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(Original article)

Validation of self-screening assessment to identify work-related musculoskeletal health status in computer users: Modified Delphi method

ความเที่ยงตรงของแบบคัดกรองด้วยตนเองเพื่อระบุสถานะสุขภาพทางระบบกระดูกและกล้ามเนื้อสำหรับผู้ใช้งานคอมพิวเตอร์: วิธีเดลฟายประยุกต์

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ABSTRACT: The objective of this study was to develop a tool for self-detection of the work-related musculoskeletal disorders (WMSDs), were named WMSDs self-assessment algorithm, to identify WMSDs' health status as a tool for screening in the workplace. This study was cross-sectional research to validate content of the WMSDs self-assessment algorithm. The algorithm was scoped aim to identification of WMSDs' health status ("Good", "Fair", and "Poor") for computer users. Criterion of each status was developed by protocol of in-depth interview, reviewed evidence, and finally validated by a modified Delphi technique with twelve professional physical therapists, including face-to-face discussion and iterated questionnaire. Consensus threshold was set at a ranking of more than 80% of respondents with the median score more than 4.9. The contents of irritability of symptoms which are presented by worsen symptoms during resting position or self-active testing were included consensus threshold (Percent agreement from 90.9 to 100 of Delphi respondent with median score$\geq$5). Likewise, being positive result from excluded conditions were included to commit "Poor" status criterion. These inclusions were completed the algorithm which is swim lane portions and connection arrows to decide the WMSDs' health status through user guideline, question in general, and question in regions, neck and upper back, shoulder, forearm, wrist, and finger. In conclusion, the algorithm can be used by healthcare practitioners in occupational-related organizations to generally characterize the WMSD' health status. However, the algorithm may be modelled to identify the WMSD' health status by healthcare practitioners or individuals with a developed version in form of web or mobile application.

Keywords: Screening; Algorithm; Self-assessment; Work-related musculoskeletal disorders

บทคัดย่อ: การศึกษานี้มีวัตถุประสงค์เพื่อพัฒนาเครื่องมือในการคัดกรองตนเองของระบบกล้ามเนื้อและกระดูกที่เกี่ยวข้องกับการทำงาน (WMSDs) ที่เรียกว่าอัลกอริธึมการประเมินตนเองของ WMSDs สำหรับระบุสถานะสุขภาพและเป็นเครื่องมือตรวจคัดกรองในที่ทำงาน การศึกษานี้เป็นการวิจัยแบบตัดขวางเพื่อตรวจสอบเนื้อหาของอัลกอริธึมการประเมินตนเองของ WMSDs โดยอัลกอริทึมมีจุดมุ่งหมายเพื่อระบุสถานะสุขภาพของ WMSDs ("ดี" "พอใช้" และ "ไม่ดี") ในผู้ใช้คอมพิวเตอร์ เงื่อนไขของแต่ละสถานะสุขภาพนั้นได้รับการพัฒนาขึ้นจากกระบวนการของการสัมภาษณ์เชิงลึก การทบทวนวรรณกรรม และกระบวนการของเทคนิคเดลฟายประยุกต์โดยนักกายภาพบำบัดระดับเชี่ยวชาญ กระบวนการเดลฟายประยุกต์หมายรวมถึงการสนทนาแบบเห็นหน้ากัน การตอบแบบสอบถามแบบวนซ้ำเพื่อยืนยันข้อคิดเห็น และการพิจารณาเนื้อหาตามเกณฑ์ฉันทามติที่ระดับมัธยฐานมากกว่า 4.9 จาก 80% ของผู้ตอบแบบสอบถาม ผลการศึกษาพบว่าเนื้อหาเกี่ยวกับการถูกกระตุ้นได้ง่ายของอาการที่เป็น ซึ่งแสดงจากอาการที่แย่ลงระหว่างท่าพัก หรือระหว่างการทดสอบด้วยตนเอง รวมทั้งอาการปวดร้าวหรืออาการทางระบบประสาท จะถูกจัดในเงื่อนไขสถานะสุขภาพ "ไม่ดี" (ระดับร้อยละของความเห็นตรงกันอยู่ระหว่าง 90.9 ถึง 100 ของผู้ตอบแบบสอบถามที่มีคะแนนมัธยฐาน≥5) เงื่อนไขของเกณฑ์ฉันทามติเหล่านี้เป็นเกณฑ์ในการสร้างอัลกอริธึมเพื่อตัดสินสถานะสุขภาพของ WMSDs ผ่านส่วนของแนวทางผู้ใช้ คำถามโดยทั่วไป และคำถามโดยระบุตำแหน่ง ได้แก่ คอและหลังส่วนบน ไหล่ ปลายแขน ข้อมือ และนิ้ว โดยสรุปอัลกอริธึมสามารถนำไปใช้เพื่อระบุสถานะสุขภาพของ WMSDs โดยผู้ปฏิบัติงานด้านการดูแลสุขภาพในองค์กร อย่างไรก็ตามอัลกอริทึมเพื่อระบุสถานะสุขภาพของ WMSD อาจเป็นโมเดลเพื่อพัฒนาในรูปแบบของเว็บหรือแอปพลิเคชันบนมือถือ เพื่อรองรับสำหรับผู้ปฏิบัติงานด้านการดูแลสุขภาพหรือการตรวจโดยพนักงานเอง

