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Development and Validation of a Fatigue Assessment Scale for U.S. Construction Workers

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Abstract

Objective—To develop a fatigue assessment scale and test its reliability and validity for commercial construction workers.

Methods—Using a two-phased approach, we first identified items for the development of a Fatigue Assessment Scale for Construction Workers (FASCW) through review of existing scales in the scientific literature, key informant interviews (n=11) and focus groups (3 groups with 6 workers each) with construction workers. The second phase included assessment for the reliability, validity and sensitivity of the new scale using a repeated-measures study design with a convenience sample of construction workers (n=144).

Results—Phase one resulted in a 16-item preliminary scale that after factor analysis yielded a final 10-item scale with two sub-scales ("Lethargy" and "Bodily Ailment").. During phase two, the FASCW and its subscales demonstrated satisfactory internal consistency (alpha coefficients were FASCW (0.91), Lethargy (0.86) and Bodily Ailment (0.84)) and acceptable test-retest reliability (Pearson Correlations Coefficients: 0.59–0.68; Intraclass Correlation Coefficients: 0.74–0.80). Correlation analysis substantiated concurrent and convergent validity. A discriminant analysis demonstrated that the FASCW differentiated between groups with arthritis status and different work hours.

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Conclusions—The 10-item FASCW with good reliability and validity is an effective tool for assessing the severity of fatigue among construction workers.

Keywords

Fatigue; construction worker; scale; reliability; validity; sensitivity

INTRODUCTION

Although consensus on the topic has not been achieved, fatigue has been broadly defined as the lassitude or exhaustion of mental and physical strength that results from bodily labor or mental exertion [Lewis and Wessely 1992]. Fatigue is a risk factor at work as it may lead to decreased motivation, and vigilance, [De Vries, et al. 2003], as well as potential accidents and injuries [Swaen, et al. 2003]. In the construction industry, workers are frequently exposed to heavy workloads [Hartmann and Fleischer 2005], physiologically demanding job tasks [Abdelhamid and Everett 2002], and long work schedules [Dong 2005], potentially predisposing them to fatigue. The extant construction literature indicates there may be an association between fatigue and occupational safety [Chan 2011, Dong 2005, Powell and Copping 2010], suggesting a greater need to further evaluate and manage fatigue in the construction workforce.

An essential issue for any fatigue study is how to measure fatigue. Unfortunately, given the general lack of consensus in the literature on a definition of fatigue, measuring it has challenged scientists for decades, a problem especially relevant to working populations [Aaronson, et al. 1999]. The traditional approach to measuring fatigue is the use of self-reported scales. Currently, there are a large number of fatigue scales in the literature that are context dependent and are largely developed based on the different objectives and study designs for the different contexts [Dittner, et al. 2004]. These scales may vary from each other in several ways including the dimensional structure, the target population, and the aspects of fatigue being assessed [Dittner, et al. 2004].

Existing fatigue scales vary from each other in at least three distinct ways. First, they may have either a unidimensional or multidimensional structure. Unidimensional scales are usually short and economical to administer [Dittner, et al. 2004], but give less information about the possible qualitative differences between reported fatigue in different working situations [Åhsberg 2000]. On the contrary, multidimensional scales provide a more detailed assessment, which is useful for comparing profiles across conditions for descriptive research or in seeking to identify mechanisms underlying specific aspects of fatigue [Dittner, et al. 2004]. Second, fatigue scales are geared to assess different target populations [Dittner, et al. 2004]. For example, some scales are designed to measure fatigue among broad worker groups [Åhsberg 2000, Bültmann, et al. 2000] while others are specific to clinical patients [Stein, et al. 1998, Vercoulen, et al. 1994]. Third, the scales may be measuring different aspects of fatigue, including phenomenology, severity and impact [Dittner, et al. 2004]. While some scales just measure a certain aspect [Mendoza, et al. 2000], many others measure a mixture of them [Beurskens, et al. 2000, Fisk and Doble 2002, Michielsen, et al. 2003].

