CHARACTERIZING PHYSICAL STRAIN IN NON-ROUTINIZED CLINICAL WORK THROUGH OBSERVATION: AN EXAMPLE OF ORAL HEALTHCARE PROVIDERS

Yiyang Fang[1], Jay M. Kapellusch[2], Nancy A. Baker[3], Shawn C. Roll[1]
University of Southern California[1], University of Wisconsin-Milwaukee[2], Tufts University[3]

The Revised Strain Index (RSI), despite its prevalence in ergonomics field practice, is designed to assess jobs with cyclic and predictable physical and behavioral patterns. The quantification of exertion force, posture, and work task duration is substantially more challenging for non-routinized work in clinical and hospital environments. Using dental hygiene work as an exemplar, we proposed a consolidated method to characterize physical exertion for non-routinized work. We conducted the RSI adaptation process in two phases. In phase one, we characterized exertion in non-routinized work and identified representative intensity and posture patterns. In phase two, we validated the consolidated method using a small subset of dental hygiene video recordings and compared the results to the conventional sampling method.

INTRODUCTION

Measurement of physical strain is essential to evaluate the risk of developing work-related musculoskeletal injuries. The Strain Index (SI) (Moore & Garg, 1995) is a job analysis tool that quantifies physical strain based on a combination of physical exposure variables. According to a recent survey of ergonomic practitioners, the SI is one of the most commonly used assessments in the field (Lowe et al., 2019). Moreover, the SI tool has been broadly utilized in research studies to evaluate injury risks in various industries, primarily manufacturing (Bovenzi et al., 2005; Colim et al., 2021; Gerr et al., 2014; Rosecrance et al., 2017) and agriculture (Gallardo et al., 2013; Guertler et al., 2016; Kuta et al., 2015). The SI has shown robust psychometric properties, including inter-rater reliability (Paulsen et al., 2015; Stevens et al., 2004), test-retest reliability (Stephens et al., 2006), and predictive validity for multiple distal upper extremity musculoskeletal injuries (Fan et al., 2014; Garg et al., 2012; Garg et al., 2014; Kapellusch et al., 2014). Building upon the strengths of the original SI model, the Revised Strain Index (RSI) algorithms (Garg et al., 2017b) were developed, further extending its use to evaluate complex work with multiple tasks within a work shift (Garg et al., 2017a, 2017b).

Despite the improved algorithms, the use of RSI remains constrained to jobs with cyclic work cycles and uniform exertion patterns. We refer to this type of work as routinized work in this paper. Take the example of assembly line workers performing the subtasks of cutting, wrapping, and driving screws (Garg et al., 2017a). The exertion force intensity, duration, and frequency required to perform each sequentially repeated over multiple work cycles. The routinized assembly work allows ergonomists to estimate physical exposure parameters for the RSI with simple sampling strategies.

In contrast, applying the RSI to work activities that are performed in a non-linear and unpredictable fashion is substantially more challenging. This type of non-routinized work is prevalent in healthcare settings. An example is dental hygiene or dental cleaning practice, where dental hygienists intermittently change how they apply exertions to remove built-up plaque and calculus from tooth surfaces (Dong et al., 2005; Villanueva et al., 2007). The variabilities in force intensity, task duration, and hand postures make the quantification of physical exposures methodologically challenging and time-consuming, given that ergonomists need to observe individual hand movements.

Although a few research studies attempted to apply the RSI to non-routinized work, none have applied it in clinical settings and hospital environments. Furthermore, no existing studies have developed a valid and convenient method to characterize variabilities in physical exposure. Most previous studies either sampled short segments of work tasks (i.e., 1-10 minutes) (Capodaglio, 2017; Quemelo et al., 2015) or failed to provide sufficient details to replicate the sampling methods (Joseph et al., 2020; Noh & Roh, 2013). One study proposed a modified application of the SI method using electromyography (EMG) data (Cabecas, 2007); however, direct measurement tools such as EMG, motion sensors, and electronic goniometers are cumbersome and have low usage within ergonomic field practice (Lowe et al., 2019) and can be challenging to use in sterile healthcare environments. Moreover, there is limited evidence of using EMG devices to quantify biomechanical forces with varying duration, frequency, and posture (Wang et al., 2021).

