational efficiency is an important moderator of workplace stress.[2,34] Thus, knowledge workers suffering from "low-energy syndrome" might want to review, in collaboration with their managers and work team, means to enhance organizational efficiency and work-effectiveness. This might be viewed as the equivalent of energy mileage. The more effective the process, the higher the return from each unit of energy put in by the knowledge worker. Alternatively, employers may seek to improve the work-effectiveness of their employees by implementing one of a number of available interventions (see Ref.[35] for a review). Such interventions may indirectly increase energy levels in those employees.

CONCLUSION

With the rapid spread of the knowledge and information society, mental energy and employee fatigue are becoming critically important determinants of employee health and productivity, particularly in the knowledge-based sectors. On the basis of the current, prospective study, employee energy can be enhanced not only by focusing on lifestyle interventions but also by targeting work-related factors, such as work-effectiveness—that is, ensuring that the employee's investment of energy is maximally translated into value-added work. Such improvements should also enhance total employee health and satisfaction.[14]

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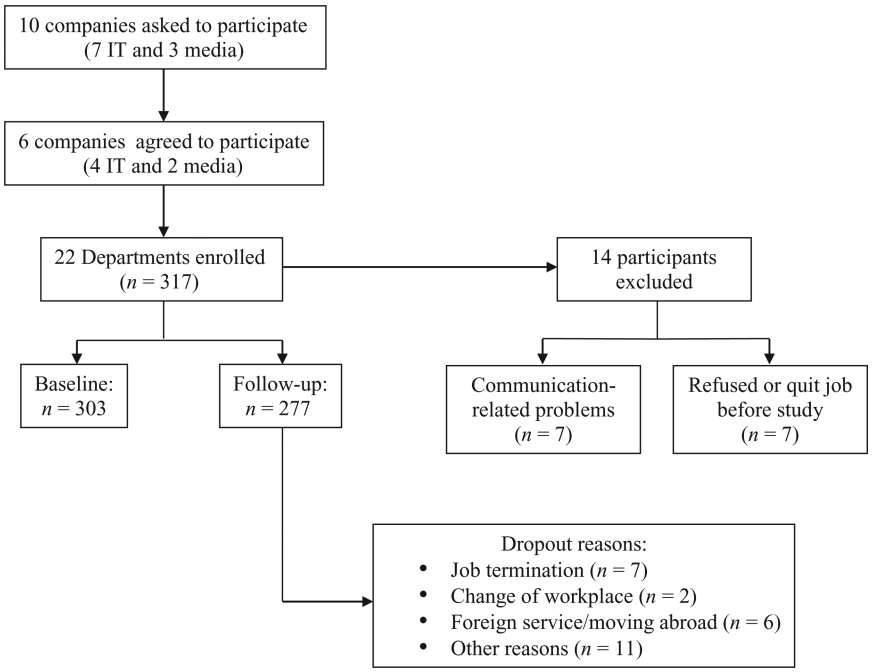

FIGURE 1.

Participant attrition over time. This flowchart explains the recruitment and retention of participants over the course of the study. IT, information technology.