There is no gold standard for measuring fatigue. Usually, a measure of fatigue is tailored to the situation in which fatigue is being studied [Aaronson, et al. 1999]. However, we are not aware of a fatigue scale developed specifically for the construction industry. Those fatigue scales designed for the general workforce or other working populations may not be applicable for construction workers, as the construction industry differs markedly from many other industries (e.g. manufacturing) in terms of occupational health and safety as well as the physical demands of the job [Deacon 2007, Ringen and Englund 2006, Ringen, et al. 1995]. The unique characteristics of construction work are usually represented by a combination of heavy workload [Abdelhamid and Everett 2002, Hartmann and Fleischer 2005], harmful working postures [Buchholz, et al. 1996, Mattila, et al. 1993], prolonged and inflexible work shifts [El-Sayegh 2008, Zou, et al. 2007], and hazardous and dynamic working conditions [Ringen and Englund 2006, Ringen, et al. 1995], necessitating a context specific scale.

Therefore, the primary goal of this study is to develop a fatigue assessment scale, and test its reliability and validity using quantitative and qualitative methods in commercial construction workers among greater New England. The newly developed scale will be: 1) multidimensional; 2) applicable for construction workers; 3) able to assess the severity of fatigue; and 4) brief and written in simple English.

MATERIALS AND METHODS

Study Design

From August 2012 to April 2013, we collected and analyzed data from a two-phase pilot research study. In phase one, we identified fatigue scale items from the extant literature for the development of a Fatigue Assessment Scale for Construction Workers (FASCW) and tested the scale with focus groups comprised of New England construction workers (3 focus groups with 6 workers in each group). During the second phase of the study we assessed the reliability, validity and sensitivity of the newly constructed fatigue scale using a cross sectional study design in a convenience sample (n=144) of unionized New England construction workers. The construction workers who participated in the focus groups and surveys for this study were employed on commercial construction sites. Data collection methods used in this study were reviewed and approved by the Harvard School of Public Health’s Institutional Review Board. The approved methods included protocols for focus groups and surveys in which construction workers were approached and invited to participate in the survey. Participants were informed verbally that by completing the survey, they indicated consent.

Phase 1: Preliminary Scale Development

Scale Item Development: The fatigue construct was initially categorized into two dimensions, physical fatigue and mental fatigue based on prior research [Marcora 2009]. Thus, the preliminary items of the FASCW were initially developed for each dimension separately. To collect the potential items for the FASCW, a comprehensive review of the literature was conducted for existing fatigue scales in Web of Science, PubMed, PsycINFO and the grey literature. Guided by our study specific aims, we selected scales based on the following criteria: 1) having a multidimensional structure and providing a detailed assessment of fatigue symptoms; 2) applicability to a working/healthy population; and 3) assessment for fatigue severity. As a result, we identified four validated and widely-used scales that may be used as references in collecting items for the FASCW, including the 30-item Fatigue Scale developed by the Research Committee on Industrial Fatigue of the Japan Society for Occupational Health [Saito, et al. 1970], the 20-item Individual Strength Checklist [Beurskens, et al. 2000], the 14-item Fatigue Questionnaire [Chalder, et al. 1993] and the 24-item Task-Induced Fatigue Scale (TIFS) [Matthews and Desmond 1998]. Unlike the former three scales that were applicable for use in the general workforce, the last scale was originally designed to assess driving fatigue. It was selected for specific survey items because it focused on task-induced fatigue and might address some common symptoms shared by both drivers and construction workers (e.g., unable to straighten up in posture) [Matthews and Desmond 1998]. Taken together, these four scales constituted a total 88-item inventory, with 32 items relating to physical fatigue and 56 to mental fatigue.

Item reduction/revision and content validation: After collecting the potential items, we conducted two rounds of item reduction/revision to obtain a preliminary version of FASCW. First, we reduced the number of scale items by using the Delphi consensus technique with a panel of researchers in construction occupational health and safety research, including senior faculty members, post-doctoral research fellows, graduate students, and research assistants (n=11). Each Delphi round with the panel was comprised of a questionnaire, an analysis, and a feedback report. The feedback report included team decisions made on the basis of their analysis and justification. Specifically, the panel had a full discussion regarding each of the 88 items and decided to exclude those that were considered to match any of the following criteria: 1) describing some other states such as stress or mood rather than fatigue (e.g., I feel anxiety); 2) too general to describe a particular symptom (e.g., I feel tired); 3) repeating the same symptom a different item has described (e.g., the item “How is your memory” is repeating the same symptom as what the other item “Become forgetful” has described); and 4) irrelevant to a construction environment (e.g., “Unaware of objects off the road”).