คำสำคัญ: คัดกรอง; อัลกอริทึม; การประเมินตนเอง; โรคทางระบบกระดูกและกล้ามเนื้อที่เกี่ยวข้องกับการทำงาน

1. INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are a wide range of inflammatory and degenerative diseases or disorders related to work and job activities which may be called as cumulative trauma disorders or repetitive strain injury. The WMSDs are an obstacle to work ability, quality of work, and are a burden on health expenditure [1, 2]. Consequence of WMSDs is continually activated by computer use including prolonged posture, awkward posture, and the repetition of task [3, 4]. Prevalence of work-related musculoskeletal symptoms in computer users has remained high in many countries [5–8] even though awareness has been raised regarding the dangers of not managing WMSDs in the workplace, particularly at the workstation.

To accomplish this problem, early detection and screening for severe cases are required. Since there are 3- clinical stages of WMSDs differentiated by the severity of symptoms from early to late stages, it implies ways to manage the cases [9, 10]. Firstly, stage 1 is defined as fatigue or discomfort or pain when continuing or performing repetitive typing or mouse using and symptoms cease when finishing work for the day or stop performing the tasks. This stage is mild and may not be self-recognized, but they can self-manage. Secondly, stage 2 is defined as having persistent pain at work and at night; it has a wide range of symptoms from simple to complex. Early detection is important to stop the consequence of disease to complexity which can be self-managed. Furthermore, this stage can progress and become more severe, requiring further investigation or treatment by professionals. Lastly, stage 3 is defined as having pain at rest, interfering with home activities, and severe sleep disturbance. The computer users at this stage need to consult and be managed by professionals. In addition, red flag signs and symptoms of musculoskeletal diseases are also determined. As a result, identification of WMSDs' health status is significant in providing effective management.

For early detection and identification, there is a requirement of creating a screening tool based on the clinical reasoning process. The algorithm can be protocol for screening, rule in, and rule out in many cases including cancer, falling, anterior cruciate ligament injury, low back pain. In addition, self-screening issues had to seek out information from clinical experience that is not at all of theory or standard assessment. Many studies used the Delphi technique to validate their algorithms to be clinically applicable for diagnosis [11, 12]. This study, therefore, aimed to develop a tool for self-detection of the WMSDs, so called a WMSDs self-assessment algorithm, to identify WMSDs' health status in computer users, both those who use desktop and portable computers. Subsequently, the workers with WMSDs conditions can be correctly and individually recommended to improve their symptoms.

2. METHODS

To develop the algorithm, a cross-sectional study was conducted. This study was approved by the Institutional review board of Mahidol University, Thailand with Reg. no: MU-CIRB

2018/242.1212. The WMSDs self-assessment algorithm was developed to align with the study's goal, comprised of four steps including determining the scope of the algorithm, prepare and perform an in-depth interview, setting off the algorithm draft, and validating the content of the algorithm. Twelve professional physical therapists were involved in the algorithm development in the process of performing in-depth interviews and validating content of the algorithm. Ten of them were included based on purposive sampling from voting by 49 physical therapists attending the physical therapy conference in February 2019. Snowball technique was also used to confirm the vote and get a greater number of experts. All of them met the criterion of having at least one publication in the field of orthopedics or ergonomics within five years and having their work related to the fields for more than 15 hours per week. Additionally, 11 out of 12 people had more than 20 years of treatment experience. The details for each step are described below (Fig. 1).

