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The development of an instrument to assess post-exertional malaise in patients with myalgic encephalomyelitis and chronic fatigue syndrome

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Abstract

Post-exertional malaise, or a variation of this term, is a key symptom of myalgic encephalomyelitis and chronic fatigue syndrome, as this symptom is mentioned in almost all myalgic encephalomyelitis and chronic fatigue syndrome case definitions. Until now there has not been a comprehensive questionnaire to assess post-exertional malaise. To rectify this situation, in this article we describe the development of a new questionnaire, called the DePaul Post-Exertional Malaise Questionnaire, which was based on input from hundreds of patients. Preliminary validation was provided by the findings of significant and predictable relationships between different domains of this post-exertional malaise questionnaire and physical functioning.

Keywords

assessment; chronic fatigue syndrome; DePaul Symptom Questionnaire; myalgic encephalomyelitis; post-exertional malaise

Post-exertional malaise (PEM), or a variation of this name, is referred to in almost all case definitions of myalgic encephalomyelitis (ME) and chronic fatigue syndrome (CFS; Carruthers et al., 2003, 2011; Fukuda et al., 1994; Institute of Medicine (IOM), 2015; Ramsay, 1988). The best known CFS research case definition criteria (Fukuda et al., 1994) simply defined PEM as “post-exertional malaise lasting more than 24 hours.” In contrast, a later clinical case definition (Carruthers et al., 2003) known as the Canadian Consensus Criteria, more comprehensively described PEM as “an inappropriate loss of physical and mental stamina, rapid muscular and cognitive fatigability … and a tendency for other associated symptoms to worsen.” A more recent clinical case definition (IOM, 2015) described PEM as “prolonged exacerbation of a patient’s baseline symptoms after physical/ cognitive/ orthostatic stress; [it] may be delayed relative to the trigger.” Although PEM is required for diagnosis for many case definitions (Carruthers et al., 2003, 2011; IOM, 2015; Ramsay, 1988), all patients are not required to have PEM for the Fukuda et al. (1994) case

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Supplemental Material

Supplementary material is available for this article online.

definition lists, as PEM is only one of the eight symptoms but only four are required for criteria to be met. This might be one of the reasons for McManimen et al.'s (2015) finding that among articles using the Fukuda et al. (1994) case definition, only between 24.7 and 100 percent of these patient samples had PEM, with a mean of 85 percent.

In spite of this variability, Brown and Jason's (2020) recent meta-analysis of studies assessing PEM found it to be 10.4 times more likely to be associated with an ME or CFS diagnosis than with the control subjects, and the authors concluded that PEM should be considered a cardinal symptom of ME and CFS. Factor analyses of the DePaul Symptom Questionnaire (DSQ) have consistently found a PEM factor score (Brown and Jason, 2014; Jason et al., 2015b). Jason et al. (2009) found that items loading on a PEM factor on the ME/CFS Fatigue Types Questionnaire had good sensitivity (90%) and specificity (93%) in distinguishing between patients and controls. Other research has reported that self-reported PEM has been found to be a discriminator between patients with ME and CFS and those with solely major depressive disorder (Hawk et al., 2006).

A variety of methods have been proposed regarding the use of activity measurement as additional measures for PEM in order to assess the extent of activity and how such activity might result in exacerbation of symptoms (Jason et al., 2012). These measures include maximal or submaximal exercise challenge, actigraphy, and time logs. Self-report methods to evaluate PEM have varied in terms of comprehensiveness. For example, Maness et al. (2019) operationalized PEM by whether a patient scored 5 or greater on this question: "Exercise brings on my fatigue" (with a rating scale ranging from 1 = *strongly disagree*, 4 = *neither agree nor disagree*, and 7 = *strongly agree*). Maes et al. (2012) used aspects of Zachrisson et al.'s (2002) Fibromyalgia and Chronic Fatigue Syndrome (FF) Rating Scale to score the severity of PEM as follows: 0 means no post-exertional malaise; 1 means mild exacerbations of fatigue/pain/neurocognitive symptoms following exercise (either cognitive or physical); 2 means moderate exacerbations of symptoms following exercise; 3 means severe, incapacitating exacerbations lasting less than 24 hours; 4 means incapacitating exacerbations lasting greater than 24 hours but less than 2 days; 5 means incapacitating exacerbations lasting greater than 2 days; and 6 means a clinical relapse. Maes et al. (2012) found that patients with PEM had more severe symptoms and more immune abnormalities than those without. Yet, their measurement of PEM combines duration and severity ratings, and other aspects of this symptom (e.g. triggers) are not assessed.

