An Investigation of the Role of Non–Work-Time Behavior in Buffering the Effects of Work Strain

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Objective: *In this exploratory study, we investigated the extent to which common leisure time behaviors, which generate positive feelings of fulfillment and personal reward, are significant in alleviating work-induced stress between successive work periods. We tested the hypotheses that such activities increase recovery from stress directly, and also by improving sleep quality, thereby alleviating maladaptive outcomes from work strain.* ***Method:*** *An on-line survey study was completed by a heterogeneous sample of 314 workers in diverse occupations, in good health.* ***Results:*** *Non–work-time behaviors play a significant role in mediating maladaptive outcomes from work strain. Multivariate analysis of these relationships indicates both direct and indirect effects, the latter being associated with mediating sleep quality. Respondents reporting higher levels of active leisure activities, exercise, and creative (hobby) and social activity, reported significantly better sleep, recovery between work periods, and lower chronic maladaptive fatigue symptomology.* ***Conclusion:*** *Active and fulfilling non–work-time behaviors are more significant in maximizing recovery from work strain than is commonly recognized. This effect is arguably due to the downregulation of stress-induced brain arousal, and stimulation of the pleasure-reward brain neurophysiology. Consistent recovery from work strain between work periods may represent a crucial factor in avoiding work-related "loss spirals" leading to maladaptive health outcomes, which can be particularly relevant to workers in inherently stressful occupations.* (J Occup Environ Med. *2007;49:862–871*)

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Overall, human kind is well adapted to withstand demanding environmental pressures that are perceived to be stressful.[1,2] Sterling and Eyer (1988) have coined the term "allostasis" to describe the processes by which this is accomplished.[3] However, extensive research performed during the last decade, extending the work begun by Cannon (1929)[4] and Selye (1956),[5,6] has identified that the capacity of the interrelated physiological systems that underpin this physiological mechanism within the brain is not unlimited.[7–9] Broadly, allostasis is achieved through the operation of a highly complex, interrelated, non-linear network of neurochemical processes throughout the brain, and whose effects extend to important bodily processes.[10] The neurochemical mechanism(s) underlying allostasis mediate the release of various hormones and neurotransmitters regulating the glucocorticoid and catecholamine output from the adrenal cortex and medulla. However, it has been demonstrated that the functioning of this process places the system itself under what McEwen (2003) has termed "allostatic load." This "load" derives from the fact that the overly long and overly frequent expressions of the relevant neurotransmitters and hormones have a cytotoxic effect, resulting in crucial damage to glucocorticoid receptors in the limbic system.[11]

Consequently, in circumstances where environmental stressors are unremitting, or very frequently experienced,[12,13] allostatic load is high with the potential to cause cellular level changes within the brain.[14,15]

Such changes have been identified as including, paradoxically, a progressive inability to regulate the allostatic mechanism adaptively. In other words, the stress response mechanism function becomes dysregulated, inducing maladaptive responses in associated networks within the overall allostasis network. The notable consequences of such an evolution include maladaptive changes within the cardiovascular,[16] immune,[17,18] and reproductive systems,[19] accompanied by significant depressive traits.[20–25]

Between 11% and 30% of European workers are affected by persistent work-related fatigue.[26–29] The US Health and Nutritional Survey identified abnormal fatigue levels among 14.3% of men and 20.4% of women,[30] and in Canada, similar levels have been reported. The economic cost of fatigue and stress and stress- and fatigue-related illness is notably high.[20,31–34]

However, examination of the current literature on stress-response neurophysiology suggests that workers *can* adapt successfully to high-stress and fatigue occupations in certain circumstance. The important determinant would seem to be whether they achieve a consistent level of *recovery* between successive sequences of work-related stress.[35–37] Intermittent stress experience followed by complete recovery can build what has been described as physiological "toughness." This is defined as low sympathetic nervous system (SAM) arousal base rates, but strong SAM arousal in response to stressors. It is associated with resistance to brain catecholamine (adrenalin and noradrenalin) depletion, and suppression of pituitary adrenal-cortical responses. Such "toughness" has been identified as corresponding with positive and effective performance in even complex tasks, emotional stability, and immune system enhancement.[38,39] However, where recovery between stress experiences is not consistently achieved, a different pattern emerges, which is associated with progressive dysregulation within the brain arousal processes, which are described above.[8,9,40,41]

