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Development of an Omaha System-Based Remote Intervention Program for Work-Related Musculoskeletal Disorders among Front-Line Nurses

Tianqiao Zhang, Ye Tian, Yanliang Yin, Yichao Tian, Suzhai Tian, Weige Sun, Ruoliang Tang

***Abstract*—**Heavy biomechanical loads at workplaces may lead to high risks of work-related musculoskeletal disorders (WMSDs). However, there is a lack of investigations on the efficacy of the ergonomic interventions with theoretical frameworks. This study aimed to formulate an Omaha System based remote intervention program on the WMSDs among nurses by systematic literature review, interviews, expert consultation. After screening title and abstract, 11 articles out of the initial search results (i.e., n=1,418) were included, 12 nurses were interviewed, and 10 experts were consulted to review the initial intervention program. Modification to the draft included (1) supplementing traditional Chinese medicine practices, (2) adding the use of assistive patient handling equipment, (3) revising the on-line training method, (4) editing and proofreading the main text of the initial program, (5) adding quizzes and exercise scales, (6) it was determined that the associated coursework should be announced promptly with multiple follow-up reminders, and (7) removing bodyweight superman exercise, and peaceful/calm meditation. In the end, the final intervention program was developed.

***Keywords*—**Omaha System, nurses, remote intervention, musculoskeletal disease.

I. Introduction

HEALTHCARE professionals, especially the nurses all over the world, are highly vulnerable to WMSDs, experiencing high incidence of neck, shoulder, and low back injuries [1]-[4]. This may partially be attributed to the undesirable working conditions commonly experienced by nurses during their daily practices and operations, such as forceful exertions during manual patient handling activities and awkward postures during intravenous therapies, drug administrations, and replacement of drainage bag/catheter, etc., resulting in excessive mechanical load and postural stress on these body parts [5]-[9]. In addition, nursing personnel, especially the front-line nurses reporting WMSDs, often experience increased psychosocial stresses and negative emotions [10], [11], resulting in poor job satisfaction and low perceived life quality [12], which may further reduce the overall patient care quality.

To reduce WMSDs among nursing personnel, many workplace interventions have been developed and implemented, including ergonomics programs, on-site education, organizational polices, and use of assistive patient handling equipment, aimed to improve caregivers' awareness of the unfavorable working conditions during daily nursing operations and attenuate the negative impact associated with these conditions [1]-[4], [9], [12]. In general, workplace interventions should follow multidisciplinary approach and coordinate all involving parties (e.g., management, nurses, patients, etc.) [13]. The Omaha System (OS) is a standardized classification system for nursing practice, including a problem classification system, an intervention system, and an outcome evaluation system [14]. In clinical practice, it has been used as a standardized tool to reduce patients' unhealthy behaviors through personalized and targeted nursing interventions and services [15]. The ongoing global pandemic of COVID-19 (SARS-CoV-2) has posed a great challenge to the ergonomic practices in healthcare facilities, particularly the hospitals. With the latest development in communication technology, remote intervention measures have been developed as an alternative, without the necessity of in-person meetings [16]. Therefore, this study aimed to use the OS as the theoretical framework to develop a remote ergonomic intervention program for front-line clinical nurses, based on comprehensive findings from literature review, structured interviews, and expert consultations, to address the workplace management of WMSDs.

II. Methods

A. Participants

From July to October 2020, recruitment meetings at a local tertiary hospital were held to explain the study and attract potential nurses to participate. A total of 94 clinical nurses from eight clinical departments provided written, informed consent to participate in this study. Employers paid nurses regular wages, and respondents received no incentives for participation. Inclusion criteria included: (1) current qualification/certificate as a nursing practitioner, (2) at least three years of clinical experience, (3) experience of negative symptom(s) (i.e., pain, numbness, soreness, and reduced activities) within the past year at the following body part(s) (i.e., low back, neck, and shoulder), lasting at least one day, and (4) regular internet access to the online survey. Several exclusion criteria were also applied, including (1) nurses in training/residency, (2) nurses with congenital spinal disorders, such as spinal deformities/ abnormalities (e.g., scoliosis, kyphosis, lordosis, etc.) and degenerative diseases (e.g., bulging and/or herniated disc), and

Tianqiao Zhang, Ye Tian, and Yanliang Yin are with the Second Hospital of Hebei Medical University, Shijiazhuang, 05000 China (e-mail: 915882707@qq.com, 690256681@qq.com, 569545099@qq.com).