Even when criteria for PEM have been defined in more comprehensive ways, problems have occurred in the way this symptom has been operationalized. For example, the case definition known as the Myalgic Encephalomyelitis: International Consensus Criteria (ME-ICC; Carruthers et al., 2011) referred to PEM as post-exertional neuroimmune exhaustion (PENE) and defined it by the following characteristics: (1) "Marked, rapid physical or cognitive fatigability in response to exertion"; (2) "Symptoms that worsen with exertion"; (3) "Post-exertional exhaustion"; (4) "Exhaustion is not relieved by rest"; and (5) "Substantial reduction in pre-illness activity level due to low threshold of physical and mental fatigability" (p. 10). Yet, it is unclear whether all five characteristics must be present or whether fewer would suffice to meet the threshold for having PEM, and it is also unclear whether these characteristics should be in one concept since it would appear that the

temporality, triggers, and response to treatment are fundamentally different. In addition, many of these characteristics are vague, such as the description of onset and duration, substantial activity reductions, and symptom severity. As an example, a severity level of "mild" was equated to a 50 percent reduction in activity levels in the original Carruthers et al.'s (2011) criteria, but a "moderate" severity level equated to a 50 percent reduction in the later released primer on this case definition (Carruthers et al., 2012). These efforts to operationalize PEM or PENE have not provided clearly defined criteria and adequate assessment tools.

The way questions are asked using self-report measures has a large role in whether patients indicate they have experienced PEM. As an example, Jason et al. (1999) found that the percentage of patients with ME and CFS who endorsed PEM questions ranged from 40 to 93 percent, depending upon how the question was asked. In another study, Jason et al. (2015a) asked patients with ME and CFS an item from the Fukuda criteria ("Do you feel generally worse than usual or fatigued for 24 hours or more after you have exercised?"). Although 25 percent of the patients responded "no," these patients did indicate that they experienced "high levels of fatigue or weakness following normal daily activity." These studies point to the critical role of symptom operationalization in identifying the true occurrence of self-reported PEM.

In an effort to better understand the different ways PEM has been formulated, McManimen et al. (2019) created questions based on the descriptions of PEM questions that have occurred in different case definitions and using an exploratory factor analysis found that central PEM items can be differentiated into two factors: a muscle factor, composed of five symptoms that referred to pain, weakness, or fatigue in muscles following exertion, and a general PEM factor, composed of 12 PEM symptoms related to a generalized feeling of physical or mental fatigue following exertion. When operationalized using a symptom threshold of at least moderate severity and occurring at least half the time, 95 percent of a sample of about 700 patients with ME and CFS had at least one symptom in the muscle factor and 99 percent had at least one symptom in the general factor.

Within the same large data set, Jason et al. (2018) found that the majority of patients did support certain wordings of both the precipitants and consequences of PEM, and considerable approval was also found for a number of ways to phrase items assessing PEM. In addition, 97 percent of patients met criteria for at least one of the five PEM questions assessed by the DSQ (Jason et al., 2010), when requiring the symptoms to be rated as at least moderate severity and occurring at least half the time. The percentage meeting PEM criteria was higher than any other PEM item(s) or combination of items examined from multiple case definitions and questionnaires. Thus, these five central PEM items from the DSQ provide an efficient and reliable screening mechanism which can identify PEM in patients with ME and CFS.

Recently, the National Institutes of Health/Health/Centers for Disease Control and Prevention (NIH/CDC PEM (n.d.)) Common Data Elements' (CDE) workgroup on PEM recommended that the five PEM items from the DSQ be used as an initial screen in step 1, to be followed up with a second step in which the researcher evaluated responses in light of

other information. Examples of other information could include other questions on the DSQ, the researcher's own evaluation, previous medical records, trigger type, and other patient-reported scales. Using a supplementary set of five PEM items from the DSQ, and in particular the duration of symptoms, in a separate data set of 376 patients with ME or CFS, 157 with multiple sclerosis (MS), and 167 with post-polio syndrome (PPS), Cotler et al. (2018) were able to differentiate those having ME and CFS versus MS and PPS. Inclusion of duration PEM items was also supported by Chu et al.'s (2018) qualitative study, which found that only 9 percent of participants stated that the duration of their PEM symptoms lasted less than 24 hours after activity.