Some stress and fatigue recovery can occur at work, during sanctioned meal breaks, waiting for task reassignment, and other spontaneous work breaks (microrecovery).[42] However, the bulk of work stress and fatigue recovery takes place in non-work time, between work shifts. This period offers the most extensive opportunity for the reversal of depleted physical and psychological resources; and reduction of stress-induced allostatic load. Mentally or emotionally high-demanding work strain has been noted to manifest a strong "spillover" effect, such that even though removal from the direct stress environment has occurred, a stress state, including anticipatory stress responses[43–45] (with accompanying high allostatic load) may persist long into non-work time.

A few studies have confirmed the significance of non–work-time recovery to subsequent work performance,[46–48] and point to the importance of consistently maintaining a balance between energy depletion at work, energy renewal at home, and the reduction of allostatic load.[37,49] However, to date (and to the best of our knowledge), the significance of different categories of non-work activity (NWA) (and their mediating or moderating role in recovery from work strain) has not been fully explored.

The accepted model of recovery from work fatigue during the intershift period seems to be essentially a function of time. Adequate recovery from acute work-related fatigue and stress is *assumed* to occur simply if an adequate amount of time is available for it, including time for efficient sleep. The implicit assumption seems to be that "recovery" is synonymous with "rest," and is essentially a *passive* process.

Passive rest may be sufficient to allow the physiological processes within the musculoskeletal system to be restored at a cellular level. However, high mental and emotional strain has been shown to recover better through *active* exercise, to levels over and above the simple "rest" afforded by being removed from the stressful (work) environment. For example, a Dutch study has identified that low levels of physical activity in men are a risk factor for the onset of persistent fatigue[50]; Israeli workers maintaining physical fitness through exercise (including sport and sport training) during leisure time reported lower levels of persistent fatigue[51]; a longitudinal study of Norwegian nurses' aides suggests that physical exercise during non-work time is protective against the progression of acute fatigue states to persistent fatigue traits.[52] In a Canadian study, women attributed their fatigue to lack of exercise,[53] and finally, the value of exercise to sleep efficiency has been confirmed in a number of studies.[54,55]

To date, however, relatively few studies have examined the relationship between common non-work activities, other than physical exercise, and fatigue and stress recovery. This is remarkable because two of the most common non-work pastimes are creative activity (including hobbies) and social activity. Broadly, creative activity offers opportunities for personal fulfillment, skill acquisition, and mastery achieved in a variety of ways ranging from the materially creative (handicrafts, art, etc) to the emotional (parenting, volunteer work, etc). There is evidence that such creative activities and hobbies play a significant role in workers' lives. Positive psychology highlights the importance of the sense of personal fulfillment as a significant component of emotional resilience.[56–59] More specifically, several studies have suggested that maintaining fulfilling creative activities in non-work time is protective against the progression of acute fatigue to burnout or chronic fatigue traits.[60–62] Similarly, the social activity that workers enjoy in non-work time is reported to be an important existential context for living, a perspective that might be termed "Working to Live."[60–64]

These activities can be argued to reduce allostatic load by stimulating a parallel "pleasure-reward" system network within the brain, whose active components include endorphins, dopamine, serotonin, etc. These chemicals have effects within the brain (broadly), which are almost the exact opposite of allostatic load.[65–70]

It is thus arguable that if a worker's response to acute work stress and fatigue includes a progressive reduction in exercise and creative and social activities, there is a commensurate loss of important sources of personal fulfillment, which might otherwise stimulate the release of pleasure-reward neurotransmitters with their stress-reducing, allostatic load-opposing potential. This *behavioral* change may lead to a prolongation of work stress spillover effects in non-work time, thereby increasing the overall period of allostatic load in any 24-hour sequence.

