The Energy Envelope Theory and Myalgic Encephalomyelitis/Chronic Fatigue Syndrome

by Leonard Jason, PhD

RESEARCH ABSTRACT

Individuals with myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) have little stamina and endurance, and pose a challenge for nursing professionals. The Energy Envelope Theory, which posits that maintaining expended energy levels consistent with available energy levels may reduce the frequency and severity of symptoms, is particularly useful when working with clients with ME/CFS. Anecdotal support from the client community for this theory supports its use as a management tool for ME/CFS, but little formal research has been done in this area. In this study, a daily energy quotient was established by dividing the expended energy level by the perceived energy level and multiplying by 100. It was predicted that those participants who expended energy beyond their level of perceived energy would have more severe fatigue and symptoms and lower levels of physical and mental functioning. Findings are congruent with the Energy Envelope Theory as they indicated that the daily energy quotient was related to several indices of functioning including depression, anxiety, fatigue, pain, quality of life, and disability. The overall results provide support for a strategy health care professionals can use when working with clients with ME/CFS.

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Severe fatigue is a common complaint of clients seeking care from occupational health nurses and other health care professionals. When clients present with myalgic encephalomyelitis/chronic fatigue syndrome, they must be provided with interventions that take their unique needs into account. If clients stay within their energy envelopes, they will respond better to interventions and may have relief from some of their more severe symptoms.

found that when individuals with ME/CFS were asked to systematically increase their daily physical activity by 30%, their overall mood, muscle pain intensity, and time spent fatigued each day worsened. The exercise protocol in this study called for participants to increase their activity by walking every day while attempting to maintain all other regular daily activities. Because no “rest days” were provided in this protocol, it is possible they approached their daily activity limit. An additional finding was that not all participants with ME/CFS could attain a 30% increase in activity, and the level of increase was inversely related to individuals’ baseline activity. Those with the lowest baseline activity levels maintained the largest increases, whereas those with the highest baseline activity levels experienced smaller increases (Black et al.).

Some have proposed that pacing activities may be an effective way of coping with limited energy (Friedberg & Jason, 1998; Goudsmit, 2001). However, the appropriate levels of activity and rest vary based on the unique condition of each individual. The concept of activity pacing is compatible with the Energy Envelope Theory (Jason, Melrose et al., 1999), which has the goal of finding balance between the extremes of total activity avoidance and high levels of daily activity increases. The Energy Envelope Theory suggests managing ME/CFS by maintaining expended energy levels within the “envelope” of perceived energy levels. Clients can then sustain physical and mental functioning while reducing symptom severity and the frequency of relapses more efficiently. Individuals with ME/CFS who use this approach need to assess their perceived energy levels (i.e., available energy) on a daily basis and use that level to gauge their energy expenditure for the day. Applying this approach as an ME/CFS management tool involves accepting and working within the limits imposed by the disease rather than struggling against them. Over time, individuals may experience fewer crashes and decreased fatigue and symptom severity. Clients may be able to expand their envelope by maintaining energy levels in this way; that is, their perceived energy levels may increase over time, allowing them to engage in more physical activity. Clients have provided anecdotal support for this theory (Friedberg & Jason).

Few empirical studies have been conducted to assess the effectiveness of the Energy Envelope Theory. In one case study, a participant rated her perceived energy, expended energy, and fatigue levels daily using a scale from 1 to 100. When she kept her expended energy levels within the envelope of her perceived energy levels, her fatigue was lower and her perceived energy tended to be higher (Jason, Melrose et al., 1999). A similar study used time series regression and found a positive significant relationship between current fatigue level and self-rated expended energy 2 days before (Jason, Tryon et al., 1999). This study involved hourly ratings of perceived and expended energy and fatigue levels and found that the number of hours worked 5 days before was negatively and significantly related to current fatigue. A third study (Pesek et al., 2000) found that when participants with ME/CFS were provided with a “buddy” to reduce activities and assist in identifying and reducing discrepancies between perceived and expended energy, overall fatigue severity and severity ratings for five of eight minor ME/CFS symptoms decreased. This finding was not statistically significant, likely due to the small sample size, but the directional trends were consistent with the Energy Envelope Theory. Although these studies are limited by small sample sizes, the directional trends warrant further investigation of this phenomenon and its possibilities as a tool for managing ME/CFS.

