

# Assessment of Upper Extremity Role Functioning in Students

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**Background** *Upper extremity symptoms associated with use of computers and other upper extremity activities are common in students. Research on these disorders requires psychometrically sound measures of health-related student role function; no such measure is available currently.*

**Methods** *Based upon input from students and clinicians, we developed a 10-item scale to measure student health-related role function. The measure was administered as part of a survey of 193 undergraduates at one university. A follow-up survey was administered 1 month later. The student health-related role function questionnaire was assessed for internal consistency, ceiling effects, convergent and discriminant validity, and responsiveness to self-reported change in functional status.*

**Results** *Eighty-two percent of students who were given the survey completed it and 65% completed a follow-up survey 1 month later. The new measure was reliable (Cronbach's  $\alpha$  0.87). Forty-six percent of respondents reported "no difficulty" on all items of the health-related student role function measure while 64% reported "no difficulty" on all items of a generic upper extremity functional status measure. This finding indicates that the new measure was better able to detect functional limitations; it had a less prominent ceiling effect. The new measure had moderately high correlations with measures of symptom severity and pain, documenting convergent validity. It distinguished students who utilized clinician services, medications, or academic accommodation from students who did not utilize these resources, documenting discriminant validity. The measure was responsive to self-perceived change, as demonstrated by a highly significant association ( $P < 0.0001$ ) between changes in score over a 1-month follow-up and students' perceptions of whether they had improved in functional abilities after the month, deteriorated or remained stable.*

**Conclusions** *The student health-related role functioning measure is reliable, valid and responsive to change. It is an appropriate measure for research on upper extremity symptoms in students.* Am. J. Ind. Med. 41:19–26, 2002. © 2002 Wiley-Liss, Inc.

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## INTRODUCTION

Upper extremity symptoms and associated functional limitations comprise an important source of disability and direct and indirect cost in the workplace [Bernard, 1997; National Academy of Sciences, 1999, 2001]. Industries characterized by highly forceful and repetitious upper extremity activities, such as poultry and meat processing, lumber, and manufacturing, have the highest rates of upper extremity disability [Cheadle et al., 1994; Bureau of Labor Statistics, 1999]. While debate continues on the specific risk factors for upper extremity disorders in computer users, epidemiological data show that computer operators are at risk, particularly those who use the computer for more than 4 hr per day [Punnett and Bergqvist, 1997]. Computer user surveys document point prevalence rates of upper extremity symptoms ranging from 20–40% [Bernard et al., 1994; Polanyi et al., 1997].

Upper extremity disorders are increasingly common in younger workers. Four percent of carpal tunnel syndrome cases and 9% of tendinitis cases reported to the Bureau of Labor Statistics in 1997 involved workers younger than 25 years old [Bureau of Labor Statistics, 1999]. This age group accounts for 15% of the workforce [Bureau of Labor Statistics, 2001], suggesting that younger workers appear to be at somewhat lower risk, as would be expected, but are indeed affected by upper extremity disorders. Similarly, over 6% of carpal tunnel syndrome (CTS) cases reported to the Massachusetts SENSOR (Sentinel Event Notification Surveillance of Risk) Program in the mid-1990s occurred in persons younger than 25 years [Massachusetts Department of Public Health, 1999]. Reported prevalence rates likely underestimate the burden of these disorders, as musculoskeletal problems are underreported in adolescents [Parker et al., 1994].

Recent data suggest that frequent episodes of upper extremity symptoms are also prevalent among college students. Half of undergraduates are affected and one-seventh experience symptoms after just 1 hour of computing [Katz et al., 2000a]. Fifteen million students are enrolled in post-secondary educational institutions in the United States (U.S. Department of Education, 1997), suggesting there may be over seven million college and university students with some level of upper extremity symptoms, and over two million with symptoms following minimal computing exposure. As college students are increasingly entering computer-intensive occupations following graduation, computer-associated symptoms and functional limitation may have significant effects on students' professional career plans and productivity.