Thus, enduring high allostatic load mediates stress response downregulation failure, mediating even higher allostatic load, and so on. In other words, a vicious cycle has been established, inducing a slow downward "loss spiral" associated with declining mental and physical health. Anecdotally, workers affected by persistent stress and fatigue speak of an evolution in their work time and NWA pattern to one of "Living to Work."

The value of adequate quality sleep to the recovery process is well established.[53,54,71,72] However, there seems to be a tendency to assume, overly simplistically, that if sufficient time for sleep is available between work periods at appropriate times of the day and night cycle, adequate restorative sleep will occur. In fact, many workers with stressful occupations frequently experience difficulties with sleep quality, because of the persistence of stress-response brain arousal in non-work time.[28,73–76] Active exercise is known to have a beneficial effect on sleep quality, which may be associated with the stress minimization effects, previously described.[71,77–80] By comparison, the influence of other non–work-time activities, such as hobbies and social contact on sleep quality does not seem to have been fully explored.

In sum, current understanding of brain psychoneurophysiology indicates that recovery from work stress and fatigue is a complex multifactorial process, which includes various behavioral elements. Importantly, all these behaviors are potentially more completely within the discretionary control of the individual worker in non-work time than (arguably) is their stress exposure during work time. Such behaviors mediate neurohormonal effects, which could be expected to enhance sleep quality and broadly improve recovery from work strain. This suggests that passive "resting" in non-work time may not promote recovery from work strain as well as is commonly accepted, particularly where such strain has a high mental and emotional, rather than physical, character. Accordingly, our hypotheses for this study were as follows:

Hypothesis 1: Participants reporting higher levels of activity in their non-work time achieve better recovery (from their end-of-shift acute fatigue).

Hypothesis 2: Participants reporting higher levels of activity during non-work time experience better sleep quality.

Hypothesis 3: Participants reporting higher levels of activity during non-work time report lower chronic fatigue experience.

Hypothesis 4: The relationship between non–work-time activity and recovery is mediated by sleep quality.

Hypothesis 5: Non–work-time activity mediates the relationship between recovery and chronic fatigue evolution.

Methods

Participants

The study population comprised 314 working adults in good general health of mean (SD) age of 40.45 (10.9) years, of whom 72% (225) were women. The majority of participants (89% [277]) worked full-time for a mean (SD) of 39.4 (9.8) hours/week in jobs they had held for a mean (SD) of 14.7 (10.6) years. Approximately 28% (87) had dependent children and 65% (203) had current partners. The high proportion of female to male participants is notable, the most likely explanation being that nearly half of all respondents identified as working in the nursing, social work, education, or health care (broadly) fields, which tend to be dominated by women. The broad breakdown of participants according to occupation is shown in Table 1.

Materials

Among the demographic questions, participants were asked if they were aware of any physical or med-

TABLE 1
Distribution of Type of Work Undertaken by Study Participants

Work Area	Frequency	Percent
Academic	3	1.0
Administration	52	16.6
Civil service	4	1.3
Counselor	4	1.3
Education	27	8.6
Engineering	10	3.2
Finance	6	1.9
Health care	19	6.1
Human resources	6	1.9
Information technology (IT)	12	3.8
Law	6	1.9
Management	12	3.8
Media	3	1.0
Medicine	10	3.2
Nursing	95	30.3
Research	10	3.2
Sales	9	2.9
Service work	8	2.5
Social work	11	3.5
Student	4	1.3
Transport	3	1.0
Total	*314*	*100.0*

ical condition that reduced their energy levels below what they considered "normal" or "average." This enabled a potentially confounding variable of fatigue associated with a pathology or disease, eg, multiple sclerosis, chronic fatigue syndrome, cardiovascular disease, etc (as opposed to simply work-related strain), to be identified within the sample. In addition to demographic questions, all participants completed the following questionnaire measures.

