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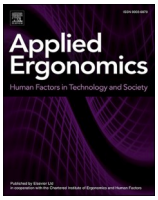

Musculoskeletal disorder risk assessment tool use: A Canadian perspective

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ABSTRACT

Canadian ergonomics professionals from the Association of Canadian Ergonomists (ACE) and Board of Canadian Registered Safety Professionals (BCRSP) participated in a web-based survey of their awareness, use, and factors influencing use of ergonomics musculoskeletal disorder (MSD) risk assessment tools. A total of 791 respondents (21.0% response rate) participated in the survey. Certified ergonomics professionals represented an important subpopulation of MSD risk assessment tool users, however; the vast majority (86.4%) of users within Canada were certified safety professionals. Average tool use varied between ACE and BCRSP groups, where ACE respondents on average use more tools than BCRSP respondents, however the top 10 tools used were similar between the groups. Over 45% of assessment tools were learned at school and average tool use was not influenced by years of experience or continuing education.

1. Introduction

Societies and organizations are faced with mounting pressure to create sustainable working conditions (United Nations, 2018). Improving ergonomics has become a major focus for organizations around the world to mitigate the rising healthcare and compensation costs associated with preventable work-related musculoskeletal disorders (Hoy et al., 2014; Ravindra, 2021; Vos et al., 2012). Pivotal to the creation of safe workplaces is the means by which hazards and risk are assessed. Risk management targeting musculoskeletal disorders (MSDs) is critical as they constitute 40% of the global compensation costs of occupational and work-related injuries and diseases (ILO, 2015). To reduce high MSD rates and associated costs, the capacity to assess and control relevant hazard exposures is required. Though several MSD assessment tools have been reported in the literature (e.g., Gallagher et al., 2017; Li and Buckle, 2005; Waters et al., 1993), little is known about the use of MSD risk assessment tools among those working as safety professionals who are not certified ergonomics practitioners within the occupational health and safety (OHS) sector.

Hazardous physical ergonomics exposures such as heavy or repetitive manual handling, non-neutral postures, and hand-arm or whole-body vibrations are considered to substantially contribute to a large proportion of work related MSDs (Lind, 2017). MSD risk assessment tools aid users in observing, quantifying, and interpreting MSD risk based physical ergonomics exposures to inform controls, as necessary to reduce exposures to acceptable levels. Often tools only target single body regions or are applicable for certain types of work operations (Waters et al., 1993), thereby requiring users to apply several tools concomitantly to robustly assess risk. Conversely, tools exist with overlapping foci, meaning that users may need to select from a variety of tools that may all equivalently target the same hazards. Given the intent of specific application and possible overlapping foci of MSD risk assessment tools, it is unsurprising that Tee et al. (2017) found better MSD risk assessment results may be obtained through the use of multiple tools. Thus professional mean tool use may be an indicator of best practice. Further, the continued development of new tools compounds these issues and may make it increasingly difficult for users to identify and correctly apply the most appropriate tool(s) for a given environment. Understanding what MSD risk assessment tools are used and why can help address these difficulties and improve current practice.

Little information exists regarding why a professional uses a particular tool and the factors that influence use of MSD risk assessment tools. Some tools have been created with their intended application within a specific sector, which might be one factor impacting tool selection. For example, the Posture, Activity, Tools and Handling (PATH), was designed primarily for use in the construction sector. However, previous trends in the PATH's overall use did not indicate a high level of specificity to the construction sector (Lowe et al., 2019), despite its design

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intent. A potential gap in knowledge translation is proposed as an explanation for unsuccessful implementation of MSD risk assessment tools (Eliasson et al., 2019). Research by Pascual and Naqvi (2008) identified that tool use was typically influenced by the work requirements of the professional conducting the assessment.