Research is needed urgently to clarify the natural history of upper extremity symptoms in students and to develop preventive and therapeutic strategies. Such research will require reliable, valid and responsive measures of the primary manifestations of these syndromes—upper extremity symptoms and attendant functional limitations. While several upper extremity functional limitations scales have been developed [Katz et al., 2000b], all have targeted working [e.g. Stock et al., 1995, 1996; Hudak et al., 1996; Pransky et al., 2000] or general adult [e.g. Levine et al., 1993] populations rather than students, and all focus on activities of daily living.

We hypothesized that available upper extremity functional status measures would be insensitive to the limitations in role function experienced by students with upper extremity symptoms. Hence, we developed a student health-related role functioning measure. In this paper, we present the development and initial psychometric assessment of the measure. We hypothesized that the student health-related role functioning questionnaire would be more sensitive to student role limitations than a generic upper extremity functional status measure, the Brigham Functional Limitations Scale [Levine et al., 1993]. We also hypothesized that the new measure would have excellent internal consistency, convergent and discriminant construct validity and responsiveness to change.

## METHODS

### Development of Student Health-Related Role Functioning Measure

The development of the measure is grounded in the conceptual work of Amick et al. [2000] who suggested a new class of generic role functioning measures focusing on primary roles, such as that of the student. However, unlike work, family, and leisure roles, which have been examined extensively in prior research, few studies have defined the student role [Burke and Reitzes, 1981]. To better describe the role, members of the research team met for several hours with four undergraduates (none of whom had upper extremity symptoms) and asked the students to discuss activities important to college campus life that required extensive use of the upper extremities. The research team also conducted a focus group in which undergraduate students who had experienced upper extremity symptoms discussed the effect of these symptoms on their functional activities. The investigators used the information gathered during these activities to develop a list of student role activities. We then asked other undergraduates and recent college graduates to

add to and refine the list. Further input was sought from clinical and health services researchers and clinicians, all of whom had an interest in upper extremity disorders. In this fashion, we generated 13 candidate items, with five responses per item. The response format requires students to assign a level of difficulty in performing the activity, from 0 = “no difficulty” to 4 = “so difficult I cannot do.”

## Sample

We performed this research at the undergraduate college of a private university. The college has 12 residential houses, where over 95% of sophomores, junior and seniors live. Undergraduate residents of one residential house were eligible. Students that did not reside in the House were excluded. The Brigham and Women’s Hospital Human Investigations Committee and the Committee on Student Research Participation at the college approved the study protocol.

## Recruitment and Data Collection Procedures

On two evenings in April 2000, study team members visited the dining hall of the residential house and invited all eligible students in the hall to complete the survey during dinner. Students handed the survey back to the investigators at the end of dinner and received a book of postage stamps as a token of appreciation. One month later the investigators mailed a follow-up survey to all students who completed the initial survey. A week later the investigators sent students a single email reminder to complete the follow-up surveys. The initial survey occurred just after spring break, and the final survey at the beginning of final examination period.

## Data Elements

Aside from the student health-related role functioning scale, the survey also contained a generic pain scale consisting of six items with Likert scale responses [Rogers et al., 2000], the Brigham Symptom Severity Scale (11 items), and Brigham Functional Limitation Scale (7 items). The Brigham scales [Levine et al., 1993; Katz et al., 1996] were originally developed to assess symptom severity and functional limitations due to carpal tunnel syndrome and have been used in a wide range of upper extremity conditions [Amadio et al., 1996; Beaton et al., 2001]. They have Likert response scales with five responses per item. The responses are weighted evenly and averaged to yield a scale score, which is then transformed to a 0–100 range (100 best).

The survey also contained information on students’ computing habits, academic major, race, age and sex, use of health care providers, medications, disability services and

school accommodations such as dropping a course or postponing an exam.

## Analyses

We compared psychometric properties of the new student health-related role function scale with a generic measure of function, the Brigham Functional Limitation scale [Levine et al., 1993].

## Reliability

Reliability was assessed with Cronbach’s  $\alpha$ , a measure of internal consistency, or intercorrelation among items. We hypothesized that the new student health-related role function scale (as well as the generic functional limitations scale) would have Cronbach’s  $\alpha > 0.70$ , which is generally regarded as adequate for group comparisons [Nunnally and Bernstein, 1994].

