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Light exposure is related to social and emotional functioning and to quality of life in older women

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Abstract

While there are data supporting the use of light in clinical populations, there has been less investigation of relationships among light and psychological variables in non-clinical samples. Subjects were 459 ethnically diverse women (mean age 67.68) recruited as part of the Women's Health Initiative. Light exposure and sleep were measured with an Actillum wrist actigraph. Subjects completed questionnaires, investigating Social Support, Social Functioning, Social Strain, Quality of Life, Satisfaction with Life, Emotional Well-being, Optimism, Negative Emotional Expressiveness, and Role Limitation Due to Emotional Problems. Significant partial correlations (controlling for age, education and ethnicity) were found between mesor light exposure and Social Functioning, Quality of Life, Satisfaction with Life, and Emotional Well-Being. Quality of Life and Satisfaction with Life were also found to be significantly correlated with morning light. The most parsimonious model to account for the variance shared between mesor light and the predictors included only Quality of Life. The variance shared between mesor light exposure and social and emotional functioning could be subsumed under the variance shared between mesor light exposure and Quality of Life. Increased light exposure is related to improved quality of life and social and emotional functioning. Increased light exposure is related to improved quality of life and social and emotional functioning.

Keywords

Phototherapy; Circadian rhythm; Interpersonal relations; Emotional disturbances; Sleep

1. Introduction

Light (or its lack) may be associated with both seasonal (Tam et al., 1995) and nonseasonal (Kripke, 1998) affective illness. Light functions as a zeitgeber (timegiver) in the human circadian system. Disruptions of circadian rhythms have been implicated in the pathogenesis of affective illness (Kripke et al., 1992). Bright light therapy has become a treatment of choice for seasonal affective disorder (SAD) (Lam and Levitt, 1999) and also may be recommended for depression that is not seasonal (Kripke, 1998; Tuunainen et al., 2001; Golden et al., 2005).

Fewer studies have examined the relationship between light and depression in the general population. One group (Kohsaka et al., 1999) found that moderately bright light (1000 lux) increased sleep quality and alertness in eight healthy elderly women studied in the fall months. Another group (Partonen and Lonnqvist, 2000) studied bright light administered to healthy people during the winter in southern Finland. This investigation of 160 office workers indicated that bright light reduced depressive symptoms and increased vitality and quality of life. Brunnstrom et al. (2004) found that improving lighting conditions significantly improved ratings of quality of life among visually impaired participants in Sweden. However, other studies (Kasper et al., 1990; Genhart et al., 1993) failed to demonstrate benefits in healthy people.

In addition to studies of the benefits of light in the general population, some research has investigated the importance of natural versus artificial light. Natural sunlight may be a more powerful mechanism for entrainment of circadian rhythms than ordinary artificial light (Lewy et al., 1980) because outdoor light is often brighter. A 1-h morning walk for 1 week in natural lighting was shown to alleviate seasonal affective disorder (SAD) symptoms versus placebo (Wirz-Justice et al., 1996). Other studies also suggest that morning light may be particularly beneficial in alleviating depressive symptoms (Clodoré et al., 1990; Eastman et al., 1998; Lewy et al., 1998; Terman et al., 1998).

Degree of behavioral and affective sensitivity to changing seasonal light patterns has been positively related to neuroticism (Murray et al., 1995; Jang et al., 1997). Those with high seasonality exhibit a strong emotional reaction to changing weather (Rosenthal et al., 1987; Albert et al., 1991; Molin et al., 1996) and demonstrate increased mood variability and sensitivity to other zeitgebers such as social cues (Reid et al., 2000). Patients with SAD may experience a greater number of negative life events and decreased social support (Michalak et al., 2004b). Additionally, SAD patients have reported low ratings of quality of life (Partonen and Lonnqvist, 1996; Michalak et al., 2004a) which may present in a seasonal pattern (Michalak et al., 2005). A more direct relationship between ambient, environmental light and social and emotional functioning, however, has not been specifically investigated.