In the current study, the relationship between a daily energy quotient and self-report measures involving a wide variety of functional areas was assessed. It was predicted that exceeding perceived energy levels would be significantly correlated with more severe fatigue, greater symptom severity, and lower levels of physical and mental functioning.

METHOD
Participants

Individuals with ME/CFS were recruited from a variety of sources, including physician referrals, announcements in the media, and recruitment offers at local ME/CFS support group meetings. One hundred fourteen individuals were recruited; 46% were referred by physicians, 34% were recruited via the media (e.g., newspapers, television, and radio), and 20% were from other sources (e.g., word of mouth from friends, family members, or other study participants). No significant demographic differences were found among individuals recruited from these various sources.

All participants were required to be at least 18 years old, not pregnant, able to read and speak English, and considered physically capable of attending the scheduled sessions. Twenty-four additional individuals who were screened were excluded for a variety of reasons (e.g., lifelong fatigue, fewer than four of the symptoms outlined by Fukuda et al., body mass index > 45, melancholic or bipolar depression, alcohol or substance abuse disorder, autoimmune thyroiditis, cancer, lupus, or rheumatoid arthritis). Bedridden and wheelchair-bound individuals were excluded due to the difficulties in making appointments. Referrals to local physicians who treat ME/CFS and to support groups were offered for these individuals.

Approaches to reduce attrition included letters and
telephone reminders for all appointments, scheduling around vacations and health-related or other crises, reimbursement for transportation costs, and participant honoraria.

After completing a consent form, prospective participants were initially screened using a structured questionnaire. Then a semistructured psychiatric interview was conducted.

**Measures**

**The Structured Clinical Interview for DSM-IV (SCID)** (Spitzer, Williams, Gibbon, & First, 1995). Axis I was used to establish psychiatric diagnoses. The professionally administered SCID requires clinical judgment in the assignment of symptoms to psychiatric or medical categories, a crucial distinction in the assessment of symptoms that overlap between ME/CFS and psychiatric disorders (e.g., fatigue, concentration difficulty, and sleep disturbance).

**The CFS Questionnaire.** This screening scale, initially validated by Jason et al. (1997), was used to collect demographic, health status, medication use, and symptom data. It used the definitional symptoms of ME/CFS outlined by Fukuda et al. (1994). Hawk, Jason, and Torres-Harding (2007) recently revised the ME/CFS Questionnaire and administered it to three groups: individuals with ME/CFS, individuals with major depressive disorder, and healthy controls. The CFS Questionnaire demonstrated 90% specificity and 93% sensitivity. In addition, most items on the CFS Questionnaire demonstrated good to very good test-retest reliability, with the majority of kappa and intraclass correlation coefficients falling above 0.70 (Hawk et al.). Each of the eight Fukuda et al. (1994) symptoms (i.e., impaired memory or concentration, sore throat, tender lymph nodes, muscle pain, multi-joint pain, new headaches, unrefreshing sleep, and post-exertion malaise) was rated on a 100-point scale. Higher scores indicate more severe symptoms.

The CFS Questionnaire was designed to assess the diagnostic criteria for ME/CFS as specified by Fukuda et al. (1994). For each symptom, participants were asked to indicate if the symptom had been present for 6 months or longer, if the symptom began before the onset of their fatigue or health problems, and how often (never, seldom, often/usually, or always) the symptom is experienced. Participants were also asked to rate the intensity of each symptom they endorsed on a scale of 0 to 100, with 0 meaning no problem and 100 meaning the worst problem possible. Items were designed to measure the presence of the eight Fukuda et al. symptoms. Also, items were used to assess the frequency with which participants avoid exercise (a 5-point scale, with 1 meaning never and 5 meaning all the time) and the degree to which fatigue impairs their daily energy levels (a 10-point scale). Higher scores indicate more impairment.