The Occupational Fatigue Exhaustion Recovery Scale. This new 15-item measure has been validated in several studies as a measure of specifically work-related fatigue.[81,82] It comprises three subscales of five items each, representing chronic fatigue, acute fatigue, and (inter-shift) recovery, respectively. However, by virtue of the nature of analyses performed in the study, the acute fatigue subscale was not utilized.

Typical items for chronic fatigue include, "I often feel I'm at the end of my rope with my work," and, "I often wonder how long I can keep going with my work." The unique Occupational Fatigue Exhaustion Recovery (OFER15) measure of recovery from acute fatigue between work periods includes items such as, "I'm often still feeling fatigued from one work period by the time I start the next one" (recoded), and "Even if I'm tired from one work period, I'm usually refreshed by the start of the next work period." The recovery subscale is of particular value in examining the relationship between NWA engagement and stress and fatigue recovery experience. Each statement is responded to on a seven-point Likert scale between parameters of "completely agree" and "completely disagree." Cronbach α coefficients for the subscales are high ($>$0.83). Reported studies indicate that the construct of recovery, measured with the OFER15 subscale, strongly and negatively correlates with the chronic fatigue subscale.

Pittsburgh Sleep Quality Inventory. The Pittsburgh Sleep Quality Inventory (PSQI) is a validated questionnaire for comprehensive analysis of overall sleep quality comprising 19 items. The elements of sleep experience measured include length of time to achieve sleep, use of sleep-inducing medication, sleep disturbances, overall sleep length, self-perception of sleep quality, and non–sleep-time functioning. The PSQI index score is a number from 0 to 21, a higher number indicating poorer sleep. The authors report that a score of 5 or less on this scale is indicative of high sleep quality with no problems associated with sleeping. Cronbach α for this scale is reported to be 0.83.[83,84]

Non-work Activity. In the absence of a suitable extant scale, a custom-designed scale was created to measure the frequency of participant involvement with different activities in non-work time. A number of areas were assessed to be potentially valuable contributors to recovery in non-work time. Exercise, creative (hobby) activity, and social activity were anticipated to be the most important.

Typical questions included "In an average working week, how much time *in total* do you spend working alone on any hobbies or creative activity you have, which give you pleasure and satisfaction, and that you do *not* regard as work? This includes such things as arts and crafts, handiwork, sewing and needlework, collecting, model-making, gardening, etc?" A seven-point Likert response scale between the parameters of "None" and "More than 5 hours a week" was provided. Five other similarly worded items determined time spent on physical exercise, general social activity, social activity within the home (involvement with partner and dependant children), interaction with family pets, and finally particular household activities (specialist cooking, do it yourself, etc). The items stress that the activity tested is *not* regarded as work, but pleasurable and personally rewarding. The activities measured are a comprehensive range of realistic and typical behaviors capable of generating positive and relaxing states in direct contrast with work-activity stress and fatigue.

Procedure

The University of South Australia ethics committee approved an approach to the Clinical Directors of three metropolitan hospitals to allow all health care personnel to be invited to participate via the hospital's intranet by logging in to the study Web site. In addition, the study was widely promoted in the local media (print, television, and radio) inviting participation of the general public by e-mailing the first author to obtain an electronic link to the study Web site.

All such e-mail requests were replied to personally, providing brief details of the study, assurance of anonymity, and a "live" electronic link to the study. In addition, it was suggested that if the enquirer had friends or colleagues who might also be interested in participating, the link to the study site might be forwarded to them. In this way, it was hoped to increase participation by a "snowballing" effect.