Data from the Women's Health Initiative (WHI) provided an opportunity to examine relationships of habitual light exposure to social and emotional functioning, and quality of life, in postmenopausal women (Matthews et al., 1997). Light was measured using a wrist actigraph. Quality of life and social and emotional functioning variables were measured using questionnaires. It was hypothesized that (1) increased light exposure would be related to improved quality of life and social and emotional functioning, (2) advanced phase (earlier timing) of the light exposure is related to improved quality of life and social and emotional functioning, and (3) morning light is more predictive of the benefits of light than day-long exposure.

2. Methods

2.1. Subjects

Subjects were 459 women recruited as part of an ancillary study of the Women's Health Initiative (WHI), a large, multi-site, longitudinal study of health in postmenopausal women; a description of methods and rationale can be found in Matthews et al. (1997) and WHI Study Group (1998). All women were post-menopausal (mean age 67.68, S.D. 7.86, range 50 to 81). Recruitment emphasized ethnic diversity. Several previous reports of data from these subjects have appeared (Jean-Louis et al., 2000, 2001a,b; Tuunainen et al., 2001; Wallace-Guy et al., 2002; Youngstedt et al., 2004).

2.2. Actillum

Light recordings were made using an ActillumTM wrist actigraph worn for 1 week. All records were hand-scored for sleep, with the assistance of a validated algorithm (Jean-Louis et al., 2001a,b). The Actillum photometer measured lux and physical activity each second, and then averaged across 1-min epochs. Lux values were log-transformed (with logarithms below 0 recoded as 0), and cosine-fitted. The mesor (fitted cosine mean) and acrophase (fitted cosine peak) of these log scores, as well as mesor of physical activity measurements, were computed using ACTION 3 software (Ambulatory Monitoring Inc., Ardsley, NY). Acrophase deviation from the group median was computed by taking the absolute value of each acrophase difference from the group median. Morning light was computed as mean log lux during the first 4 h after awakening, usually involving most of the awake hours before noon. Phase-response curve data suggest that this would cover the most sensitive portions of the advance portion of the phase-response curve (except those during sleep).

2.3. WHI questionnaires

Social and emotional functioning were assessed using self-report questionnaires designed for use as part of the WHI (Matthews et al., 1997; WHI Study Group, 1998). These measures were designed by national committees, based on a review of contemporary psychometric methods and are thought to be reliable and valid (Matthews et al., 1997; Anderson et al., 2003; Langer et al., 2003). Questionnaires were administered by staff during subjects' visits to WHI offices.

Social Support was measured as the sum of the scores of responses to the question: "How often are these kinds of support available?" The following possible responses were each measured on a 1 to 5 Likert scale and summed: "Someone to listen when need to talk," "Someone to give good advice," "Someone can take to the doctor," "Someone to have a good time with," "Someone to help understand a problem," "Someone to help with daily chores," "Someone to share private worries/fears," "Someone to do something fun with," and "Someone to love you/make you feel wanted." Thus possible scores ranged from 5 to 45.

Social Functioning was measured by averaging two ratings (on a 0–100 scale), where the subjects reported the degree to which physical or emotional problems interfere with social functioning by determining extent and frequency.

Social Strain was measured as the sum of the following items measured on a 1 to 5 Likert scale: "Number of people who get on nerves," "Number of people who ask too much," "Number of people who exclude you," and "Number of people who try to coerce."

Quality of Life was measured using a 1 to 10 scale that simply asks respondents to "rate the quality of your life (10 being highest)," and Satisfaction with Life was measured using a 1 to 10 scale that simply asks respondents to "rate your satisfaction with the quality of your life (10 being highest)."

Emotional Well-being was measured on a 0–100 scale (100 reflecting highest well-being) computed from variables asking, "Have you been very nervous," "Felt down in the dumps," "Felt calm and peaceful," "Felt downhearted and blue," and "Have you been happy?"

Optimism was measured as the sum of the following items measured on a 1 to 5 Likert scale (5 being highest): "Usually expect the best," "Expect something that can/will go wrong (reverse-scored)," "Always hopeful about future," "Expect more good things than bad," "Hardly ever expect things to go my way (reverse-scored)," and "Rarely count on good things happening (reverse-scored)."

Negative Emotional Expressiveness was measured as a 1–5 rating scale (5 representing greatest amount of expression of negative emotions) averaged from following items: “Usually people around me know when I’m angry,” “You can tell from my facial expressions how I’m feeling,” “I express disappointment,” and “If angered, I may cause a scene in a public place.”