Moreover, the employment role of the professionals who conduct MSD risk assessments varies greatly (Theberge and Neumann, 2010), where MSD hazard assessments may be conducted within Canada by a diverse group of professionals whose primary focus is on ergonomics or others with an interest, or workplace role related to the assessment of MSD hazards in the workplace. Certified ergonomists (i.e., Canadian Certified Professional Ergonomist (CCPE) engage in the practice of ergonomics as their primary work and may only be granted CCPE certification following the successful completion of an ergonomics focused bachelor's degree – or higher – and who have met the minimum requirement of five years of professional experience within the field. Members of the Association of Canadian Ergonomists (ACE) must possess an ergonomics degree (bachelor's degree or higher) from a recognized university and are selected based on their professional and academic performance. Certified safety professionals (i.e., Canadian Registered Safety Professional (CRSP; governed by the Board of Canadian Registered Safety Professionals (BCRSP)) require a minimum of a bachelor's degree in any field or a two-year diploma in occupational health and safety from a recognized academic institution as well as 48 months of professional OHS experience. ACE and BCRSP members may hold CCPE certification in addition to their ergonomics of OHS designation. Previous studies have focused exclusively on Certified Professional Ergonomists (ie. CCPE equivalent) in the United States, Canada, United Kingdom, and Australia (Dempsey et al., 2005; Lowe et al., 2019). However, acknowledging the diversity in the individuals conducting MSD risk assessments, it is important to extend this line of inquiry beyond certified ergonomists to better understand the landscape of tool use within the broader OHS system as well as identify potential opportunities for improvement.

The purpose of this study was to better understand the use of MSD risk assessment tools among CCPEs and BCRSPs in Canada, professionals that are most likely to have a work responsibility related to MSD hazard assessment within a Canadian context. Acknowledging that both CCPEs and BCRSPs are routinely required to support MSD risk assessment, it is important to understand how MSD tool use, rational for tool use, and education on tool use compares between groups to help identify opportunities to standardized practice, in terms of guidance for selecting, applying and learning about MSD hazard assessment tools. The objectives of the study were to: 1) describe the characteristics of individuals who may be routinely responsible for assessing MSD risk; 2) identify the MSD risk assessment tools used by CCPEs and BCRSPs most frequently; and 3) describe where assessment tools were learned and how professional group, work experience, and continuing education influence MSD risk assessment tool use.

2. Methods

2.1. Survey design

The investigators held unstructured key informant interviews with American (1) and Canadian (3) CPEs to identify the scope and types of items to consider in the survey. Three themes were identified: 1) what MSD risk assessment tools are used; 2) why do professionals choose to use those tools; and 3) how are MSD risk assessment tools used. A literature review was conducted to identify candidate survey items. In total, 17 articles were reviewed in full-text which resulted in nine items included in the candidate item pool. An additional 14 items were generated by the research team. Follow-up consultation with the same three CPEs narrowed the survey focus to include only themes 1 and 2 due to concerns of clarity and interpretability regarding the assessment of theme 3 (how are tools used). Informants recommended that the MSD risk assessment tools investigated include those previously assessed by (Dempsey et al., 2005) and (Lowe et al., 2019). A number of additional assessment methods were also considered. Additions included: Ergo Job Analyzer (Engineers, 2003); DUET – Distal Upper Extremity Tool (Gallagher et al., 2018); EJMS – Ergonomic Job Measurement System (Ridyard et al., 2001); MANTRA – Manual Task Risk Assessment Tool (Burgess-Limerick et al., 2004); Handpak (Potvin, 2007); BRIEF – Baseline Risk Identification of Ergonomic Factors (Li et al., 2003); LiFFT – Lifting Fatigue Failure Tool (Gallagher et al., 2017); QEC – Quick Exposure Checklist (Li and Buckle, 2005); Utah Back Compressive Force model (Merryweather et al., 2009); Utah Shoulder Moment estimation (Steele et al., 2013); and Washington State Caution/Hazard Zone checklist ("Washington State department of Labor and Industries Evaluation Tools," 2019). In total, 24 MSD risk assessment tools were considered for investigation within this study.

A total of 18 candidate items were included in an online pilot survey. The three CPEs completed the pilot survey. Semi-structured interviews were conducted with the CPEs whose recommendations resulted in the modification of nine candidate items, the amalgamation of four items, and the removal of 2 items. The final version of the survey contained 12 items related to demographics, MSD risk assessment tool use, practice characteristics, and education. Respondents were able to select a single most relevant categorical response with the exception of sector of practice which allowed for the selection of one or more relevant areas of practice. A separate "multiple sectors of practice" category was included in analysis that included all respondents who identified multiple sectors of practice exclusive to those who identified only a single sector of practice. The survey was formatted in English for electronic, web-based administration and conducted online via the Qualtrics platform (Qualtrics XM, Provo, Utah, United States of America). It was estimated that the survey would take five to eight minutes to complete.