Such a method of recruitment is criticizable on several theoretical grounds, which need to be addressed. For example, it was essentially limited to subjects with Internet connections. This can be argued to bias the sample in favor of higher socioeconomic status groups, although the penetration of Internet connectivity is reported to be currently of the order of 66% or more within Australia.[85] The reported occupational characteristics of the population do suggest a bias toward occupations with inherently higher psychosocial strain, as opposed to manual workers. However, this was the group that was particularly of interest, because the principle aim of the study was to explore the outcomes of the mediating or moderating effects of non–work-time behavior on high (neurocognitive) work strain.

It could be argued that the sample distribution was skewed as a consequence of "volunteer bias," whereby more fatigued workers might be less willing to participate, for example. By contrast, it can also be argued that fatigued workers may be more willing to contribute because of a greater personal interest in the subject. On balance, it was felt that these latter opposed positions are ultimately self-canceling. In addition, the study was of adequate size to ensure adequate statistical power for the analyses performed. In sum, it was felt that the study population was appropriate for the exploratory study being conducted, which was concerned more with testing the relationship between factors within the sample as an exemplar, and less with demonstrating absolute generalizability of findings.

A total of 395 full responses to the on-line questionnaire were received. Of these, a total of 79 participants responded affirmatively to the question about abnormal energy levels due to conditions (medical) other than workplace demands. Accordingly, these responses were excluded from subsequent analysis.

TABLE 2
Pearson *r* Correlations Between Age, Gender, Work Status, and Fatigue and Recovery, and Sleep Quality Scores

	OFER-CF	OFER-IR	Sleep Quality	NWAC Level	Age	Gender	Work Status
OFER-CF	(0.89)						
OFER-IR	−0.62*	(0.88)					
Sleep quality	−0.44*	0.44*	(0.85)				
NWAC level	−0.33*	0.29*	0.27*	(0.83)			
Age	−0.05	0.05	0.01	0.00	1.00		
Gender	−0.02	−0.04	0.06	0.00	0.03	1.00	
Work status	0.03	−0.01	0.09	0.08	0.08	−0.08	1.00

Numbers in parentheses are Cronbach α coefficient (where applicable).
$^*P < 0.001$.
OFER indicates occupational fatigue exhaustion recovery; CF, chronic fatigue; IR, intershift recovery; NWAC, nonwork activity; Sleep Quality, Pittsburgh Sleep Quality Index recoded; Part-Time, part-time working.

Results

Statistics

All statistical analyses were performed using SPSS 12 (Chicago, IL). Analysis of the study population size with the G-Power statistical application[86] indicated that a study *N* of 316 ensured a power of 0.95 to detect a small to medium effect size (0.075) at an α value of 0.05 in multiple correlation F tests with five predictors, and a small to medium effect size (0.2) in correlations *t* tests. In other words, there was a less than 5% chance of any statistically significant relationship being identified in these analyses of the population, which had occurred by chance.

Histograms of scores on the fatigue, recovery, sleep, and age variables were examined, which indicated they were normally distributed and therefore suitable for analysis without transformation.

Correlation Analysis

Pearson correlations (*r*) between the subscale scores of age, gender, work status, and other variables are reported in Table 2. A number of these are notable. The non-significant correlations among gender, age, work status, and other variables reported suggest that although the sample contained more women than men, this was not of significance. Similarly, the absence of any significant correlation between scale scores and work status suggested that the inclusion of a small percentage (<11%) of part-time workers in the sample was not likely to affect the overall results. By contrast, the correlations between the NWA and sleep quality, chronic fatigue, and recovery scores were all notably significant and in directions (respectively) that were predicted in Hypotheses 1, 2, and 3.

Regression Analysis of Non-work Activities and Recovery

The NWA measure contained six different activities. To determine their relative significance in predicting recovery, a linear regression analysis was performed with the OFER-IR (Recovery) score as the dependent variable and the separate forms of activity (items NWA 1 to 6) entered as independent variables in one block using the stepwise method of entry recommended by Tabachnick and Fidell.[87]

The results of this analysis indicated, as expected, that exercise ($\beta = 0.141$), creative (hobby) activity ($\beta = 0.135$), and social activity ($\beta = 0.236$) were the only significant predictors, explaining a total of 20% of the variance of recovery:

Final regression equation: F (3, 311) = 19.78, $P = 0.000$; adjusted $r^2 = 0.196$.