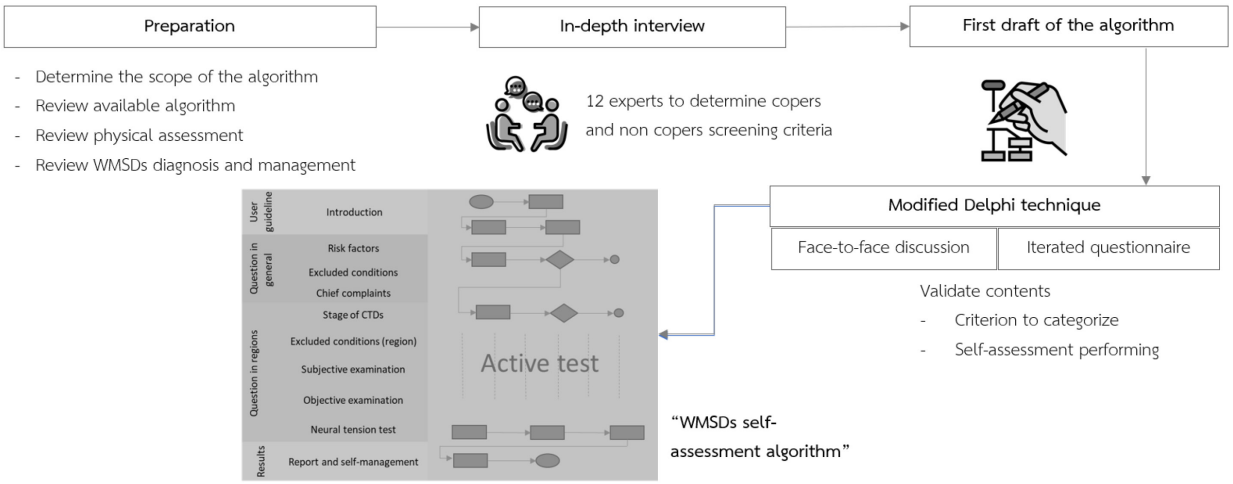

Fig. 1 Flowchart for algorithm development

Step1: Determine the scope of the algorithm

Scope of the algorithm was set aligned with the purpose of this study. The algorithm was composed of modified assessment for self-testing, flowchart for report, and term for classification. There was scope on.

- Assessments are correct and simple.
- Protocol of algorithm is safe.
- Flowchart can categorize WMSDs' health status as either able to manage their condition on their own ("Good" or "Fair" status) or in need of a physical therapist or health consultant ("Poor" status).

Content of self-assessment and its criteria for classification had been modified with the tacit knowledge and clinical experience from the clinicians. As a result, this algorithm aligned with the aim that it was not developed to substitute physical therapist's assessment, but it helped to screen WMSDs. This scope was conveyed to the experts throughout the in-depth interviewing process.

Step 2: Prepare and perform an in-depth interview

Following the scope and goal of this study, a set of major and probing questions was developed. The questions were used in the in-depth interview by the interviewer who was trained in a mock interview. The eligible experts had been informed about their roles prior to an hour-long interview with them. The in-depth interviews were conducted in February and March 2019. They were asked two open-main questions including "What are the tests that computer users can perform on their own?" and "What are the criteria to classify who need a physical therapist or a doctor after self-assessment?". These questions were asked until no new issues were encountered with a total of twelve experts. The in-depth information was grouped and reported in frequency.

Step 3: Set off the algorithm draft

The in-depth information had been reviewed with evidence or theory support before it was applied into the algorithm draft. Specificity of the standard assessment was examined to be included in the draft. Additionally, in terms of process and prioritization of assessments, the standard assessment in orthopedic field were followed [13, 14]. The algorithm draft was synthesized with two knowledge sources: gathering of in-depth answers and evidence reviewing. Regarding the criterion to categorize WMSDs' health status, there were "Good", "Fair", and "Poor" similar across regions, neck and upper back, shoulder, forearm, wrist, and fingers. To classify as "Good", there were no complaints at any regions and no positive self-assessment. To classify as "Fair", there were having complaints, and finding of positive sign, however that symptoms were low or middle level of pain or functional limitation. To classify as "Poor", there were having positive result from red flag screening or having complaints with middle or severe level of pain or functional limitation. All the criterions and self-assessment were applied in the swim lane and flowchart such as starting point, rectangular flow, diamond flow, arrows, connector point, and ending point as the algorithm draft to validate.