2.2. Survey administration

The survey was administered within two distinct populations through partnerships with ACE and the BCRSP (CCPE designation not exclusive to either population). Study inclusion required participants to hold a full ACE or BCRSP membership and to practice in Canada. Each organization identified eligible study participants within their respective memberships through email (ACE = 577; BCRSP = 3,204). Eligible participants were emailed a link to the web survey with a follow-up reminder email sent two weeks following the invitation. Survey data were de-identified to maintain participant confidentiality. Study information including all email correspondence and informed consent documentation were sent to eligible participants in both English and French.

2.3. Data analysis

Counts and percentages were used to describe the respondent characteristics. The frequency of tool use was reported by a response (yes) to use of a given tool in the survey. Each tool was also queried with a categorical response to why a participant chose to use each MSD risk assessment tool and how they came to learn of the tool. The average number of tools used in practice for each respondent was calculated as a sum of all (yes) responses to each of the 24 tools. The top 10 tools for respondents were reported by the percentage of respondents out of the total amount of respondents who used any tools in each professional group (ACE and BCRSP).

The variable "mean number of tools used", as described above, was used as a dependent variable for analyses in the second and third objectives. Mean tool use by sector of practice was analyzed using a one-way ANOVA, with Bonferonni adjusted post hoc comparisons. Given the range of avenues to pursue a career in ergonomics and MSD prevention in Canada, average tool use was also analyzed by years of experience and continuing education days. The variable *years of*

experience was created as a categorical variable (3 levels: 10 or less years, 11–20 years, 21 or more years).

The variable of *continuing education* was created as a categorical variable (3 levels: 5 or less days, 6–10 days, 11 or more days). The influence of professional group, years of experience, and days of continuing education were observed through a general linear model with main and interaction effects. All analyses were conducted using SPSS version 27 software (IBM Corporation, Armonk, New York, United States of America).

3. Results

In total, 791 respondents provided consent to participate in the survey. This equated to an overall response rate of 21.0% (ACE response rate = 19.4%; BCRSP response rate = 21.3%). However, 76 respondents did not complete the survey (incomplete data) and were removed prior to analysis, resulting in a total sample of 715 responses (19.0%).

3.1. Participant characteristics

Respondents reported practicing in all ten Canadian provinces and three territories. Table 1 shows the respondents' demographic information and other characteristics of ergonomics practice. There were more male than female respondents in OHS and ergonomics professional roles. Most respondents were corporate consultants – those employed as an OHS professional within a specific company, compared with independent consultants – self-employed or employed within a consultancy firm. Years of experience varied from less than 10 years through over 21 years. As noted earlier, most respondents were from the BCRSP professional group, and few respondents (<10%), held the Canadian designation as a professional ergonomist (CCPE). The majority (53%) of ACE respondents held the CCPE designation. Over 64% of respondents reported using MSD risk assessment tools less than once per month, with most respondents representing the service, construction, manufacturing, or multiple sectors.

Table 1
Participant characteristics of all respondents.

Characteristic	n	($\%_{valid}$)
Professional Group		
Association of Canadian Ergonomists (ACE)	102	(14.2)
Board of Canadian Registered Safety Professionals (BCRSP)	613	(85.8)
Gender (N = 505)		
Male	291	(57.6)
Female	213	(42.2)
Age (years) (N = 512)		
40 or less	118	(23.0)
41 to 50	130	(25.4)
51 to 60	174	(34.0)
Greater than 60	90	(17.6)
Current occupation (N = 708)		
Independent consultant	113	(16.0)
Corporate consultant	399	(56.4)
CCPE Certification (N = 708)		
No	461	(65.1)
Yes	55	(7.7)
Years of Experience (N = 517)		
10 or less years	209	(40.4)
11–20 years	183	(35.4)
21 or more years	125	(24.2)
Sector of practice (N = 504)		
Services	125	(24.8)
Manufacturing	92	(18.3)
Healthcare	44	(8.7)
Construction	109	(21.6)
Forestry/mining	27	(5.4)
Transportation	25	(5.0)
Multiple	81	(16.1)
Assessment frequency (N = 505)		
More than once per week	39	(7.7)
Once per week	32	(6.3)
Once every two weeks	36	(7.1)
Once per month	70	(13.9)
Less than once per month	327	(64.8)
Highest level of education (N = 295)		
Bachelor's Degree	185	(62.7)
Master's Degree	104	(35.3)
Doctorate	5	(1.7)
Annual continuing education (N = 509)		
5 or less days	140	(27.5)
6–10 days	176	(34.6)
11 or more days	192	(37.7)