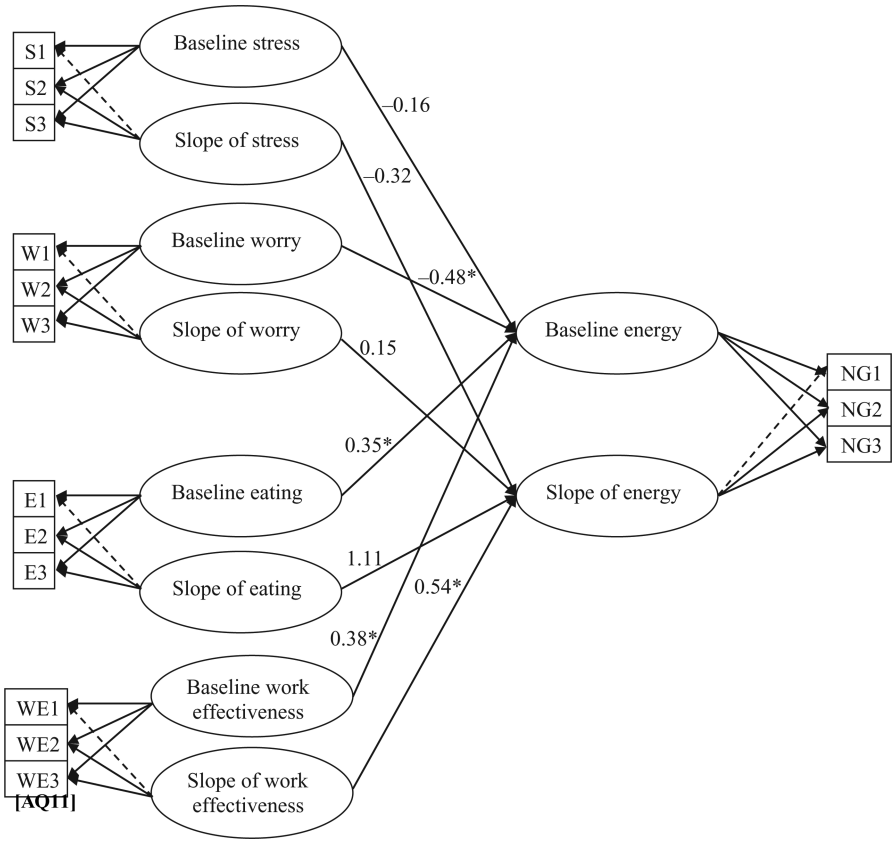

FIGURE 2.

Latent growth model depicting the prediction of change in energy over time. Baseline levels of stress, worry, satisfaction with eating habits, and work-effectiveness predict baseline energy levels, but linear change in energy is predicted only by linear change in perceptions of work-effectiveness over time. Directional pathways that are significant at $P < 0.05$ are denoted with a. *Baseline stress correlated significantly with baseline worry ($r = 0.43$; $z = 5.25$) and baseline satisfaction with eating habits ($r = –0.27$; $z = –3.42$). These correlations are not shown in the figure for reasons of clarity.

TABLE 1

Descriptive Statistics for Continuous Demographic Variables and Variables of Interest*

	Baseline			6 mo			12 mo		
	M	**SD**	***n***	***M***	**SD**	***n***	***M***	**SD**	***n***
Satisfaction with eating habits	51.32	24.00	279	55.93	22.49	258	57.08	22.24	263
Regular exercise	47.62	30.07	260	52.19	28.40	258	52.22	27.60	253
Exercise satisfaction	36.68	30.19	260	41.24	29.88	258	41.82	29.43	253
Personal reflection	48.90	26.51	260	51.68	26.74	258	52.53	26.09	253
Number of breaks	48.47	27.10	260	48.48	26.80	258	49.89	24.84	253
Work reflection	46.00	23.86	260	45.84	23.65	258	47.08	25.33	253
Work intensity	69.87	16.83	260	68.72	18.69	258	68.80	17.65	253
Satisfaction with hours	–1.18	1.06	260	–1.20	1.09	258	–1.17	1.09	253
Work effort	74.90	16.52	260	73.94	16.95	258	74.31	18.20	253

*All given scales variables were measured using visual analog scale response systems, with the exception of satisfaction with hours. All visual analog scale variables had a range of 0 to 100, whereas satisfaction with hours had a range of –8 to 8. For satisfaction with hours, negative numbers indicate that the participants are working more hours than desired.

