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School of Occupational Therapy

Investigation of Risk Factors for Musculoskeletal Disorders in an Obstetrician-Gynecologist and Orthopedic Surgeon

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Under the direction of the research advisor:

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A Research Project Entitled

Investigation of Risk Factors for Musculoskeletal Disorders in an Obstetrician-Gynecologist and Orthopedic Surgeon

Submitted to the School of Occupational Therapy at University of Indianapolis in partial fulfillment for the requirements of the Doctor of Occupational Therapy degree.

By:
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Abstract

The purpose of the study was to determine risk factors for musculoskeletal disorders (MSD) in an obstetrician-gynecologist (OB/GYN) surgeon and an orthopedic surgeon. A prospective case series format and mixed method design was used to gather quantitative and qualitative data by using the Rapid Upper Limb Assessment (RULA) to measure MSD risk factors during surgery observation; the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) to measure upper extremity symptoms and function, reflecting a typical work week for each surgeon; observation of surgeon office hours; and semi-structured interviews with each surgeon. Researchers compared the RULA scores to established exposure levels for MSD risk and interpreted the QuickDASH scores by comparing to normative data. Transcribed interview data were analyzed through open coding, member checking, and organizing data into smaller categories. Three themes emerged from the data: (a) both surgeons had risks for MSD during occupational performance outside of work, (b) both surgeons had risks for MSD during work inside and outside the operating room (OR), and (c) both surgeons had MSD symptoms exacerbated by work tasks. Surgeons had more opportunities to modify MSD risk outside the OR.

Keywords: musculoskeletal disorders, obstetrician-gynecologist, occupational therapy, orthopedic, QuickDASH, Rapid Upper Limb Assessment, risk factors, surgeons

Investigation of Risk Factors for Musculoskeletal Disorders in an Obstetrician-Gynecologist and Orthopedic Surgeon

Musculoskeletal disorders (MSD), or repetitive strain injuries, are defined as injuries to the musculoskeletal and nervous system as a result of risk factors including overexertion, repetitive motion, awkward or sustained postures, localized pressure, and vibration (Occupational Safety and Health Administration [OSHA], 2017). Common conditions of MSD include carpal tunnel syndrome (CTS) and rotator cuff tears, among others (Roll, 2017). Risk factors address how the body is positioned in space relative to duration, effort, and frequency (OSHA, 2017). These risk factors are typically reduced by altering standing positions, modifying equipment design, and optimizing appropriate breaks (OSHA, 2017). In 2015, MSD accounted for 31% of the total cases of nonfatal occupational injuries requiring days off of work among all workers, making MSD one of the leading causes of absenteeism in the workplace (Bureau of Labor Statistics [BLS], 2016).

The estimated annual cost of MSD conditions for medical care and lost wages was $213 billion in 2012 (Weinstein, Yelin, & Watkins-Castillo, 2014). This cost is projected to increase unless there is implementation of evidence-based practice with access to effective interventions and prevention education (Weinstein et al., 2014). Musculoskeletal disorders, caused by risk factors in the workplace, lead to loss of productivity, ultimately costing companies and the government valuable time and money (BLS, 2016). Employers spend approximately $3 billion per year on MSD injuries of the hand and wrist, shoulder, cervical spine, lumbar spine, and knee among state workers (Davis, Dunning, Jewell, & Lockey, 2014).

In a systematic review, Long, Bogossian, and Johnston (2013) found prevalence rates of 45%, 40%, and 35%, respectively, for MSD of the neck, shoulder, and upper back among midwives, nurses, and doctors. Risk factors for MSD in surgeons, doctors, and dentists included prolonged static postures, repetition, awkward and cramped positions, inadequate training, and age (Zeb, Shah, Javed, Darain, & Rahman, 2016). Ruitenburg, Frings-Dresen, and Sluiter (2012) found hospital doctors were unaffected by postures that typically produced fatigue within their work environment, but surgeons that worked in sustained postures were affected by fatigue. Similarly, Cavanagh, Brake, Kearns, and Hong (2012) found dynamic and static postural stresses lead to fatigue and disability in surgical practice. Researchers reported laparoscopic surgeons lacked proper knowledge regarding how their techniques and postures may be contributing to their overuse injuries (Miller, Benden, Pickens, Shipp, & Zheng, 2012).

Researchers have not described risk factors for MSD reflecting surgeons' work outside the operating room (OR) or surgeons' nonwork activities. The purpose of this study was to identify risk factors which could lead to MSD for an orthopedic surgeon and an obstetrician-gynecologist (OB/GYN) surgeon. Orthopedic surgeons correct problems that arise in the skeleton, including the ligaments and tendons (American Academy of Orthopaedic Surgeons, 2016). OB/GYN surgeons perform surgical operations focusing on disorders associated with the female reproductive system (American College of Surgeons, 2016). Utilizing a prospective case series format, the primary investigator (PI) and occupational therapy student (OTS) researchers completed a comprehensive analysis of risk factors for MSD experienced by two surgeons. Demands of surgical procedures, surgical environment, work beyond operative procedures, and occupations outside of work were considered. Researchers used the Rapid Upper Limb Assessment (RULA) to measure MSD risk factors during surgery and the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) to measure upper extremity symptoms and function in two surgeons. By identifying risk factors for MSD in surgeons, it is possible to provide a foundation for reducing risk for MSD during all occupational performance.

Literature Review

The client factors identified in the literature included gender, age, years of experience, and ergonomic training that contributed to MSD risk factors. Franasiak et al. (2012) and Sutton, Irvin, Zeigler, Lee, and Park (2014) studied differences in symptoms experienced and treatment sought by male surgeons compared to females. Males who had a glove size of 5.5-6.5 reported significantly less shoulder discomfort than females of the same glove size (Sutton et al., 2014). Females who had larger glove sizes of 7-8.5 received treatment for their wrist, thumb, or fingers more often than male surgeons of the same glove size (Sutton et al., 2014). Female gynecologic surgeons who performed minimally invasive surgery (MIS) wore smaller gloves, were shorter in stature, and reported more physical strain than their male counterparts (Franasiak et al., 2012).

Researchers have found conflicting results when examining the relationship between age and frequency of MSD (Alzahrani, Alqahtani, Tanzer, & Hamdy, 2016; Batham & Yasobant, 2016; Eleftheriou et al., 2012). Among vaginal surgeons and dentists, those who were younger had a higher frequency of work-related MSD (Batham & Yasobant, 2016; Kim-Fine, Woolley, Weaver, Killian, & Gebhart, 2013). In contrast, results of a survey of 402 orthopedic surgeons showed that the rate of MSD increased as age increased (Alzahrani et al., 2016).

Findings on the impact of years of experience on MSD occurrence have been varied (AlQahtani, Alzahrani, & Harvey, 2016; Alzahrani et al., 2016; Franasiak et al., 2012; Kim-Fine et al., 2013; Liang et al., 2013). Among orthopedic surgeons, the number of work-related injuries was significantly higher with those who had been in practice for more than 21 years (Alzahrani et al., 2016). AlQahtani et al. (2016) found that being in practice more than 10 years was associated with an increased number of body regions involved in MSD. Results from two studies indicated surgeons performing laparoendoscopic single-site surgery and urologic procedures via laparoscopy had fewer symptoms as they gained experience with performing the surgery (Liang et al., 2013; Morandeira-Rivas et al., 2012). Contrasting results were found with vaginal and gynecologic surgeons who performed MIS: those who had fewer years of experience were at higher risk for work-related MSD (Franasiak et al., 2012; Kim-Fine et al., 2013).

Formal training in OR ergonomics has not been shown to have significant benefit in reducing occurrence of MSD (Franasiak et al., 2012; Quinn & Moohan, 2015; Vijendren, Yung, Sanchez, & Duffield, 2016). Eighty-three percent of laparoscopic trainees reported receiving training on body positioning and room layout during surgery; however, only 13% understood proper grasps for suturing (Quinn & Moohan, 2015). Although some of the laparoscopic trainees received instruction on proper ergonomics to prevent MSD, 85% still developed a MSD during training, including back, shoulder, and neck pain (Quinn & Moohan, 2015). Similarly, Franasiak et al. (2012) found that only 16% of gynecologic oncology surgeons who performed MIS had received formal training in ergonomics, yet a majority of the surgeons reported symptoms of physical strain. For these surgeons, ergonomic training was limited to body positioning in the OR or the physical environment of the OR (Franasiak et al., 2012). Similarly, Vijendren et al. (2016) found that despite interventions, such as completion of e-learning modules to increase surgeons' understanding of ergonomic principles, the impact of ergonomic training on incidence of MSD was unclear.