Subsequently, in order to identify the items and language that were pertinent to construction work, we conducted a total of three focus group sessions with six construction workers in each group representing 11 different trades, including foremen and journeymen. Workers in the focus groups were first directed to answer the following question: “What are the typical symptoms you feel when you are fatigued?” Then each worker was given a copy of the scale items previously selected from the Delphi process and asked to review each item independently. For each item, workers were asked to determine whether it was “relevant (score=2),” “somewhat relevant (score=1)” or “not relevant (score=0)” according to their actual feeling of fatigue. They were also asked to classify each item as either physical fatigue or mental fatigue. The average score of each item was calculated and those items with a score less than one were excluded. The purpose of this method was to ensure that the retained scale items, on average, were at the level of “somewhat relevant” or “relevant” to construction workers’ fatigue experience. A scale item was also dropped if less than 80% of the workers rated the item into the expected dimension [Stein, et al. 1998].

Phase 2: Factor Analysis and Scale Validity

Participants and survey administration: In Phase 2, we conducted a repeated-measures study to assess the internal consistency, test-retest reliability, criterion validity and construct validity of the newly constructed fatigue scale items obtained from Phase 1. In collaboration with our construction company partners, we identified four different unionized, medium to large commercial construction sites in New England. The sites were a mixture of new construction and renovation projects, with buildings that ranged from 337,000-square feet to 1.3 million-square feet.

At each construction site, the study team initially contacted the site's general contractor management staff for access to the site's workers. During their coffee and/or lunch breaks, workers were approached and informed of the study, and invited to participate in completing the baseline survey. Workers who were 18 years or older, spoke and read English, were currently employed at the construction site, and expected to be at the same site one week later from their baseline administration date were eligible to complete the survey. In order to assess the test-retest reliability of the fatigue scales, workers were asked to include their first and last name as well as company name on a separate detachable sheet at the end of the baseline survey. Our study team revisited each of the four construction sites one week later and invited workers who had completed the baseline survey to participate in a follow-up survey containing identical survey measures. In order to minimize the potential for variability in fatigue levels between the two surveys, the time interval between surveys was only one week, and both surveys were conducted at the same point during the day. Our team collected 209 baseline and 160 follow-up surveys, of which 144 were successfully matched by worker name, company name, and worker demographics. Participants were given a $10 gift card for completing each survey.

Survey Measures: In addition to the preliminary version of FASCW, the baseline and follow-up surveys included elements to test the validity of the scale, including the Profile of Mood States Fatigue Subscale (POMS-F) and the Ratings of Perceived Exertion (RPE) scale. The preliminary version of FASCW asked respondents "to what extent do you feel each of the following symptoms right now?" Respondents may select an option on a 5-point Likert scale (1 = not at all, 5 = completely). The Profile of Mood States Fatigue Subscale (POMS-F) [McNair, et al. 1992] consists of seven items that assess the feelings of fatigue and weariness. Respondents were asked to "read each item carefully and then circle one answer which best describes how you feel right now" on a 5-point scale (0 = not at all; 4 = extremely). Total scores range from 0 to 28. The POMS-F has been widely used to assess fatigue in healthy populations and has been shown to have good reliability and validity [Renger 1993]. The Rating of Perceived Exertion (RPE) scale [Borg 1982] is a category measure to assess the level of exertion ranging from 6 to 20, where 6 signifies "no exertion at all" and 20 signifies "maximal exertion." It was selected not as a measure of fatigue, but as a construct that is theoretically related to fatigue, namely the worker's perceived exertion. The respondents were asked to "Choose the number from below that best describes your level of exertion right now." The score is used in this study to test the convergent validity of the new developed fatigue scale as it has been found previously to be highly correlated with heart rate, lactate levels, %VO2max, and breathing rate [Borg, et al. 1987]. Subsequent studies have supported the validity of the RPE scale in a wide range of populations [Chen, et al. 2002, Dunbar, et al. 1992]. In addition, the survey contained demographic information (i.e.. age, gender, trade, height, and weight), as well as the participants' health conditions (e.g., arthritis status, functional limitations) and job characteristics (e.g., job title, work hours).