TABLE 2

Descriptive Statistics for Discrete Demographic Variables and Variables of Interest

	n	%	*n*	%	*n*	%
Gender						
Male	184	61.5	175	61.8	170	61.6
Female	115	38.5	108	38.2	106	38.4
Education						
High school or less	136	48.7	117	45.3	125	47.5
More than high school	143	51.3	141	54.7	138	52.5
Marital status						
Single	59	21.1	57	22.1	64	24.3
In a relationship	12	4.3	10	3.9	6	2.3
Married/cohabiting	208	74.6	191	74.0	193	73.4
Age, yr						
<20	10	3.6	9	3.5	9	3.4
21–30	66	23.7	50	19.4	47	17.9
31–45	103	36.9	98	38.0	106	40.3
46–60	97	34.8	94	36.4	94	35.7
60	3	1.1	7	2.7	7	2.7
Children at home						
Yes	143	51.3	129	50.0	141	53.6
No	136	48.7	129	50.0	122	46.4
Yearly income, Crown						
0-100,000	16	5.7	1	0.4	6	2.3
100,000-250,000	45	16.1	37	14.3	42	16.0
250,000-400,000	170	60.9	162	62.8	154	58.6
400,000	48	17.2	58	22.5	61	23.2
Daily coffee, cups						
0	45	16.1	29	11.2	34	12.9
1–3	135	48.4	138	53.5	145	55.1
4–6	84	30.1	76	29.5	76	27.0
6	15	5.4	15	5.8	15	4.9
Daily caffeine, cups						
0	231	82.8	209	81.0	220	83.7
1–3	46	16.5	46	17.8	42	16.0
4–6	1	0.4	3	1.2	1	0.4
6	1	0.4	0	0.0	0	0.0
Tobacco						
Yes	58	20.8	57	22.1	58	22.1
No	221	79.2	201	77.9	205	77.9
Mobility						
Walk without problems	255	98.1	251	97.3	247	97.6

	n	%	*n*	%	*n*	%
Walk with some problems	5	1.9	7	2.7	6	2.4
Bedridden	0	0.0	0	0.0	0	0.0
Worry tendency						
Don't worry	155	59.6	177	68.6	177	70.0
Worry to some degree	95	36.5	75	29.1	69	27.3
Worry a great deal	10	3.8	6	2.3	7	2.8

TABLE 3

Final Model of the Hierarchical Regression Predicting Energy in Knowledge Workers at Baseline*

Block	Predictor	β	t	P	r^2
Demographics	Age	–0.07	–1.14	0.26	0.003
	Gender (female)	–0.07	–1.35	0.18	0.004
	Education (high school or less)	–0.04	–0.74	0.46	0.001
	Marital status (single)	0.11	2.05	0.04	0.01
	Annual income	–0.02	–0.26	0.80	<0.001
Eating	Satisfaction with eating habits	0.16	2.75	0.01	0.02
Stimulants	Coffee	0.06	0.95	0.35	0.002
	Caffeinated beverages	–0.04	–0.82	0.42	0.002
	Tobacco	0.06	1.11	0.27	0.003
Activity	Number of children	0.04	0.74	0.46	0.001
	Regular exercise	0.18	1.88	0.06	0.008
	Exercise satisfaction	0.09	0.99	0.32	0.002
	Mobility	–0.09	–1.68	0.10	0.007
Rest	Personal reflection	0.05	0.84	0.40	0.002
	Number of breaks	–0.006	–0.11	0.91	<0.001
	Work reflection	0.06	1.12	0.26	0.003
Work	Work intensity	–0.12	–1.76	0.08	0.007
	Satisfaction with hours	–0.08	–1.51	0.13	0.005
	Work effort	0.17	2.53	0.01	0.02
	Work-effectiveness	0.15	2.43	0.02	0.01
Stress	Overall stress	–0.15	–2.42	0.02	0.01
	Work stress	–0.001	–0.02	0.98	<0.001
	Tendency to worry	–0.35	–6.36	<0.001	0.09

*Reference categories for nominal variables are indicated in parentheses and were coded as zero in the regression analyses. r^2 represents the squared semipartial correlation, which indicates the unique percentage of variance accounted for in the outcome by each predictor.

