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Validity and responsiveness of the work functioning impairment scale (WFun) in workers with pain due to musculoskeletal disorders

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Abstract: Objective: To determine the convergent validity and responsiveness of the work functioning impairment scale (WFun) in workers with musculoskeletal disorder-related pain. **Methods:** Participants were extracted from an internet user study and prospectively examined using the pain intensity numerical rating scale (pain-NRS), the work ability numerical rating scale (productivity-NRS), and the WFun at baseline, 2 weeks, 6 weeks, and 3 months. The convergent validity and responsiveness of the WFun were examined by multilevel regression analysis. **Results:** A total of 786 workers participated and 593 completed all surveys. The WFun score gradually increased and decreased as the pain-NRS and the productivity-NRS increased, respectively. Changes in the WFun score steadily increased and decreased as changes in the pain-NRS and the productivity-NRS increased, respectively. Multilevel analyses showed that all linear associations were significant. **Conclusions:** The convergent validity and responsiveness of the WFun were consistent with the expected direction and magnitude.
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Introduction

The concept of presenteeism refers to the phenomenon of a person attending work despite complaints and ill health that require prompt rest and absence[1], and it underscores the decreased productivity and below-normal work quality of the person at work[2]. Presenteeism not only increases the risk of an individual's future health problems but can also affect his/her job performance. Previously, it was thought that absenteeism, or not attending work, was the main cause of productivity loss. Recent studies, however, indicate that presenteeism, rather than absenteeism, is the main factor associated with productivity loss[3,4]. Therefore, studies have sought to develop tools to assess the extent to which medically related problems negatively affect job performance and to evaluate the associated loss in productivity.

Many such tools have been devised, including the Work Limitation Questionnaire (WLQ)[5], the Work Productivity and Activity Impairment Questionnaire (WPAI)[6], the Endicott Work Productivity Scale (EWPS)[7], and the Stanford Presenteeism Scale (SPS)[8,9]. Studies using these tools have revealed that presenteeism may result from any of several causes, including depression[10-12], stress[13], burnout[14], and fatigue[15]. One factor with a particularly strong impact on presenteeism is pain[16-18], which has been shown to be associated with depression and stress[19,20]. Further, individuals experiencing pain are associated with high levels of absenteeism and presenteeism, which often leads to work change or work loss[21-24].

The various available productivity assessment tools are designed on the basis of differing concepts. While some center on the loss of productivity associated with the period of time for which the person was experiencing difficulties, others examine physical or emotional factors, which, for example, indicate the intensity of pain in patients with pain-related problems or the degree of mental problems in patients with depression. In contrast, few tools evaluate workers' health-related abilities in the workplace. There is a crucial distinction between a person's productivity and their ability to function. Productivity is associated with output, which is defined by various factors, including an individual's ability to function, the work environment, technology, and workers' knowledge. Productivity can be improved, even if an individual's ability to work is reduced, by modernizing old work environments and technology using such methods as implementing assembly lines. In the health management of workers, evaluation tools focusing on workers' health-related abilities may be more suitable. Furthermore, tools that are not affected by illness type are preferable.

Fujino et al. developed an original questionnaire, the "work functioning impairment scale" (WFun), which evaluates a worker's health-related ability to complete their work tasks[25]. "Functioning" refers to "the ability of the individual to perform particular defined tasks."[26] The WFun was developed to correlate the severity of a person's health problems with the degree by which they limit the person's "functioning" at work. This concept is closely related to quality of life, but it differs from worker performance and behavior[25]. One of the features of the WFun was based on the Rasch model, a common statistical method used to evaluate individuals' latent abilities according to item responses[27-30]. The inclusion of this model means that the WFun can assess the ability of individual workers to perform at work at the time of measurement. Past studies have assessed and proven the quality of the WFun[25,31] in accordance with consensus-based standards for the selection of health measurement instruments (COSMIN)[32,33], a guide that is used to evaluate the methodological quality of newly developed health-related patient-reported outcomes. However, quality assessment of the WFun is not yet sufficient because it has not been verified for responsiveness, a requirement of COSMIN.

Tools used to assess and improve health problems must be validated to ensure that they can reliably detect changes over time. We aimed to assess the convergent validity and responsiveness of the WFun in workers with musculoskeletal disorder-related pain. In particular, we wanted to confirm that the constructs of interest are actually changed, rather than detecting general changes or clinically significant changes. We adopted the measurement definitions used by COSMIN[32,33]. In addition, we defined convergent validity as how well two theoretically related measures of constructs are actually related. Responsiveness was defined as the ability to detect changes in a measure of construct over time. According to COSMIN, responsiveness is an aspect of validity, and it is treated as a separate measurement to emphasize the difference between the validity of a single score and the validity of the change score[32]. Assuming that the WFun exhibits good convergent validity and good responsiveness, we hypothesized that 1) workers with high WFun scores would score higher on the pain numerical rating scale (pain-NRS) and lower on the work ability numerical rating scale (productivity-NRS) than workers with low WFun scores, and 2) workers with positive changes in the WFun would show more positive changes in the pain-NRS and more negative changes in the productivity-NRS than workers with negative changes in the WFun.