**Assessment of ME/CFS.** This screening evaluation included an in-depth health-related and neurological history and general and neurological physical examinations. It also included a structured instrument, a modified version of the CFS Questionnaire (Komaroff et al., 1996), assessing signs and symptoms via a health history to rule out other disorders. Relevant health information was gathered to exclude other possible causes of chronic fatigue, such as exposure to tuberculosis, AIDS, and sexually transmitted diseases. Information on prescribed and illicit drug use was also assessed and recorded. Results of recent Pap smears and mammograms were included for women. Finally, the history of all symptoms related to ME/CFS was gathered.

Laboratory tests in the battery were the minimum necessary to rule out other illnesses (Fukuda et al., 1994) and included a chemistry screen to assess liver, renal, and thyroid functioning; complete blood count with differential, platelet count, and erythrocyte sedimentation rate; arthritic profile, including rheumatoid factor and antinuclear antibody; hepatitis B, Lyme disease, and HIV screens; and urinalysis. A tuberculin skin test was also performed. The study physician performed a detailed examination to detect evidence of diffuse adenopathy, hepatosplenomegaly, synovitis, neuropathy, myopathy, and cardiac or pulmonary dysfunction.

**Beck Depression Inventory (BDI-II)** (Beck, Steer, & Brown, 1996). Depressive symptomatology was measured with the BDI-II, a 21-item, self-report instrument with well-established psychometric properties. This version of the BDI is more consistent with DSM-IV criteria for major depressive disorder. The BDI-II is the only depression rating scale to have been empirically tested and interpreted for both depressed and nondepressed clients with ME/CFS (Johnson, DeLuca, & Natelson, 1996). Higher scores indicate more severe depression.

**Beck Anxiety Inventory (BAI).** Anxiety symptoms were measured with the BAI, a 21-item, self-report measure with established and replicated construct validity (Steer, Clark, Beck, & Ranieri, 1995). Factor analysis of the BAI and BDI yielded a first-order factor labeled “anxiety” that had salient loadings for all 21 items on the BAI, but only one item on the BDI. Also, a high frequency of anxiety disorders is reported in psychodiagnostic studies of ME/CFS (Pepper, Krupp, Friedberg, Doscher, & Coyle, 1993). Higher scores indicate more anxiety.

**Fatigue Severity Scale** (Krupp, LaRocca, Muir-Nash, & Steinberg, 1989). This scale measured fatigue using nine items rated on a 7-point scale. It is sensitive to different aspects and gradations of fatigue severity. Most items on the Fatigue Severity Scale are related to behavioral consequences of fatigue. Previous findings have shown the scale can discriminate among cases of ME/CFS, multiple sclerosis, and primary depression (Pepper et al., 1993). In addition, the Fatigue Severity Scale (Krupp et al.) was normed on a sample of individuals with multiple sclerosis, individuals with systemic lupus erythematosus, and healthy controls. Taylor, Jason, and Torres (2000) compared the Fatigue Scale (Chalder, Berelowitz, Pawlikowska, Watts, & Wessely, 1993) with the Fatigue Severity Scale (Krupp et al., 1989) using a sample of healthy controls and an ME/CFS-like group. Within the ME/CFS-like group, the Fatigue Severity Scale (Krupp et al.) was more closely associated with severity ratings for the eight Fukuda et al. (1994) ME/CFS
symptoms and functional outcomes related to fatigue. Higher scores indicate more fatigue.

Perceived Stress Scale (PSS) (Cohen, Kamarck, & Mermelstein, 1983). This is a 4-item revised version of a previous 14-item measure of global perceived stress during the previous month. The authors report a reliability coefficient of 0.72 for the 4-item version. The total stress score was used in the present study. It has a range of 0 to 16, with higher scores indicating more stress.

Brief Pain Inventory (Cleeland & Ryan, 1994). This instrument measures the intensity of pain (pain severity) and the interference of pain in individuals’ lives (pain interference). Higher scores indicate more severe and persistent pain and higher interference with functioning. This measure exhibits adequate levels of reliability to assess pain in noncancer samples, with reliability coefficients of 0.70 and above. It also demonstrates adequate concurrent validity with other generic pain measures, and has been shown to be sensitive to changes in pain status over time. Keller et al. (2004) assessed the reliability of the Brief Pain Inventory with samples from noncancer pain patients. Findings indicated that the Brief Pain Inventory was comparable to pain levels reported in the literature for cancer patients, and coefficient alphas were greater than 0.70. This study also replicated the factor structure of the Brief Pain Inventory. The Brief Pain Inventory had a strong relationship to other generic measures of pain. The Brief Pain Inventory also discriminated among levels of condition severity, and was sensitive to change in condition over time for arthritis patients.