Step 4: Validate content of the algorithm

The algorithm draft was validated by the Modified Delphi method. This method was composed of a face-to-face discussion at the first round and iterated questionnaire at the second round onwards[15]. At the first round, face-to-face discussion was conducted at Mahidol University in July 2019. This round had been used to achieve a convergence opinion in specific issues. The algorithm draft was presented to minimize communication limitations and allow any other concepts of assessment to arise during a face-to-face discussion. For iterated questionnaires, the content of algorithm draft had already been adjusted in detail through discussion and revised into the questionnaire with 7-LiKert scale (1 = No chance, 2 = Very unlikely, 3 = Unlikely, 4 = Moderated chance, 5 = Likely, 6 = Very likely, 7 = Certain to happen). The ranking scale was chosen since it expresses a similar sense to clinical experience and perspective of Delphi respondents [16, 17]. From the second round onwards, time range of each round were approximately four weeks, and were conducted from September to November 2019. The experts independently answered questions as anonymity to judgment. This aimed to reduce potential of group or any other pressure. According to the questionnaire, the content was presented in four sheets which

was composed of criteria for "Poor", "Fair", or "Good" on neck and upper back, shoulder and forearm, wrist and finger, and nerve gliding test.

The result from the second round was sent individually with median and interquartile as statistical feedback via an email to each expert to confirm their judgement. After the third round, statistical processing was applied to rearrange the algorithm draft to the complete WMSDs self-assessment algorithm. Statistical Package for Social Science (SPSS) Software for Windows version 23.0 for statistical analysis was applied. For consideration of consensus threshold, inclusion was set at ranking more than 80% of respondents with a median score more than 4.9 [18].

3. RESULTS

Answers from a total of twelve experts were grouped into both main questions. The contents on the topic of the assessment that computer users can perform on their own was to establish consistency with all neck and upper extremities regions. Both subjective and objective examinations were important. They were composed of excluded conditions such as red flag questions, stage of WMSDs, level of symptoms as pain scale and active movement test of muscle and nerve. In addition, criteria for "Poor" status were presented in table 1.

Table 1 Answer from in-depth interview

Self-assessment: "What are the tests that computer users can perform on their own?"		**%**
Excluded conditions	Abnormal sensation (numbness, pins and needles)	33.3
Symptoms	Severity and irritability of symptoms	83.3
Stage of work-related musculoskeletal disorders		41.7
Active movement test	Physiological or functional movement test	83.3
	Others: isometric test, muscle lengthened test	8.3
	Neural tension test	25
Criteria for "Poor" status: "What are the criteria for office workers who needs a physical therapist or a doctor after self-assessment ?".		
Being positive result from red flag screening		91.7
Stage 3 of work-related musculoskeletal disorders		33.3
Moderate to severe pain severity		58.3
High pain irritability		16.7
Having referred pain or neurological symptoms		100

The content of the algorithm draft was validated by the modified Delphi method by eleven clinicians, having one dropped out. The criterion of "Poor" was illustrated causation by regions listed in table 2. Additionally, criteria for "Fair" was presented in range of percentage of agreement across the region. These criteria were classified to aim for self-management in each potential condition such as neck-upper back postural syndrome, increased shoulder movement, medial epicondylitis, trigger finger. The criteria for "Good" was considered if there were not met the "Poor" and "Fair" criteria.

Table 2 Percent agreement on Modified Delphi technique.