Ruoliang Tang is with the Sichuan University-Pittsburgh Institute (SCUPI), Sichuan University, Chengdu, Sichuan, PR China (corresponding author, e-mail: rio.tang@scupi.cn).

(3) for females, being pregnant or with a history of pregnancy within the past year. For the convenience of study management in the presence of COVID-19, participants were grouped by their corresponding departments, which were randomly assigned into the two study groups, i.e., the intervention group (IG) or the control group (CG). As a result, nurses from four departments became the IG, while the rest of the nurses (i.e., from the other four departments) became the CG (see Fig. 1 for details).

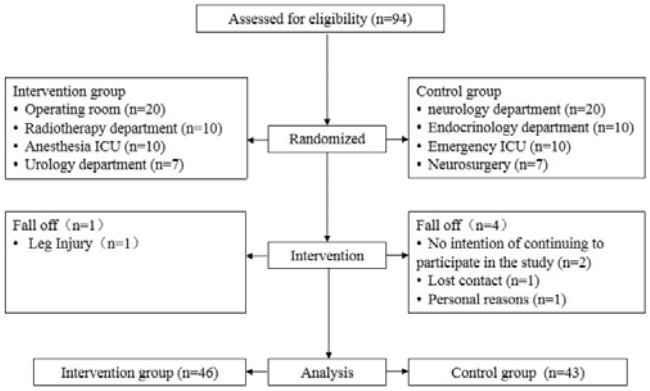

Fig. 1 Flow diagram of the inclusion and exclusion of study participants.

B. Systematic Literature Review Protocol

A comprehensive systematic literature reviewed was performed based on the search results from online literature databases, i.e., PubMed (n = 373), Web of Science (n = 232), Cochrane Library (n = 281), China National Knowledge Infrastructure (CNKI, n = 207), Wanfang Data (n = 302), and Cumulative Index to Nursing and Allied Health (CINAHL, n = 23), using key words, including "nurses/registered nurses", "low back pain/neck pain/shoulder pain", "musculoskeletal disorders", and "randomized controlled*/*controlled".

Inclusion criteria included: (1) study subjects had neck, shoulder, back pain or other WMSDs with clear clinical diagnosis, (2) the study outcome measures included the severity of WMSDs or the awareness of WMSDs among study subjects, and (3) the study was conducted as randomized controlled trials. Some exclusion criteria were also applied, including (1) articles derived from the same study, (2) articles without clear descriptions of methodology, and (3) articles without full-text option.

Based on the pool of available articles, two reviewers, independently, extract relevant publication data, including author name(s), article title, year of publication, journal title, number of subjects, intervention protocol, outcome evaluation measures, and conclusion. After the screening, eleven (n = 11) articles out of the initial search results (i.e., n = 1,418) were included (Table I).

C. Structured Interviews

In the process of developing the intervention program, participating nurses were approached by research team members to learn their initial understanding and/or concerns of WMSDs and if they were willing to get involved in the program development (i.e., recorded structured interview). A total of twelve (n = 12) nurses agreed to participate. During the interview, the following questions were asked, including "How much do you know about WMSDs, such as neck, shoulder, or low back pain?", "What information do you want to learn about WMSDs?", "Do you have any suggestions for a remote intervention program for nurses?". Meanwhile, research team members observed each participant's body language, facial expressions, and tone of voice. On average, the structured interviews lasted about 45 minutes (i.e., 40-60 minutes). Based on the results, a few modifications were made to the initial draft of intervention program, including (1) the addition of self-mitigation strategies derived from traditional Chinese medicine, (2) the addition of assistive devices and equipment at work (e.g., sliding sheets, transfer belts, transfer pads, mobile boards, etc.), (3) the addition of proper office ergonomics practices, (e.g., maintaining good working posture, placing items at the elbow height, etc.), and (4) the modification of online training method (i.e., DingTalk®, Alibaba Group Holding Limited, Hangzhou, China). Meanwhile, these results also helped determine the program schedule, such that the information module was offered once a week for 6 weeks, each lasted about 20–30 minutes, while the exercise module was offered 5 times/week for 6 weeks, each lasted about 15–20 minutes. As a result, the initial intervention program was developed.