3.2. MSD tool use in practice

There were 403 respondents who reported using one or more of the MSD risk assessment tools investigated within this study, where the average number of tools used was ($n = 4.7 \pm 0.2$). Fig. 1 shows the distribution of the MSD risk assessment tools and the reasons for use for respondents who identified using any given tool. All 24 MSD risk assessment tools investigated had reported use in the Canadian context. Canadian safety professionals most commonly reported using MSD risk assessment tools that were efficient and easy to use, available or familiar, and that were appropriate for the job. Cost considerations were reported as a reason for use among seven MSD risk assessment tools.

Indicated in Table 1, most respondents conducted MSD risk assessments for the service, construction, and manufacturing industries or provided ergonomics across multiple sectors. Fig. 2 shows the mean number of MSD risk assessment tools used by respondent who reported tool use by sector of practice. Reported MSD risk assessment tool use differed significantly by sector of practice ($p < 0.001$). The manufacturing, healthcare, and transportation sectors had the greatest proportion of tool users at 90.3%, 88.6%, and 80.0% respectively. While the construction, forestry & mining, and services sectors had lesser proportional MSD assessment tool users at 66.1%, 70.4%, and 70.4% respectively.

The various MSD risk assessment tools used within each sector of practice among respondents was tabulated as shown in Table 2. The NIOSH Lifting Equation was found to be the most commonly used tool among each sector of practice. All but the transportation sector of practice were observed to use a similar subset of MSD risk assessment tools that included the RULA, REBA, and Psychophysical Materials Handling Data.

3.3. Factors influencing learning of assessment tools and average use

For each tool, respondents were asked where they learned of the given assessment tool. Across tools, the most common place that respondents learned of a tool was at school (45%). Respondents were less likely to learn of tools through their own independent research or at conferences. Fig. 3 displays the average percentages of where respondents were to learn of MSD assessment tools.

The average number of tools used was analyzed descriptively by respondent group and as a factor of experience and education. Descriptively, professional organization influenced the use of MSD tools. The average number of assessment tools used in practice was higher for ACE respondents ($n = 7.9 \pm 0.4$) compared to BCRSP respondents ($n = 2.8 \pm 0.2$) ($F_{(1,377)} = 71.1$, $p < 0.001$). Given the difference in average tool use by respondent group, the distribution of the top 10 tools used was gathered and described for both groups (Table 3). For each respondent group (ACE and BCRSP), the percent of respondents for each tool was reported out of the total number of tool users for the respective respondent group (those who answered "yes" to using MSD tools). The ACE group had higher percentages of tool users across the all the top 10 tools, whereas the BCRSP group had a higher percentage for just one tool. This top tool was the NIOSH lifting equation. For the BCRSP group (right side of Table 3), the percent of respondents employing the NIOSH lifting equation was higher than for any other tool. By comparison, a