Occupational demands leading to MSD risk factors in the literature included physical environment, sequencing and timing, and surgical tools. Research indicates that older ORs, without the advantages of modernization, led to increased risk of staff injury (Cutner, Stavroulis, & Zolfaghari, 2013). Fixed equipment in older ORs caused staff to maintain awkward positions; cramped rooms restricted movement and led to safety hazards from cables and wires (Cutner et al., 2013). Researchers concluded that modernization of the workplace was crucial in order to prevent injury to surgeons and surgical staff (Cutner et al., 2013).

The development of MSD can be influenced by duration of work and break sessions (Maciel, Millen, Xavier, Morrone, & Silva-Junior, 2012). In 2012, Maciel et al. used a cross-sectional design to investigate workplace ergonomics and recommended improvements to reduce fatigue and muscle overuse among colonoscopist doctors. Results indicated a high potential for injury in body structures crucial to the colonoscopy evaluation process, including the wrists, hands, and fingers (Maciel et al., 2012). Results showed significantly dangerous biomechanical factors, that included force of the hand in the clamped position, static positioning of the upper extremity, and forced flexion and extension of the wrist (Maciel et al., 2012). Recommendations to reduce risk factors included placement of furniture, positioning of patients, and the adoption of regular breaks (Maciel et al., 2012).

A risk factor shown to contribute to overuse injuries in surgeons is the tool design (Yu et al., 2016). In a study by Gonzalez, Salgado, and Moruno (2015), laparoscopic surgeons used tools with varying handle sizes and then rated the handles based on their ergonomic principles. The results from surgeon ratings indicated that four handle sizes were necessary to accommodate the surgeons' hand sizes (Gonzalez et al., 2015). Similarly, Yu et al. (2016) found that wrist position associated with using tools created risk factors for surgeons. Researchers studied the wrist positions of eight surgeons while using four tools to complete tasks during laparoscopic surgeries (Yu et al., 2016). The participants completed specific tasks that simulated surgery and found that the tool requiring neutral wrist position was preferred due to the adjustable handle (Yu et al., 2016). Also, the researchers suggested that tool handles causing wrist flexion and extension more than 15 degrees from neutral increased risk for MSD (Yu et al., 2016).

Lee et al. (2014) found that surgeons who used laparoscopic tools had greater cumulative muscle workload from the biceps and flexor carpi ulnaris during surgery as compared to those who used robotic instruments. Muscle activity from the trapezius was greater if surgeons were new to robotic surgery (Lee et al., 2014). Yu et al. (2016) found that tools impacted performance, but additionally identified experience as influencing physical demands. In a study of female surgeons who used laparoscopy, Sutton et al. (2014) found surgeons' physical symptoms were due to instrument design. In a study conducted by Kavalersky et al. (2015), a redesigned surgical hammer decreased the risk of injury to orthopedic surgeons, and improved surgical performance compared to a standard medical hammer (Kavalersky et al., 2015).

Researchers have found that surgeons' performance skills can contribute to MSD risk factors. Ruitenburg et al. (2012) recorded the duration and frequency of postures and tasks of general surgeons, internal medicine doctors, and medicine doctors. In comparison with hospital doctors, surgeons performed fine repetitive movements 26 times longer while standing 130% longer (Ruitenburg et al., 2012). The results also indicated surgeons spent 80 minutes using repetitive movements, and hospital doctors only spent three minutes using repetitive movements (Ruitenburg et al., 2012). Due to the longer duration of physically strenuous work, more surgeons reported neck and arm pain along with difficulties coping with job demands (Ruitenburg et al., 2012).

High finger exertion associated with wrist postures during surgery has been shown to lead to MSD in surgeons (Maciel et al., 2012). Maciel et al. (2012) measured physical strain, posture, strength of hands, repetition of work, tools used, and job performance of doctors during colonoscopies. After analyzing six 30-minute exams, results indicated that the sustained pincer grip required during the entire colonoscopy was a risk for injury (Maciel et al., 2012). Craven, Franasiak, Mosaly, and Gehrig (2013) evaluated hand and wrist posture, task exposure per day, and exertion through intensity, duration, and speed in five gynecologists. Results indicated that surgeons spent 80% of their workday in the OR (Craven et al., 2013). Surgeons often rushed to complete their work by using near maximal intensity of exertion, which was potentially hazardous to the gynecologic surgeons (Craven et al., 2013).

Researchers have found that the patient's positioning often determines the surgeon's placement in the OR (Youssef et al., 2011). Researchers compared standing positions and surgical techniques during four simulated laparoscopic colonoscopy procedures and found that the between-standing position and one-handed technique required less effort, frustration, and physical demand as measured by the RULA (Youssef et al., 2011). Another group of researchers found that the conventional positioning of the patient in retroperitoneoscopic upper urinary tract surgery was associated with poor surgical ergonomics because it forced the surgeon to use unbalanced posture and elevated muscular efforts (Fan et al., 2014).

The height of the surgical table and positioning of the monitor were contributing factors to MSD risk (Liang et al., 2013; Maciel et al., 2012; Sutton et al., 2014). According to Sutton et al. (2014), 43% of surgeons who completed laparoscopic surgery indicated that their physical symptoms were due to the height of the OR table. Results from Liang et al. (2013) indicated that surgeons had fewer MSD symptoms when the table was at pubic height. Another study showed that surgeons adjusted the table, made accommodations, and positioned themselves in less awkward positions to prevent MSD symptoms (Maciel et al., 2012). Liang et al. (2013) found that neutral head position during surgery was established by controlling monitor height to avoid spinal axial rotation and neck extension. To maintain this position, Liang et al. (2013) recommended that the monitor should be positioned in front of the surgeon and 10-15 degrees below surgeon eye level.

During vaginal surgery, the types of chairs used by the surgeons affected their musculoskeletal discomfort (Singh et al., 2016). The results indicated (a) significantly higher discomfort scores for two of the four chairs, (b) no difference in postural loads among the chairs, and (c) increased comfort when chairs dispersed pressure (Singh et al., 2016). Researchers have shown a positive relationship between body mass index (BMI) of patients and reports of physical strain by surgeons using MIS through laparoscopy (Franasiak et al., 2012). These correlations have not been reported by surgeons performing robotic surgery with MIS, even when patients are obese according to BMI (Franasiak et al., 2012).

Researchers investigating MSD risk factors for surgeons have focused their assessments on the OR environment and surgeons' tasks during procedures, yet risks can also arise from work tasks out of the OR and nonwork tasks. Researchers of the current study expanded identification of risk factors for MSD in surgeons by using multiple sources of quantitative and qualitative data.

Method

Participants

In a purposive sample, the PI and OTS researchers recruited one orthopedic surgeon and one OB/GYN surgeon to participate in the study. According to Portney and Watkins (2009, Chapter 14), purposive sampling can yield participants who are effective informants and who meet specific criteria for the study. The PI completed informed consent procedures with both surgeons and enrolled them in the study.

Measures

RULA. The RULA is an observation tool consisting of a single worksheet, containing diagrams of postures and scoring tables in which researchers and clinicians evaluate posture, force, and repetition for the upper arm, lower arm, wrist, neck, trunk, and leg regions (McAtamney & Corlett, 1993). The RULA is used to measure MSD risk levels on a four-point scale of exertion (McAtamney & Corlett, 1993). The four levels of scoring are defined as: (a) acceptable if not maintained or repeated for long periods (score of one or two); (b) requiring further investigation, possible changes required (score of three or four); (c) requiring change in the near future (score of five or six); and (d) requiring immediate change (score of seven). The body is divided into two sections in the RULA, and only one side of the body is evaluated at a time; Section A involves the arm and wrist, and Section B involves the neck and trunk (McAtamney & Corlett, 1993).