Cotler et al.'s (2018) newly created DSQ-PEM, which allows for a stage 1 sensitivity screen to identify PEM, and supplementary items to differentiate those with PEM from other fatiguing illnesses, this was assembled from a larger DSQ that was intended to assess overall symptoms of ME and CFS rather than just PEM. Patients and scientists have called for the creation of a new more comprehensive instrument to assess PEM (IOM, 2015; Jason et al., 2018). The current investigation was an effort to create such an instrument to assess PEM in individuals with ME and CFS, and this study relied on information generated from both the scientific literature and input from hundreds of patients.

Method

Participants

Participants were required to be over the age of 18 years, able to read and write in English, and have a current diagnosis of ME or CFS. Individuals were recruited by contacting several patient organizations, as well as through postings on social media outlets. Participants completed the questionnaire online using Research Electronic Data Capture (REDCap), a secure online survey tool (Harris et al., 2009). The data set reported in this article is different from the samples recruited by McManimen et al. (2019), Jason et al. (2018), and Cotler et al. (2018) mentioned in the introduction.

Approval was obtained from the DePaul University Institutional Review Board to conduct this study. Initially, patients were notified that a new PEM questionnaire was being created. Patients with ME and CFS provided their ideas to the authors for possible items, and a questionnaire was developed during the spring of 2018. As the study is large and complex, the first part of the parent study was a community-based participatory project, where patients were actively involved in helping create a PEM survey, and patients had multiple opportunities to provide feedback to the investigators who posted new versions of the suggested survey questions on the first author's Facebook page. A long PEM survey was assembled, using questions suggested by patients, and this long PEM survey was then posted (after obtaining Institutional Review Board (IRB) approval) and multiple patient organizations disseminated this survey. Holtzman et al.'s (2018) parent article describes this participatory process and what our group learned from this patient-derived survey. Holtzman et al.'s article also provides comprehensive demographic and clinical characteristics of the sample, as well as the responses to all questions. Holtzman et al.'s article does not provide relationships between the PEM components and a measure of disability (i.e. physical functioning). That patient-derived PEM survey was extremely long, as literally hundreds of

patients requested that we include items on it to assess PEM. Many of these items were redundant and there was a need to specify a more concise measure and to assess its psychometric properties.

This article uses data collected from that parent study (Holtzman et al., 2018) to construct a new PEM instrument that conceptually covers the primary areas of PEM as indicated in articles reviewed in the introduction, including triggers of PEM, symptom consequences of PEM, defining features of PEM, duration and latency of PEM symptoms, and the influence of pacing. In addition, this study related these domains to a disability rating scale. Therefore, this study is different from the Holtzman et al.'s investigation in that in this study, a new condensed and theoretically derived PEM questionnaire is presented, along with psychometric properties of this new instrument (specifically how different aspects of the PEM instrument are related to a measure of physical functioning).

For this study, we recruited an international online convenience sample of 1534 adults self-identifying as having ME or CFS. Of the participants, 41.1 percent reported currently living in the United States. Of those living outside of the United States, 26.1 percent were living in Great Britain, 7.8 percent in Australia, 6.6 percent in Canada, 3.2 percent in Norway, 2.5 percent in the Netherlands, 2.4 percent in New Zealand, and less than 1 percent from the following countries: Germany, Sweden, Spain, Belgium, Ireland, Finland, South Africa, Denmark, France, Switzerland, Austria, the Czech Republic, Italy, Argentina, Aruba, Brazil, Romania, the Channel Islands, Colombia, Croatia, the Dutch Caribbean, Holland, India, Israel, Japan, Laos, Lithuania, Pakistan, Portugal, Senegal, and Thailand. The sample consisted of mostly females (84.6%), who were White/Caucasian (97.5%; 2% identified as being of Latino or Hispanic origin). Within our sample, 56.6 percent were married or living with a partner, while many had a standard college degree (39.3%) and were currently receiving disability payments (45.7%). The majority of our sample had a diagnosis of CFS (50.7%), with 27.2 percent having a diagnosis of both ME and CFS and 22.0 percent indicating being diagnosed with ME. In addition, 94.4 percent indicated they had been diagnosed with ME or CFS by a medical doctor.