Given the challenges in applying RSI to non-routinized jobs, this paper proposes a consolidated method to sample and characterize common physical exposure patterns, allowing ergonomists to apply RSI through live and video observations. We selected dental hygiene work to demonstrate this consolidated method because dental hygienists have a high prevalence of developing musculoskeletal injuries in the upper extremities (Hayes et al., 2009; Netanely et al., 2020).

DATA SOURCES

The RSI quantifies physical exposure risk based on 5 variables: intensity of exertion, efforts per minute (i.e., frequency of exertions), duration per exertion, hand/wrist posture, and duration of work per day. The RSI score is the product of 5 numeric multipliers corresponding to each variable. We used observational and self-report exertion data to define the exertion criteria, characterize common patterns of exertion force and wrist posture, and identify RSI multipliers corresponding to each pattern.

Video recordings and live observations were conducted with students in two dental hygiene bachelor's degree programs while they provided one-on-one dental hygiene services to patients from local communities. We recorded videos using three GoPro cameras (GoPro, Inc.; San Mateo, CA) arranged in orthogonal views to capture work activities from overhead, front, and lateral perspectives (Figure 1). Institutional Review Boards at both universities approved the protocol for this study, and we obtained informed consent and photo releases from all participants and patients. The standardized video collection and observational coding protocol have been described in a previous publication (Roll et al., 2021). One researcher conducted all live observations, using an interval sampling method to collect data every 15 minutes while the participants performed dental scaling tasks. For each interval sample, the researcher identified the intensity of exertion and estimated wrist angles at an increment of 5 degrees. Participants rated the intensity of exertions on a Borg CR-10 perceived exertion scale (Borg, 1982) immediately following live observation sessions. We obtained 19 videos and 17 live observations from 36 dental hygiene students.

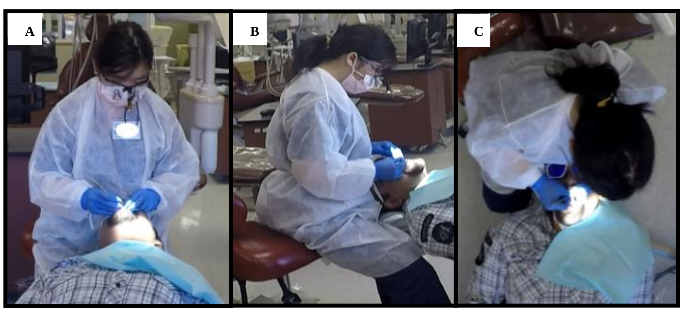

***Figure 1**. Video camera views from the front (A), lateral (B), and overhead (C) positions.*

RSI ADAPTATION PHASE 1

Defining Exertion

In the original RSI model, one exertion is defined as the direct application of force to complete a work task once. Applying this definition for hand-intensive work like dental cleaning would be extremely time-consuming and would inflate the effort per minute variable to an abnormally high value, ultimately overestimating the RSI scores. We attempted to apply the original definition on a small set of video recordings, and all RSI results were over 30. Because the RSI model is designed to consider any score over 10 as 'hazardous' (Garg et al., 2017b), exceedingly high RSI scores lack discriminative power for meaningful risk classification. To make the process more efficient and avoid grossly overestimating strain, we defined one exertion as the direct continuous application of a dental scaling instrument with similar intensity and wrist posture patterns until a rest break of at least 15 seconds. The characterization of exertion force and posture patterns are described in the following sections.

Intensity of Exertion Patterns

In the RSI model, intensity of exertion (e.g., exertion force) represents the percentage of maximum strength (% MVC) required to perform the task once. In the case of dental hygiene work, the intensity of exertion is the amount of force required to hold a dental scaling instrument (static force) and stabilize the instrument against resistance to remove plaque, stains, or calculus from teeth (resistive force). Power-driven tools like ultrasonic dental scalers only require static force to hold the instrument. Conversely, dental scaling using hand-held instruments (i.e., manual scaling) requires resistive force to remove built-up plaque on teeth. Depending on the mouth area, plaque accumulation, and gum pockets' depth, varying force intensities are needed to perform manual scaling.