The RULA is a free assessment that does not require a formal training protocol or advanced education in ergonomics; however, researchers or clinicians who plan to use the RULA should use training materials available from the authors to use and score the RULA (McAtamney & Corlett, 1993). Researchers found that occupational therapy students with no RULA training successfully used the RULA to measure risk factors in simulated observations; there were no difference in students' scores when compared to those of clinicians (Chen, Falkmer, Parsons, Buzzard, & Ciccarelli, 2014). This finding made the RULA an appropriate choice for the current study as the PI and OTS researchers measured MSD risk factors in surgeons. Although there are no normative data available, researchers have established construct validity and interrater reliability for the RULA (McAtamney & Corlett, 1993).

The RULA has yielded valid and reliable results for measurement of MSD risks in hospital-based settings. For example, researchers used the RULA to evaluate posture, force, and frequency, which were variables identified as risk factors for MSD in surgeons during robotic gynecologic oncology procedures (Craven et al., 2013). Similarly, researchers used the RULA to measure standing position (between-standing or side-standing) and hand technique (two-handed or one-handed) during four simulated laparoscopic colonoscopy procedures (Youssef et al., 2011). The results of these studies support the use of the RULA to measure similar risk factors for MSD in the current study.

QuickDASH. The QuickDASH measures the "physical function and symptoms in persons with any or multiple MSD of the upper limb" through self-rating of items (Beaton, Wright, Katz, & the Upper Extremity Collaborative Group, 2005, p. 1038). The QuickDASH has a Disability/Symptom section and two optional modules, Sports/Performing Arts and Work (Beaton et al., 2005). Each item is self-rated through a Likert scale with scores ranging from one to five. Within the Disability/Symptom section, a score of one means the participant reported "none," "not at all," "not limited at all," or "no difficulty" as answers (Kennedy, 2011, p. 259). A score of five in the Disability/Symptom section means the client reported "unable," "extreme," "extremely," or "so much difficulty that I can't sleep" as answers (Kennedy, 2011, p. 259). For the optional modules, a one means the participants reported "no difficulty" and a five means the participants reported "unable" (Kennedy, 2011, p. 260). For the Disability/Symptom section, 10 or 11 items need to be answered to be scored (Beaton et al., 2005). The score is found by summing the values for each item and dividing it by the number of responses (Beaton et al., 2005). The value is then subtracted by one and multiplied by 25 to get a score on a scale 0-100 (Beaton et al., 2005). For the optional modules, all items must be rated to calculate a score (Beaton et al., 2005). The value for the optional modules is found by adding the values of the items and dividing the sum by four (Beaton et al., 2005). One is then subtracted from the average of the value and multiplied by 25 to get a score on a scale from 0-100. Lower scores indicate higher function, and higher scores indicate lower function. Researchers and clinicians who use the QuickDASH can use the published guidelines to learn administration and scoring.

In the development of the QuickDASH, a Cronbach's alpha of .94 was found, indicating high test-retest reliability (Beaton et al., 2005). Gabel, Michener, Melloh, and Burkett (2010) found high internal consistency with a Cronbach's alpha of .92 for the QuickDASH for individuals with upper extremity MSD. High test-retest reliability was found within three studies

(Gabel et al. 2010; Mintken, Glynn, & Cleland, 2009; Wu, Edgar, & Wood, 2007). Intraclass correlation coefficient (ICC) for the QuickDASH was calculated as .90 (Mintken et al., 2009) and .91 (Gabel et al., 2010).

Convergent construct validity for overall problem, overall pain, ability to function, and ability to work was found to be $r = .70$, $r = .73$, $r = .80$, and $r = .76$, respectively (Beaton et al., 2005). For criterion validity, the QuickDASH had a moderate correlation ($r = -.44$) with the Short-Form Health Survey (SF-12) for neck and upper extremity MSD (Fan, Smith, & Silverstein, 2008). Also, the QuickDASH had a high correlation with the Disabilities of the Arm, Shoulder and Hand (DASH) ($r = .98$) for shoulder pain and with the DASH ($r = .97$) for neck pain (Mehta, MacDermid, Carlesso, & McPhee, 2010; Mintken et al., 2009).

Several studies have shown the QuickDASH to be an effective measure of clinical change. According to Beaton et al. (2005), the responsiveness for “change in a group of patients undergoing treatment/expected to improve” was found to be a standardized response mean (SRM) = 0.79 (p. 1038-1046). Responsiveness for “change in those rating their problem as better” was found to be SRM = 1.03 (Beaton et al., 2005, p. 1038-1046). Franchignoni et al. (2013) reported 10.83 and 15.91 points as the minimal clinically important difference (MCID) for the DASH and QuickDASH, respectively for patients undergoing physical therapy.

Normative data for the DASH can be applied to the QuickDASH due to the similarity of construct validity and responsiveness of the two tools (Hunsaker, Cioffi, Amadio, Wright, & Caughlin, 2002). Normative data for the general US population for DASH Function/Symptom, DASH Optional Sports/Performing Arts Module, and DASH Optional Work Module have been established as 10.1, 9.75, and 8.81, respectively (Hunsaker et al., 2002). QuickDASH was selected to measure physical function and symptoms of upper extremity MSD of the participants in the study. Information gathered through the QuickDASH provided insight as to which work and nonwork tasks and activities were difficult for the surgeons.

Interview. The interview questions for the surgeons were designed by the OTS researchers to gain an understanding of MSD risks during nonwork and work activities not measured by the RULA and upper extremity function and symptoms as measured by the QuickDASH (American Occupational Therapy Association, 2017; Eleftheriou et al., 2012; Epstein, Colford, Epstein, Loye, & Walsh, 2012; Sharan & Ajeesh, 2012; Yoon & Yoon, 2013). The interview consisted of 13 standard questions that were refined based on feedback from an expert panel of occupational therapy faculty at an accredited university, to increase the validity of the interview. Categories of questions included contrast, descriptive, and structural (Stein, Rice, & Cutler, 2013, Chapter 4). (See Appendix).

Procedures

This study took place in a community hospital for general care. The OTS researchers and the PI, a registered occupational therapist, studied one orthopedic surgeon and one OB/GYN surgeon using a prospective case series format. A mixed method design was used to gather qualitative and quantitative data (Stein et al., 2013, Chapter 4). Researchers observed (a) a right total knee arthroplasty (TKA), (b) revision of a right TKA, and (c) a laparoscopic assisted vaginal hysterectomy with salpingectomy with assistance from a second surgeon.

The PI and OTS researchers, who completed seven research-oriented courses, were from an accredited Occupational Therapy Doctorate program. Students were trained to understand The Health Insurance Portability and Accountability Act as part of their coursework. The PI and OTS researchers completed the Collaborative Institutional Training Initiative as required by the Institutional Review Board to protect human subjects. Before data gathering began, the study was approved as exempt by the Institutional Review Board of the University of Indianapolis, as well as, the Institutional Review Board for the community hospital in which the surgeons were observed.

OTS researchers prepared for the interviews of the surgeons by completing a mock interview with the PI. For the RULA, the PI and OTS researchers individually viewed a YouTube video of a total hip arthroplasty with anterior approach to practice administering and scoring. After scoring, the PI and OTS researchers discussed and came to a consensus on scoring to improve interrater reliability. The OTS researchers also reviewed the QuickDASH scoring and normative data individually and collectively.

The PI educated the OTS researchers in OR procedures for observers including proper attire, appropriate area to observe, avoidance of intrusion into the sterile field, items allowed in the OR, and communication allowed during procedures.

Data Collection

The PI confirmed case, time, date, and received each surgeon’s approval two days prior to the procedure. The PI accompanied one student in the OR, where they each used the RULA to score the right and left upper extremity in one or two observations of each surgeon and recorded observations with field notes. Following the scoring, the PI and OTS researcher compared scores with the remaining OTS researchers to ensure correct scoring.

Aside from the risk factors identified using the RULA, researchers recorded frequency, duration, and type of repetitive and sustained gripping and pinching, lateral and tripod pinch, vibratory tools, and air temperature in the OR. Observation of the orthopedic surgeon's office hours occurred to observe risk factors when not performing surgery in the OR.

A semi-structured interview for each surgeon took place at the surgeons’ convenience. Due to unique answers to standard questions from the participants, researchers added questions throughout the interview to gather more information. As an expert in the field, the PI was present during the interview to ensure clinically relevant data were being gathered. Interviews were completed over the phone with the phone on speaker. Two OTS researchers and the PI were present to conduct the interview for the first interview with the orthopedic surgeon, and one OTS researcher and the PI were present for the second interview with the OB/GYN surgeon. These interviews were recorded using an audiotape, which was later transcribed. OTS researchers recorded handwritten notes during the interview.