Measures

DePaul Post-Exertional Malaise Questionnaire.—The DePaul Post-Exertional Malaise Questionnaire's (DPEMQ) first two parts assess basic sociodemographic information and onset and possible triggers of symptoms. The survey next assesses how participants experience PEM, their preference for common phrases used to describe PEM, and the next section presents a list of symptoms that are exacerbated after physical and cognitive exertion. The DPEMQ also assessed duration and length of recovery time of PEM, and possible effects of pacing. Appendix A (Supplementary Material) contains a copy of the new DPEMQ.

Section 1.—The first part of the DPEMQ involves basic sociodemographic information on age, gender, marital status, education level, employment status, current annual income, and annual income prior to becoming ill. Next, patients are asked about their diagnosis of ME or CFS, as well as who diagnosed them. Finally, patients are asked how long ago their illness

with ME or CFS began, whether their illness has been present for at least 50 percent of the time since they got ill, how they would describe the course of their illness (constantly getting worse, constantly improving, persisting (no change), relapsing and remitting, and fluctuating), and an impairment item that describes their illness for the last 6 months (a range of choices from “I can do all work or family responsibilities without any problems with my energy” to “I am not able to work or do anything. I am bedridden/completely incapacitated”).

Section 2.—The next section deals with onset and triggers of PEM. Onset was assessed by asking whether it was immediate or delayed (each question has the following possible responses: all of the time, most of the time, about half the time, and a little of the time). Patients can be categorized into immediate or delayed by taking the response of the item that indicates that they have one type onset more frequently than the other. Whether basic activities of daily living or emotional stress trigger PEM symptoms was assessed with the following anchor points: all of the time, most of the time, about half the time, or a little of the time. Patients were also asked whether there are instances in which the specific precipitants cannot be identified. Two questions where more than 90 percent of patients answered affirmatively to the original survey are also included: “On a day you are recovering from symptom exacerbation, does it take less exposure than usual to trigger your symptoms?” and “If you have a mild overexertion over several days, can this also produce an abnormal physical of cognitive response?” Finally, items (e.g. light, heat, cold, noise, visual overload, watching a video, and sensory overload) are included where over 50 percent indicated affirmative to these triggers.

Section 3.—The next section includes central features of PEM with the following question: “If you go beyond your energy limits by engaging in pre-illness tolerated exercise or activities of daily living, do you experience any of the following.” Each of the next six items was endorsed by over 97 percent of our sample and include “An onset that is immediate or delayed by hours,” “Post exertional-exhaustion,” “A loss of functional capacity and/or stamina,” “Symptom exacerbation,” “An abnormal response to minimal amounts of physical and/or cognitive exertion,” and “A severity and duration of symptoms that are out of proportion to the initial trigger.” An individual would have to endorse at least one of these items on the DPEMQ to be considered having PEM.

Section 4.—In the next section, participants indicate what symptoms are made worse by physical or cognitive exertion. PEM items from the DSQ (Jason et al., 2010), Ramsay’s clinical description of ME (Ramsay, 1988), the ME-ICC (Carruthers et al., 2011), and the CDC’s description of PEM were included. Each item was rated for frequency for the past 6 months on a 5-point Likert-type scale: 0 = *none of the time*, 1 = *a little of the time*, 2 = *about half the time*, 3 = *most of the time*, 4 = *all of the time*. The scale patients filled out in the survey did not have a severity item as the questionnaire was already extremely long. However, in the new questionnaire in Appendix A (Supplementary Material), a severity scale has been added and each symptom is also rated for severity over the past 6 months on a 5-point Likert-type scale: 0 = *symptom not present*, 1 = *mild*, 2 = *moderate*, 3 = *severe*, 4 = *very severe*. The DPEMQ instrument assesses the top 12 symptoms endorsed by at least 80

percent of our sample including reduced stamina and/or functional capacity, cognitive exhaustion, problem thinking, unrefreshing sleep, muscle weakness/instability, physically fatigued while mentally wired, insomnia, aches all over your body, muscle pain, flu-like symptoms, dizziness, and temperature dysregulation. For each symptom, frequency and severity will need to be multiplied by 25 and then added and divided by 2 (although the data included in the current article only include frequency ratings). These scores on a 100-point scale are then averaged to determine each patient's symptom burden for PEM.