In view of the results of this analysis, only the scores for exercise, hobby, and social activity were used thereafter for further testing of the hypotheses. Analysis of these items considered as a three-item scale indicated a coefficient of internal reliability (Cronbach α) of 0.85. The sum of scores for these items was used to create a factor termed NWA.

Multivariate Analysis of Variance

Scores on the factor NWA were distributed between a minimum value of 3 and maximum value of 21. Accordingly, scores on the NWA scale were categorized into low (values between 0 and 9), medium (values between 9.1 and 15.0), and high (values between 15.1 and 21) to create the factor NWA Level.

Hypotheses 1, 2, and 3 predicted that higher NWA (NWA Level) would have a beneficial effect on

TABLE 3
Multivariate and Univariate Statistics for Sleep Quality and Recovery and Chronic Fatigue According to Non-work Activity Level: Low, Medium, and High

	Multivariate		Univariate						
			NWA Low (N = 94)		NWA Medium (N = 154)		NWA High (N = 66)		
Source	*df*	*F* Ratio	Mean	SD	Mean	SD	Mean	SD	*F* Ratio
Sleep quality			8.78	3.15	7.8	3.45	6.7	3.2	7.43*
Recovery	6618	10.92**	42.48	21.7	53.98	23.4	67.12	20.6	23.73**
Chronic fatigue			54.94	22.91	42.73	22.9	31.51	21.6	28.96**

*P < 0.05; **P <0.001.
[a]Multivariate F ratio based on Wilk's Lambda Statistic = 0.82, Univariate df = 2312.
df indicates degrees of freedom; NWA, non-work activity level; Recovery, OFER-IR subscale score; Chronic Fatigue, OFER-CF subscale score; Sleep Quality, Pittsburgh Sleep Quality Index score.

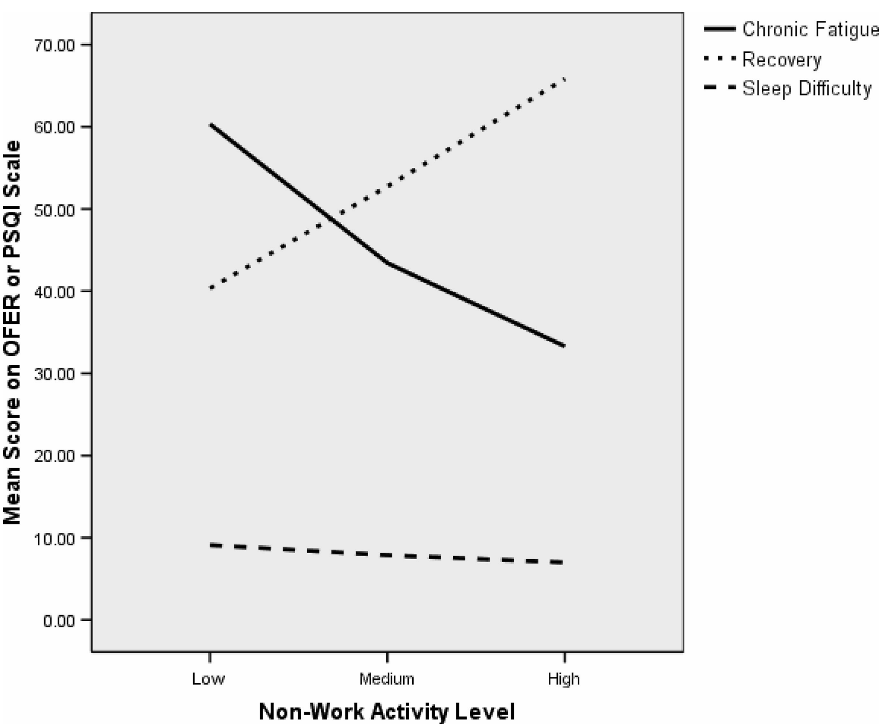

Fig. 1. Mean scores for chronic (maladaptive) fatigue, inter-shift recovery, and sleep difficulty according to NWA level.