Conditions	**%**				
Criterion of "Poor" due to:	Neck	Shoulder	Forearm	Wrist	Hand
Excluded conditions	81.8-90.9	81.8-90.9	81.8-90.9	63.6-81.8	63.6-100
Pain scale greater than 4/10 after self-assessment	72.7	70	-	90.9	90.9
Having referred pain or neurological symptoms after self-assessment	90.9	100	-	90.9	-
Worsen of symptoms	90.9	100	-	90.9-100	90.9-100
Criteria for "Fair" for self-management	81.8	90.9	72.7-100	72.7-90.9	72.7-90.9

† Delphi respondent with median score≥5

The completed algorithm was revised by using consensus threshold from the result of the modified Delphi technique. It was presented via swim lane portions and connection arrows, user guideline, question in general, and question in regions. The algorithm starts at a "user guideline" that provides an introduction and target group of users and flows to "question in general". This section shown in Fig. 2 evaluates risk factors for recommendation, excluded questions for categorized "Poor", and chief complaints for "Good" or flowing to the next section, "questions in regions". In this section, it is evaluated in each region depending on their symptoms by using flow of stage and excluding conditions (Fig. 2). In addition, section of question in region required subjective and objective examination including discomfort scale, pain scale, and active movement test (Fig. 3). Each of the self-assessment was attached with categorized questions including pain intensity, pain irritability, and neurological or referred symptoms. By categorization, flow into "Poor" when involving in a pain scale greater than five, referred pain, neurological symptoms, or worsen symptoms, and "Fair" when not having any above symptom's criteria. Finally, all users were additionally asked to test their neural tension (Fig. 4).