We consulted with two dental hygiene experts to characterize dental scaling tasks, who identified three intensity patterns for manual dental scaling: light (L), moderate (M), and heavy (H). The experts and one researcher independently observed and categorized 9 randomly selected video segments. The first round of categorization was conducted without a standardized definition and yielded 70% agreement for categorizing intensity. Following this coding round, the dental hygiene experts and research team developed standardized definitions for each intensity pattern (Table 1). A second coding round using these definitions resulted in 89% agreement. In addition to the three intensity patterns, we added descriptions for ultrasonic scaling (US) and non-scaling (N).

***Table 1.** Intensity of exertion patterns.*

Patterns		Description
L	Light	Continuous strokes applying minimal force; no patient head movement.
M	Moderate	Deliberate strokes with moderate force; minimal to moderate movement of the patient's head.
H	Heavy	Discontinuous movements of the hand holding the scaling instrument due to increased resistance; moderate to heavy movement of the patient's head.
US	Ultrasonic	Anytime when the dental hygienist is using an ultrasonic scaling instrument.
N	No scaling	Anytime when the dental hygienist is not actively applying force on the patient.

Once we identified the intensity patterns, we conducted live observations to obtain self-reported Borg CR-10 ratings and quantify a standardized exertion intensity for each pattern. In total, we collected 424 manual scaling samples, of which 76 were pattern L, 251 were pattern M, and 97 were pattern H. The average self-reported Borg CR-10 ratings for patterns L, M, and H were 2.63, 3.98, and 5.60, respectively. We assumed a Borg rating of 1.0 for pattern US.

Next, we estimated duty cycles that accounted for static and resistive forces occurring with each exertion. Although the RSI eliminated duty cycle estimation due to high correlations with duration per exertion and effort per minute, we used duty cycles to ensure that defining an exertion that incorporated both resistive force and brief rest would not overestimate strain. We randomly selected 10 video recordings to estimate duty cycles and extracted 2 clips for each exertion force pattern (L, M, H, and US). We timed segments where participants actively applied force to patients' teeth requiring resistive force (i.e., duty time). The average duty cycle for patterns L, M, H, and US were 83%, 75%, 67%, and 89%, respectively. We rounded the duty cycle percentages to the nearest 5%, resulting in duty cycle percentages for patterns L, M, H, and US of 80%, 75%, 70%, and 90%, respectively.

Lastly, we calculated the duty-cycle-modified intensity ratings using the self-reported Borg CR-10 ratings for the duty time and assuming a Borg rating of 1 for the static force required to hold the instrument during off-duty time. The duty-cycle-modified exertion ratings for patterns L, M, H, and US were 2.30, 3.24, 4.22, and 1.00. The corresponding intensity multiplier (IM) values were 2.93, 3.99, 5.37, and 1.57, respectively. We rounded the RSI multipliers to the nearest 0.5 for simplicity in completing real-time assessments, resulting in final values of 3.0, 4.0, 5.5, 1.5, and 1.0. Figure 2 presents intermediate steps to finalizing the IM values.

Original Borg Ratings

L	M	H	US
2.63	3.98	5.60	1.0

Duty Cycle

Pattern	L	M	H	US
Duty cycle	80%	75%	70%	90%
Off-Duty	20%	25%	30%	10%

Duty-cycle Modified Exertion

L	M	H	US
2.30	3.24	4.22	1.00

RSI Multipliers

L	M	H	US
2.93	3.99	5.37	1.57

Final Exertion Multipliers

L	M	H	US	L
3.0	4.0	5.5	1.5	1.0

Figure 2. *Intensity of exertion force multiplier calculation*

Wrist Posture Patterns

We used dental hygiene expert consultation and video observations to establish three general categories of wrist posture: flexion, neutral, and extension. We defined extension posture as wrist extension greater than 30 degrees and flexion posture as any wrist flexion. Because the RSI posture multiplier (PM) is relatively constant at 1.0 for wrist angles between 0 degrees and 30 degrees of extension, we identified this range as neutral. Next, we collected 295 wrist posture samples through video and live observations to validate our categorization and estimate representative wrist angles for each posture category. Data shown in Figure 3 provide the relative distribution of samples aligning with the proposed flexion, neutral, and extension posture categories where positive wrist angle values represent wrist extension and negative values represent wrist flexion.