recovery (OFER-IR score), sleep quality (PSQI score), and chronic fatigue (OFER-CF score). These hypotheses were tested simultaneously in a multivariate analysis of variance analysis with NWA Level as the independent variable and scores on the sleep quality, recovery, and chronic fatigue scales as dependent variables. Neither the Box test for equality in covariance matrix nor the Levene test of error variance was significant (P = 0.754 and P = 0.185, 0.487, and 0.710, respectively [for the three dependant variables]).

The results of this analysis are presented in Table 3. They indicate a significant effect of NWA Level on recovery, sleep quality, and chronic fatigue scores, as predicted in Hypotheses 1, 2, and 3.

This effect is also graphically illustrated in Fig. 1. It indicates a progressive and linear effect on chronic fatigue (which is reduced), inter-shift recovery (which is increased), and sleep problems (which are also reduced) according to the level of engagement with activity(s) (which have a stress response down-regulating capacity) during the non-work period between work shifts.

Testing for Mediation

A variable may be considered a *mediator* to the extent to which it carries the influence of a given independent variable (IV) to a given dependent variable (DV). Generally speaking, mediation can be said to occur when 1) the IV significantly affects the mediator, 2) the IV significantly affects the DV in the absence of the mediator, 3) the mediator has a significant unique effect on the DV, and 4) the effect of the IV on the DV shrinks upon the addition of the mediator to the model.[88]

Hypotheses 4 predicted that NWA Level would mediate the relationship between recovery and chronic fatigue. Hypothesis 5 predicted that sleep quality would mediate the relationship between NWA and recovery. These were investigated using the Sobel test of mediation by applying the following formula:

$$z\text{-value} = a{*}b/\mathrm{SQRT}(b^2{*}s_a^2 + a^2{*}s_b^2)$$

where a = raw (unstandardized) regression coefficient for the association between the IV and the mediator; s_a = standard error of a; b = raw regression coefficient for the association between the mediator and the DV (when the IV is also a predictor of the DV); and s_b = standard error of b.[88]

For Hypothesis 4, the Sobel test statistic was -3.64, $P = 0.0002$, and for Hypothesis 5, the Sobel test statistic was 3.43, $P = 0.0005$.

The Sobel test results confirm that 1) non–work-time activity is a significant mediator of the relationship between recovery and chronic fatigue, and that 2) sleep quality significantly mediates the relationship between non–work-time activity and recovery, both as predicted by Hypotheses 4 and 5, respectively.

Discussion

Analysis of these exploratory study results confirmed all of the hypotheses, and suggested strongly that, within the study population, a worker's pattern of non–work-time activity (notably in the areas of social contacts, exercise, and creative [hobby] activity) was significant in determining their quantum of sleep quality, recovery from acute work-related strain between successive work periods, and (reduced) chronic maladaptive fatigue experience.

As with any single-wave correlational survey study, it is acknowledged that it is not possible to infer causation from these results, and the composition of the study population, as a particular exemplar, is such that wider generalization of the results may be limited. Further, although we identify a clear association between non–work-time activity, sleep efficiency, recovery, and chronic fatigue, there is an important question that remains unanswered, namely, does work-strain recovery (with its value to sleep and chronic fatigue reduction) depend on non–work-time activity, (as we suggest), or does recovery (by some other means) permit more NWA? Other studies, for example, of a longitudinal quasi-experimental nature or experimental intervention design, are required to answer such questions definitively.