The QuickDASH was completed by the surgeons at the end of a typical work week because of the instructions to rate items based on symptoms and function during the past week. Surgeons completed the QuickDASH and optional modules and mailed the document to the PI and OTS researchers.

To support the validity of findings and document the thought process of all decisions in the data interpretation process, researchers completed an audit trail (Portney & Watkins, 2009, Chapter 14).

Data Analysis

After configuration of individual Group A and B scoring, the total RULA score was found using Table C; based on an algorithm, the total score was interpreted to determine exposure level to risk factors of MSD.

The PI and OTS researchers interpreted the transcribed data through open coding and received approval of accuracy and clarifications from the interviewees. The goal of coding was to dissect the data and rearrange it into categories that facilitated comparison between items in the same category and between categories (Stein et al., 2013, Chapter 4). To enhance interpretive validity, member checking was performed, which involved transcribing the notes following the interview and bringing them back to the interviewee for approval of accuracy (Guba, 1981; Johnson, 1997). OTS researchers and PI classified and categorized data into similar groups through content analysis; researchers compared and interpreted the data related to other data to provide meaning (Johnson & Christensen, 2014).

The data were scored using standardized instructions from the QuickDASH manual. The data scores were then compared to normative data for the QuickDASH and optional modules. OTS researchers made note of items with extreme scores.

While completing the two case studies, OTS researchers implemented the process of triangulation, in which multiple methods were used to tabulate and analyze risk factors for MSD for the surgeons (Stein et al., 2013, Chapter 4). These multiple methods, including the use of quantitative tools such as the RULA and QuickDASH, as well as, qualitative methods such as an interview and field notes, allowed for a multiple method analysis of MSD risk factors. Triangulation allowed for the same information to be documented and understood in multiple ways, which increased the validity and trustworthiness of the data analysis (Stein et al., 2013, Chapter 4). The goal of the mixed methods design was to reach data saturation, where all relevant data were retrieved (Stein et al., 2013, Chapter 4).

Results

Three themes emerged from the data: (a) both surgeons had risks for MSD during occupational performance outside of work, (b) both surgeons had risks for MSD during work in and outside the OR, and (c) both surgeons had MSD symptoms exacerbated by work tasks.

Theme A

Both surgeons had risks for MSD during occupational performance outside of work. Surgeons described occupations related to instrumental activities of daily living (IADL), work, social participation and leisure that involved child rearing, care of pets, driving and community mobility, home management, meal preparation, volunteer participation, and leisure participation. Both surgeons had spouses and two school-aged children. Child rearing involved transporting children, participating in children's sports, and spending time with children. (See Table 1.1 and Table 1.2).

Home management and care of pets included lifting and carrying loads by both surgeons: "I . . . fed the chickens last night, and so I carried a 40 pound bag of chicken feed 250 feet . . . up and down a hill . . . [I had to] fill buckets [with chicken feed]" (Surgeon 1, Lines 46-48). One surgeon cleaned and kept track of pets: "I have two dogs and a rabbit" that need "corralled or cleaned up after. … [I least enjoy] real dirty stuff like cleaning out the rabbit cage" (Surgeon 2, Lines 36, 38, 62-63). Additional occupations outside of work included volunteer and leisure participation that included repetitive movements of the upper extremity: "I coach baseball and soccer, always, sometimes softball . . . I throw at least an hour solid of batting practice about once or twice a week . . . I probably throw on average 200-400 pitches with those kids" (Surgeon 1, Line 28-33).

The orthopedic surgeon reported spending less time in leisure participation of woodworking compared to the past. Nonetheless, he recognized that the risk factor of vibration through use of tools during this activity was similar to that experienced in his job as an orthopedic surgeon:

> I do woodworking on the side as well and I may spend four to five hours probably per week, doing things of that nature, which includes use of similar vibratory tools . . . two years ago I would get up around four and . . . work in my woodshop until 6 a.m. and then go into work and then probably come home and . . . if I had the time do some more stuff at night. (Surgeon 1, Lines 99-102)

The OB/GYN described child rearing, meal preparation, and gardening as her leisure participation. "I most enjoy spending leisure time with my kids . . . cooking when I have the opportunity . . . and outside work like gardening types of activity" (Surgeon 2, Line 58-60). She indicated that she spent “3 hours in the evening and an hour in the mornings so . . . during the week and on weekends it could be around 8 hours a day” (Surgeon 2, Line 52-54) doing leisure activities. The OB/GYN surgeon described that “yard work and. . . deeper cleaning activities [at home] where I’m . . .bending and squatting down and lifting . . .probably affect me in similar areas to where my work does” (Surgeon 2, Lines 247; 248). Additionally, she described prolonged standing at home, which combined with work demands to increase her symptoms: “I can stand and clean and do laundry and [do tasks] in the kitchen . . .and especially if I’ve been at work all day . . .by 10:00 at night I’m really feeling pretty old” (Surgeon 2; Lines 109-111).

The orthopedic surgeon’s primary concern was his lower back pain that he believed could be from inadequate rest and sleep. However, the surgeon was also frequently involved in other IADLs around the home that may contribute to symptoms. The orthopedic surgeon described meal preparation as enjoyable leisure participation. Lawn care, as part of home management, was considered a leisure activity; however, he explained he no longer completed this task. “I actually enjoy mowing the grass . . . when I get the chance to, but it’s a three and a half hour process, so I don’t do it any longer” (Surgeon 1, Lines 70-71). He stated that he experienced MSD symptoms in multiple activities, such as CTS symptoms of numbness and tingling while mowing the grass and arthritis in his right hand. He reported monitoring his arthritis symptoms and believed they resulted from pinching and other IADL. In addition, he stated, “if I put my shoulder back [and] lean my head far back my arms go to sleep” (Surgeon 1, Lines 185-186). In reference to woodworking, the surgeon described being “pretty good about being ergonomic” (Surgeon 1, Line 92). He was aware that his woodworking resulted in muscular fatigue, reporting that his hands got tired when carving wood.

On the QuickDASH, both surgeons reported mild difficulty with heavy household chores, recreational activities, and sleep. The OB/GYN surgeon also reported mild difficulty with opening a tight or new jar and slight limitation in performing daily activities outside of work. The orthopedic surgeon rated himself as having severe difficulty with bathing his back and rated his social participation as slightly limited. In contrast, the OB/GYN surgeon reported no limitation in social activities. The orthopedic surgeon identified baseball and woodworking as two activities on the Sports and Performing Arts modules of the QuickDASH with a score of 25, reflecting disability greater than the normative value of 9.25 (Figure 2.1). No sports or performing arts activities for the OB/GYN were reported. The orthopedic surgeon and OB/GYN surgeon scored 20.45 and 13.64 on the QuickDASH, respectively, with the normative value of 10.10 (Figure 2.2).

Theme B

Both surgeons had risks for MSD during work in and outside the OR. Surgeons varied in time spent performing scheduled OR procedures with the OB/GYN spending 8 hours a week and the orthopedic surgeon spending 15-20 hours per week (Figure 3.1 and Figure 3.2). Surgeries observed for the current study were 60-70 minutes with a temperature of 64°F. The environment during all surgeries was relaxed, and casual conversation among professionals occurred with several instances of staff entering and exiting the OR. During one procedure, the lights were dimmed by the circulating nurse to visualize the monitor screen better.

Both surgeons reported differences in surgical task demands based on their positioning relative to: (a) the type and location of surgical procedure for the patient, (b) surgeon hand dominance, and (c) characteristics of the patient. For example, the orthopedic surgeon preferred a right THA rather than a left THA due to hand dominance and having “to move [himself into] position on a left hip more than a right hip” (Surgeon 1, Lines 174-176). The OB/GYN surgeon preferred to be perpendicular to the patient’s left side due to hand dominance and directing surgical instruments. For the orthopedic surgeon, revision of total joints was described as more demanding because of awkward postures and longer duration of standing, whereas for the OB/GYN surgeon, vaginal surgeries were more demanding due to the required tugging and "pulling" (Surgeon 1, Lines 162-163; Surgeon 2, Line 205). Larger patients with more scar tissue required more muscle power and torque with surgical instruments. During the procedure, the orthopedic surgeon commented on "surgeons' disease" in reference to sustained neck flexion during operative procedures (Surgeon 1, Line 187).