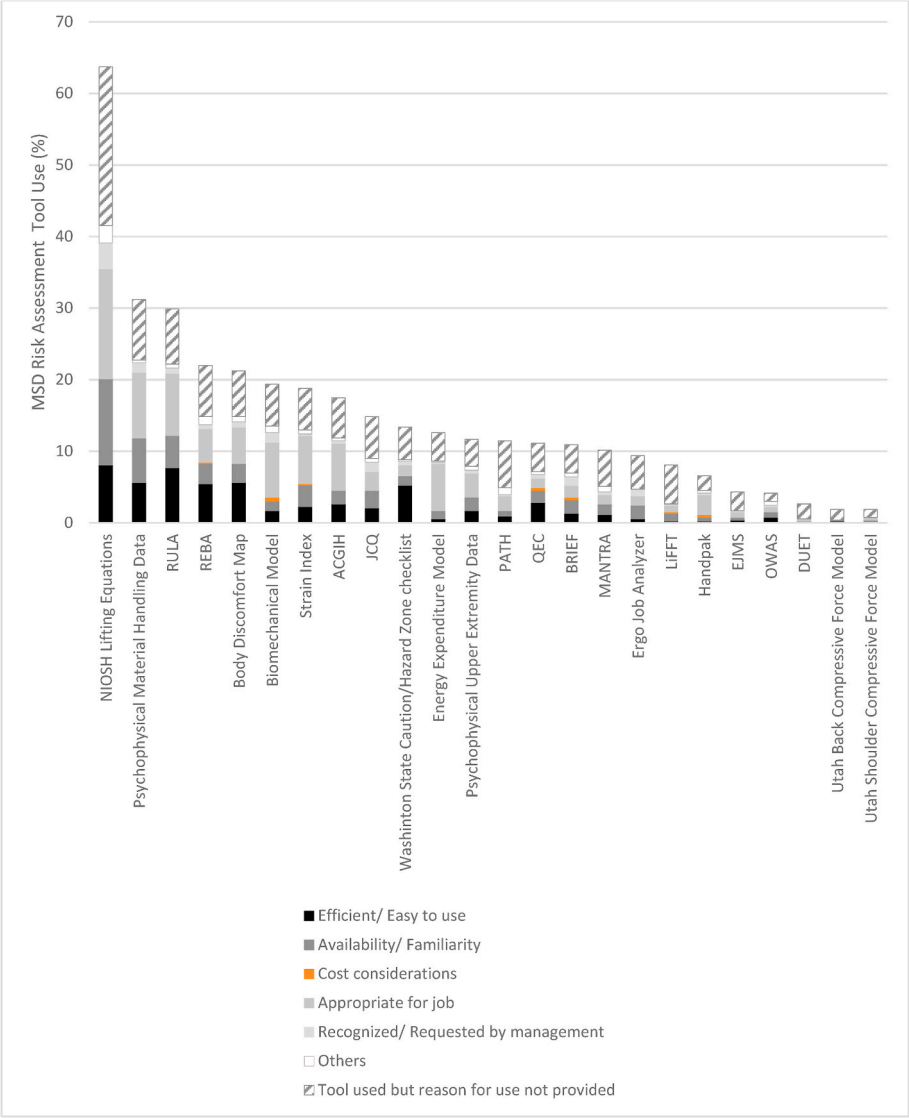

Fig. 1. Frequencies of Canadian professional MSD risk assessment tool use with the reported reason for use. Total length of bar represents the total number who have ever used the tool (N = 403).

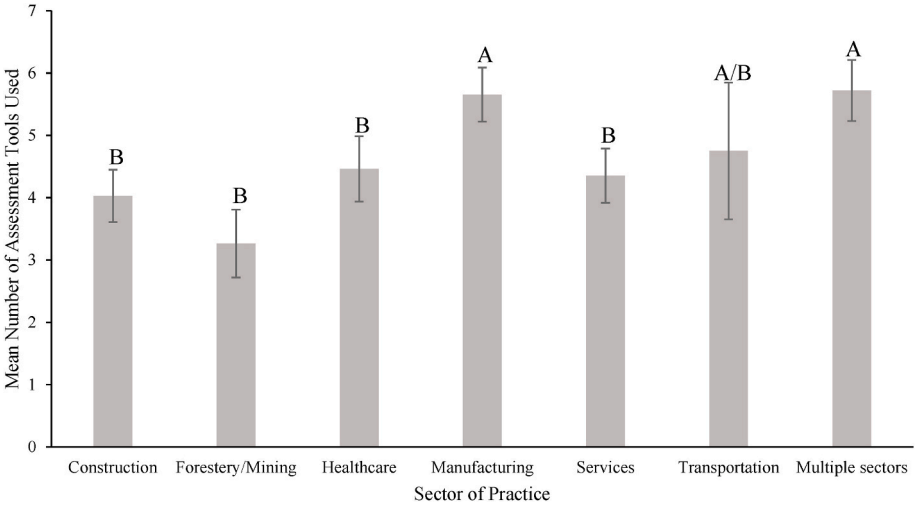

Fig. 2. Mean number of MSD risk assessment tools used by sector of practice among respondents who reported any tools use. Error bars represent the standard error from the mean. "A" and "B" denote category means that differ, A/B denotes no difference from either A nor B at the 0.05 level (N = 403).

Table 2
Top 5 MSD Risk Assessment Tools Used by each Sector of Practice.