Nevertheless, the statistical power of this study was high, and the support for the study hypotheses is sufficiently strong to suggest that such further investigations are well merited. Furthermore, the neurophysiological literature suggests that adequate recovery from high-stress brain arousal, particularly when it is a regular (daily) feature, does not occur by chance or entirely through passive rest, unless the time available for such rest is generally much longer than the normal inter-shift period. In addition, a common naturalistic observation of individuals who become "burned out" or suffer disabling stress-related depression is that it tends to follow to a similar pattern. This is, typically, high work strain progressively leading to increasingly passive rest and disengagement, *which is not recuperative*, and a progression to ultimately maladaptive outcomes. Clinical management of such end states frequently involves stimulation of activity and engagement, not more rest or passivity. Thus, of the two possible explanations of our results, which we acknowledge, we would argue that ours is to be preferred.

According to current descriptions of brain neurophysiology, these effects can be argued to result from an activation of elements of "hedonistic" brain psychophysiology that have been described. The value of physical exercise to both sleep quality and recovery has already been identified in numerous other studies. However, to the best of our knowledge, this is the first study that has confirmed the value of other common activities such as hobbies and social activity to the work-strain recovery process. It is notable that the regression analysis indicated that the NWA most predictive of enhanced recovery was social activity. Exercise was also confirmed as being of significance, but interestingly, was less so than social activity; creative (hobby) activity was the least predictive.

At a practical level, these findings are potentially of some importance. For example, an individual worker may have limited control over how work-stress minimization practices are implemented in their workplace, if at all. In addition, despite the best implementation of such stress-reducing practices, certain occupations may remain inherently stressful. By comparison, however, a worker can be assumed to enjoy much higher discretionary control over their activities and behaviors in non-work time. We have shown such activity to have a significant potential capacity to affect their work-related strain recovery. These observations are consistent the few other studies that have examined non–work-time behavior effects, particularly by Sonnentag,[46,47] and Fritz and Sonnentag.[89] They are also in accordance with a longitudinal study by Demerouti (2004), who identified progressive increases in burnout incidence among workers experiencing significant work-home interference problems.[90]

The logical conclusion to be drawn from our results is that for workers who do work in inherently stressful occupations, their *conscious and deliberate* involvement with appropriate non–work-time activities may potentially constitute an important factor in determining whether they enter upon a slow downward spiral toward maladaptive responses to their work strain, over time, or are able to avoid them. We would thus argue that this is an important matter, which needs to be well understood by workers in high-strain, particularly mental or emotional strain, work areas.

Any worker (or their family) who observes a change in their pattern of NWA, as a result of job strain, wherein they begin to abandon the activities we have identified, may be starting on just such a downward spiral. This might be synonymous with a slow transition from a broad existential position of "Working to Live" to one of "Living to Work." For workers who are already experiencing notable declines in neurophysiologically beneficial leisure-time activity, because they feel (consistently) they are "... too tired" to do otherwise, a serious consideration of reordering of work and non-work priorities might be indicated. Our study results suggest that this may be the outward and visible indicator of downward loss spirals with serious end-state potential for health breakdown and premature career curtailment.

Significance

At the organizational level, our results would suggest that any investment directed toward the promotion of employee social activity, exercise, and personal hobby (creative) activity outside work hours, can yield a valuable return in maintaining long-term worker health. For extensively and expensively trained and valued employees, this is no small consideration. Conversely, rewarding (directly or indirectly) behaviors that reduce an employee's non–work-time stress response downregulation activity may be ultimately counterproductive. This can occur in many insidious ways, for example, by rewarding (in some sense) employees who remain connected to work (in some way) during non-work time. This may be via electronic communications systems such as Internet-connected Personal Digital Assistants, pagers, or by taking work home for completion that cannot be completed in a normal industrious day.

Such practices may have short-term benefits to the organization, and (perhaps) for the ambitious worker anxious to demonstrate he or she is "working harder." However, during the longer term, our observations suggest that they can be predicted to result in higher levels of adverse health consequences, with career-compromising potential.

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