TABLE 4

Final Model of the Hierarchical Regression Predicting Energy in Knowledge Workers at 6 Months*

Block	Predictor	*β*	*t*	*P*	r^2
Demographics	Age	–0.04	–0.69	0.49	0.001
	Gender (female)	–0.10	–1.87	0.06	0.006
	Education (high school or less)	0.02	0.33	0.74	<0.001
	Marital status (single)	0.12	2.23	0.03	0.01
	Annual income	0.03	0.64	0.52	0.001
Eating	Satisfaction with eating habits	0.14	2.57	0.01	0.01
Stimulants	Coffee	–0.11	–2.09	0.04	0.008
	Caffeinated beverages	–0.05	–0.92	0.36	0.002
	Tobacco	0.09	1.73	0.09	0.006
Activity	Number of children	0.10	2.01	0.046	0.008
	Regular exercise	0.05	0.54	0.59	0.001
	Exercise satisfaction	0.08	0.89	0.37	0.002
	Mobility	–0.11	–2.23	0.03	0.01
Rest	Personal reflection	0.004	0.07	0.95	<0.001
	Number of breaks	0.10	1.98	0.049	0.008
	Work reflection	0.07	1.27	0.20	0.003
Work	Work intensity	–0.03	–0.42	0.68	<0.001
	Satisfaction with hours	0.06	1.20	0.23	0.003
	Work effort	0.16	2.36	0.02	0.01
	Work-effectiveness	0.16	2.76	0.006	0.02
Stress	Overall stress	–0.31	–5.21	<0.001	0.06
	Work stress	–0.07	–1.02	0.31	0.002
	Tendency to worry	–0.24	–4.70	<0.001	0.05

*Reference categories for nominal variables are indicated in parentheses and were coded as zero in the regression analyses. r^2 represents the squared semipartial correlation, which indicates the unique percentage of variance accounted for in the outcome by each predictor.

TABLE 5

Final Model of the Hierarchical Regression Predicting Energy in Knowledge Workers at 12 Months*

Block	Predictor	*β*	*t*	*P*	r^2
Demographics	Age	–0.08	–1.48	0.14	0.004
	Gender (female)	0.004	0.07	0.94	<0.001
	Education (high school or less)	0.06	1.24	0.22	0.003
	Marital status (single)	0.02	0.32	0.75	<0.001
	Annual income	0.03	0.61	0.54	0.001
Eating	Satisfaction with eating habits	0.31	5.80	<0.001	0.07
Stimulants	Coffee	0.07	1.34	0.18	0.004
	Caffeinated beverages	0.03	0.68	0.50	0.001
	Tobacco	0.03	0.62	0.54	0.001
Activity	Number of children	0.06	1.07	0.29	0.002
	Regular exercise	0.06	0.63	0.53	0.001
	Exercise satisfaction	–0.02	–0.17	0.87	<0.001
	Mobility	–0.04	–0.89	0.37	0.002
Rest	Personal reflection	0.02	0.29	0.77	<0.001
	Number of breaks	0.08	1.54	0.13	0.005
	Work reflection	0.01	0.25	0.81	<0.001
Work	Work intensity	0.04	0.48	0.64	<0.001
	Satisfaction with hours	0.009	0.18	0.86	<0.001
	Work effort	0.13	1.97	0.051	0.008
	Work-effectiveness	0.32	4.92	<0.001	0.05
Stress	Overall stress	–0.16	–2.65	0.01	0.01
	Work stress	–0.09	–1.23	0.22	0.003
	Tendency to worry	–0.15	–2.75	0.007	0.02

*Reference categories for nominal variables are indicated in parentheses and were coded as zero in the regression analyses. r^2 represents the squared semipartial correlation, which indicates the unique percentage of variance accounted for in the outcome by each predictor.

TABLE 6

Fit Indices for the Latent Growth Models of Energy*

	df	χ^2	RMSEA	CFI	NNFI
Baseline model	55	153.32†	0.08	0.96	0.93
Predictive model	85	240.90†	0.08	0.94	0.93

*In comparing the two models, the predictive model was a significantly worse fit ($\Delta\chi^2 = 87.58$ greater than $\chi^2_{critical} = 43.77$), but there was little change in practical fit. RMSEA, Root Mean Square Error of Approximation.