D. Expert Consultation

Selected experts were consulted to review the initial intervention program. In consideration of the heterogeneity and accessibility of experts during the COVID-19 pandemic, a total of ten experts (n = 10) were included, based on the following inclusion criteria: (1) work tenure ≥ 10 years, (2) active role in nursing management, occupational health, psychology, and rehabilitation, (3) bachelor's degree or above for nurses and master's degree or above for clinicians. Two rounds of online questionnaire were administered via Wenjuanxin® (Changsha Ranxing Information Technology Co., Ltd, Hunan, China). The time elapsed between the two sessions was one week. In this iterative process, the initial program was carefully examined and revised until unanimous agreement and consistency was reached. The coefficient of variation (CV) was used to evaluate the consistency of the itemized intervention program. The recovery rate of the questionnaire represented experts' positive coefficient. A given expert's authority coefficient was assigned according to his/her job title, the familiarity with the indicators and associated judgment basis. In practice, an authority coefficient greater than 0.70 is considered high, where a CV less than 0.25 is considered acceptable. In general, the results showed that all experts were enthusiastic and genuinely interested in this study and all CVs were less than 0.25, indicating consistent and coordinated outcomes (Table II).

In specifics, three experts offered four suggestions on how to improve nurses' compliance. Based on these suggestions, the following amendments were made to the initial program: First, the main text of the initial program was thoroughly edited and proofread, allowing for the nurses' comprehension of the

technical details. Secondly, quizzes and exercise scales were added to improve the nurses' compliance. Thirdly, it was determined that the associated coursework should be announced promptly with multiple follow-up reminders. Lastly, two maneuvers were removed from the initial daily health exercises (i.e., xiao yan fei, and peaceful/calm meditation). In the end, the final intervention program was developed (Table III).

TABLE I
BASIC INFORMATION OF INCLUDED LITERATURE

Author, year	Country	Sample size		Intervention program		Intervention time	Evaluation tool*	Conclusion
		T	C	T	C			
Jianhe, 2017 [17]	China	50	50	Knowledge training on WeChat platform: the harm, risk factors and self-treatment methods of WMSDs	Conventional control	5 months	General data questionnaire	Cognitive scores increased significantly, and pain intensity decreased significantly
Jun, 2019 [18]	China	101	104	Introducing WMSDs knowledge, conduct routine education of daily protection and exercise, and implement planned behavior training	Health education	40 min/session/week, for 4 weeks and followed up for 8 weeks	VAS, Protective awareness questionnaire	Reduce pain increase, strong awareness of protection
Shuhui, 2008 [19]	China	60	60	1. Lifestyle intervention: life posture; 2. Dietary intervention; 3. Exercise intervention; 4. Manual therapy and drug treatment	Manipulation therapy and medical therapy	A total of 4 weeks	Self-reported pain intensity	Lifestyle intervention can promote the recovery of patients with neck and shoulder pain
Wenjie, 2015 [20]	China	50	50	Exercise: Arm extension against the wall; Head and hand struggle; Lean back; Swing arm and neck; Standing arm exercises; neck swing; Standing arm practice; Hold your elbow from behind; Back touching exercise	N/A	30 min/session, 3 sessions/week, for a total of 10 weeks	VAS SF-12	Neck and shoulder exercises can reduce the pain intensity and improve the quality of life
Bellido-Fernández, 2018 [21]	Spain	9	9	Abdominal low-pressure gymnastics exercise	Manipulation therapy	30 min/session, twice a week, in the first 3 weeks, once a week for the remaining 2 weeks	NRS ODI	Both groups had reduced pain levels and improved disability
Hiroyuki, 2019 [22]	Japan	1430	1799	Stretch exercise: Active exercise to stretch your back	N/A	6 months	FABQ	Effectively reduce pain and relieve pain deterioration
Pardis, 2018 [23]	Iran	18	18	Multi-step core stability training: including 34 core stability training movements	N/A	3 times/day, for 8 weeks	VAS SF-36	The SF-36 and VAS scores were significantly improved in the intervention group
Maryam, 2019 [24]	Iran	25	25	Traditional Chinese medicine acupoint massage: Baihui point, Neiguan point, Yongquan point, etc.	Placebo control	3 times/week for 3 weeks	SF-36	The quality of life has been improved significantly
Dehghan, 2016 [25]	Iran	52	50	Knowledge training, guidance to change bad body posture, and identify nonergonomic factors to improve	N/A	8 weeks	NMQ RULA	The prevalence of WMSDs was significantly reduced as compared to the control group
Warming, 2008 [26]	America	203	134	1. Train nurses in handling and transferring patients; 2. Physical exercise	Traditional patient handling method	60 min/session, twice a week for 8 weeks	NRS	There was a significant decrease in the pain level
Jaromi, 2018 [27]	Hungary	67	70	Apply the practice and patient handling techniques to distribute written materials	Simple life instruction	20 min/day, 5 days/ week for 12 weeks	VAS	The VAS scores were significantly lower in the intervention group nurses than in the control group