Sector	Ranked Reported MSD Risk Assessment Tool Use (Tool (% use))				
	1st	2nd	3rd	4th	5th
Construction	NIOSH Lifting Equation (49.5%)	Rapid Upper Limb Assessment (19.3%)	Rapid Entire Body Assessment (17.4%)	Job Content Questionnaire (17.4%)	Baseline Risk Identification of Ergonomic Factors (15.6%)
Forestry/ Mining	NIOSH Lifting Equation (51.9%)	Job Content Questionnaire (22.2%)	Rapid Upper Limb Assessment (18.5%)	Body Discomfort Map (18.5%)	Rapid Entire Body Assessment (14.8%)
Healthcare	NIOSH Lifting Equation (77.3%)	Psychophysical Material Handling (47.7%)	Rapid Upper Limb Assessment (34.1%)	Rapid Entire Body Assessment (27.3%)	Biomechanical Model (25.0%)
Manufacturing	NIOSH Lifting Equation (79.6%)	Psychophysical Material Handling (50.5%)	Rapid Upper Limb Assessment (43.0%)	Rapid Entire Body Assessment (37.6%)	Strain Index (34.4%)
Services	NIOSH Lifting Equation (62.4%)	Psychophysical Material Handling (28.0%)	Rapid Upper Limb Assessment (24.8%)	Body Discomfort Map (16.8%)	Rapid Entire Body Assessment (16.0%)
Transportation	NIOSH Lifting Equation (64.0%)	Psychophysical Material Handling (24.0%)	Energy Expenditure Model (24.0%)	Ergo Job Analyzer (24.0%)	Baseline Risk Identification of Ergonomic Factors (24.0%)
Multiple Sectors	NIOSH Lifting Equation (70.4%)	Rapid Upper Limb Assessment (45.7%)	Psychophysical Material Handling (43.2%)	Body Discomfort Map (30.9%)	Strain Index (29.6%)

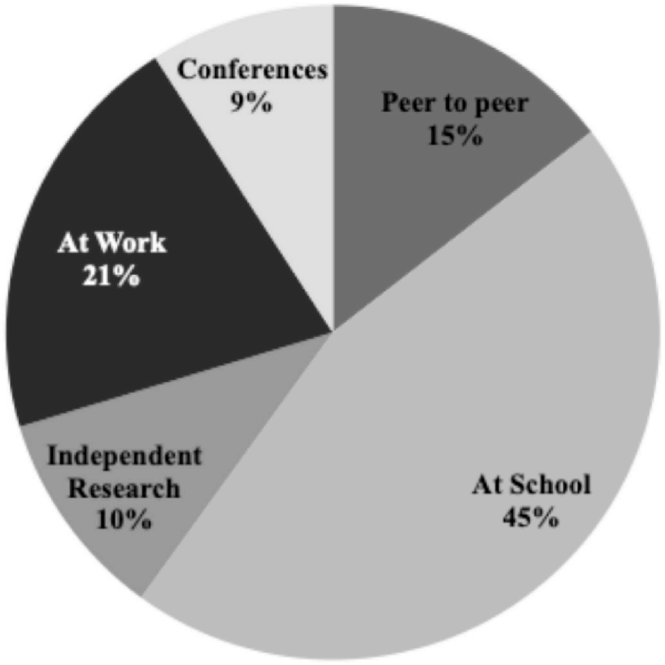

Fig. 3. Reporting of where MSD tools were learned reported as a percentage of all responses.

similar proportion of the ACE respondents reported using Psychophysical Material Handling Data and the NIOSH lifting equation, and percentage of respondents for the top 10 tools used was greater than that of BCRSP. Across both groups, when asked about how the tool users learned of any given tool, the most common response was at school (ACE = 47.3%, BCRSP = 44.2%), compared to other avenues such as conferences, (ACE = 7.3%, BCRSP = 10.3%), peers, (ACE = 9.3%, BCRSP = 17.9%), on the job, (ACE = 19.2%, BCRSP = 21.4%), or through their own research. (ACE = 16.8%, BCRSP = 6.1%).

Percentage reported as the percent of tool users which refers to respondents who indicated using at least 1 tool in their ergonomics role. Reported for each respondent group (ACE Tool User N = 68, BCRSP Tool User N = 319).

Across both ACE and BCRSP respondents, there were no main effects of years of experience or amount of continuing education. There was an interaction of work experience and continuing education on the average number of tools used ($F_{(4,377)} = 2.56$, $p < 0.05$). However, upon simple effects analysis for the interaction with conservative adjustment there were no differences determined between years of experience and continuing education on average tool use.

Table 3
Top 10 MSD Risk Assessment Tools Used as a Percentage of Tool Users in each Respondent Group.