Role limitation due to emotional problems was measured on a 0–100 rating scale (100 reflecting greatest impairment) computed from items that asked how emotional problems have affected functioning in terms of time spent, amount of accomplishment, and amount of care given to work.

2.4. Data analysis

The relationships among light variables, quality of life and social and emotional variables were investigated by using partial correlations (controlling for age, education level, and ethnicity). Six ethnic groups were entered as pseudo-variables of 0 (absent) or 1 (present) for White, Black, Asian, Hispanic, Native American and Other. Because outdoor exercise effects and outdoor light effects could be confounded, correlations of emotional variables with light exposure were also controlled for the mesor (daily mean) of Actillum wrist activity. To ascertain any added benefit of morning light, hierarchical regression models were used (first entering age, education and ethnicity covariates, then entering mesor light, and then morning light). Finally, a stepwise regression procedure was employed to investigate the relative variance contributions of the quality of life, social and emotional variables to light exposure.

3. Results

3.1. Subject characteristics

The sample was ethnically diverse, with 68.2% reporting being White, 13.6% Hispanic or Latino, 10.1% African-American or Black, 4.5% Asian or Pacific Islander, 1.6% Other, and 1.3% American Indian or Alaskan Native. Additionally, a wide range of educational backgrounds was represented (highest level achieved): 0.2% didn’t go to school, 0.9% grade school (1–4 years), 0.9% grade school (5–8 years), 4.0% some high school, 11.2% high school diploma or GED, 10.1% vocational or training school, 35.3% some college or associate degree, 12.3% college graduate or baccalaureate degree, 11.9% some graduate or professional education, 11.6% master’s degree, and 0.7% doctoral degree.

Actillum recordings were taken a mean of 290 days following questionnaire administration (range 21 to 1819 days). Correlation strength was not found to be systematically weaker in subjects for whom Actillum recordings were taken after a longer period following questionnaire administration versus a shorter time interval.

Overall mean and standard deviations of the variables are reported in Table 1. Because some responses were missing, N values are also reported (for example, almost half of the subjects were never laboriously scored for morning mean lux).

3.2. Partial correlations

Partial correlations between light and social and emotional variables are reported in Table 2. Significant partial correlations (controlling for age, education and ethnicity) were found between mesor light exposure and Social Functioning, Quality of Life, Satisfaction with Life, and Emotional Well-Being. Quality of Life and Satisfaction with Life were also found to be significantly correlated with morning light.

Physical activity (Actillum activity mesor) was significantly correlated with light mesor ($r = 0.293$, $P < 0.0005$). When correlations were repeated adding physical activity as a covariate, the strength of the correlations declined overall, but direction did not. These values can be seen in Table 3. Only the correlation with Satisfaction with Life no longer met significance criteria, suggesting that a notable portion of the variance shared between light and Satisfaction with Life might be confounded with affects of outdoor physical activity.

No significant partial correlations were found between light acrophase or acrophase deviation (sample median 13:44:22) and any social or emotional variables. However, acrophase deviation was significantly correlated with quality of life (partial $r = -0.132$, $P = 0.01$, $n = 423$) and satisfaction with life (partial $r = -0.135$, $P = 0.005$, $n = 423$), indicating that phase deviation was negatively associated with global quality of life.

3.3. Mesor versus morning light

Hierarchical linear model comparisons were used to ascertain whether the observed correlations between morning light and both Quality of Life and Satisfaction with Life describe shared variance unique to morning light (after controlling for mesor light). In the case of satisfaction with life, no significant portion of unique variance was explained by morning light, though the significant unique variance of quality of life was contributed by morning light (this analysis was limited only to subjects for whom morning light data were obtained).

For Quality of Life, a model that included demographic covariates (age, education and ethnicity) and mesor light accounted for a significant amount of variance ($F(9,401) = 4.819$, $P = 0.0005$, adjusted $R^2 = 0.077$), and a significant gain was made with the inclusion of morning light (partial $F(1,400) = 5.760$, $P = 0.05$, R^2 change = 0.013). Thus, the overall model including morning light was significant ($F(10,400) = 4.965$, $P = 0.0005$).

