Normative values of the Western Ontario Rotator Cuff (WORC) Index for the general population in the USA

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ABSTRACT
Objectives There are limited data on Western Ontario Rotator Cuff (WORC) Index scores in a population without shoulder pathology. The primary purpose was to provide normative reference values for the WORC in an adult population with healthy shoulders. The secondary purpose was to identify demographic factors and comorbidities that may impact WORC scores.

Methods The WORC survey was completed by patients and family members at a suburban outpatient orthopaedic centre. Patients with current shoulder injury or former upper extremity surgery were excluded. Percentage scores were calculated for total and subscale measures. Demographic factors and comorbidities were evaluated to identify possible risk factors for an abnormal baseline score (less than 100).

Results There were 988 participants (434 men, 554 women). Overall WORC median (IQR) was 98.64 (94.3 to 100). Each subscale was greater than 96 for all sex-based and age-based subgroups. Median WORC scores were greater than those reported in previous literature following surgery for shoulder pathology. Demographic risk factors for poor WORC scores included body mass index (BMI) greater than 30 (p<0.05), tobacco use (p<0.05), a history of shoulder problems (p<0.001) and a history of shoulder injections (p<0.001).

Conclusions This study provides baseline values for the WORC survey in a US suburban population across a range of age groups, demonstrating that surgery for shoulder pathology often results in improved WORC scores, but may not return patients to baseline.

Level of evidence Descriptive epidemiology study; Level of evidence: III.

INTRODUCTION
In 2010, there were roughly 11.5 million office visits for complaints of shoulder pain in the USA, making it the third most common musculoskeletal complaint. In assessment of these patients, multiple subjective and objective measures have been used, including patient-reported outcomes (PRO). One such PRO, the Western Ontario Rotator Cuff (WORC) Index, was developed in order to measure the severity of shoulder pain and the impact that pain has on patient quality-of-life.

The WORC relies on patient self-reporting and consists of 21 questions grouped into five categories: physical symptoms, sports/recreation, work, lifestyle and emotions. Since its development, the WORC has been translated into multiple different languages including Japanese, Dutch, Portuguese and Norwegian. It has been independently validated in multiple studies and compared positively to other indices of shoulder injury, including the SPADI, OSS and SDQ.

In addition to use in non-operative patients, the WORC has been used in multiple studies to assess surgical outcomes for various shoulder conditions; examples include the comparison of surgical versus conservative interventions for full thickness rotator cuff tears, the comparison of different surgical methods for rotator cuff repair and the assessment of quality of life following subacromial decompression. A positive correlation has been found between scores on the WORC and functional outcomes like range of motion and strength. Despite the widespread availability and use of the WORC, there is no current study which provides normative data for the WORC. Normative data would be helpful to establish a baseline for comparison when the WORC is used in studies to assess the outcome of an intervention or a specific pathology.

What are the new findings
- This study provides a normative dataset of Western Ontario Rotator Cuff (WORC) Index scores, as a point of comparison for outcomes following repairs of shoulder pathology.
- This study provides baseline values for the WORC survey in a US suburban population across a range of age groups, demonstrating that surgery for shoulder pathology often results in improved WORC scores, but may not return patients to baseline.
- Demographic risk factors for lower WORC scores include smoking, body mass index above 30, history of shoulder problems or history of shoulder injection.
was that normative WORC values will vary between patients with different demographic factors.

**MATERIALS AND METHODS**

**Study population**

The WORC was distributed at an orthopaedic clinic in a suburban setting over the course of 3 months. The geographic region of the current study experiences temperatures that range from below 0°F to 100°F, and yearly rainfall and snowfall totals both exceed 30 inches. Over 3 million (3,524,583) people live in the metropolitan area and over 60% (63.6%) of the population is between the ages of 18 and 64 years. The median household income is greater than US$56,516 (70,425), less than 10% (9.3%) of households are below the poverty level and over 90% of the adult population had health insurance in 2015.16