The Pittsburgh Sleep Quality Index (Buysse, 1989). Sleep disturbances were measured by this index, developed to measure sleep quality and sleep disruptions in psychiatric research participants. Nineteen questions, using a scale from 0 to 3, generate seven “component” scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The scores for these seven components are summed for a global score, which can range from 0 to 21. Higher scores indicate poorer sleep quality.

The Quality of Life Scale (Burckhardt & Anderson, 2003). This instrument measures satisfaction with a variety of life activities for individuals with various chronic illnesses. Sixteen items are rated on a Likert-type scale from 1 to 7. The scale measures six conceptual “quality of life” domains: material and physical well-being; relationships with others; social, community, and civic activities; personal development and fulfillment; recreation; and independence. Higher scores indicate more overall life satisfaction. This instrument differs from other measures in that it acknowledges individuals place different priorities on aspects of life quality. This 16-item scale demonstrated high test-retest reliability, and convergent and discriminate construct validity in groups of individuals with various stable chronic illnesses, including post-ostomy surgery, osteoarthritis, rheumatoid arthritis, fibromyalgia, chronic obstructive pulmonary disease, and insulin-dependent diabetes (Burckhardt & Anderson). High correlations ($r = 0.67$ to 0.75) have been found between the Quality of Life Scale total score and the Life Satisfaction Index-Z. Also, the Quality of Life Scale discriminates levels of quality of life in populations that would be expected to differ (e.g., healthy adults vs. those with chronic illnesses).

Self Efficacy. This instrument measures an individual’s sense of control related to ME/CFS complaints. The ratings from each of the five questions are summed for a total score. Higher scores indicate higher levels of self-efficacy. The reliability coefficient ranges from 0.70 to 0.77. The scale has been used in a major trial of ME/CFS and cognitive behavioral therapy (Prins et al., 2001).

Medical Outcomes Study-Short Form-36 (SF-36) (Ware & Sherbourne, 1992). This is a 36-item, broadly based self-report measure of function (physical functioning, role functioning-physical, role functioning-emotional, bodily pain, general health, vitality, mental health, and health transition) related to health status. A higher score indicates better health and functioning. Test construction studies (McHorney, Ware, Lu, & Sherbourne, 1994; McHorney, Ware, & Raczek, 1993) have shown adequate internal consistency, significant discriminate validity among subscales, and substantial differences between patient and non-patient populations in the pattern of scores. All scales passed tests for item internal consistency (97% passed) and item-discriminant validity (92% passed). The median reliability coefficient across scales was 0.85. SF-36 has also indicated sufficient psychometric properties in measuring functional status in an ME/CFS population (Buchwald, Pearlman, Umali, Schmaling, & Katon, 1996). A behavioral treatment study of ME/CFS clients showed the SF-36 to be sensitive to treatment changes (Deale, Chalder, Marks, & Wessely, 1997).

Perceived and Expended Energy. Participants were asked to rate perceived energy (their estimation of their available energy resources) and expended energy (their estimation of the total amount of energy exerted) over the past 24 hours on a 100-point scale, with 0 meaning no energy and 100 meaning abundant energy similar to when they were completely well. Expended energy can be greater than perceived energy, particularly when participants push themselves beyond their energy limits. The percentage of available energy expended was derived by dividing the participants’ expended energy by their perceived energy and multiplying by 100. This represents the daily energy quotient. Numbers less than 100 indicated that the participants expended less than their perceived maximum available energy, whereas numbers greater than 100 indicated that the participants expended more energy than their perceived maximum available energy. Fatigue was also rated on a 100-point scale, with higher scores indicating higher fatigue in the past 24 hours. Hawk et al. (2007) found test-retest reliability for perceived energy, expended energy, and fatigue to be 0.73, 0.50, and 0.84, respectively.