## Scaling Properties

Ceiling effects were assessed by determining the number of students who responded “No difficulty” to every one of the items on the scale. (A smaller number of students at the ceiling indicates that the scale is better able to detect minor levels of functional limitation.) We hypothesized that the student health-related role functioning scale would have a less prominent ceiling effect than the generic functional measure. The number of students who did not answer each item was recorded. For each item we examined the correlation between the item and the total scale. We hypothesized moderate to high correlations (0.30–0.80) for each item on both scales.

## Validity

Convergent validity refers to the extent that the scale is associated with other measures of the same or a similar concept as that measured by the scale. Discriminant validity refers to the extent that the scale is able to distinguish between groups that differ with respect to the concept measured by the scale [Streiner and Norman, 1995]. We assessed convergent validity with correlations between the student health-related role functioning scale and other measures we hypothesized to be related to student role function, including pain, symptoms, and generic functional limitations. To assess discriminant construct validity we compared the student role functioning scores between groups hypothesized to differ in functioning. These groups included self-reported symptomatic versus asymptomatic students; those who had seen a physician for upper extremity problems versus those who had not; those who were

taking medications for upper extremity symptoms and those who were not; and those who had used a school accommodation versus those who had not. We hypothesized worse (higher) student health-related role functioning scores among those who had seen a clinician, used medications for upper extremity discomfort; and used an accommodation.

### **Responsiveness**

We assessed responsiveness to self-reported change in status by examining the associations between changes in student health-related role function scores and students' perceptions of their change in functional status between initial administration and the follow up survey at 1 month [Fortin et al., 1995]. We hypothesized that scores would be unchanged in students who felt their functional abilities were unchanged, worse in students who felt their functional abilities deteriorated and better in students who felt their functional abilities improved.

All data were double entered to ensure accuracy. Analyses were conducted using SAS (6.03 ed., Cary, NC).

## **RESULTS**

### **Sample Characteristics**

The House had 425 residents. The study team printed 250 questionnaires and distributed all of them to consecutive diners in the house on two consecutive evenings. We received surveys from 204 of these 250 students. Eleven respondents were found to be ineligible because they did not reside in the house, leaving 239 eligible students and 193 eligible respondents (81% response rate). Of the 193 eligible respondents, 46% were female, 38% represented racial or ethnic minority groups, 36% were sophomores, 36% juniors, and 28% seniors. (Freshman do not live in the House.) The 193 respondents were sent the follow-up survey 1 month later and 125 returned surveys, for a response rate of 65%. Those students who completed the 1-month follow-up did not differ from the students who did not complete the follow-up questionnaires with respect to scores on the student health-related functioning scale, the generic functional status and symptom severity scales and the mental health scale. Similarly, there were also no differences in those who did and those who did not complete the follow up in the proportion who had seen a physician or used medication for upper extremity symptoms at baseline. Seventy-three percent of females completed the follow-up as compared with 59% of males ( $\chi^2 = 4.0$ ,  $P = 0.05$ ).

### **Item Reduction**

Three items were omitted after field testing because they were endorsed infrequently (type one page on the

computer, search through the Web, and carry a tray in the dining hall). The final instrument, shown in Figure 1, consists of 10 items.

### **Reliability**

The Cronbach's  $\alpha$  of the student health-related role functioning scale was 0.87, while the Cronbach's  $\alpha$  of the Brigham functional limitations scale was 0.85. Item to total correlations were in the range of 0.35 to 0.85 for both scales (Table I).

### **Scaling Properties**

The number of students with a score of zero (no limitations; at the "ceiling") was 88 (46% of respondents) for the student health-related role functioning scale and 123 (64%) for the Brigham functional limitation scale ( $P < 0.001$ ; Table I). No student had the worst possible score on either measure. At the individual item level, 13% of students reported some difficulty on each of the least challenging items on the student health associated role functioning measure (complete assignments on time, do assignments on the computer as well as you'd like; correspond as often as you would like by email). Fully 36% reported some difficulty on the most challenging item (type 10 pages). In contrast, fewer than 3% of students reported difficulty on each of several less challenging items of the generic Brigham Functional Limitations Scale (buttoning clothes, gripping the phone handle, household chores and bathing and dressing, while 28% reported difficulty with the most challenging item (writing; Table I).