Of the 295 samples, 162 were neutral, 22 were flexion, and 111 were extension. The mean, median, and mode values for wrist extension were 45.7, 45, and 45 degrees; thus, we chose 45 degrees as the most representative wrist angle for extension posture. The mean, median, and mode values for wrist flexion were -19.3, -15, and -15 degrees. We chose -15 degrees to represent flexion posture instead of the mean value of -19.3 degrees to prevent the overestimation of the posture multiplier. The final PM values for wrist flexion, neutral, and extension were 1.17, 1.00, and 1.06, respectively, all with the same PM of 1.00.

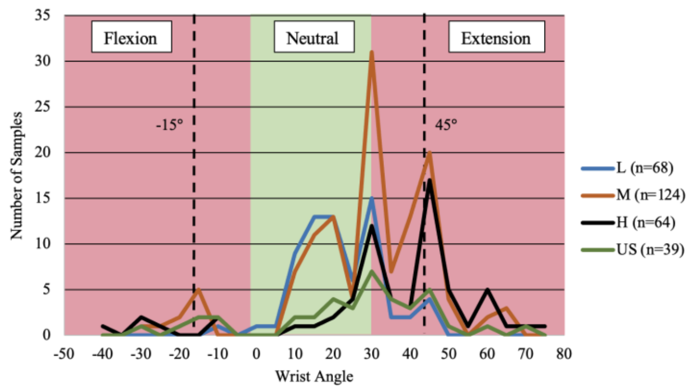

Figure 3. *Wrist posture patterns and representative angles.*

RSI ADAPTATION PHASE 2

RSI and COSI Calculation Using the Consolidated Method

The RSI score is the product of 5 numeric multipliers, including intensity of exertion (IM), efforts per minute (EM), duration per exertion (DM), hand/wrist posture (PM), and hours of work per day (HM). The Composite Strain Index (COSI) algorithm estimates the overall physical stain of multi-task work shift by combining the RSI scores of individual subtasks (Garg et al., 2017a). The calculation of RSI and COSI is straightforward for routinized work where the administrator can identify subtasks (e.g., driving screws and cutting wires) with distinct exertion force, duration, and posture. Yet it is difficult to generalize such procedures to non-routinized work where every exertion is characterized by varying physical exposure parameters. For example, a dental hygienist may alternate between heavy exertion with low frequency and light exertion with high frequency depending area of the mouth and the amount of build-up on the teeth. Therefore, we propose a consolidated definition for subtasks in the RSI model to consider exertions with the same intensity pattern as a subtask. Using this definition, subtask RSI scores of each dental cleaning session can be calculated for each intensity pattern and combined using COSI calculations.

We calculated subtask-level RSI and COSI scores on 5 randomly selected video recordings of dental hygiene patient visits. A typical dental hygiene patient visit in university-run clinics includes assessment, patient education, faculty consultation, instrumentation, and other administrative duties. We only applied the RSI on instrumentation activities because instrumentation consists of the most strenuous work tasks in dental hygiene, including teeth scaling and root planting. One researcher used Observer® XT (Noldus, Inc.; Wageningen, Netherlands, Version 14.1) video coding software to apply the RSI by manually coding the intensity of exertion and posture patterns. Duration, count, and frequency (i.e., effort per minute) parameters were automatically recorded along with the pattern codes. An Excel calculation spreadsheet (Microsoft, Inc.; Redmond, WA, USA, Version 2016) was created to compute subtask-level RSI and COSI scores.