Methods

This series of studies was conducted via an internet investigation aimed at registered users. A commercial testing company performed an internet test user study. An email asking for participation in the study was sent to approximately 20,000 of 2 million registered internet test users. Users were screened for the use of statements such as "I am currently employed," "I currently have pain in muscles and joints that hinder my work or my daily life," and "I am between 20 and 59 years of age." We initially targeted 600 subjects for the study. To account for subjects dropping out during the follow-up, the first 786 respondents who satisfied the screening process and who agreed to participate in the questionnaires were enrolled in the study. We requested information about the respondents' age, sex, and job type, as well as their pain- and work-related conditions. All answers were self-reported and anonymized.

Evaluation of pain[34]

Subjects were asked to indicate in which of the following body parts he/she felt pain: head, neck, shoulder, upper back, lower back, hip joint, upper extremities, lower extremities (including knees), and other. An 11-point pain-NRS was used to evaluate pain intensity, with 0 indicating no pain and 10 indicating the worst possible pain. Subjects were asked to indicate the average intensity of pain that he/she experienced within the last week.

Evaluation of work-related condition

The question "what is your current work capacity on a scale of 1 to 10 if '10' represents the best health condition you have experienced so far?" was used to generate a generic score on the productivity-NRS to evaluate subjects' self-reported work productivity.

The WFun assesses responses to seven items[25]: "I haven't been able to behave socially," "I haven't been able to maintain the quality of my work," "I have had

trouble thinking clearly," "I have taken more rests during my work," "I have felt that my work isn't going well," "I haven't been able to make rational decisions," and "I haven't been proactive about my work." Respondents are required to choose from one of the following five response categories for each item: 1, "not at all"; 2, "one or more days a month"; 3, "about one day a week"; 4, "two or more days a week"; and 5, "almost every day." The final WFun score was the sum of the scores of the 7 items. Scores could range from 7 to 35, with higher scores indicating worse work ability.

Follow-up survey

Follow-up surveys were conducted at two weeks (wave 2), six weeks (wave 3), and three months (wave 4) after the baseline survey (wave 1). Respondents were asked questions related to the pain-NRS, the productivity-NRS, and the WFun at all waves.

Statistics

The convergent validity of the WFun for the pain-NRS and the productivity-NRS were examined by multilevel regression analyses in which repeated measurements were nested in individuals. The model used the WFun as a dependent variable and the pain-NRS and the productivity-NRS as independent variables.

The responsiveness of the WFun for the pain-NRS and the productivity-NRS were also examined by multilevel regression analyses. The change scores were calculated for the WFun, the pain-NRS, and the productivity-NRS by subtracting the follow-up score from the score at the previous wave. Change in the WFun was used as a dependent variable and changes in the pain-NRS and the productivity-NRS were used as independent variables.

All analyses were performed using STATA software (version 14). Statistical significance was determined using two-sided tests at a significance level of 0.05.

Results

Of the 786 subjects, 722 (92%), 680 (87%), and 593 (75%) subjects responded to the follow-up second, third, and fourth wave surveys, respectively. Since all items had to have a corresponding response, there were no missing data in the follow-up phases.

Table 1 shows the characteristics of the study subjects. Subjects' characteristics did not significantly differ among the waves. Low back pain was the most frequently reported symptom (30%), followed by pain in the shoulder (24%), lower extremities and knee (18%), and head and neck (12%).

Table 2 summarizes the convergent validity of the WFun for the pain-NRS and the productivity-NRS. For convergent validity, the cumulative total number of respondents collected across all four waves was 2,781. The mean WFun score gradually increased as the pain-NRS increased. The mean WFun score was 10.2 in subjects with zero on the pain-NRS and 20.3 in those with the highest score on the pain-NRS. Multilevel analyses showed a significant linear association between the pain-NRS and the WFun scores. Moreover, the mean WFun score gradually increased as the productivity-NRS decreased. The productivity-NRS was also associated with the WFun in the multilevel analyses. These results support hypothesis 1.

Table 3 shows the responsiveness of the WFun to changes in the pain-NRS and the productivity-NRS. For responsiveness, the cumulative total number of respondents collected across all four waves was 1,995. The mean WFun score steadily increased with increases on the pain-NRS. Multilevel analyses revealed that subjects who reported a decrease in the pain-NRS, indicating improved health conditions, reported a decreased change in the WFun, which indicates an improvement in the ability to function at work. Conversely, subjects who reported an increase in the pain-NRS experienced an increased change in the WFun. The change in the WFun was also linearly associated with a change in the productivity-NRS. Multilevel analyses showed that subjects who reported an increase in the productivity-NRS, indicating an improvement in the ability to work, reported a decrease in the WFun. These results support hypothesis 2.