Section 5.—The last section deals with duration, recovery, and pacing. In the DPEMQ, patients are asked "Does your prolonged, unpredictable recovery period from symptom exacerbation last days, weeks," and whether the severity and duration of symptom exacerbation was out-of-proportion to the type, intensity, frequency, or duration of the exertion (from all the time, most of the time, about half the time, a little of the time). Participants are next asked whether pacing allowed them to completely avoid symptom exacerbation or avoid symptom exacerbation only to a certain degree. Participants finally are asked how effective was pacing in reducing level of severity of symptoms (from very effective, moderately effective, mildly effective, and barely effective).

Medical Outcomes Study 36-item Short-Form Health Survey (SF-36 or RAND Questionnaire).—The Short-Form Health Survey-36 (SF-36) measures the impact of participants' health on physical and mental functioning (Ware and Sherbourne, 1992). The measure results in eight subscales: Physical Functioning, Role Physical, Bodily Pain, General Health, Social Functioning, Mental Health, Role Emotional, and Vitality. Higher subscale scores indicate less impairment. The SF-36 evidences strong psychometric properties, including good internal consistency and discriminant validity (McHorney et al., 1994). In our study, we only included the Physical Functioning subscale, in part to reduce the length of the extensive questionnaire.

Statistical analyses.—With scores from the physical functioning scale as the dependent variable, *t*-tests were employed to evaluate items that were binary (e.g. yes and no responses) on the DPEMQ. For items on the DPEMQ that were ordinal, we used Pearson Correlation coefficients to assess their relationship with the physical functioning variable.

Results

Tables 1 and 2 relate the PEM domains of the DPEMQ to the physical functioning scale. Those who experienced a delayed onset reported higher physical functioning scores (M = 27.66, standard deviation (SD) = 20.69) than those who did not experience delayed onset (M = 23.52, SD = 23.18), $t(1502) = 2.12$, $p < .05$. Various triggers were significantly related to physical functioning, such that those whose PEM is triggered by basic activities of daily living reported worse physical functioning (M = 22.06, SD = 18.42) than those who did not report this trigger (M = 46.40, SD = 20.79), $t(1504) = -21.05$, $p < .001$. Worse physical functioning was also found for those with positional changes that trigger PEM, as well as several sensitivities (i.e. chemicals, foods, light, heat, cold, noise, visual overload, watching movement, and sensory overload).

The score that indicated the total illness burden for symptoms (average of 12 symptoms based on frequency ratings) was significantly related to the physical functioning subscale ($r = -.39$, $p < .001$), suggesting the PEM illness burden was related to physical impairments.

Duration of PEM symptoms was also significantly correlated to physical functioning, $r = -.29$, $p < .001$. Those who had PEM duration lasting days, weeks, or even months reported significantly worse physical functioning ($M = 26.80$, $SD = 20.62$) than those who did not experience this prolonged PEM duration ($M = 39.53$, $SD = 25.16$), $t(1500) = -4.79$, $p < .001$. In addition, variations in exertion were shown to have a relationship with physical functioning. Physical functioning was worse for those whose illness severity was out-of-proportion to the type ($r = -.23$, $p < .01$.), intensity ($r = -.23$, $p < .01$.), frequency ($r = -.21$, $p < .01$.), and duration ($r = -.24$, $p < .01$.) of the exertional trigger. Finally, the effectiveness of pacing in avoiding symptom exacerbation was also significantly related to the physical functioning, $r = .18$, $p < .001$.

Discussion

This study described the development of a new scale to measure PEM. The DPEMQ assess many of the key characteristics of PEM, including triggers, onset, duration, and effects of pacing. As indicated in the introduction, many scales that have attempted to measure PEM have not included several of these key domains, and as a consequence, they did not comprehensively assess this construct. Findings do suggest that PEM can both be described based on self-report data, and that there are a range of degrees of PEM, and different domains of the scale were related to physical functioning, providing preliminary validation of the DPEMQ.