*ODI: Oswestry Disability Index. NRS: Numerical Rating Scale. RDQ: Roland–Morris Disability Questionnaire. NMQ: Nordic Musculoskeletal Disorders Questionnaire. RULA: Rapid Upper Limb Assessment. NRS: Low Back Pain Rating Scale. SF: Quality of Life Scale. VAS: Visual Analog Scale.

III. STUDY PROTOCOL

A. Intervention Program for the Intervention Group

The intervention group (IG) participated in the remote and OS-based intervention program mentioned above. The implementation process was as follows: First, a research team was formed, including two investigators to supervise the implementation of the program and other related logistics, seven head nurses from the seven clinical departments to recruit nurses, two quality control experts to monitor participants' performance in the program, one rehabilitation expert to provide guidance on daily exercise and address questions, and two research assistants for data collection and documentation. To implement the remote program, online services were employed as the platform, including DingTalk® (Alibaba Group Holding Limited, Hangzhou, China) and WeChat® (Tencent Holdings Ltd., Shenzhen, China), to execute the actual itemized program (i.e., DingTalk group) and broadcast other supplemental information and schedule notification/reminder (i.e., WeChat group). In this study, program execution included two primary modules, i.e., an information module and an exercise module, implemented at the same time. To execute the information module, researchers and IG participants logged in to the DingTalk group through their respective accounts. The

execution plan included a live broadcast every Monday from 18:30–19:00 and a recording of the event available for one week after its premiere. All videos were recorded by the same researcher. Individual participant's learning activities and performance (e.g., length of active participation, frequency of learning, etc.) were monitored through the functions provided by the online service providers. Meanwhile, IG participants were able to communicate with the research team members for their question and concerns. To execute the exercise module, previously recorded education videos were used. During the first week, IG participants were instructed through video conferences to learn the daily health exercises. The researchers were live and available to address participants' questions during their exercise sessions through one-on-one video conference calls. In the next five weeks (2nd to 6th week), IG participants had to check in and follow the module by themselves by uploading photos of their exercise to the DingTalk group, which were then used by researchers to provide feedback and further guidance. Content of the specific intervention program is listed in Table III.