Tool	ACE	Tool	BCRSP
Psychophysical Material Handling Data	99%	NIOSH Lifting Equation	87%
NIOSH Lifting Equation	93%	Rapid Upper Limb Assessment (RULA)	32%
Rapid Upper Limb Assessment (RULA)	82%	Psychophysical Material Handling Data	31%
Rapid Entire Body Assessment (REBA)	66%	Job Content Questionnaire	23%
Biomechanical Model	65%	Rapid Entire Body Assessment (REBA)	23%
Body Discomfort Map	62%	Body Discomfort Map	22%
Strain Index	62%	Posture Activity Tools Handling (PATH)	19%
Hand Activity Level (HAL)	53%	Biomechanical Model	18%
Energy Expenditure Model Material Hand.	47%	Strain Index	18%
Psychophysical Upper Extremity Data	46%	Hand Activity Level (HAL)	18%

4. Discussion

Building from previous surveys (Dempsey et al., 2005; Lowe et al., 2019) this study collected data about MSD hazard assessment tool use from both certified ergonomists, but also certified safety professionals that are also often mandated to complete MSD risk assessments within the Canadian context. Our findings show that while certified ergonomics professionals represent an important subpopulation of MSD risk assessment tool users however in comparison, the vast majority (86.4%) of MSD risk assessment tool users within Canada were more likely to be certified safety professionals. By capturing MSD risk assessment tool use from both the ACE and BCRSP professional groups, these findings expand the knowledge on MSD risk assessment tool use across the diversity in ergonomics professionals in Canada.

When compared to previous surveys by (Dempsey et al., 2005; Lowe et al., 2019) the addition and modification of 10 tools within this survey had little impact on the order of tool use frequency. However, the proportional frequency of tool use was found to be lower than previously reported. The NIOSH lifting equations, Psychophysical Material Handling Data, RULA, and Biomechanical modelling had the greatest reported use across all three studies. Consistent with the findings reported by (Lowe et al., 2019) the reported use of RULA, REBA, Strain Index, and ACGIH tools retained a large relative proportional prevalence of use by Canadian safety professionals (both CCPE and BCRSP). The ten

most frequently used tools were fairly consistent between professional groups. The NIOSH lifting equation and psychophysical material handling data were two of the most common tools used by ergonomics professionals.

Notably, the ACE professional group utilized a wider range of tools compared to the BCRSP group, as indicated by an overall higher average tool use of over 7 tools compared to an average of 3 tools. The ACE group also had a higher percentage of respondents reporting a broader use of the top 10 tools (Table 3). One explanation for this is that ACE members, as a result of their targeted focus in ergonomics, may have simply learned about more tools. In turn, this may provide ACE members with a larger selection of tools from which to draw on when completing MSD risk assessments. While ACE and BCRSP members share overlaps in the most commonly used tools, ACE members may be considering risk from additional perspectives by using additional supplementary tools. We do not know if the use of more tools leads to better MSD risk control, but surmise that there is an opportunity to expose a broader range of OHS professionals (inclusive of BCRSP professionals) to more tools to ensure the MSD risks can be adequately assessed from a range of perspectives (i.e., appropriate tools).

Sector of practice was found to have a significant influence on the mean number of MSD risk assessment tools used. Research suggests that better MSD risk assessment results may be obtained through the application of multiple tools (Tee et al., 2017). The work-related tasks differ greatly between sectors of practice and require the application of different MSD risk assessment tools. Our finding that practitioners who work in the manufacturing sector use significantly more MSD risk assessment tools when compared to those in construction, forestry/mining, healthcare, and services sectors may be due to the prevalence of work-tasks within this sector involving large complex multi-segment movements with varying risks. An additional explanation may be that many of the described MSD risk assessment tools have been developed, applied, and implemented within the manufacturing sector (Vignais et al., 2013; Wells et al., 2007). Our findings suggest that regardless of sector of practice at least the five most frequently used MSD risk assessment tools remained fairly consistent. However, it remains unclear whether the number of tools developed with the intent of application within a specific sector has a significant influence on mean tools use.