Similar results were shown with Satisfaction with Life. A model that included demographic covariates (age, education and ethnicity) and mesor light accounted for a significant amount of variance ($F(9,401) = 3.954$, $P = 0.0005$, adjusted $R^2 = 0.061$), and a significant gain was made with the inclusion of morning light (partial $F(1,400) = 4.799$, $P = 0.05$, R^2 change = 0.011). Thus, the overall model including morning light was significant ($F(10,400) = 4.072$, $P = 0.0005$).

3.4. Shared variance among predictors

A stepwise regression procedure was used to ascertain whether the correlations between mesor light and social and emotional functioning variables were describing shared variance that is unique to each predictor or is shared among them. The regression was structured such that the dependent variable was mesor light, and the independent variables were entered. First, age, education and ethnicity were entered, and next, the variables that were shown to have correlated with mesor light were entered in a stepwise procedure.

The most parsimonious model that accounted for the variance shared between mesor light and the predictors (overall $F(9,416) = 7.912$, $P < 0.0005$) included only Quality of Life ($B = 0.028$, $SE = 0.008$, $t = 3.756$, $P < 0.0005$). The variance shared between mesor light exposure and both social and emotional functioning was subsumed under the variance shared between mesor light exposure and Quality of Life. To further investigate this relationship, the stepwise regression was repeated, this time including just Quality of Life and an ordinal income variable as predictor variables (controlling for age, ethnicity and education), so that it could be ascertained whether Quality of Life contributed variance over and above income. Indeed, the outcome of this analysis was similar, such that the most parsimonious model that accounted for the variance shared between mesor light and the

predictors (overall $F(9,409)=8.277$, $P<0.0005$) included only Quality of Life ($B=0.032$, $SE=0.008$, $t=4.138$, $P<0.0005$) in addition to the entered demographic variables.

Further analysis showed that all of the social and emotional variables correlated significantly with Quality of Life, except for Negative Emotional Expressiveness. Partial correlations (controlling for age, education and ethnicity are reported in Table 4).

4. Discussion

The present study investigated correlates of light exposure in a diverse sample of postmenopausal women. The hypotheses were partially supported: (1) increased light exposure is related to improved quality of life and social and emotional functioning, (2) morning light exposure is related to improved quality of life and social and emotional functioning, and (3) morning light is more predictive of the benefits of light than all-day exposure.

Previous studies have demonstrated mixed results regarding the psychological effects of light in non-clinical samples, with both positive (Kohsaka et al., 1999; Partonen and Lonnqvist, 2000; Brunnstrom et al., 2004) and negative findings (Kasper et al., 1990; Genhart et al., 1993). The current results support a relationship, demonstrating that increased light, especially in the morning, may be related to improved social and emotional functioning and subjective quality of life.

In relation to social and emotional functioning, while there has been a great deal of research on the role of light on circadian rhythms (Czeisler, 1995) and depression (Tuunainen et al., 2001) and social factors in the entrainment of circadian rhythms (Ehlers et al., 1988; Monk et al., 1990; Elmore et al., 1994), less attention has been paid to the unique contribution of light to social and emotional functioning.

Reid et al. (2000) studied the differential sensitivity to external (i.e., social) zeitgebers on mood fluctuations for subjects who demonstrate varying degrees of seasonality of mood. Results demonstrated that highly seasonal individuals were more responsive to external zeitgebers and had more pronounced mood cycling. These findings, along with the present results, support the importance of social situations possibly mediating the relationship between circadian rhythms, light and mood.

Highly seasonal individuals have also demonstrated emotional disturbances (Murray et al., 1995; Jang et al., 1997). Since the mechanisms underlying these seasonal relationships may be related to changes in light exposure, the present study further explores this idea by studying relationships between light exposure and emotional variables in a non-clinical sample.

The present study contributes by examining the specific relationships among light and social and emotional functioning, domains that have not previously been investigated in diverse samples studied year round. While the reported benefits of bright light in non-clinical samples have been mixed, the current results suggest that light may have at least small benefits for undiagnosed samples. In addition, this study explores the possible added benefit of morning light.

Overall, morning light appears to have marginal importance over and above all-day light. These results suggest that although morning light may be related to overall subjective quality of life ratings, it may not have specific benefit in the domains of social and emotional functioning.