TABLE II
COEFFICIENT OF VARIATION AND MEAN STANDARD DEVIATION OF EACH ITEM

Dimensions	Item content	Mean ± SD	CV
Basic knowledge of neck, shoulder, and low back pain	Related concepts and basic knowledge of neck, shoulder, and low back pain	4.7 ± 0.48	0.10
	Knowledge of human spine anatomy	4.4 ± 0.70	0.16
	The relationship between bad posture and neck, shoulder, and back pain	4.8 ± 0.42	0.09
	Risk factors for neck, shoulder, and back pain	4.5 ± 0.71	0.16
	Harm of neck, shoulder, and back pain	4.5 ± 0.71	0.16
Common awkward postures in nursing operation	Common awkward postures in nursing operation	4.8 ± 0.42	0.09
	Common awkward postures in daily life	4.5 ± 0.71	0.16
Knowledge of Ergonomics	Knowledge of ergonomics and occupational biomechanics	4.1 ± 0.74	0.18
	The perfect combination of ergonomics and nursing operation	4.5 ± 0.71	0.16
Reasonable nursing operation posture	Ten reasonable postures for commonly used nursing operations (venous operation, turning over, and patting back, tidying up the bed unit, desk work, etc.)	4.6 ± 0.70	0.15
Nurses are accustomed to reasonable postures in daily life	Correct sitting, lying, and standing posture	4.5 ± 0.53	0.12
	Other common life reasonable postures	4.5 ± 0.53	0.12
Self-relief method	Other self-relief methods for neck, shoulder, and back pain (Chinese medicine, acupoint pressing, walking backwards, etc.)	4.7 ± 0.67	0.14
Practical courses	Practice courses, doing deep breathing exercises and meditation with nurses	4.8 ± 0.42	0.09
	Daily exercises for neck, shoulders, and low back (China Copyright Registration Certificate-2021-L00058684)	4.6 ± 0.70	0.15

Mean ± SD (Mean ± standard deviation): used as a measure of importance, i.e., the higher the more important. CV (Coefficient of Variation): represents expert consistency, and the smaller the CV, the more consistent. (CV < 0.25 is generally considered acceptable)

B. Intervention for the Control Group

For participants in the control group (CG), we hosted a seminar, introducing the same information module and exercise module as listed in the intervention program, in the beginning of the study. For the remainder of the study, CG participants were also given regular health-focused seminars (e.g., work and life guidance). They were informed that at any time, they could ask researcher questions or voice their concerns.

C. Workplace Ergonomics Assessments

The Quick Exposure Check (QEC) [28] was used to assess workplace exposures to musculoskeletal risk factors affecting the low back, shoulder/arm, wrist/hand, and neck. The overall outcome measure consisted of two parts, including (1) expert evaluations and (2) participant's self-assessments. Assessment results were interpreted according to previously established metric (Table IV). Secondly, a specially developed online questionnaire (Wenjuanxin®, Changsha Ranxing Information Technology Co., Ltd, Hunan, China) was also administered among all participants to collect demographic data, work schedule, work-related mental pressure, and self-reported postural stress at work, such as trunk flexion and twisting. Detailed guidance was published in the DingTalk group.

Two rounds of data collection were performed. At baseline, two investigators independently observed and video-taped each participant's daily nursing activities, and subsequently assigned their scores, while participants were also asked to provide their self-evaluation scores. As a result, overall QEC scores and the corresponding risk levels were obtained. At the end of the 6th week, a second data collection was performed using the same procedures.

IV. DISCUSSION

In the literature, it has been commonly agreed that lack of knowledge in ergonomics and inadequate exercise (e.g., strength training, stretch, flexibility, etc.) among workforce are risk factors of the development of the WMSDs, particularly the bodily pain in neck, shoulder, and low back. Based on the current interviews with the initial twelve participating nurses, it was evident that front-line clinical nurses were not able to fully comply with routine exercise program or ergonomic trainings, primarily due to the tight yet highly variable work schedule. In this proposed remote intervention program, information module is delivered via online platform and cloud services, where participants can access all the contents at any time and location they prefer, without the disturbance to their already packed schedule. Similar approach has achieved satisfactory performance and compliance among patients with chronic conditions. Meanwhile, conference call-based training sessions may also help the participants execute the program more efficiently to achieve the desired performance and outcome. Through intense yet fragmented training sessions, researchers can summarize participants' performance during multiple in-class quizzes and provide instant feedback to highlight the progress they accomplish and pinpoint their mistakes, errors, and issues to work on, which may help consolidate their knowledge of workplace ergonomic practices and improve their awareness and understanding of WMSDs. On the other hand, the tasks required through the training module are simple, easy-