In this study, those who had an immediate PEM onset or whose PEM was triggered by basic activities of daily living reported worse physical functioning. Physical functioning was also worse for those with PEM triggers of positional changes and chemical, food, light, heat, cold, noise, visual overload, watching movement, and sensory overload sensitivities. In addition, total illness PEM symptom burden was significantly related to the physical functioning, and physical functioning was worse for those whose illness severity was out of proportion to the type, intensity, frequency, and duration of the exertional trigger. Finally, higher duration of PEM symptoms was related to worse physical functioning, and the effectiveness of pacing was related to better physical functioning. These findings are all understandable as those with more varied types of PEM triggers were more severely impacted, whereas those using pacing were able to reduce this severity.

Clearly, there are other more biological ways to measure PEM than self-report instruments such as the DPEMQ. However, cardiopulmonary exercise assessments can be expensive, and 2-day exercise challenge cannot be assessed for those who are most impaired. Therefore, inexpensive and easy to administer self-report scales have several benefits, however, there is still a need to validate such scales with more objective and biological markers of ME and CFS.

PEM is a difficult symptom to measure for a variety of reasons. For example, many patients experience PEM if they engage in exertion, but some patients have learned to pace or stay within their energy envelope (Jason et al., 2013), which can greatly diminish PEM. These individuals still have the potential for experiencing PEM, however, they might not have experienced it in the past 6 months, and therefore assessment of this symptom is complicated. There needs to be items on questionnaires that assess questions such as what would happen if a patient were to engage in exertion producing activities, as well as if they are pacing to reduce symptom exacerbation, and these types of questions need to supplement items tapping past activities.

It is sometimes difficult to differentiate fatigue from PEM. For example, if a person has constant high levels of fatigue, it is likely that they might not be able to identify triggers of this fatigue. For such an individual, differentiating PEM from ongoing fatigue could represent a challenging task. In addition, there are some patients who experience PEM after a period of time has elapsed from the precipitating event, and it can at times be difficult to determine the onset stimuli of symptom exacerbation versus the ongoing baseline fatigue and other symptoms. Thus, there are subtle factors that can interfere with the assessment and differentiation of PEM from fatigue. However, it is important to differentiate the fatigue that occurs on an ongoing basis versus PEM that involves exacerbation of symptoms due to various triggers.

The creation of this PEM instrument relied heavily on input from hundreds of patients, and this type of research is within the rubric of community-based participatory research. This type of participatory work has infrequently occurred in the ME and CFS fields, where names given to the illness, case definitions, and treatment modalities have generally been determined by federal agencies or scientists, with minimal input from patients or patient organizations. However, there are multiple benefits from engaging in research that is more participatory and collaborative (Jason, 2012), as patients often have a unique experience base that is not available to those who have not directly experienced the illness, and particularly for symptoms like PEM that are so different from what occurs among healthy individuals or many other chronic illnesses. In addition, by actively involving patient groups in the decisions around instrument development and policy, patients ultimately feel more appreciated and committed to ongoing scientific activities, and this can aid collaborative efforts when requesting more funding and resources from the federal government and elsewhere.

There were a number of limitations in this article, and a central one alluded to above is the lack of confirmation of self-report PEM items with other more biological measures. There is a need to assess the newly created instrument’s relationship to findings from cardiopulmonary exercise assessments, which also measure exertion intolerance. In addition, there is a need for more than a cross-sectional assessment of PEM, and this would involve longitudinal data to confirm duration of PEM symptoms over time. With the development of more sophistical date collection devices including smart phones and the use of momentary ecological assessments, there are now unparalleled opportunities to collect time series data sets of behaviors and activities that can further help in the assessment of PEM. It is also of importance to validate this new questionnaire in other populations of ME/CFS and other

chronic fatiguing health conditions. The data reported in this article did not include severity ratings for symptoms, and thus this aspect of the DPEMQ will need further validation with patients. Also, this instrument was created for adults and therefore, a pediatric version of the measure needs to be developed, as some terms and questions might not be appropriate for youth with ME and CFS. Finally, this measure is somewhat long, but as specific PEM issues are assessed beginning at question 24 (whereas other issues including sociodemographics are assessed in Section 1 up to question 23), if researchers or clinicians prefer to use a briefer set of questions just related to PEM, it is possible to just administer Sections 2–5 of the DPEMQ.