Data Analysis: In total, we collected 144 matched sets of baseline and follow-up surveys. The follow-up survey data were used for all analyses including the assessment of factor structure, reliability and validity, while the baseline survey data were only used for the assessment of test-retest reliability. Analyses were run in SAS version 9.3.

First, an exploratory factor analysis was performed using the follow-up survey data in order to identify the number of underlying dimensions (factors) needed to explain the inter-correlations among scale items [13]. A varimax criterion of rotation was used in order to align these factors to a more interpretable structure (grouping). The final factors and items were determined based on the following criteria. First, each factor had a clear drop in the scree plot. When the slope of the line in the scree plot approaches zero, it can be assumed that deleting additional factors would not result in discarding significant variance [Floyd and Widaman 1995]. Second, each factor should have a minimum of three items with significant factor loadings [Comrey 1988]. Third, each item in the retained factors should load at or above 0.4 on one factor while not loading similarly on another factor [Williamson, et al. 1997]. In addition, items in each factor should be evaluated to make sure they are theoretically relevant [Stein, et al. 1998]. The result of the factor analysis was a final version of FASCW.

Internal consistency of the final FASCW was assessed by computing Cronbach's alpha coefficients using follow-up survey data. Test-retest reliability was assessed by calculating the Pearson Correlations Coefficient as well as the Intraclass Correlation Coefficient (ICC) between results of the baseline and follow-up surveys.

The validity of the FASCW was evaluated by comparing responses of FASCW with other measures from the follow-up survey. Concurrent validity was evaluated by computing the correlations between the FASCW and an existing validated fatigue measure [Mosby 2009], the Fatigue subscale of Profile of Mood States (POMS-F). Convergent validity was evaluated by computing correlations between the FASCW and a measure of a construct that is theoretically related to fatigue [John and Benet-Martinez 2000], namely the Rating of Perceived Exertion (RPE). Discriminant validity was evaluated by comparing the FASCW scores between worker groups with and without arthritis and by work hours. First, a comparison was made between participants who self-reported doctor-diagnosed arthritis versus participants without arthritis. As subjective fatigue was highly associated with arthritis status according to existing literature [BELZA, et al. 1993, Huyser, et al. 1998], it was expected that participants who had any form of arthritis would report greater fatigue than those who did not. A comparison of FASCW scores was also conducted between subjects with different work hours per week in the last 30 days. The responses were categorized into 1) 40 hours or less and 2) more than 40 hours.

RESULTS

Phase 1

Phase 1 development resulted in a 16-item preliminary scale (Table I) each with a 1 (not at all) to 5 (completely) response. From the 88 identified items from various validated fatigue questionnaires reported in the literature the Delphi Process reduced these to 37. Focus groups with the construction workers then reduced these 37 items to 12 in order to identify which items were most relevant to construction workers and to support efficient administration on the construction site. In addition, the focus groups identified four new items relevant to the construction worker experience (i.e., “Body movement slows down,” “Arms/legs feel numb,” “Feel achy in joints”, and “Feel cramp in muscle”). Among these 16 items in the preliminary scale, 9 related to physical fatigue and 7 to mental fatigue.

Phase 2

Sample characteristics—The 144 recruited participants ranged in age from 19 to 60 years (mean = 42.4, SD = 10.3), had worked in the construction industry for an average of 19.1 years (SD = 10.0), and were all male (Table II). The sample covered more than 18 construction trades, including carpenter, cement/concrete worker, general labor, demolition worker, electrical worker, excavation worker, and iron worker. Ninety-two percent of study participants reported belonging to a union.

Factor structure and final reduction to 10 items—The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.911, indicating the sample was highly reliable for factor analysis [Dziuban and Shirkey 1974]. Based on the factor analysis and the final item selection criteria described in the Method section, 2 factors with 5 items each were retained, producing a brief, 10-item measure (Table III). The first factor was termed “Lethargy,” which included symptoms such as “lacking in energy,” “body movement slows down” and “thoughts easily wander.” The second one described the symptoms of “Bodily Ailment,” including “arms/legs feel numb,” “shoulders feel stiff/pain,” “eyes feel strained”. Since the responses were on a 1–5 scale, the ranges of scores for the 10-item FASCW and its 5-item subscales are 10 to 50 and 5 to 25, respectively.