RESULTS

Of the 114 participants, 4 were excluded because of incomplete data (Jason et al., 2007). The sample’s daily
energy quotients ranged from 50 to 5,667. One individual’s expended energy was 85 and his perceived energy was 1.5. Dividing his expended by perceived energy resulted in a score of 56.67, and multiplying by 100 increased the score to 5,667. The average score was 339 (SD = 685); 13.6% of the sample had a daily energy quotient less than 100 and 86.4% had a daily energy quotient greater than 100. Given the skewed distribution of the sample, Spearman’s rank order correlation was used to calculate the strength of the relationship between variables because it does not require a linear relationship between variables or that variables be measured on interval scales.

A significant positive correlation was found between the daily energy quotient and the daily (past 24 hours) fatigue rating \( r(N = 110) = 0.56, p < .01 \), with higher daily energy quotients associated with higher daily fatigue ratings. Of the eight Fukuda et al. symptoms examined, only post-exertional malaise was significantly related to the daily energy quotient \( r(N = 110) = 0.22, p < .05 \). Higher daily energy quotients were associated with higher severity ratings for this symptom.

The Table presents the results of Spearman’s rank order correlational analysis of the daily energy quotient and participants’ scores on various self-report measures. All significant results were in the expected direction. Higher daily energy quotients were associated with higher levels of depression, anxiety, fatigue severity, and sleep problems; diminished quality of life; lower levels of physical functioning and vitality; and more difficulties with work or daily activities.

A significant positive correlation was found between daily energy quotients and the frequency with which participants avoided exercise \( r(N = 108) = 0.20, p < .01 \), with high daily energy quotients associated with greater frequency of exercise avoidance, participants’ rating of the degree to which fatigue impaired daily energy levels \( r(N = 109) = 0.34, p < .01 \), and higher levels of impairment.

**DISCUSSION**

Overall, the results of this study are compatible with the Energy Envelope Theory, an applicable construct for health care workers. The present study found that the daily energy quotient was related to several indices of functioning, including depression, anxiety, fatigue, pain, quality of life, and disability. The findings suggest that individuals with ME/CFS experience a range of negative symptoms and disability when they extend beyond their energy envelope. In other words, being overextended (i.e., exerting more energy than an individual has available) was associated with encountering negative outcomes in a variety of areas. Certainly, this finding has implications for the clinical care of workers with this illness.

From the Energy Envelope Theory (Jason, Melrose, et al., 1999), occupational health nurses might assist individuals with ME/CFS to pace their activity according to their available energy resources. In this approach, the phrase “staying within the envelope” is used to designate a comfortable range of energy expenditure in which an individual avoids both overexertion and underexertion, maintaining an optimal level of activity over time. Findings from the present study support this assertion. The Energy Envelope Theory would not endorse either unilaterally increasing or decreasing activity. Some employees with ME/CFS need to be encouraged to increase their activity, when they perceive additional energy to do so. However, some individuals with ME/CFS need encouragement to do less and decrease the imbalance between perceived and expended energy. This theory emphasizes understanding the varying needs of individuals with ME/CFS. The key is to avoid overexpanding energy supplies or consistently going outside the “envelope” of available energy. Once this balance has been achieved, it may be possible to slowly increase activity without jeopardizing function (King, Jason, Frankenberry, & Jordan, 1997; Pesek et al., 2000). Rather than focusing on a cure, this

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<th>Table</th>
<th>Spearman Correlation Coefficients for Daily Energy Quotient and Self-Report Measures</th>
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<tr>
<td></td>
<td>Daily Energy Quotient (N = 110)</td>
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<tr>
<td></td>
<td>Beck Depression Inventory (depression)&lt;sup&gt;a&lt;/sup&gt; 0.27**</td>
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<td></td>
<td>Beck Anxiety Inventory (anxiety)&lt;sup&gt;a&lt;/sup&gt; 0.23*</td>
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<td>Fatigue Severity Scale (fatigue)&lt;sup&gt;a&lt;/sup&gt; 0.22*</td>
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<td>Perceived Stress Scale (stress)&lt;sup&gt;a&lt;/sup&gt; 0.14</td>
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<td>Brief Pain Inventory (pain)&lt;sup&gt;a&lt;/sup&gt; 0.21**</td>
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<td>Pittsburgh Sleep Quality Index (sleep problems)&lt;sup&gt;a&lt;/sup&gt; 0.25*</td>
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<td>Self-Efficacy Scale (self-efficacy)&lt;sup&gt;b&lt;/sup&gt; 0.05</td>
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<td></td>
<td>Quality of Life Scale (quality of life)&lt;sup&gt;b&lt;/sup&gt; -0.38**</td>
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|       | Short Form-36
|       | Physical functioning (functioning)<sup>b</sup> -0.21* |
|       | Role-physical (problems with daily activities)<sup>b</sup> -0.20* |
|       | Bodily pain (pain)<sup>b</sup> -0.15 |
|       | General health (health)<sup>b</sup> -0.15 |
|       | Vitality (vitality) -0.22* |
|       | Social functioning (interference in function)<sup>b</sup> -0.18 |
|       | Role-emotional (emotional functioning)<sup>b</sup> -0.17 |
|       | Mental health (nervousness and depression)<sup>b</sup> -0.19 |