In summary, this article provided the background and process of developing a new measure to assess PEM. This symptom is at the core of what patients with ME and CFS experience, and yet to date, most efforts have not measured PEM in a comprehensive way. As investigators begin to use common instruments to measure PEM and other symptoms, as recommended by the NIH/CDC CDE's working groups, there is a also a need to develop a consensus on what scores signify thresholds for meeting symptom criteria.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

SF-36 Physical functioning scores in patients with and without varying aspects of PEM (N= 1534).

Item	Yes		No		*t*	*p*
	N	*M* (*SD*)	*n*	*M* (*SD*)		
Immediate PEM onset	1092	24.74 (19.54)	414	34.17 (23.06)	−7.94	***
Delayed PEM onset	1379	27.66 (20.69)	125	23.52 (23.18)	2.12	*
Basic activities of daily living trigger PEM	1181	22.08 (17.76)	325	46.40 (20.79)	−21.05	***
Positional changes trigger PEM	976	22.06 (18.42)	527	36.96 (21.97)	−13.97	***
Emotional events trigger PEM	1405	27.15 (20.86)	98	30.46 (22.20)	−1.51	.131
Precipitant cannot be identified	1283	26.78 (20.32)	215	31.28 (24.24)	−2.92	**
During recovery, less exposure than usual to trigger PEM	1425	26.91 (20.65)	73	32.74 (23.75)	−2.33	*
Mild overexertion over several days trigger PEM	1461	26.96 (20.64)	40	39.38 (28.45)	−3.71	***
Chemicals trigger PEM	874	24.40 (19.86)	509	32.86 (22.58)	−7.26	***
Foods trigger PEM	918	25.50 (20.08)	454	31.86 (22.67)	−5.29	***
Light trigger PEM	1035	23.82 (19.58)	386	36.71 (22.35)	−10.62	***
Heat trigger PEM	1123	24.29 (19.69)	295	39.24 (21.80)	−11.34	***
Cold trigger PEM	1003	24.48 (19.25)	390	35.44 (23.65)	−8.93	***
Noise trigger PEM	1285	25.10 (19.70)	173	42.95 (23.61)	−10.91	***
Visual overload trigger PEM	1204	24.98 (19.58)	226	39.87 (23.92)	−10.10	***
Watching movement trigger PEM	794	22.30 (19.11)	556	34.51 (22.01)	−10.85	***
Sensory overload trigger PEM	1264	25.14 (19.81)	173	42.23 (23.28)	−10.41	***
Prolonged duration of PEM	1438	26.80 (20.62)	64	39.53 (25.16)	−4.79	***
Severity out-of-proportion to type of exertion	1450	26.82 (20.58)	51	38.82 (26.11)	−4.05	***
Severity out-of-proportion to intensity of exertion	1433	26.98 (20.67)	64	33.75 (25.46)	−2.54	*
Severity out-of-proportion to frequency of exertion	1284	25.64 (20.22)	193	37.07 (22.74)	−7.20	***
Severity out-of-proportion to duration of exertion	1366	26.56 (20.60)	121	35.04 (23.23)	−4.29	***
Pacing allows you to completely avoid PEM	90	37.67 (24.83)	1408	26.69 (20.50)	4.86	***
Pacing allows you to avoid PEM to a certain degree	1326	27.73 (20.52)	169	23.99 (23.75)	2.19	*

PEM: post-exertional malaise; SF-36: Short-Form Health Survey-36; SD: standard deviation.

Higher SF-36 scores indicate better physical functioning.

*$p < .05$;

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** $p < .01$;

*** $p < .001$.

Table 2.

Correlations between SF-36 physical functioning scores and aspects of PEM ($N = 1534$).

Items	Correlation with SF-36
Immediate PEM onset frequency	−.17**
Delayed PEM onset frequency	−.04
Length of delayed onset	−.04
How often do basic activities of daily living trigger PEM	−.45**
How often do positional changes trigger PEM	−.37**
How often do emotional events trigger PEM	−.18**
Total illness burden	−.39**
Length of prolonged duration	−.29**
How often is severity out-of-proportion to type of exertion	−.23**
How often is severity out-of-proportion to intensity of exertion	−.23**
How often is severity out-of-proportion to frequency of exertion	−.21**
How often is severity out-of-proportion to duration of exertion	−.24**
Pacing effectiveness	.18**

PEM: post-exertional malaise; SF-36: Short-Form Health Survey-36.

Items have been transformed to continuous variables based on time periods selected by the participant or frequency score.

** $p < .01$.