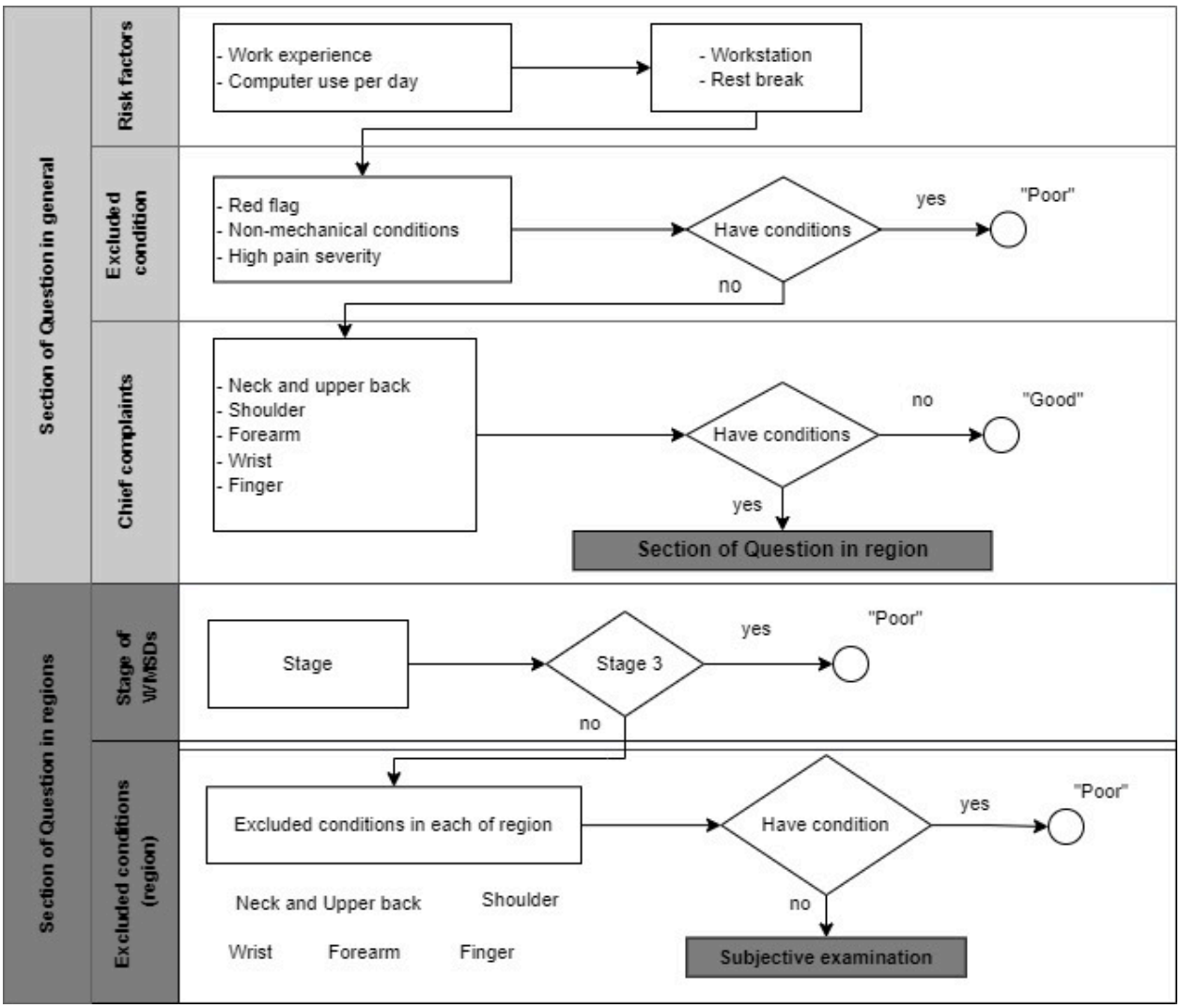

Fig. 2 Flow chart of section of "question in general" showed direction in different results; "Good", "Poor", or flow to section of "question in regions".

Remark: Red flag was determined on abnormal sensation (numbness, pins and needles), muscle weakness (arm and leg), experienced unexplained weight loss, constant pain or night pain, chest pain or rapid breathing during upstairs, experienced trauma or sport trauma, failure of conservative intervention (a month). In each region, blurry vision, nausea was asked on neck and upper back. Experienced chest pain, positive painful arch, worse symptom when raise your arm overhead was required on shoulder region. Lastly, getting worse symptom when weigh on flexed or extended wrist was criteria to exclude of forearm region.

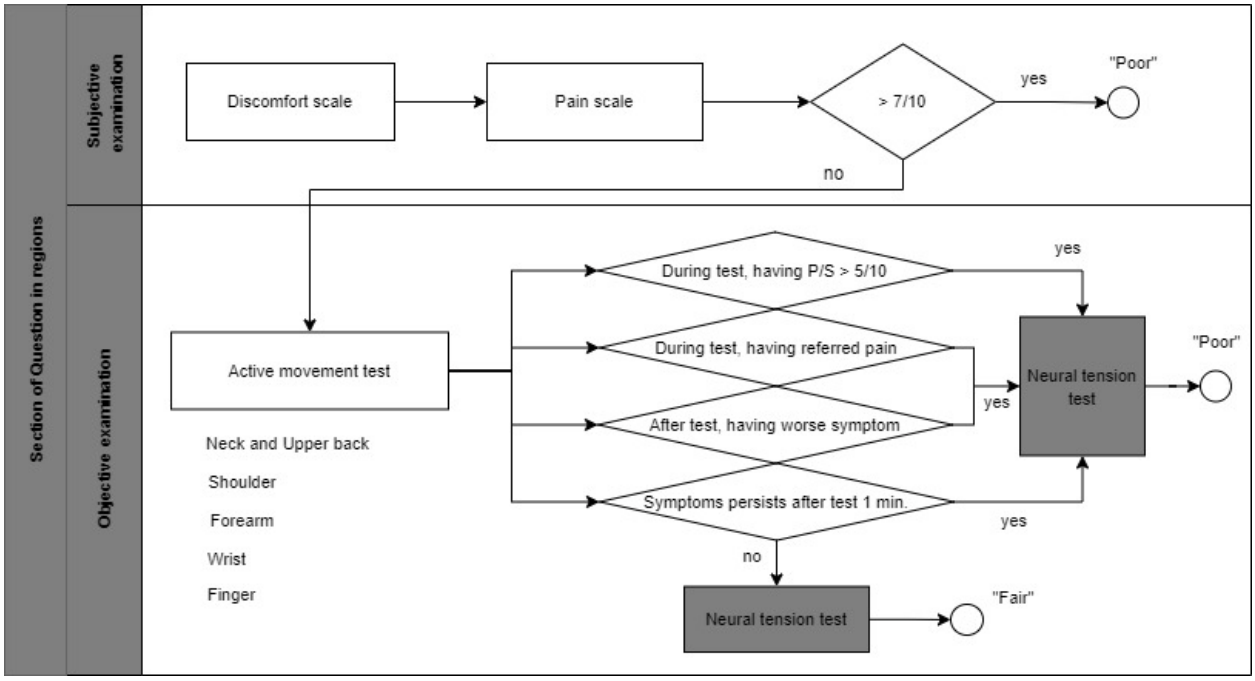

Fig. 3 Flow chart of partial section of "question in regions" showed direction in different results on subjective and objective examination. Symptoms during or after active movement test were criteria to determine the results. Active movement test was gathered with condition of the tests that computer users can perform on their own.