Reliability—Internal consistency of the scale and it subscales was supported by good Cronbach's alpha coefficients (Table IV): FASCW (0.91), Lethargy (0.86), Bodily Ailment (0.84). Additionally, consistency between test-retest samples separated by two weeks were indicated by acceptable correlation coefficients between the scale and its subscale values at the two sample times (Table IV): Pearson Correlations Coefficients (0.59–0.68), Intraclass Correlation Coefficients (0.74–0.80).

Validity—The results indicated significant high correlations (0.66–0.71) between the FASCW and the Fatigue subscale of Profile of Mood States (POMS-F) (Table V), suggesting that the FASCW was measuring a similar construct measured by the POMS-F and had good concurrent validity. There were significant high correlations (0.70–0.75) between the FASCW and the measure of perceived exertion, suggesting good convergent validity of FASCW.

Discriminant Validity—Significant differences in the expected direction were found between subjects with and without arthritis on the scores of FASCW and its two subscales (Table VI). In addition, participants who worked more than 40 hours per week were found to report a higher score of fatigue than those who worked 40 hours or fewer (Table VI). These results suggested that the FASCW was able to discriminate subjects with different arthritis status and work hours.

DISCUSSION

The goal of this study was to develop a fatigue assessment scale and test its reliability and validity for construction workers on commercial worksites in New England. Our two phase approach provided a 10-item scale that represents the most typical fatigue symptoms experienced by construction workers. Statistical analyses on internal consistency and test-retest correlations suggested satisfactory reliabilities of the FASCW. Comparisons of the FASCW with other fatigue-related measures indicated that the FASCW had good concurrent, convergent, and divergent validities. In addition, sensitivity studies demonstrated that the FASCW was able to differentiate between groups who were expected to differ in their level of fatigue according to existing literature. Overall, the two-dimension FASCW is supported by the present study to be a brief and effective tool for assessing the severity of fatigue among construction workers. The FASCW instrument can be used by researchers for academic studies as well as by practitioners for assessing the level of fatigue among workers and supporting fatigue management programs.

While we initially hypothesized that mental and physical fatigue are two basic categories of fatigue [Marcora 2009] we found that among the 10 items of the FASCW, 3 of them (i.e., “lacking in energy,” “my thoughts easily wander” and “eyes feel strained”) are pertinent to mental fatigue, whereas the remaining 7 items are pertinent to physical fatigue. Given that these mental health items remained in the list following our two-phased evaluation suggests that the mental health component of the fatigue scale is an important concept for construction workers that should not be overlooked. Furthermore, “Bodily Ailment” and “lethargy” are two dimensions generated from factor analysis, which served not only to understand the factor structure of the fatigue scale, but more importantly, to extract the most critical items for the scale. Once we determined the final items of the scale, the distinction between mental and physical may help us to better understand the feature of construction workers’ fatigue. In previous studies, since construction work has been largely characterized from a physical perspective [Abdelhamid and Everett 2002, Hartmann and Fleischer 2005], the mental workload of construction workers and its consequence (e.g., mental fatigue) have not been discussed as much. Construction work requires a certain degree of mental effort as workers need to be engaged, focused and alert while working on dynamic and hazardous construction sites [Gürcanli and Müngen 2009]. Given the complexity of the construction environment, mental fatigue may be a relevant safety factor (compared to physical fatigue) as it has a direct, adverse effect on workers’ cognitive ability in detecting, understanding and coping with potential risk [Csathó, et al. 2010, Lorist, et al. 2005].

The development and validation of the FASCW is not without limitations. First, the influence of weather or climate on fatigue symptoms was not taken into account as the measure was developed and validated in a convenience sample of largely unionized commercial construction workers from the New England area during the winter season. It is possible that samples from other geographic areas with hot summer climates may result in some symptoms related to heat stress [Chan, et al. 2012]. It is also possible that different types of construction settings, like residential, may have different challenges that affect workers' fatigue. Thus, the reliability and validity of the FASCW with samples from different geographic areas and construction types still need to be examined. Second, all the participants in the present study were male workers from the New England area, and so the psychometric properties of the FASCW with female workers, as well as workers from different cultural, ethnic and socioeconomic backgrounds have yet to be assessed. In addition, further studies on the FASCW are needed to establish its sensitivity to change over time and its associations with acute safety outcomes such as accidents and injuries.