to-understand, and effective. During the interview, most female nurses reported that after the day job, they might also assume other family duties, such as meal preparation, child tutoring, etc.; therefore, they are less likely to participate in programs that requires travelling or without flexible schedule. Self-administered training may address these concerns, as nurses have options to learn by themselves, which saves valuable time so they can set aside more time for family and personal needs. Finally, during this difficult time (i.e., COVID-19 pandemic), healthcare personnel, coping with substantial stress from work and family, must comply with local and federal control policies to reduce crowding or group activities. The proposed remote intervention program involves no personal contact or crowding among clinical nurses from different departments, hospitals, or regions, offering a more applicable means to improve workplace ergonomic practices and reduce the risk of WMSDs among healthcare workers.

TABLE III
REMOTE INTERVENTION PROGRAM FOR NURSES WITH NECK, SHOULDER, AND LOW BACK PAIN BASED ON THE OS

Direction category	Target/guide	Description of intervention	Intervention forms and effective participation criteria	Intervention time and frequency
Teaching, guidance, and consultation (TGC)	Anatomy/ physiology, behavior modification, teaching, and discipline	The 1st dimension--Related concepts of neck, shoulder, and low back pain; knowledge of human spine anatomy; poor posture of the neck, shoulder, and back; risk factors and things that harm the neck, shoulder, and back The 2nd dimension--Publicity and education of common awkward postures in nursing operation and daily life The 3rd dimension--Application of the principles of human mechanics (enlarging the supporting surface, reducing the deviation of the gravity line, reducing the volume of the object to be transported, etc.) in nursing The 4th dimension--Explanation of the reasonable postures of nurses' common nursing operations (turning the patient over and patting their back, tidying up the bed unit, desk work, etc.), with a total of 10 common nursing operations The 5th dimension--Explanation of the correct postures of nurses in daily life, such as correct sitting, lying, and standing postures The 6th dimension--Self-mitigation methods for neck, shoulder, and low back pain (e.g., hot/cold compress, massage, acupuncture points, etc.) and using protective equipment (slip, belt, transfer pad, moving board, etc.)	Dingding group for online; live broadcast time is every Monday from 18:30–19:00, but participants can re-watch it within 1 week. Effective viewing criteria: ① viewers need to watch the video in its entirety, and the viewing time is the same as the video time; then, ② after each class, an in-class quiz was added, and the passing rate was 70% for effective listening. Viewers who score lower than 70% will be reminded to watch again and supervised by the researcher.	Week 1 to 6, 20–30 min/time/week; instructor: research team member. Course QR code (scan the following code in DingTalk):
Treatments and procedures (TP)	Relaxation/ breathing techniques, deep breathing exercises,	Send each nurse a video of "Mindfulness Meditation Journey," which includes deep breathing exercises and "Cell Regeneration" mindfulness meditation music to relieve muscle tension	During the first week, a video conference via DingTalk was held from 21:00–21:30. Then, during weeks 2–6, the nurses exercised on their own but checked in 5 days a week. Those who did not check in were reminded by the researcher.	Week 1 to 6, 15–20 min/time/day, 5 days/week, 6 weeks in total; instructor: research team member.
	Sports, and health care	Teach nurses to perform daily exercises for the neck, shoulder, and low back		
Case management (CM)	Support system	Always pay attention to nurses' neck, shoulder, and low back pain; encourage nurses to use hospital resources to perform activities to improve neck, shoulder, and low back pain; and develop individual rehabilitation plans for nurses in need	The exercise compliance questionnaire was used to investigate the compliance of nurses; to ask them about neck, shoulder, and low back pain; and to provide care and support	Research participants: research team and nurses
Supervise (S)	Behavior modification	In the DingTalk group, nurses were encouraged to use correct postures to perform nursing operations and exercises and to track their neck, shoulder, and low back pain		

TABLE IV
QUICK EXPOSURE CHECK SCORES AND THE CORRESPONDING RISK LEVELS

	Risk Levels			
	Low	Medium	High	Extremely High
Back, Shoulder/Arm, and Hand/Wrist	10 to 20	22 to 30	32 to 40	42 to 56
Neck	4 to 6	8 to 10	12 to 14	16 to 18

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