Table 2 summarizes the COSI and subtask-level RSI results. The highest COSI score was 13.6 (video 2), and the lowest was 7.68 (video 5). The COSI results of videos 1 and 2 exceeded the hazardous threshold of 10 points. Although the remaining 3 videos fall under the 'safe' category, it is worth noting that video 4 scored exactly at the threshold of 10.0 points. The average duration of exertion for each pattern varied substantially across the videos, ranging from 38.5 seconds to 102.7 seconds per exertion. Likewise, efforts per minute (frequency) varied significantly. For instance, in video 5, the count of exertion pattern L was 2, resulting in the lowest efforts per minute of 0.02; while the count of exertion for pattern N was 44, resulting in the highest efforts per minute of 0.44. The total duration of work ranged from 0.96 to 1.62 hours across 5 videos. Wrist posture had minimal impact on the final RSI results because of the small multiplier values.

ID #	COSI	Sub-task	RSI	IM	PM	Exertion Count	Effort per minute	EM	Duration per exertion (second)	DM	Hours per day	HM
1	12.6	L	4.34	3.00	1.03	15	0.15	0.14	54.10	17.2	1.62	0.59
		M	7.57	4.00	1.03	33	0.34	0.18	53.12	16.9	1.62	0.59
		H	7.89	5.50	1.04	17	0.17	0.14	51.24	16.3	1.62	0.59
		N	2.57	1.00	1.00	30	0.31	0.18	80.39	24.7	1.62	0.59
2	13.6	L	3.84	3.00	1.05	5	0.07	0.12	60.5	19.20	1.17	0.53
		M	10.45	4.00	1.05	25	0.36	0.19	79.4	24.41	1.17	0.53
		H	8.61	5.50	1.07	12	0.17	0.14	59.9	19.03	1.17	0.53
		N	1.89	1.00	1.00	18	0.26	0.16	67.6	21.33	1.17	0.53
3	9.3	L	2.62	3.00	1.03	7	0.12	0.13	39.3	12.64	0.96	0.52
		M	7.76	4.00	1.06	13	0.23	0.16	72.7	22.74	0.96	0.52
		US	2.43	1.50	1.03	13	0.23	0.16	61.9	19.64	0.96	0.52
		N	2.07	1.00	1.00	22	0.38	0.20	65.1	20.62	0.96	0.52
4	10.0	L	2.61	3.00	1.03	14	0.20	0.15	38.5	12.39	1.23	0.54
		M	5.93	4.00	1.06	28	0.30	0.17	48.2	15.40	1.23	0.54
		H	6.28	5.50	1.06	6	0.05	0.11	83.6	25.40	1.23	0.54
		N	2.90	1.00	1.00	27	0.32	0.18	102.7	29.35	1.23	0.54
5	7.68	L	3.69	3.00	1.09	2	0.02	0.11	57.7	18.35	1.61	0.56
		M	5.73	4.00	1.09	16	0.17	0.14	49.9	15.90	1.61	0.56
		H	5.30	5.50	1.09	4	0.04	0.11	42.8	13.70	1.61	0.56
		US	3.02	1.50	1.09	28	0.29	0.17	57.7	18.33	1.61	0.56
		N	2.81	1.00	1.00	43	0.44	0.21	72.2	22.61	1.61	0.56

Table 2. *RSI and COSI results using the consolidated method (n=5).*

Comparison with a Conventional Method

To further examine the validity of the consolidated method, we compared our method with a conventional method that approximates more to the original RSI sampling strategy. The definition of one exertion in the conventional method was the direct application of force with the same apparent intensity pattern or wrist posture, and any change in intensity or posture was coded as a separate exertion regardless of duration. The intensity of exertion patterns L, M, H, US, and N remained, but instead of using duty cycles, the IM value corresponding to the average Borg CR-10 rating was used and holding of the instrument without direct application of force was coded as an independent intensity pattern (i.e., Hold). Regarding wrist posture, the conventional method no longer used neutral, extension, and flexion patterns; instead, the coder recorded wrist angles in 5-degree increments. Table 3 summarizes the key differences between the two sampling methods.