Despite the abovementioned study limitations, this study has several strengths. The 10 items in the FASCW have examined different sources of fatigue: 6 of them are from existing scales while the remaining 4 items are from focus groups with construction workers. While we identified common items shared by the FASCW and existing scales, the newly identified symptoms have revealed some novel characteristics specific to construction work. For example, the symptom "my body movement slows down" may be attributed to the dynamic and physically demanding nature of construction work [Ringen, et al. 1995]. While on a jobsite, a construction worker is constantly in motion, working in different areas of the jobsite, moving heavy materials, and/or working in awkward postures. Under these conditions, construction workers may be more sensitive to any slowing down of their movements as compared to those who work in a relatively stable/fixed working environment (e.g., manufacturing, transportation). In addition, the symptom "My joints (e.g., knee, elbow) feel achy" may be relevant to the frequent use of harmful postures or heavy manual material handling [Buchholz, et al. 1996, Li and Lee 1999].

These study results also support the notion that a measure of fatigue is usually tailored to the work environment in which fatigue is studied [Aaronson, et al. 1999]. The preliminary items of the FASCW were collected from four validated and widely used fatigue scales for the working population; however, the final FASCW only retains one item from the Individual Strength Checklist, two from the Fatigue Questionnaire, two from the Fatigue Scale by Japan Society for Occupational Health, and one from the Task-Induced Fatigue Scale. Thus it can be seen that none of these four scales can efficiently capture a comprehensive set of symptoms for construction workers' fatigue. Even within the construction workforce, the specific fatigue symptoms may differ due to the subjective nature of fatigue itself [Dittner, et al. 2004]. Workers with different work conditions and socio-cultural background may have their own definitions and experiences of fatigue. Therefore, it is crucially important to have a comprehensive understanding of the target workforce before measuring their fatigue.

CONCLUSION

In conclusion, though not a substitute for other existing fatigue scales used in the general worker population, and not yet shown to be associated with important construction worker outcomes (i.e., illness, injuries or fatalities), the FASCW appears to be a promising and simple fatigue assessment instrument that may find other applications through further construction health and safety research and practice. The FASCW may also help researchers and practitioners to better understand the typical fatigue symptoms of unionized commercial construction workers, so as to take possible actions for fatigue regulation and management.

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Table 1

Items characteristics of the preliminary Fatigue Assessment Scale for Construction Workers

Items		Source	Physical fatigue	Mental fatigue
Q1.	Thinking requires effort	20-item CIS		✓
Q2.	My thoughts easily wander	20-item CIS		✓
Q3.	Lacking in energy	14-item FQ		✓
Q4.	I have less strength in muscles	14-item FQ	✓	
Q5.	Whole body feels tired	30-item Fatigue Scale	✓	
Q6.	Legs feel tired/heavy	30-item Fatigue Scale	✓	
Q7.	Yawning	30-item Fatigue Scale		✓
Q8.	Eyes feel strained	30-item Fatigue Scale		✓
Q9.	Shoulder feels stiffness or pain	30-item Fatigue Scale	✓	
Q10.	Hearing ability reduced	24-item TIFS		✓
Q11.	Feel stiff in the legs and arms	24-item TIFS	✓	
Q12.	My body movement slows down	Focus group survey	✓	
Q13.	My arms/legs feel numb	Focus group survey	✓	
Q14.	My mind feels clear (positive question)	Focus group survey		✓
Q15.	I feel cramps in muscles	Focus group survey	✓	
Q16.	My joints feel achy	Focus group survey	✓	

Table 2

Social-demographic and work characteristics among New England construction worker participating in a baseline survey for the Fatigue Assessment Scale pilot study in April 2013 (n=144).