**Design and enrollment**

The study was reviewed by our institutional review board and was determined to be exempt from further review under federal guidelines 45 CFR Part 46.101(b) category 2: Surveys and interviews. All ethical standards of maintaining patient confidentiality have been employed, including those in accordance with the US Health Insurance Portability and Accountability Act. Study participants were consecutive male and female visitors, older than age 18. While sitting in the waiting rooms for acute care, MRI and general clinic, the study participants were approached about the study and they agreed to complete the survey. Visitors who were being seen at that visit for shoulder concerns, who reported a history of shoulder or elbow surgery or were employees of our institution were excluded from participation. If the participants had a history of shoulder problems or injections, but no active shoulder problems, they were allowed to be included, in an effort to evaluate what effect previous problems would have on their WORC score. Family members or friends accompanying clinic patients were included as long as they otherwise met the above criteria. Research staff asked patients about exclusion criteria when distributing surveys.

**Demographic and medical questionnaire**

Participants were asked to complete a page of background information that included demographics (including age, gender, smoking status, employment status and occupation), a short orthopaedic history and a short medical history. The orthopaedic history was comprised of yes or no questions regarding high blood pressure and diabetes.

**WORC**

Participants were asked to complete the WORC questionnaire for either their right or left shoulder. Laterality was randomly preassigned by the study. All information was self-reported and no identifying information was collected. The WORC questionnaire is divided into five discrete sections comprising a total of 21 questions: Section A: Physical Symptoms asks about pain, range of motion, weakness and mechanical symptoms; Section B: Sports/Recreation focuses on the effect of the shoulder symptoms on overall fitness level and the ability to do specific exercises; Section C: Work relates the effect of the involved shoulder to yard work, overhead activity, compensation with the unaffected arm and the ability to lift objects below shoulder level; Section D: Lifestyle asks about activities of daily living as well as sleep quality; Section E: Emotions focuses on depression, frustration and worries about the effect of the shoulder on occupation. Each question is scored on a scale of 0–100 and responses are summed for a total of up to 2100.

The participant responses on the WORC were graded using the procedure outlined in the survey for scoring the index. Item scores were summed in each category to generate five subscale scores, and an overall total, for each participant. Possible subscale scores range from 0 to 100, with lower scores indicating rotator cuff disease or dysfunction and higher scores indicating normal or healthy rotator cuff function. Due to the summation-based scoring system, surveys with missing values were excluded. Body mass index (BMI) for each patient was calculated by dividing weight in kilograms over squared height in metres.

**Statistical analysis**

Normative descriptive values were calculated for each subscale by sex, age range and history of injury in the past year. These included medians, quartiles, IQRs, minimum and maximum values. Non-parametric statistical analysis was used because the data were not normally distributed based on the Shapiro-Wilk test for normality. Differences in outcomes were compared using the Kruskal-Wallis or Mann-Whitney U test. Scores were compared by age range for male and female cohorts (18–25, 26–35, 36–45, 46–55, 56–65, 66–75 and 76 plus). Within each age cohort, variations in the WORC were compared for each sex. Outcomes for participants with a history of shoulder injury in the past year were compared with those with no history of injury. The effect of laterality on the mean WORC score was also explored. Differences due to risk factors (prior shoulder problems, shoulder injections, tobacco use, BMI>30, high blood pressure and diabetes) were calculated. A regression analysis was also performed to assess the effect of variables on WORC scores. Analysis was performed using a combination of Microsoft Excel and SPSS. P<0.05 was defined as statistically significant.

**RESULTS**

The final study cohort consisted of a total enrolment of 988 participants, with 434 men and 554 women. In total, 1024 surveys were completed; 36 surveys were excluded because they were incomplete in more than one category. In addition, six respondents did not indicate whether or not they had a history of upper extremity injection in the past year and were excluded from analysis pertaining to that variable. Six per cent of respondents reported a history of shoulder problems within the past year and 5% indicated an upper extremity injection or procedure in the past year. Eight per cent of respondents indicated that they are current tobacco users. See table 1 for patient demographics and descriptive variables.