<sup>a</sup>Higher scores mean more problems or worse functioning.  
<sup>b</sup>Higher scores mean fewer problems or better functioning.  
* \( p < .05 \).  
** \( p < .01 \).
approach focuses on improving clients’ abilities to cope with this illness. Interventions tailored by occupational health nurses and other health care professionals are needed to meet the unique needs of these workers.

Although a link between overexertion and exacerbation of symptoms and disability is likely, the mechanism is not clear. Miller and Cohen (2001) proposed that negative emotional responses are due to evaluating stressful experiences as significant threats and exceeding available coping resources. They also cited studies that suggest negative emotional responses can cause distressed clients to engage in behaviors (e.g., altered sleep patterns, alcohol and tobacco use, or decreased physical activity) that conceivably modify immune responses. In addition, negative emotional states might activate the sympathetic division, whose fibers, descending from the brain to lymphoid tissues such as bone marrow, thymus, and spleen, could release substances that influence immune responses. Distress also can activate the hypothalamic-pituitary-adrenal axis and hormonal products from these systems can dysregulate the immune system. It is possible that when clients with ME/CFS go beyond their energy envelopes, it is a stressful experience and contributes to behavioral, sympathetic, and immune response dysregulations.

STUDY LIMITATIONS

The findings of this study should be interpreted with caution because all of the measures were based on self-reported data. Clearly, researchers need to collect behavioral data from actigraphs or biological data in future studies. Actigraph data are measurements of motion and activity, whereas biological data can include neuroendocrine or immunological data. In addition, the daily energy quotient is an estimate of hypothetical constructs, and errors may occur in estimating the extent of perceived or expended energy within a particular 24 hours. Finally, the correlations are low; thus, much of the variance that can be explained by the correlation between variables was not taken into account.

Even with these limitations, this study supports anecdotal information supplied by individuals about the relationship between feeling overextended and exacerbation of symptoms. Future research in this area might examine longitudinal data sets to determine whether energy expenditures can predict long-term outcomes for individuals with ME/CFS (Jason & Choi, 2008). Additional research examining the relationships between energy quotients and biological measures of functioning is also warranted.

CONCLUSION

This study provides some support for the Energy Envelope Theory. In this study, the daily energy quotient was related to depression, anxiety, fatigue, pain, quality of life, and disability. The findings suggest that when clients with ME/CFS are overextended and exert more energy than they have available, they encounter more difficulties. The author believes that this theory can be particularly helpful for occupational health nurses who provide clinical care for clients with this illness.

IMPLICATIONS FOR OCCUPATIONAL HEALTH NURSES

When clients with ME/CFS present to occupational health nurses, they must be provided with interventions that take their unique needs into account. Occupational health nurses have a unique role to play in developing and implementing treatment plans for such clients. In addition to coordinating comprehensive planning, occupational health nurses can use the Energy Envelope Theory when working with clients diagnosed with ME/CFS. If clients stay within their energy envelopes, they will respond better to interventions and may have relief from some of their more severe symptoms. Occupational health nurses might use this information to assist clients in maintaining more manageable work schedules. In addition, occupational health nurses can help clients better manage this illness, which, ultimately, may lead to a higher quality of life and more appropriate and enduring employment.

REFERENCES