Discussion

We evaluated the convergent validity of the WFun for the pain-NRS and the productivity-NRS and the responsiveness of the WFun to changes in the pain-NRS and the productivity-NRS in workers with pain due to musculoskeletal disorders. We found significant linear associations in all cases.

A health-related patient-reported outcome is a subjective self-evaluation of a patient's health status that is not interpreted by a doctor or another individual. It is therefore important that the methodological quality of the tools used to obtain such outcomes is properly verified. According to COSMIN, when a gold standard is not available, hypothesis testing should be used to evaluate a tool's validity. Previous studies on the WFun have shown a good fit to the Rasch model in terms of specific objectivity and proven construct validity; and they have validated it against the hypothesis test of convergent validity by job disruptions, SPS, the Short Form 8 Health Survey (SF-8), and changes in employment status, and discriminant validity by sex, age, employment status, job type, and income[31]. In this study, we confirmed the convergent validity and responsiveness of the WFun in workers with pain. Our results were consistent with our hypotheses.

Recent systematic reviews have assessed the quality of evaluation tool measurement properties using the COS-

Table 1. Characteristics of the study subjects

	Wave 1	Wave 2	Wave 3	Wave 4
Number of subjects	786	722	680	593
Follow-up period from baseline	baseline	2 weeks	6 weeks	3 months
Sex, male	50%	52%	52%	53%
Age, mean (SD)	40.1 (10.1)	40.3 (10.1)	40.4 (10.1)	41.0 (10.0)
Job type				
Mainly desk work	50%	49%	49%	50%
Jobs mainly involving interpersonal communication	18%	18%	18%	18%
Mainly labor	32%	33%	33%	33%
Part of body with pain				
Head and neck	12%			
Shoulder	24%			
Upper back	4%			
Lower back	30%			
Hip joint	3%			
Upper extremities	9%			
Lower extremities and knee	18%			
Other	1%			
Pain-NRS, mean (SD)	4.6 (1.9)	4.4 (2.0)	4.6 (2.0)	4.3 (2.1)
Productivity-NRS, mean (SD)	6.4 (1.9)	6.5 (2.0)	6.5 (1.9)	6.5 (2.0)
WFun, mean (SD)	15.6 (7.1)	15.3 (7.5)	15.8 (7.3)	15.3 (7.6)

SD, standard deviation; Pain-NRS, pain numeric rating scale; Productivity-NRS, productivity numeric rating scale; WFun, work functioning impairment scale.
Pain-NRS ranges from 0 to 10, where 0=no pain and 10=worst possible pain.
Productivity-NRS ranges from 0 to 10, where 0=least productive and 10=most productive in his/her work experience.
WFun ranges from 7 to 35.

MIN checklist[35,36]. One such review[37] showed that of 21 presenteeism evaluation tools, three had sufficient measurement properties, and only two tools, the EWPS and the SPS 6-item version (SPS-6), were adequate for assessing responsiveness to reveal important changes in constructs over time. In the responsiveness study described above[38], work productivity and work ability were used to calculate change scores. Work productivity and work ability were assessed by single items that asked patients with rheumatoid arthritis or osteoarthritis to rate their changes in productivity from the baseline to being able to conduct their usual work activities. Our survey used a pain intensity assessment to calculate change scores due to the strong impact that pain has on presenteeism[17,18]. To our knowledge, this is the first report to use pain, determined by a numerical rating scale, in a presenteeism evaluation tool to assess responsiveness.

Pain often becomes chronic and, as well as being associated with presenteeism, can lead to negative consequences, such as early retirement, work disability, and absenteeism[21-24]. According to a five-year registry-based follow-up study, 12.6% of women and 8.8% of men take long-term sick leave owing to musculoskeletal diagnoses[39]. Many studies have further confirmed that work-related outcomes worsen as severe pain increases[40], which was also observed using the WFun in this study. There are many pain-related diseases, including arthritis, irritable bowel syndrome, fibromyalgia, repetitive strain injury, neuropathic disease, and cancer; and there are many types of pain, including back pain, musculoskeletal pain, shoulder pain, headache, and menstrual pain. There are disease-specific evaluation tools for some of these diseases, which are widely used to improve the understanding of a patient's health status and therapeutic outcomes. However, while these tools may be useful for characterizing the condition of a particular disease, they may not be useful for occupational health evaluations. The WFun can be used as a common management tool for all employees because it aims to assess an individual's ability to work in the workplace rather than the status of a specific disease. That is, it may be more effective to evaluate and manage occupational health using a broader assessment viewpoint

Table 2. Convergent validity of work functioning impairment scale (WFun) for pain numeric rating scale (NRS) and productivity-NRS.