Task demands during surgery for both surgeons were also influenced by: (a) types of instruments used, (b) types of hand use needed to use instruments, (c) scheduling of procedures, and (d) breaks during procedures. For example, the orthopedic surgeon, unlike the OB/GYN, frequently used vibratory tools. Gripping and manipulating were repetitive and sustained during the procedures and included composite grip, pistol grip, tip pinch, palmar pinch, hook grip, cylindrical grip, and lateral pinch. Resisted thumb extension also occurred to use dissection scissors and to perform suturing that required resistive finger flexion with end-range extremes of wrist and forearm positions. The orthopedic surgeon often used his left hand as a stabilizer and occasionally utilized his right hand as a hammer.

The orthopedic surgeon was scheduled to complete several consecutive surgeries using neighboring ORs with no breaks between procedures. One unexpected delay for TKA procedure was observed because lab results were not available. Mixing of cement during TKA required a two minute pause during the procedure. Both surgeons rested upper extremities on patients with the orthopedic surgeon demonstrating fewer and shorter breaks in comparison to the OB/GYN.

For the left and right sides of both surgeons, the RULA score was a seven during surgery, which is the highest possible score indicating a need to assess and implement a change (McAtamney & Corlett, 1993). Positions of highest MSD risk for both surgeons included lower arm, neck, and wrist twist, with an addition of neck position for the orthopedic surgeon and trunk position for the OB/GYN surgeon. For the leg score, both surgeons scored the lowest possible score. Both surgeons scored higher than the QuickDASH work module (optional) normative value of 8.81, with the orthopedic surgeon scoring 12.5 and the OB/GYN surgeon scoring a 25 (Figures 1.1 and 1.2). Scores indicated that both surgeons experienced decreased function related to use of their upper extremities during work.

Both surgeons worked outside of the OR meeting with scheduled patients, documenting operative procedures and office visits, using the computer to review patient charts, and fulfilling scheduled on-call hours at the hospital. In a single week, the time worked in addition to surgery was 60-70 hours for the orthopedic surgeon and 40-50 hours for the OB/GYN surgeon (Figure 3.1 and Figure 3.2). The OB/GYN surgeon described her routine as being on-call one night a week and every sixth weekend. After working a full day, a typical on-call routine included staying in the hospital to either sleep, work, or chart, followed by another full day of work for the OB/GYN surgeon.

The OB/GYN surgeon used a documentation template and dictated typical cases hands-free on the phone for 60-70% of her cases. She used tablets for documentation three days a week for 3 hours a day, and after work hours she used a desktop computer. She indicated she used an external mouse for comfort and had difficulties using her dominant hand and forearm during documentation. The orthopedic surgeon indicated that he spent “15-20 minutes of documentation per person,” (Surgeon 1, Line 62; 64-65), which was mostly completed using a hands-free dictaphone. To complete all documentation, he completed “2 to 3 hours of computer work at home” (Surgeon 1, Lines 55-56; 121-123) each work night, 6 hours on a tablet with keyboard attached at work, and another hour on his cell phone.

The orthopedic surgeon reported his worst posture as occurring during office hours with examinations of scheduled patients. He explained that during exams, he placed his laptop on his thighs and used a rolling stool with no back support. He also reported lifting or palpating extremities from a seated position that caused neck flexion, hip flexion, and reversal of normal spinal curvatures. The surgeon explained that he recognized his postures were poor and resulted in lower back and neck pain, but he used them to create a more informal atmosphere for the patient.

The PI observed sustained and awkward postures and positioning outside of examination rooms of the orthopedic surgeon. During office hour observation, the surgeon's laptop was positioned on top of the counter about waist height, requiring 90 degree elbow flexion, sustained neck flexion of 20 to 40 degrees, sustained wrist extension of 20 to 40 degrees, and a neutral thoracic spine. He used a cell phone to make phone calls and to text while using both hands with sustained neck flexion.

Theme C

Both surgeons had MSD conditions and/or symptoms exacerbated during work tasks for which they received past or current treatment. The OB/GYN surgeon described seeking treatment for her diagnosis of right lateral epicondylitis by receiving site injections to alleviate pain. When asked what made her symptoms worse, she replied, "I can't even say that it's just surgery that aggravates it because I feel like the computer stuff can aggravate it just as much" (Surgeon 2, Lines 189-190). She also described foot and leg pain, as well as, bunions that were "definitely more painful after standing for prolonged periods of time" (Surgeon 2, Lines 181-182).

The OB/GYN indicated she did not "do a good job utilizing" her nondominant hand and stated that her "neck pain is almost always on the right" (Surgeon 2, Lines 183-184). When asked what made her symptoms better she replied, "rest makes it better. So if I have a prolonged period of time off . . . at least two-three days then when I go back on Monday it's much better" (Surgeon 2, Lines 188-189).

The orthopedic surgeon experienced lower back and neck pain due to awkward and sustained postures during patient examinations. He described hip pain as more sacroiliac pain due to prolonged standing. The orthopedic surgeon also recognized improved posture while sitting at home with computer use: "It is a big Mac . . . . [and has a] big screen so I am sitting back comfortably [when I use it]" (Surgeon 1; Lines 126-127).

Surgeons reduced demands on the body primarily for work related tasks. The OB/GYN surgeon stated that she had a "limited modification ability in OR" so it was important to make modifications outside the OR (Surgeon 2, Lines 257-258). Both surgeons indicated ergonomic changes that could be made to reduce their own risk factors; the OB/GYN surgeon had made ergonomic changes to her office work area including use of mobile tables, but she described these "to be a little cumbersome and I haven't really taken to using [those]" (Surgeon 2, Lines 166-167). Both surgeons described their preferences for using desktop computers, as contrasted by laptops, cell phones, or tablets, because of reduced musculoskeletal discomfort during documentation or chart review. The orthopedic surgeon planned to purchase a new desk chair to improve posture while completing computer work tasks at home. One surgeon was self-monitoring MSD in his arthritic right hand.

Discussion

Risks for MSD in the OR were similar to those reported by other researchers with most risks unable to be modified. Similar to the findings of Ruitenberg et al. (2012), the surgeons in this study had (a) abducted arms, (b) fixed and forward cervical spines that occasionally included rotation, (c) consistent static loads inflicted on shoulders and neck regions, and (d) long-term fixed lower back postures during surgery. In contrast to the findings of Ruitenberg et al. (2012), the surgeons in this study used asymmetric postures. Additionally, the orthopedic surgeon experienced sustained and awkward postures during work outside the OR, which researchers have not described. Other researchers have not shown highest scores on the RULA based on observation of TKA revision or laparoscopic assisted vaginal hysterectomy with salpingectomy surgery as was shown in the current study. Studies also have not shown the greatest risk of MSD resulting from upper body positioning during these procedures, as was observed in the current study. Similar to Craven et al. (2013), the researchers in the current study used the RULA that confirmed MSD risk during operative procedures. In contrast, Craven et al. (2013) measured risk factors during robotic surgery and did not report awkward postures observed and/or reported by surgeons while using technology and examining patients outside of the OR. The latter findings in the current study showed additional MSD risk related to posture for surgeons when completing work tasks outside of the OR.

Similar to researchers' reports, repetitive movements and exertion were observed as risk factors within the OR in the current study (Batham & Yasobant, 2016; Maciel et al., 2012). The identification of repetitive movement and exertion outside of the OR in this study provided additional depth to current MSD risk factor research for surgeons, and is similar to findings for other professions. In a study completed by Zeb et al. (2016), risk factors for MSD were found to be prevalent among surgeons, doctors, and dentists. Although the participants in the current study were surgeons, their work outside of the OR included prolonged static postures, repetition, and awkward and cramped positions that could lead to MSD, similar to other professionals (Zeb et al., 2016).