Remark: Neck and upper back: check neck and chest muscle tightness, check getting better when you have movement on chest and upper back, check active and repetitive neck lateral flexion (LF), Check active and repetitive neck rotation (rot.).

Shoulder: check active and repetitive shoulder hand behind back (HBB), check active and repetitive shoulder hand behind back (HBN).

Forearm: check the lengthening of the forearm flexor muscles, check the lengthening of the forearm extensor muscles.

Wrist: check active and repetitive wrist flexion, check active and repetitive wrist extension, Phalen's test.

Finger: check active and repetitive finger flexion, check active and repetitive finger extension, Test for DeQuervain's tenosynovitis.

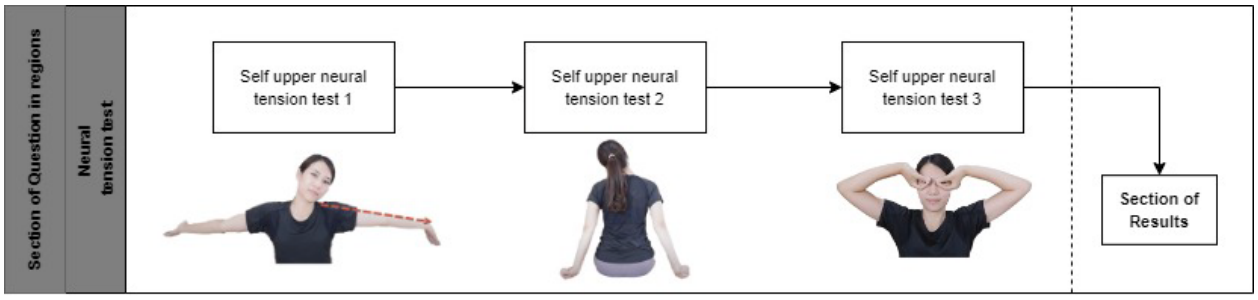

Fig. 4 Flow chart of the last active movement test that provide to all users to judge level of recommendation, not related with the different results, and flows to section of the "Result".

Remark: Neural tension test 1: 90 degree of shoulder abduction, stretch arm-wrist-finger, turn head to opposite site (left), and check symptom on right side (Do other side).

Neural tension test 2: fist the hands, extended shoulders, turn head to opposite site (left), and check symptom on right side (Do other side).

Neural tension test 3: make OK sign, supinated forearm, place three fingers on the checks, and check symptom.

4. DISCUSSION

The development of WMSDs self-assessment algorithm was to obtain the content which began with an in-depth interview to bring tacit knowledge from clinical experiences and theories. The experts reflected in their clinician view that this algorithm can help the workers recognize their WMSDs' health status and bring to stop consequences of disorders. Although, the self-assessment has had limitations including correction of movement tests, and compensated movement. As a result, subjective examination on symptoms including pain and behavior of symptoms were recommended by most of the experts. The initial step was to screen for resting symptoms. Every time a self-test was performed, the pain scale was also recognized. Similarly, the previous studies applied measure outcomes to self-detect on the diseases including neck disability index (NDI), disabilities of the arm, shoulder, and hand (DASH) [19, 20]. For objective examination, the experts advised the simple tests that can be self-tested and judged by behavior of symptoms or pain similar to the subjective examination. The experts advised to use functional movement instead of physiological movement as much as possible for self-detection due to a lack of skill to test correction. A functional movement test is a standard protocol that is asked to be done by the patient, and it can represent the symptom [13]. Additionally, tests with repetition were clearly used for representing symptoms as described in the principle of mechanical diagnosis and therapy [21] that any symptoms arising from repetitive movement must be avoided since it can make the symptoms worse. Another self-assessment, since the neurodynamic test is used to alarm for the possible risk of WMSDs [22], it was included and tested for all users. The neurodynamic test which was described by Butler is sequentially composed of shoulder girdle, forearm, wrist, and fingers movements and tested by the clinician [23]. Conversely, neurodynamic movement in the arms were adapted to treat at-home and improved the symptoms [24]. As a result, the upper neurodynamic movement was advised to be adaptive for self-assessment for WMSDs prevention.