Sample Characteristics	**N (%)**†
Age	
19–34 year olds	38 (26.4)
35–44 year olds	35 (24.3)
45–54 year olds	50 (34.7)
55 and older	21 (14.6)
Years in Construction Industry	
1–10	35 (24.3)
11–20	47 (32.6)
21–30	46 (32.0)
31 or more	15 (10.4)
Gender	
Male	144 (100.0)
Body Mass Index (BMI)	
Normal or Underweight	23 (16.0)
Overweight	67 (46.5)
Obese	54 (37.5)
Race / Ethnicity	
White	130 (92.3)
Black or African American	3 (2.1)
Native Hawaiian / Pacific Islander	1 (0.7)
American Indian or Alaska Native	2 (1.4)
Hispanic and Latino	4 (2.8)
Education	
Grade 11 or less	6 (4.2)
Grade 12 or GED (High school graduate)	74 (51.4)
College 1 year to 3 years (Some college or technical school)	49 (34.0)
College 4 years or more (College graduate)	9 (6.3)
Job Title	
Foreman	27 (18.8)
Journeyman	82 (56.9)
Apprentice	15 (10.4)
Others (e.g. engineer, surveyor)	20 (13.9)
Trade††	
Carpenter	32 (22.2)
Cement/concrete worker	30 (20.8)
General labor	29 (20.1)
Demolition worker	15 (10.4)
Electrical worker	14 (9.7)

Sample Characteristics	**N (%)**[†]
Excavation worker	13 (9.0)
Iron worker	13 (9.0)
Operation Engineer	13 (9.0)
Bricklayer	12 (8.3)
Plumber	11 (7.6)
Power tool operator	11 (7.6)
Scaffold builder	9 (6.3)
Others	40 (27.8)

[†]Differences in sub-total population sample due to item non-response or missing

[††]Individual worker may belong to two or more trades

Table 3

Rotated factor structure of Fatigue Assessment Scale for Construction Workers (n = 144)

	Factor Loadings	
Items	**Lethargy**	**Bodily Ailment**
Q3. Lacking in energy	0.80	
Q4. I have less strength in muscles	0.78	
Q6. Legs feel tired/heavy	0.75	
Q12. My body movement slows down	0.62	
Q2. My thoughts easily wander	0.55	
Q13. Arms/legs feel numb		0.83
Q9. Shoulders feel stiff/pain		0.67
Q16. My joints (e.g. knee, elbow) feel achy		0.63
Q8. Eyes feel strained		0.56
Q15. I feel cramps in muscles		0.55
Variance accounted for	30.4%	22.1%

Table 4

Cronbach's Alpha coefficients and Test-Retest Correlations for FASCW (n=144)

	Cronbach's Alpha Coefficients	Test-retest Pearson Correlations Coefficients	Test-retest Intraclass Correlation Coefficients
FASCW	0.91	0.66**	0.79**
Lethargy	0.86	0.68**	0.80**
Bodily Ailment	0.84	0.59**	0.74**

** P<0.01

FASCW=Fatigue Assessment Scale for Construction Workers

Table 5

Correlations of FASCW with POMS-F and RPE(n=144)

	POMS-F	**RPE**
FASCW	0.71**	0.75**
Lethargy	0.66**	0.70**
Bodily Ailment	0.67**	0.70**

** P<0.01

FASCW = Fatigue Assessment Scale for Construction Workers; POMS-F = Profile of Mood States-Fatigue subscale; RPE = Rate of Perceived Exertion.

Table 6

FASCW scores comparison between subjects with and without arthritis, and subjects with different work hour per week

	Mean (Standard Deviation)		
	Subjects with arthritis (N=50)	**Subjects without arthritis (N=88)**	**p**
FASCW (10–50)	26.96 (8.42)	22.78 (6.85)	.002
Lethargy (5–25)	13.40 (4.33)	11.72 (3.82)	.020
Bodily Ailment (5–25)	13.56 (4.66)	11.06 (3.49)	.000
	Subjects worked more than 40 hours per week (N=37)	Subjects worked 40 hours or less per week (N=80)	p
FASCW	27.08 (7.80)	23.41 (7.82)	.020
Lethargy (5–25)	13.70 (4.12)	11.80 (4.13)	.022
Bodily Ailment (5–25)	13.38 (4.17)	11.61 (4.21)	.036

FASCW = Fatigue Assessment Scale for Construction Workers