Consolidated Method			Conventional Method		
Exertion Pattern	Duty Cycle Modified Borg CR-10	IM	Exertion Pattern	Borg CR-10	IM
Light	2.3	3.0	Light	2.6	3.3
Moderate	3.2	4.0	Moderate	4.0	5.0
Heavy	4.2	5.5	Heavy	5.6	8.0
Ultrasonic	1.0	1.5	Ultrasonic	1.0	1.5
None	0.0	1.0	None	0.0	1.0
			Hold	1.0	1.5
Posture Pattern	Wrist Angle				
Extension	15 degrees		No pattern categories. Observe and calculate an averaged wrist angle for each exertion.		
Neutral	0-30				
Flexion	45 degrees				

Table 3. *Consolidated and conventional method comparison*

Table 4 presents the COSI and subtask-level RSI results calculated using the conventional method for the same 5 videos as reported using the consolidated method (i.e., table 2). The highest COSI score was 15.7 (video 2), and the lowest COSI score was 8.0 (video 4). Consistent with the consolidated method, videos 1 and 2 exceeded the hazardous threshold of 10 points, and the remaining 3 videos were classified as safe. In contrast to the consolidated method, the conventional coding of video 4 scored around 2 points below the threshold, whereas video 5 scored 1.6 points higher than the consolidated method. The average duration per exertion in the conventional method was significantly shorter than in the consolidated method. The most significant difference was pattern H in video 4, where the duration per exertion decreased from 83.6 seconds in the consolidated method to 18.6 seconds in the conventional method. In terms of efforts per minute, the conventional method's exertions were two to three times as frequent compared to the consolidated method across all 5 videos. The posture multipliers calculated using the conventional methods were generally higher than the consolidated method, except for video 1. Coding of all 5 videos took about 30 hours using the conventional method (i.e., 4.5 hours per hour of video) versus18 hours (i.e., 2.7 hours per hour of video) using the consolidated method.

ID	COSI	Subtask	RSI	IM	PM	Exertion Count	Efforts per minute	EM	Duration per Exertion (seconds)	DM	Hours per day	HM
1	11.8	L	2.80	3.30	1.03	33	0.34	0.18	23.1	7.61	1.62	0.59
		M	5.43	5.00	1.01	71	0.73	0.28	19.4	6.48	1.62	0.59
		H	6.98	8.00	1.01	31	0.32	0.18	25.0	8.20	1.62	0.59
		N	2.18	1.00	1.00	62	0.64	0.26	44.7	14.31	1.62	0.59
		Hold	0.33	1.50	1.00	30	0.31	0.18	5.3	2.09	1.62	0.59
2	15.7	L	1.74	3.30	1.41	14	0.18	0.20	13.5	4.64	1.17	0.53
		M	10.14	5.00	1.60	87	1.22	1.23	17.0	5.73	1.17	0.53
		H	9.29	8.00	1.79	33	0.50	0.47	16.4	5.53	1.17	0.53
		N	1.57	1.00	1.00	35	0.50	0.22	40.5	12.99	1.17	0.53
		Hold	1.14	1.50	1.32	82	1.16	0.39	7.3	2.71	1.17	0.53
3	8.4	L	2.03	3.30	1.53	22	0.38	0.20	11.4	4.00	0.96	0.52
		M	6.13	5.00	1.48	44	0.76	0.20	16.4	5.53	0.96	0.52
		US	2.05	1.50	1.55	39	0.68	0.27	19.1	6.39	0.96	0.52
		N	1.84	1.00	1.00	33	0.57	0.24	46.1	14.75	0.96	0.52
		Hold	0.58	1.50	1.28	37	0.64	0.26	5.8	2.26	0.96	0.52
4	8.0	L	1.94	3.30	1.28	33	0.45	0.21	11.3	3.95	1.23	0.54
		M	5.69	5.00	1.41	64	0.87	0.32	13.6	4.67	1.23	0.54
		H	4.15	8.00	1.06	13	0.18	0.14	18.6	6.21	1.23	0.54
		N	2.74	1.00	1.00	38	0.51	0.23	69.7	21.91	1.23	0.54
		Hold	0.61	1.50	1.21	62	0.84	0.31	4.9	1.98	1.23	0.54
5	9.24	L	2.88	3.30	1.52	4	0.03	0.11	27.1	8.85	1.61	0.56
		M	8.15	5.00	1.66	24	0.26	0.16	31.7	10.28	1.61	0.56
		H	6.14	8.00	1.44	6	0.06	0.12	23.8	7.83	1.61	0.56
		US	2.61	1.50	1.50	54	0.56	0.24	25.2	8.26	1.61	0.56
		N	2.81	1.00	1.00	45	0.45	0.22	70.3	22.10	1.61	0.56
		Hold	0.65	1.50	1.28	29	0.31	0.17	9.2	3.31	1.61	0.56