**Subscales**

All median subscore values were greater than 96 in all age groups.

**Laterality**

Laterality was exactly equal, with 494 respondents for each side. There were no statistically significant differences in any of the subscales, or the total score, between left-sided and right-sided responses.

**Sex**

Women scored higher than men on the Total Score (p=0.05) and on the Physical Symptoms (p<0.05), Sports/Recreation (p<0.01) and Work (p=0.25) subscales. Median values on the
Lifestyle (p=0.67) and Emotions (p=0.15) subscales were equivalent for men and women.

### Age

The 66–75 and 75+ age groups tended to have higher scores than other age groups. Specifically, the 66–75 age group was found to be statistically significant when compared with other age groups for the Total Score (p<0.01), and for the Physical Symptoms (p<0.01), Sports/Recreation (p<0.05), Work (p<0.05), Lifestyle (p<0.05) and Emotions (p<0.05) subscores. Across all age groups, scores tended to be lowest on the Physical Symptoms subscore, with the 18–25 age group reporting the overall lowest median score (p<0.05). In addition, the 18–25 age group also had the lowest Total Score (p<0.05) and the lowest Work subscore (p=0.53). The 36–45 age group had the lowest median subscores under Sports/Recreation and Lifestyle. The median Emotion subscore was equivalent across all age groups.

### History of shoulder problems or treatment

The 58 respondents who indicated a history of shoulder problems were significantly more likely to score lower on the survey in all categories, with a median total score of 75.52 (p<0.001). The 48 respondents with a history of upper extremity injection were also significantly more likely to score lower on all the survey categories, with a median total score of 95.36 (p<0.001).

### Other factors

The following non-shoulder related risk factors were significantly correlated with a decrease in WORC score: BMI greater than 30 (p<0.05; figure 1) and the use of tobacco (p<0.05; figure 2). Having diabetes (p=0.26) or high blood pressure (p=0.63) were not significantly associated with lower scores.

### DISCUSSION

The WORC has been used to compare outcomes in shoulder pathologies and procedures to address those pathologies, but currently, no normative dataset exists for the WORC. This study provides normative values for an adult US population. The key findings from the study were: highest (best) WORC scores were found in the 66–75 age group, women reported higher WORC scores than men and WORC scores were lower (worse) in study participants with a history of shoulder injury or injection, elevated BMI and smoking.

The overall median score reported here (98.64) was higher than WORC results seen in patients with shoulder injury/pathology, suggesting that this is an appropriate normative dataset and that the WORC instrument is sensitive enough to distinguish between normal and non-normal shoulders. The median score is also higher than that observed in studies of normal shoulders. The median score is also higher than that observed in studies of normal shoulders. The median score is also higher than that observed in studies of normal shoulders.
WORC also suggests that once shoulder pathology has begun, it may not always be possible to get patients back to their same functional baseline. All of these are important points on which to counsel our shoulder patients in clinic.

We observed slight variation across ages and between males and females. The 66–75 year age group had the overall highest median scores and the 18–25 age group scored the lowest on the Total Score and two of the subscores. No other statistically significant differences existed between ages groups. The study does not allow us to identify the causes for these findings, but it is possible that the functional expectations and perceptions differ between older and younger adults, which could lead to lower quality-of-life assessments in younger adults. There is some evidence for this age group effect seen in previous studies, although again the differences are not statistically robust. For example, Saraswat et al12 found that elderly patients (age 70 and over) had the worst WORC baseline mean, but at 1-year of follow-up, their mean change had increased as much as the younger age groups, and at 10 years of follow-up this group was reporting the best WORC mean. Baysal et al18 did a quality-of-life (QOL) study that noted baseline-to-1 year follow-up change was best in their oldest cohort (≥age 60) and this high satisfaction level did not fall, up to 5 years of follow-up. Regardless of the cause, it is important for clinicians to be able to counsel patients that expectations on outcomes instruments may vary depending on age.