During observation of surgeons in the current study, 1-2 minute spontaneous pauses during surgical procedures could have been used to regain neutral stance and correct head, neck, and trunk flexion. Although the researchers observed these brief pauses, there were no opportunities for prolonged rest breaks, a recommendation based on findings of Maciel et al. (2012). Lack of rest breaks during physically strenuous work could lead to neck and arm pain, symptoms that were reported by both surgeons and findings that were in accordance with Ruitenburg et al. (2012). Similarly, Maciel et al. (2012) found that short periods of rest were available between operative cases, however, surgeons did not use these periods for reduction of MSD risk. The OB/GYN surgeon in the current study stated that rest made her symptoms decrease, supporting the recommendation for regular rest breaks in the literature (Maciel et al., 2012). Although Gutierrez-Diez et al. (2018) recommended that breaks should be up to 5 minutes for every 2 hours of surgical intervention, it is unclear if the surgeons in the current study would be able to include these scheduled breaks as none were observed during data collection.

Consistent with the literature, both surgeons in this study explained that a more strenuous day led to experiencing more MSD related symptoms (Ruitenburg et al., 2012). Likewise, surgeons identified patient size as one factor that increased task demands during operative procedures (Franasiak et al., 2012). In contrast to the literature, surgeons in this study also identified revisions of total joints and scar tissue as patient factors that increased task demands. Franasiak et al. (2012) found a positive relationship between BMI of the patient and physical strain reported by surgeons who performed laparoscopic procedures. The results indicated increased reports of strain when sustained and awkward positions were necessary (Franasiak et al., 2012). It is likely that the orthopedic surgeon in this study frequently operated on a patient who was overweight or obese during TKA and THA procedures, as Suleiman et al. (2012) found that 90% of TKA patients and 77% of THA patients were overweight or obese. The OB/GYN in the current study described that performing vaginal delivery led to the most musculoskeletal symptoms because the positioning required her to use her upper body in sustained postures with high exertion. Although researchers have reported MSD risk factors for OB/GYNs during laparoscopic procedures, risk factors for vaginal deliveries have not been reported (Craven et al., 2013).

Gonzalez et al. (2015), Kavalersky et al. (2015), Sutton et al. (2014), and Yu et al. (2016) studied types, sizes, and handle angles of surgical instruments, and made recommendations for modifications or replacement with new instruments to reduce MSD risks. In contrast, researchers in the current study found that risk factors arose from the use of instruments which included sustained and awkward postures, and sustained and repetitive grip and pinch. Only some of these risks were measured by the RULA, confirming the value of additional detailed observations of task demands related to surgical instrument use to understand MSD risk more completely. Task demands of surgical procedures may make it difficult or impossible to consider alternate instruments or change in how current instruments are used to reduce MSD risk.

Prior to this study, researchers have not used the QuickDASH to measure "physical function and symptoms" for MSD in surgeons (Beaton et al., 2005, p. 1038), yet both surgeons had disability greater than the normative value for the work module. It is possible that completion of the QuickDASH increased surgeon awareness of risk factors for MSD of the upper extremity, but this cannot be confirmed. Surgeons in the current study more often attributed MSD symptoms and decreased work performance to demands of work, however, roles and tasks outside of work may be part of the cause, as risk factors for development of MSD can occur during all tasks and in all contexts. It is also possible that surgeons rated items on the work module based on performance of work in the OR, not necessarily outside of the OR which could result in a more narrow view of work performance.

In the current study, task demands during work outside the OR and during nonwork tasks demonstrated MSD risks. In contrast, researchers investigating MSD risk factors for surgeons have focused their assessments on the OR environment and surgeons' tasks in the OR (Ruitenberg et al., 2012; Zeb et al., 2016). In the current study, risk factors for MSD were found outside of the OR and outside of work tasks; both surgeons had diagnosis of MSD and disability greater than the normative data of the QuickDASH. A study by Sacouche, Morrone, & Silva-Júnior (2012) indicated hospital workers whose occupation of work entails the IADL of home establishment (laundry) were affected by MSD. Although surgeons were not participants in the study, it showed the prevalence of MSD risk factors such as repetitive movements, awkward postures, and exertions in one IADL, which could occur in the surgeons' roles as parent, spouse, home manager, and pet owner (Sacouche et al., 2012). The surgeons identified tasks within their occupations that had potential to make them symptomatic or already had caused symptoms, but were unable to determine risks in all occupations completed. Although researchers have not described risk factors for surgeons outside of work, risk factors for MSD were possible across contexts and roles.

Data from the Centers for Disease Control indicated that among individuals with MSD conditions, activities of daily living (ADL) were self-reported as the most difficult to perform compared to other occupations (Weinstein et al., 2014). This finding was similar to surgeons' reports in the current study, as the orthopedic surgeon reported that his most difficult task was washing his back, which he rated severely difficult. Moreover, ADL and IADL participation could contribute to MSD symptoms, but are often perceived to be work-related (Sacouche et al., 2012; Weinstein et al., 2014).

Surgeons had more opportunities to modify MSD risk factors during work outside the OR, and during nonwork tasks because of greater control over decisions to use technology and perform tasks, with less reliance on others. Yet, the literature does not address surgeons' opportunities to reduce risk factors across all contexts and roles. Opportunities for modifications outside of the OR included improving posture and reducing loads on upper extremities during patient examinations by standing and moving closer to patients for the orthopedic surgeon. In addition the orthopedic surgeon could use a more neutral stance with reduced head and neck flexion during use of the computer. It could have been that the OB/GYN surgeon's use of mobile tables during patient examinations would reduce MSD risk, but this could not be confirmed. Sleep postures and documentation during on call work for the OB/GYN could have also produced MSD risk but these were not observed. Because surgeons had more control over, and more opportunities for modifications outside of the OR, these modifications are even more important for decreasing the cumulative impact of MSD risk factors (Alzahrani et al., 2016).

Outside of work the orthopedic surgeon described occupations that had risks for MSD, including using vibratory tools for woodworking, lifting loads while caring for pets, and throwing a softball repetitively. Additionally, the orthopedic surgeon continued computer work at home to review patient charts and complete documentation. The OB/GYN lifted loads and used awkward and sustained postures during home management and care of pets outside of work. Reducing risks during these occupations would likely be more feasible and reduce the cumulative effect of MSD risk for both surgeons.

It was less feasible to modify tasks in the OR due to positioning of equipment, time frames for completion of surgical procedures, location and task performance of other personnel, and location and maintenance of the sterile field. Altering position of the monitor to use a more symmetric head position may have been possible during one procedure, but this was only discussed with one surgeon, and was not attempted. Eliminating use of hand for hammering was discussed with one surgeon who agreed that using instruments instead would reduce stress. It is also possible that surgeons could use pauses more intentionally to rest upper extremities and regain neutral postures.

Surgeons did not describe the value of reducing MSD risks across occupations that would improve occupational performance for all occupations. Instead, surgeons expressed awareness of what tasks exacerbated symptoms. Similar to results of Miller et al. (2012) it is possible the surgeons of this study lacked the knowledge to reduce the MSD risk factors during surgeries. In contrast to Miller et al. (2012), the researchers of this study found they also may have lacked knowledge in reduction of risk factors for occupations outside of work and work outside of the OR, however, this cannot be confirmed as researchers did not have opportunities to discuss these in detail.

In the QuickDASH, the orthopedic surgeon reported more disability when compared to the OB/GYN surgeon. However, the OB/GYN surgeon reported more disability on the QuickDASH work module. Only indirect comparisons can be made to Franasiak et al. (2012) who found that female surgeons performing gynecologic surgery reported more physical strain than did males. Contrary to Franasiak et al. (2012), the OB/GYN surgeon also described deliveries, not necessarily surgery, as causing physical strain. The OB/GYN sought treatment for her symptoms, in alignment with reports from Sutton et al. (2104) who found that female surgeons more often received treatment compared to their male counterparts. The male surgeon in the current study opted to self-manage his symptoms. Different decisions on managing symptoms could be explained by surgeons' unique expertise and knowledge of their conditions, but this was not confirmed.

Surgeons rarely described modifications to reduce risk factors across occupations; modifications they described included work tasks, not nonwork tasks. Similar to researchers' findings (Franasiak et al., 2012), the surgeons within the current study showed initiative to reduce some risk factors for MSD, but these were few and limited to work tasks. The surgeons did not describe the value of making modifications of nonwork tasks to reduce MSD risk. Although one surgeon described making modifications to reduce risk factors for continuing work on the computer at home, it is unclear if the surgeon recognized this modification as a method to reduce risk factors for nonwork tasks on the computer. This lack of recognition is consistent with the literature, where researchers have not described modifications to reduce MSD risk during nonwork tasks and tasks outside of the OR for surgeons.