### **Validity**

We hypothesized that the student health-related role functioning scale would be highly correlated with the Brigham generic functional limitation scale and with measures of pain and symptom severity. The correlations shown in Table II support these hypothesized associations ( $0.60 < r < 0.70$  for each), establishing convergent validity.

We also hypothesized that the mean student health-related functional scores would be statistically significantly worse among students who had seen a health professional, used medications for upper extremity discomfort, or used a school accommodation than among students who had not utilized these resources. The data in Table III support these hypothesized associations as well, documenting discriminant validity.

### **Responsiveness**

Eight students (7% of those that completed the follow-up survey) considered their ability to do academic,

## Student Functional Limitations Scale

	No difficulty	Mild difficulty	Moderate difficulty	Severe difficulty	So difficult I cannot do at all
(a) Type 10 pages (double space) on the computer	0	1	2	3	4
(b) Complete assignments on the computer (such as typed papers) on time	0	1	2	3	4
(c) Do assignments on the computer as well as you would like	0	1	2	3	4
(d) Complete handwritten assignments (such as problem sets)	0	1	2	3	4
(e) Correspond as often as you would like by email with friends, faculty and others	0	1	2	3	4
(f) Take notes in class by hand	0	1	2	3	4
(g) Take timed written examinations	0	1	2	3	4
(h) Do extracurricular activities (such as sports, musical instruments, hobbies)	0	1	2	3	4
(i) Use the mouse (or other computer pointing device) repeatedly	0	1	2	3	4
(j) Carry your books around campus	0	1	2	3	4

**FIGURE 1.** In the past 2 weeks, how much difficulty have you had with the following activities as a result of pain/discomfort in your hands, wrists, arms, shoulders or neck? (CIRCLE one answer for each line).

extra-curricular and daily activities to be *better* at the 1 month follow up than at the initial survey. The mean student health-related functioning score in these students *improved* by 4.7 points (SD 6.0). Among the 104 students (85% of the cohort) who considered their ability to do these activities to be the *same*, the mean scores were essentially *unchanged* (worse by 0.027 points, SD 8.0). Finally, among the 10 students (8%) who considered their ability to have *worsened*, the mean student role functioning scores *worsened* by 9.7 points (SD 13.5). These associations between changes in student health-related role functioning scores and perceived improvement in function were highly statistically significant ( $P < 0.0001$ ).

## DISCUSSION

We have presented a new ten-item student health-related role functioning scale and reported its initial field testing and psychometric assessment. The measure will be useful in research on an important emerging public health problem, upper extremity musculoskeletal syndromes in students [Katz et al., 2000a]. With as many as seven million undergraduate students potentially affected in the United States, research on prevalence, risk factors, natural history, prevention, and treatment of these syndromes in students is needed urgently. Measurement of the impact of these

disorders on students' lives is critical for research on burden of illness, natural history and treatment outcomes. The health-related student role functioning scale will be a useful tool for achieving these research goals.

Our findings document that the student role functioning measure has excellent reliability, convergent and discriminant validity, and responsiveness to self-perceived change. As hypothesized, it correlated highly with the generic function scale ( $r = 0.68$ ) and had striking associations with measures of pain and symptom severity. It distinguished students who consulted health care providers for upper extremity symptoms, received medication, and utilized academic accommodations from those who did not use these resources. The student health-related upper extremity role functioning scale is also responsive to students' self-reported change in functional status over a 1-month period.

As with other role specific measures [Amick et al., 2000] the items are tailored to a particular role (functioning as a student). Many items (e.g. completing assignments on time, doing assignments well, taking timed examinations) reflect the salient theme of academic responsibility noted in a prior formal analysis of the student role [Burke and Reitzes, 1981]. Because the measure is tailored to the college setting it is sensitive to students' functional limitations. Over 13% of students reported difficulties with each

**TABLE I.** Number of Respondents Missing, Mean Score, Range and Percent of Respondents at Ceiling for Items From Student Health-Related Role Functioning and Brigham Functional Limitations Scales