Women scored equal to or higher than men in all categories. Previous studies focused on outcomes related to rotator cuff pathology found that women generally score lower than men in satisfaction with quality of life.12 15 19–22 The findings from this study would then suggest that shoulder pathology may differentially affect men and women, which is also important for counselling patients.

It is well-documented that smoking is associated with poor outcomes following orthopaedic and other surgical procedures as well as a slower recovery in general.23–25 Specifically related to rotator cuff pathology, smoking was linked to a larger tear area due to decreased tendon vascularity.26 Other studies have found links between smoking and joint pain, with pain improvement following smoking cessation.27 Several papers have linked smoking to higher levels of musculoskeletal pain, but these have focused on limited populations such as female veterans,28 patients with fibromyalgia29 and persistent back pain.30 We found a statistically significant difference between smoking and poor scores on the WORC in our normal sample. While the exact relationship is unclear, it is possible that the negative effect on healing from smoking results in longer-term impacts from old injuries in non-operative patients and that it results in poor healing in surgical patients. Similar effects may be noted in patients with higher BMI.

It should be noted that the WORC instrument is a long questionnaire and there is a burden placed on patients to complete this. Despite this, because of the comprehensive assessment in the WORC, we felt it was important to assess the complete WORC instrument. One limitation of the WORC is the total score of the entire instrument. We evaluated each subdomain and feel that the normative data from the subdomains may be even more helpful to future work in assessing each subdomain, rather than the total score, especially since there were different findings across the subdomains. There is also the ShortWORC instrument, and future study should evaluate the normative data for this instrument. Another important note is that the WORC was designed as a disease-specific instrument, but we feel that understanding how the instrument performs in the general

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Figure 1 (A) Age vs WORC Total Score in patients with a BMI less than 30 (n=701). (B) Age vs WORC Total Score in patients with a BMI greater than or equal to 30 (n=279). The dotted line represents a regression line. BMI, body mass index; WORC, Western Ontario Rotator Cuff.

Figure 2 (A) Age vs WORC Total Score in non-smokers (n=906). (B) Age vs WORC Total Score in smokers (n=73). The dotted line represents a regression line. WORC, Western Ontario Rotator Cuff.
population is an important way of understanding whether our interventions return patients with rotator cuff pathology to a baseline state.

Additional limitations must be considered with this study. As with any PRO, there could be recall bias, such that respondent answers could have been impacted by other musculoskeletal conditions affecting the respondent. To minimise this possibility, the research staff utilizing the WORC carefully explained the study purpose and requested that participants only respond based on their current shoulder function. There is also potential for selection bias due to the metropolitan location of the orthopaedic centre. It is possible that this does not fully represent populations in other areas, such as rural areas or in other countries.

CONCLUSION
This study provides baseline values for the WORC survey in a US suburban population across a range of age groups. The study demonstrates that, while surgery for shoulder pathology often results in improved WORC scores, WORC scores may not be restored to baseline. Risk factors for a lower score include smoking, a BMI above 30, a history of shoulder problems or a history of shoulder surgery.

Contributors
MT is the corresponding author and has been involved in all facets of the study. Likewise, SEK has been involved in all facets of the study. CEU has been involved in data compilation, data analysis and interpretation. LRH has been involved in study design and data collection. MCO has been involved in the design and conduct of the study, data analysis and data interpretation as well as statistical analysis. RSS has been involved in study design, data interpretation and statistical analysis. All authors were involved in the writing and editing of the manuscript.

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Competing interests
None declared.

Patient consent for publication
Not required.

Ethics approval
This study was reviewed by our Institutional Review Board at the University of Minnesota as study #160588144 and determined to be exempt from further review under federal guidelines 45 CFR Part 46.101(b) category 2: Surveys and interviews. All ethical standards of maintaining patient confidentiality have been employed, including those in accordance with the US Health Insurance Portability and Accountability Act (HIPPA).

Provenance and peer review
Not commissioned; externally peer reviewed.

Data availability statement
All data relevant to the study are included in the article or uploaded as supplementary information. Deidentified participant data in form of a medical questionnaire.

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