MSD risk assessment tools that are efficient and easy to use, deemed appropriate for the task, and that were available and familiar were used more frequently. The most common reason professionals used a given tool was familiarity. Familiarity, while not a surprising finding is an important consideration, particularly in how tools are taught and disseminated. Interpreting this with the findings of where tools are often learned, almost half of respondents reported learning of tools at school, while the other half reported other means such as learning at work or from peers. Highlighted by Shorrock and Williams (2016), MSD assessment tool users are faced with some constraints when it comes to implementing such tools in practice. The authors outlined the accessibility, usability, and contextual constraints to human factors/ergonomics in practice (Shorrock and Williams, 2016). As a usability constraint, user-centred design (a core component of human factors/ergonomics) is sometimes left out in the methodological consideration and development of assessment tools (Shorrock and Williams, 2016). Considering the responses of Canadian ergonomists, as we move forward in developing and evaluating MSD assessment tools, we should consider the tool in practice along with the practitioner perceptions, experiences, and usability.

No differences were found in average tool use by years of experience or amount of continuing education. As seen in other professionals, like nursing or teaching, years of experience can sometimes be attributed to greater confidence or self-efficacy (Gainer, 2016; Van Dyk et al., 2016). While years of experience may be considered to positively influenced tool use due to greater breadth in assessment experience, those with less experience on average used the same number of tools. Returning to the finding that most respondents learned of tools through their education (at school) and choose a tool based on familiarity, it could be posited that once these professionals learn of a tool and find it is useful, they continue to use the same ones in practice. Also, given that days of continuing education had no impact on average tool use, it does appear that new ergonomics tools may not be learned or acquired in this model of learning. Although using a greater number of tools does not equate to a more effective assessment, it does offer a larger toolkit to tailor the assessment tool to the task/job/scenario. As tools continue to be developed, these findings warrant future planning into how new tools are taught and disseminated to currently practicing ergonomists.

4.1. Strengths and limitations

This study has a number of strengths. The overall response rate for this study was 21.0% which was similar to the response rate reported for Canadian participation of the survey by (Lowe et al., 2019). This survey took five to eight minutes to complete and only four potential respondents declined to participate at the consent screen. The study was conducted with support of two national ergonomist and safety professional organizations which reduced the potential for negatively affecting participation due to anti-spam law opt-in requirements as previously reported in the literature (Lowe et al., 2019). Furthermore, study information was produced in both Canadian official languages and promoted by the ACE and BCRSP leadership to encourage participation. Given the study objectives to investigate MSD risk assessment tool use, ACE and BCRSP members were the most appropriate population to target. The inclusion of both certified and uncertified professional ergonomists was critical to ensure these findings were representative among all practitioners.

There were also some limitations that should be noted when considered the study findings. While great care was taken to include a broad range of relevant MSD risk assessment tool within this investigation, this was not a comprehensive survey of all MSD risk assessment tools. The MSD risk assessment tools investigated were selected based on previous studies of tool use (Dempsey et al., 2005; Lowe et al., 2019) with careful consideration of additional relevant tools through subject matter expert consultation. The survey included all MSD risk assessment tools suggested by (Lowe et al., 2019) for consideration of inclusion in future research. However, the survey did not include an option for participants to write-in other tools they used.

The sample of practicing safety professionals within this study may not be a true representation of the population. As reported by (Lowe et al., 2019) practitioners with fewer years experience have been observed to participate less in similar surveys and thus may have been under-represented in our study sample.

5. Conclusions

While previous research has focused exclusively on certified ergonomics professionals, this study sought to better understand the use of MSD risk assessment tool among a broad population of Canadian professionals. The average number of assessment tools used in practice was higher for ACE respondents compared to BCRSP respondents, yet the ten most frequently used tools were consistent between professional groups. Given the established literature on the diversity of MSD risk factors in workplaces, having a greater number of assessment tools in a professional's toolkit may be helpful in problem solving and accounting for more than just a small subset of risk factors. It is interesting that the two group differ in the number of tools used and future efforts should explore why this difference exists and what it means in terms of assessment quality and efficiency. The manufacturing, healthcare, and transportation sectors had the greatest proportion of respondents who reported using one or more tools, yet again the most frequently used tools were fairly consistent between all sectors of practice. Although School was the greatest single location for learning about tools, more than 50% of the tools used were learned through other experiences, a finding that

reinforces the need to expand opportunities for continued learning and development in MSD risk assessment.

Ethics approval and consent to participate

This article does not contain any individual data. Ethics approval was granted by the University of Waterloo Research Ethics Committee (43002). All participants gave informed consent prior to completion of the survey.

Consent for publication

Not applicable.

Availability of data and material

Data available on request from the corresponding author.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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