There are several important limitations to this study. First, due to its correlational nature, no causal relationships can be inferred. The causal mechanisms of the relationship between light and quality of life and social and emotional functioning may be bidirectional in nature or follow complex pathways, such that those who receive more light will experience improvements in functioning and, reciprocally, those with better functioning may receive more light. The additional caveat of the importance of morning light may add to the complexity of this relationship.

Another limitation of this study was that although the sample was relatively large and diverse, it consisted only of postmenopausal women volunteers of the WHI. Results may not be generalizable to the whole population.

A third limitation of the study is that the goal of the WHI was not to evaluate the relationship between light and biopsychosocial factors. Thus, data collection was not designed for this purpose, and some measures may not have been optimal for these purposes. The intervals between collection of the questionnaires and the light measurements were certainly too long to optimally assess the relationships.

Further research should aim to extend these findings by (1) exploring additional biopsychosocial correlates of light exposure and timing and (2) extending the current findings into a more generalizable sample.

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Table 1

Means and standard deviations for light, social and emotional functioning variables

Variable	N	Mean	S.D.
Mesor log ₁₀ [Lux]	436	1.10	0.27
Morning light Mesor log ₁₀ [Lux]	271	1.77	0.47
Acrophase deviation ^a	437	00:03:09	00:54:35
Social Support	434	35.55	8.12
Social Functioning	445	86.57	21.29
Social Strain	442	6.48	2.61
Quality of Life	446	8.24	1.65
Satisfaction with Life	446	8.10	2.06
Emotional Well-being	442	79.75	14.98
Optimism	441	23.73	3.58
Negative Emotional Expressiveness	446	2.81	0.63
Role Limitation Due to Emotional Problems	444	82.88	31.15

^aRepresented as clock time (hh:mm:ss).

Table 2

Partial correlations between light variables and social and emotional variables, controlling for age, education and ethnicity

Variable	<u>Mesor light</u>		<i>P</i>	<u>Morning light</u>		<i>P</i>
	<i>N</i>	<i>r</i>		<i>N</i>	<i>r</i>	
Social Support	414	0.086	NS	252	0.091	NS
Social Functioning	422	0.158	0.005	259	0.107	NS
Social Strain	421	-0.030	NS	258	0.035	NS
Quality of Life	422	0.185	0.0005	260	0.216	0.001
Satisfaction with Life	422	0.134	0.05	260	0.154	0.01
Emotional Well-being	421	0.128	0.05	256	0.113	NS
Optimism	421	0.062	NS	256	0.098	NS
Negative Emotional Expressiveness	422	-0.057	NS	260	0.001	NS
Role Limitation Due to Emotional Problems	422	0.094	NS	259	0.076	NS

Table 3

Partial correlations between light variables and social and emotional variables, controlling for age, education, ethnicity and physical activity measured by the Actilume

Variable	<u>Mesor light</u>		<u>P</u>		<u>Morning light</u>		<u>P</u>	
	N	r	N	r	N	r	N	r
Social Support	413	0.081	NS	251	0.088	NS	251	0.088
Social Functioning	421	0.117	0.05	258	0.093	NS	258	0.093
Social Strain	420	-0.011	NS	257	0.042	NS	257	0.042
Quality of Life	421	0.145	0.005	259	0.193	0.005	259	0.193
Satisfaction with Life	421	0.093	NS	259	0.141	0.05	259	0.141
Emotional Well-being	420	0.126	=0.01	255	0.110	NS	255	0.110
Optimism	420	0.014	NS	255	0.084	NS	255	0.084
Negative Emotional Expressiveness	421	-0.022	NS	259	0.014	NS	259	0.014
Role Limitation Due to Emotional Problems	421	0.057	NS	258	0.064	NS	258	0.064

Table 4

Partial correlations between quality of life and social and emotional variables, controlling for age, education and ethnicity

Variable	<i>N</i>	<i>r</i>	<i>P</i>
Social Support	420	0.517	<0.0005
Social Functioning	431	0.414	<0.0005
Social Strain	428	−0.319	<0.0005
Satisfaction with Life	432	0.819	<0.0005
Emotional Well-being	428	0.546	<0.0005
Optimism	427	0.470	<0.0005
Negative Emotional Expressiveness	432	0.005	NS
Role Limitation Due to Emotional Problems	430	0.256	<0.0005