Table 4. *RSI and COSI results using the conventional method (n=5).*

DISCUSSION

The RSI assessment tool quantifies the risk of developing work-related musculoskeletal injuries based on a combination of physical exposure factors. Despite its recent improvements over the 1995 SI model, the utility of the RSI is restricted to routinized work in the manufacturing industries. To address this limitation, we proposed a consolidated methodology to apply the RSI algorithms on non-routinized work tasks. The consolidated method characterizes common intensity of exertion and wrist posture patterns in non-routinized work and modifies definitions of exertion and subtasks to allow convenient and valid quantification of strain. This methodology paper serves as an example for ergonomists and researchers to apply the RSI assessment in clinical and hospital-based environments.

Our preliminary validation results indicate that the RSI scores were consistent with physiological and biomechanical principles of distal upper extremity disorders. Across all 5 videos, consolidated RSI scores of moderate and heaving scaling were higher than that of light scaling, ultrasonic scaling, and non-scaling subtasks. These results aligned with the RSI model assumptions that work tasks requiring greater exertion force are more likely to cause muscle fatigue and strain in the body, yielding higher RSI scores. Additionally, the consolidated COSI results also confirmed our expectations that dental hygiene work conducted using power-driven ultrasonic scaling devices (videos 3 and 5) scored lower than pure manual scaling (videos 1, 2, and 4).

The method comparison results further validated the accuracy of the consolidated method in terms of risk classification. The COSI results indicated that consolidated and conventional methods agreed on the risk categories of the videos. Videos 1 and 2 were categorized as 'hazardous' whereas the remaining 3 videos were classified as 'safe' according to both methods. Furthermore, the consolidated method was more time efficient as the coding time for the conventional method was almost 2 times longer.

However, the consolidated method might be limited in certain circumstances, as indicated by the comparison results. The COSI result for video 4 differed notably between the two methods. The consolidated method potentially overestimated the strain in video 4 because of the prolonged exertion duration for heavy scaling as this sampling method bundled short (<15 seconds) breaks and holding durations into large segments of exertions. Theoretically, the duty cycle modifications would balance out longer exertion durations in the consolidated method; however, when a worker is inclined to take short breaks between exertions, like in video 4, the consolidated method might overestimate the RSI results. On the other hand, the wrist posture variable might lead to slight underestimations of strain, like in videos 2 and 5. The consolidated wrist posture categories did not account for extreme wrist postures caused by workers' habits or physical constraints in the work environments.

To address the limitations described in the previous paragraph, we suggest that ergonomists be cautious in interpreting RSI results around the 10-point threshold to avoid misclassifying risk. Based on the preliminary validation results, the consolidated method results were consistent for work tasks with high risk (COSI > 12) and with low risk (COSI < 8) but not those with moderate risk (COSI between 8 and 10). Therefore, work habits or environmental factors must be considered when applying the consolidated RSI method.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Jane L. Forrest and Joan Beleno-Sanchez, who provided consultation as experts in dental hygiene clinical practice and education, and Dr. Kryztopher Tung, who participated in the initial development of the consolidated methodology.

FUNDING

This work was supported by the Centers for Disease Control (CDC) National Institute for Occupational Safety and Health (NIOSH) grant #: R01-OH010665. The views expressed in this paper are solely the authors' responsibility and do not necessarily represent the views of the CDC or NIOSH.

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