Measure	Cumulative total number across the 4 waves	Mean WFun score	SD	Multilevel analyses*		
				Coefficient	SE	*p*
Pain-NRS						
0	79	10.2	5.1	Reference		
1-2	410	11.8	6.0	1.5	0.7	0.034
3-4	766	14.4	6.6	2.9	0.7	<0.001
5-6	1110	16.0	7.2	3.8	0.7	<0.001
7-8	362	19.2	8.1	6.1	0.7	<0.001
9-10	54	20.3	9.6	7.0	1.0	<0.001
Productivity-NRS						
9-10	310	11.4	6.7	Reference		
7-8	1205	13.5	6.1	1.1	0.4	0.002
5-6	881	16.6	6.9	2.9	0.4	<0.001
3-4	270	19.7	8.0	5.2	0.5	<0.001
0-2	115	23.6	8.7	7.7	0.6	<0.001

SD, standard deviation; SE, standard error.
Higher scores on pain-NRS and WFun indicate worse pain and low ability to work due to pain, respectively. Higher scores on productivity-NRS indicate better ability to work.
* Multilevel analyses were conducted such that repeated measurements were nested in individuals.

Table 3. Responsiveness of change in work functioning impairment scale (WFun) for changes in pain numeric rating scale (NRS) and productivity-NRS.

Change in measure	Cumulative total number across the 4 waves	Mean change in WFun score	SD	Multilevel analyses*		
				Coefficient	SE	*p*
Pain-NRS						
–9 to –4	78	–2.6	8.0	–2.4	0.7	0.001
–3 to –2	280	–1.1	6.7	–1.0	0.4	0.018
–1 to 1	1311	–0.2	6.0	Reference		
2 to 3	270	1.1	6.6	1.2	0.4	0.003
4 to 7	56	2.2	5.2	2.4	0.9	0.005
Productivity-NRS						
5 to 10	30	–2.2	9.3	–2.3	1.2	0.044
1 to 4	659	–1.3	6.3	–1.4	0.3	<0.001
–1 to 0	1011	0.1	5.8	Reference		
–4 to –2	265	1.4	6.9	1.3	0.4	0.003
–10 to –5	30	2.8	8.7	2.7	1.2	0.024

SD, standard deviation; SE, standard error.
Positive change scores on pain-NRS and WFun indicate worsened pain and reduced ability to work due to pain, respectively. Positive change scores on productivity-NRS indicate improved ability to work.
* Multilevel analyses were conducted such that repeated measurements were nested in individuals.

than one that focuses on specific diseases or their degree of severity within a given individual.

The present findings may suggest that the WFun offers the following advantages in worker management: (1) it consists of a few (seven) simple question items; (2) it is a specialized index for evaluating workers' ability to function at work and is easy to interpret without being constrained by the type or severity of health problem; (3) its total score is associated with a sufficient statistical evaluation, so there is no need to analyze the answer[31]; (4) it does not include health information, so non-medical staff can handle the data[41]; and (5) it is an objective tool in which the differential test function has been examined, so it can be used regardless of age, industry type, or occupation[31].

Several limitations of the present study should be mentioned. First, we did not confirm the diagnosis of the subjects' health problems. Second, we did not obtain information about interventions, including medical treatment or changes in working conditions, during the follow-up. In particular, changes in working conditions may improve a worker's health-related function, which can mitigate work-functioning impairments without improvement in the worker's actual health conditions. Third, in terms of hypothesis testing, the results only indicate the direction of the association, and it is difficult to explain the magnitude of difference. Fourth, we used the productivity-NRS, a single item question, to confirm convergent validity in this study because it has been widely used as a component of many existing presenteeism tools[5,8,9,42]. However, the productivity-NRS itself is also ambiguous, and its validity has not been fully confirmed. Convergent validity should be verified using other presenteeism or work functioning evaluation tools. Multi-item measurements are generally better for assessing complex constructs than single-item measurements[43]. Therefore, it is important to select the most appropriate tool for the study question. Finally, the WFun was originally developed in Japanese and, as such, the English translated items in this report might be found to be inaccurate by back translation or cross-cultural validation.

In conclusion, the present study verified the convergent validity and responsiveness of the WFun for pain intensity, measured by the pain-NRS, among individuals with musculoskeletal disorders. The WFun also showed good convergent validity and responsiveness of self-reported productivity, as measured by a generic numeric rating scale. Nevertheless, further verification of the validity and responsiveness of the WFun is required, such as by targeting other populations or by performing a comparison with other tools.

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Conflicts of interest: None declared.

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