Item	Missing	Item-total	Mean	Range	% at ceiling
<b>A. Student health-related role functioning scale</b>					
Type 10 pages	4	0.72	0.52	0–3	64%
Complete assignments on the computer on time	2	0.67	0.18	0–3	87%
Do assignments on computer as well as you'd like	2	0.60	0.18	0–3	87%
Complete handwritten assignments	4	0.59	0.32	0–3	78%
Correspond as often as you would like by email	2	0.72	0.17	0–2	87%
Take notes in class by hand	1	0.62	0.42	0–4	71%
Take timed written examinations	1	0.68	0.56	0–3	67%
Do extracurricular activities	1	0.38	0.28	0–3	82%
Use mouse (or other pointing device) repeatedly	1	0.54	0.19	0–2	84%
Carry your books around campus	1	0.43	0.21	0–3	85%
Entire Student Health-Related Role Function Scale		—	7.8	0–60	46%
<b>B. Generic Brigham Functional Limitations Scale</b>					
Writing	0	0.38	0.35	0–3	72%
Buttoning clothes	1	0.43	0.03	0–1	97%
Holding a book while reading	0	0.60	0.21	0–3	84%
Gripping the phone handle	0	0.82	0.03	0–2	97%
Opening jars	2	0.77	0.09	0–4	94%
Doing household chores	0	0.52	0.01	0–1	99%
Carrying grocery bags	0	0.67	0.08	0–2	94%
Bathing and dressing	0	0.63	0.02	0–2	99%
Entire Brigham Functional Limitations Scale		—	2.6	0–53	64%

item (Table I), and 36% reported difficulty with the most challenging item (typing ten pages). In contrast, the items in the generic measure (Table I) tap basic activities of daily living and activities that are not directly relevant to most students, such as household chores. Not surprisingly, fewer than 3% of students reported limitations with any of the items on the generic measure (Table I), except writing (28% had limitations) and holding a book (16%), which tap the student role.

Our study has important limitations, which should be addressed in further investigations. First, the measure was developed and validated among undergraduates at a single

private institution. The scale should be further validated in other undergraduate settings (public universities, non-residential schools) and in other age and academic groups including graduate and technical schools, high schools and middle and even elementary schools, where early computing habits may be established. Also, while we developed the measure to tap role limitations arising from computer associated upper extremity symptoms, the measure may also reflect symptoms arising from other mechanical exposures such as sports and music. Future work should attempt to distinguish the contribution of these various biomechanical stressors. Finally, the study did not include physical

**TABLE II.** Pearson Correlation Coefficients Between Student Health-Related Role Functioning Scale, Brigham Functional Limitations Scales, and Measures of Symptom Severity and Pain Severity

	Student functional limitations	Brigham functional limitations	Generic pain severity	Brigham symptom severity
Student functional limitations	1.0			
Brigham functional limitations	0.68	1.0		
Generic pain severity	0.65	0.51	1.0	
Brigham symptom severity	0.62	0.60	0.77	1.0

$P < 0.0001$  for all correlations.

**TABLE III.** Mean Student Functional Limitation and Brigham Generic Functional Limitation Scores in Subgroups of Students Defined by Utilization of Resources, Medication Use, and Academic Accommodation

	Student functional limitations			Brigham generic functional limitations		
	Mean	SD	P	Mean	SD	P
Utilization of health care resources						
Yes	13.5	17.4	0.05	5.0	10.4	0.14
No	6.8	9.5		2.1	4.3	
Medication use						
Yes	11.5	14.8	0.05	4.3	8.9	0.11
No	6.9	9.9		2.1	4.3	
Academic accommodation						
Yes	20.1	16.8	0.005	7.6	13.9	0.09
No	6.7	9.9		2.1	4.5	

examination of students and did not attempt to specify the type of upper extremity disorder [Rempel et al., 1992] in each subject (such as epicondylitis, carpal tunnel syndrome, tendinitis of the wrist and of the rotator cuff, forearm pain, wrist pain, etc.). Further validation work should be conducted in carefully studied cohorts to establish the validity of the measure in students with specific upper extremity disorders, and with a broad spectrum of acute and chronic upper extremity syndromes.

In summary, we have developed a student health-related role functioning measure and recommend it for research on students with upper extremity symptoms. The measure is reliable, valid, responsive to perceived change and more sensitive to student upper extremity functional limitations than a generic measure of upper extremity functioning. We encourage other investigators to perform additional psychometric evaluation and we recommend the measure for research on the important problem of upper extremity symptoms and disability in students.

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