The results from the interview were gathered and combined with theoretical based assessment from Opdenakker, 2006 [25] and the available algorithms from Burton et al., 2014 and De Marco et al., 1998 [26, 27] to create the new algorithm draft of this current study. The algorithm was validated by protocol of the modified Delphi technique due to a variety of tests in the experts' opinions. Additionally, a few experts viewed that to screen the WMSDs which commonly presents with complicated symptoms is difficult for one without experience to diagnose or test by themselves, however others suggested opposingly. To be more understandable among experts, the first round a face-to-face discussion was set to confirm scope of this study, screening WMSDs' health status, and allowed any other concepts of assessment to arise during the discussion before the contents of self-assessment settled. This method of combining the face-to-face and survey was similar to the study of Schneider P, 2016 [15] and Krausch-Hofmann S, 2021[28].

With regard to the WMSDs self-assessment algorithm, questions for screening, self-detect, and judgement to result were put into sections of question in general and in regions. The first section covered questions to find risk factors as characteristics of the computer users such as awkward

posture, long duration for sitting, etc. [3, 4]. Therefore, number of working hours, year of experience, daily working behavior and the adjustment of workstation, were selected. In addition, excluded questions were supported as "Poor" by previous studies. Complicated symptoms or other systematic symptoms such as muscle weakness, impaired sensation, chest pain, and accident history were included as criteria for screen musculoskeletal outpatients [29]. Additionally, weakness, referred symptoms, and impaired sensation were criteria for "Poor" both excluded questions and self-assessment. The symptoms can be aggravated and be caused by serious conditions including stiffness in the nerve pathways, nerve compression from herniated disc, nerve disturbances, degeneration of the cervical spine which may require specific assessment by specialists or imaging techniques [13]. The second section, the classification of WMSDs stage and functional limitation were concerned, stage 3 was also used as assessments for "Poor" result because persistent, strong, and irradiated pain, complex symptom, and pain can affect life's daily activities [9, 10]. For the objective examination, active movement [13] and active special tests such as Painful arch test [30], Mill's test [31], Phalen's test [32] which are high specificity were selected as the activated activities. Neural tension tests in the arm were fed into the algorithm. This is because previous studies have found that the muscles used while working on a computer are the muscles that are placed around or supplied with the median, radial, and ulnar nerves [33]. Additionally, it is used to alarm the possible risk of WMSDs in computer use [22]. Worse or remaining symptoms after the self-assessment were criteria for "Poor" because these referred to derangement syndrome of the mechanical diagnosis and therapy [21]. Another criterion to categorize was pain intensity, NRS-11. It was "Poor" at a rating scale of more than 7 out of 11 before starting the test or more than 5 during or after the test. Although the result of the modified Delphi technique showed pain cutting points during or after the test, was inconsistent in five regions, it was nevertheless used. In previous studies, pain intensity is an important tool used in determining the behavior of symptoms in the patients. [11, 13, 16, 17, 34, 35] Moreover, pain intensity was highly expressed in the in-depth interview protocol. As a result, the cutting point of pain intensity was adjusted into 5 out of 11 NRS during or after the test as the same range of moderate pain [35]. Similarly, the previous studies illustrated mild, moderate, severe at ≤3, 4-6, ≥7 in patients with musculoskeletal pain [34, 35].

In conclusion, the WMSDs self-assessment algorithm was approved by the content validity conducted in in-depth interview, face-to-face meeting and iterated surveyed questionnaires as the modified Delphi technique ensured the validity. The algorithm alone can be used by healthcare practitioners in occupational-related organizations to generally characterize the WMSD' health status. By this way, "Good" and "Fair" status, a self-manageable case can be detected and managed by the computer users before it progressed to be more severe. For further study, this algorithm can be developed in a form of application software to be simply used by workers and must be further investigated for its specificity and sensitivity as a tool for self-screening and receive specific recommendation based on result of self-assessment.

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