Limitations

Both surgeons received the highest exposure level for MSD risk as measured by the RULA before the surgical procedures were completed; additional risk factors were observed after the highest score was obtained, demonstrating that a ceiling effect was reached on the RULA (Portney & Watkins, 2009, Chapter 14). Not all risk factors nor the number of those risk factors were measured by the RULA. Another limitation was that researchers did not observe on-call work for either surgeon and only observed office hours for the orthopedic surgeon, relying on self-reports of their actions. Additionally, researchers relied on surgeons' descriptions of nonwork activities and work outside of the OR rather than observations of these activities. This could have produced inaccurate reports of MSD risk. Regarding the results of the QuickDASH, the surgeons could have rated themselves on one aspect of work rather than on all aspects of work. Therefore, the results given by the surgeons in the work module may be narrowed to more operative work rather than considering other aspects of their work occupation. Researchers conducted only one interview with each surgeon, limiting the opportunity to ask additional questions following analysis of the data and preventing data saturation. The prospective case series design used in this study yielded in depth and specific data for MSD risks for two surgeons, preventing generalization of the findings to other surgeons.

Conclusions

As a result of this study, researchers identified three themes related to two surgeons and risk factors for MSD across all occupations. Both surgeons had risks for MSD during occupational performance outside of work, had risks for MSD during work that included work inside and outside the OR, and had opportunities to reduce MSD risk, with greater opportunities outside the OR. These findings confirm that MSD risk factors for one orthopedic surgeon and one OB/GYN surgeon resulted from work in and outside of the OR, as well as, outside of work.

Researchers who have studied risk factors for MSD among surgeons have limited their data collection and analyses to work in the OR or have concluded that work tasks can explain MSD risk. Likewise, researchers have attributed MSD exacerbation to surgeons' lack of modifying work performance in the OR. The findings of this study indicate that MSD risks occur during all aspects of work for surgeons and during occupations outside of work, filling a gap in the literature. Moreover, there are more opportunities to reduce MSD risk outside of the OR, highlighting the importance of a more comprehensive understanding of MSD risk across roles and contexts. Considering risk factors across all occupations, especially nonwork related tasks, presents a greater opportunity to modify the environment and tasks to reduce and prevent MSD symptoms and increase surgeon performance.

Recommendations

Researchers should gather data in multiple roles, environments, and occupations to ensure risk factors of MSD are being analyzed comprehensively for orthopedic and OB/GYN surgeons. Due to the ceiling effect of the RULA in the current study, researchers should seek ~~out~~ alternative or additional assessment tools to identify MSD risks in the OR more thoroughly. Additionally, researchers should observe occupational performance outside of the OR and outside of work to identify MSD risk factors.

Occupational therapists who provide services for orthopedic and OB/GYN surgeons should identify MSD risks across all occupations to prevent and/or reduce MSD risk and MSD conditions. Occupational therapists should also educate orthopedic and OB/GYN surgeons on the importance of recognizing and reducing MSD risk outside the OR and outside work occupations.

Orthopedic and OB/GYN surgeons should recognize and use brief breaks during and in between surgical procedures to correct postures and reduce other MSD risks. If applicable, surgeons should collaborate with OR staff to modify scheduled procedures to achieve better distribution of demanding surgeries. Additionally, surgeons can seek recommendations from occupational therapists to take advantage of more opportunities outside the OR and occupations beyond work to reduce MSD risks. Interventions to reduce MSD risk factors may include modifications to task performance and the environment.

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Table 1.1 *Occupational Profile of the Orthopedic Surgeon*

Occupational Profile: Orthopedic Surgeon	
Age	40
Years of Experience	13
Surgery Observed	Right total knee arthroplasty (R TKA) and revision of R TKA
Risk Factors in Occupations	Home management, care of pets, child rearing, volunteer, leisure participation, rest and sleep
Roles	Parent, home manager, pet owner, spouse, coach, woodworker, cook, surgeon
Risk Factors Identified	Repetitive movement; awkward and sustained postures; vibration; positioning; lack of rest; sustained and repetitive grip and pinch

Table 1.2 *Occupational Profile of the Obstetrician/Gynecologist Surgeon*

Occupational Profile: Obstetrician/Gynecologist Surgeon	
Age	43
Years of Experience	16
Surgery Observed	Laparoscopic assisted vaginal hysterectomy with salpingectomy
Risk Factors in Occupations	Child rearing, care of pets, home management, meal preparation, leisure participation
Roles	Parent, home manager, pet owner, spouse, gardener, surgeon
Risk Factors Identified	Repetitive movement; sustained and awkward postures; positioning; patient size; lack of rest; sustained and repetitive grip and pinch

Figure 2.1 Comparison of Orthopedic Surgeon Scores of QuickDASH to Normative Data

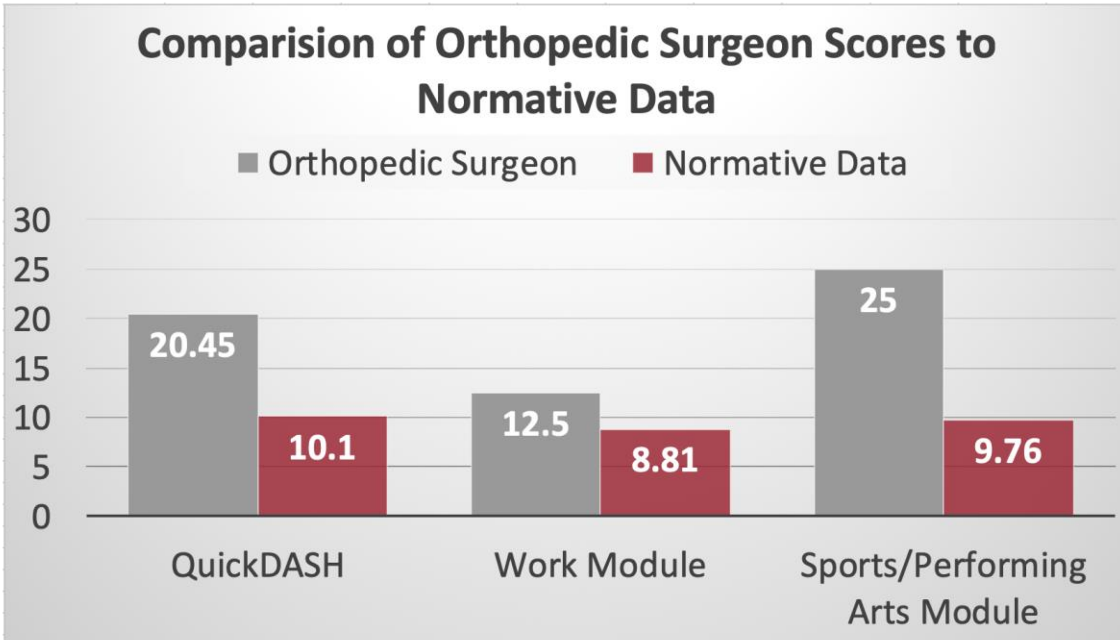


Figure 2.2 Comparison of Obstetrician/Gynecologist Surgeon Scores of QuickDASH to Normative Data

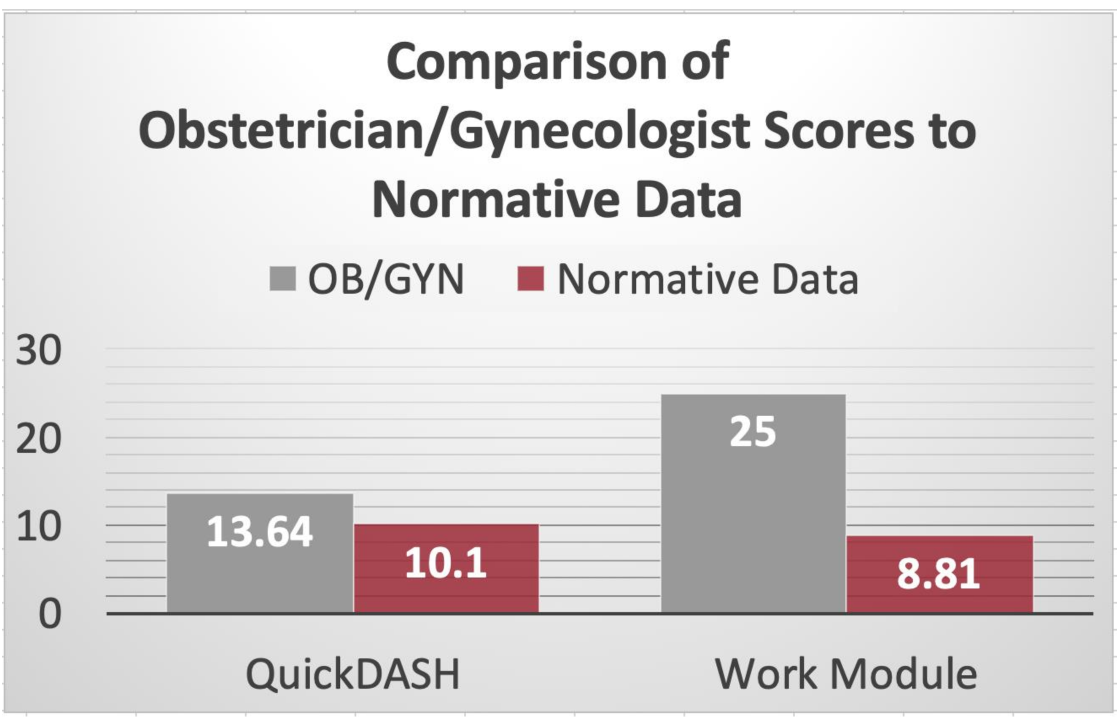


Figure 3.1 Percentage Time Use in Single Week for Orthopedic Surgeon

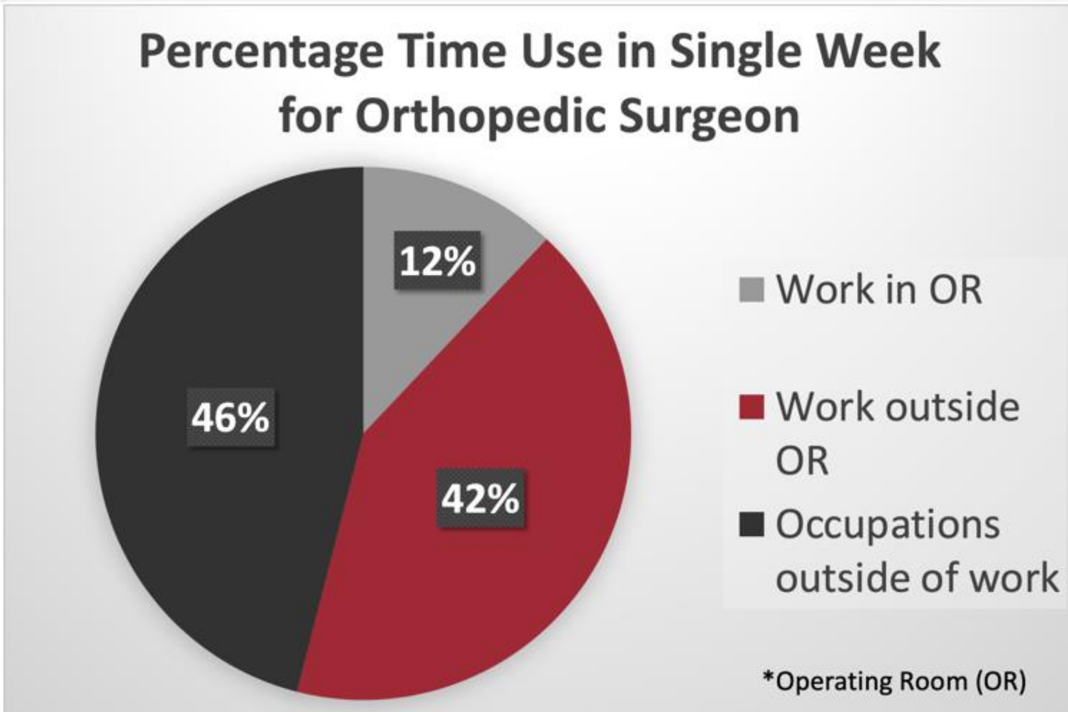
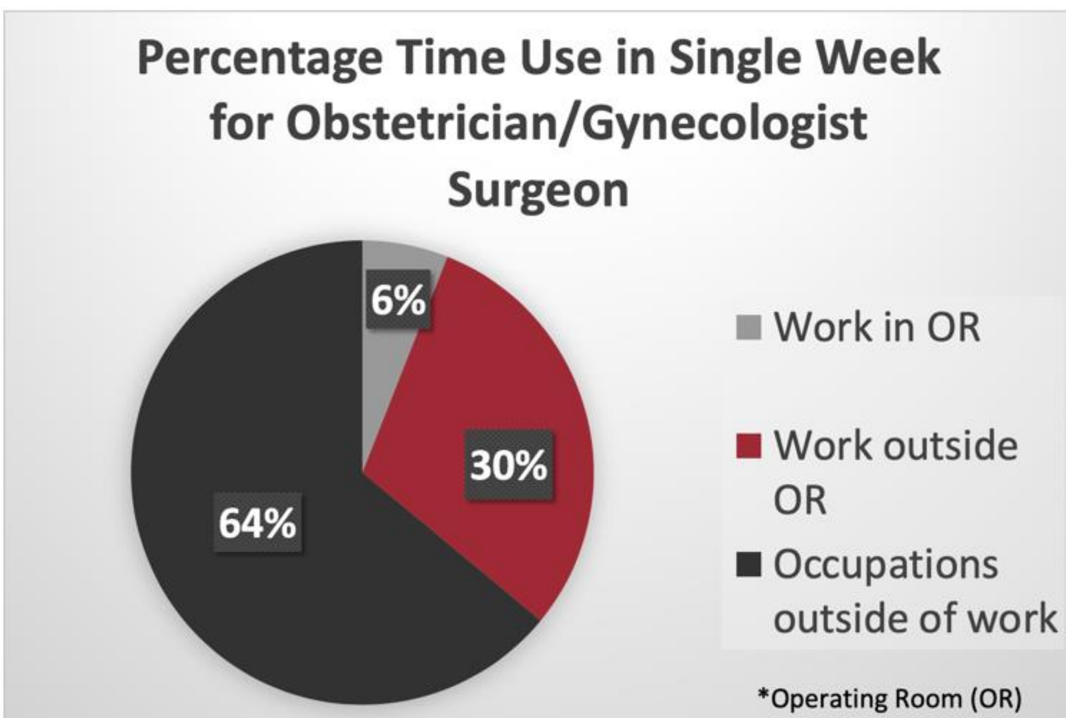


Figure 3.2 Percentage Time Use in Single Week for Obstetrician/Gynecologist Surgeon



Appendix

Interview of Surgeons

1. Please describe the following:
   a. your age
   b. number of years working as a surgeon
   c. number of hours working weekly performing surgery
   d. number of hours working weekly beyond performing surgery
2. Describe your roles beyond the role of surgeon. (For example, parent, spouse, friend, colleague, caregiver). Describe the musculoskeletal demands, if any, that are associated with these roles.
3. Describe your activities during a typical non-work day. (For example, leisure, rest, sports, home maintenance). How much time do you spend on these activities?
4. Describe what you most and least enjoy doing when you aren't at work, and why.
5. Do you perform non-work tasks that are similar to tasks performed during surgery? If yes, please describe. (For example, prolonged standing, fine motor, close visual work, awkward and/or sustained positions, use of tools) Do these tasks produce musculoskeletal symptoms? If yes, please describe.
6. Describe how non-work activities are different or the same now compared to 5 years ago.
7. Tell us how work activities are different or the same now compared to 5 years ago.
8. What kind of technology do you use at work when not completing surgical procedures? (For example, cell phone, laptop, tablet). How often and for how long do you use this technology?
9. What kind of technology do you use when not at work? (For example, cell phone, laptop, tablet). How often and for how long do you use this technology?
10. Do you currently have musculoskeletal symptoms? If yes, describe location and symptoms. What makes your symptoms better or worse?
11. Describe your surgery schedule. (For example, how many and what types of surgeries are scheduled weekly? How many and what types of surgeries do you perform when on call?)
12. Describe what you believe is most demanding on your body as a result of performing surgical procedures. Are there surgical procedures that are more or less demanding on your body than others? If yes, please describe.
13. Describe what you believe is most demanding on your body as a result of non-work activities.