


Functional outcome measures for distal radius fractures: A systematic review

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Abstract

Objective: This systematic review aimed to identify and describe the utility of functional outcome measures reported in intervention trials between 2010 and 2020, and to map these measures to the International Classification of Functioning, Disability and Health (ICF) model.

Method: The search was carried out on MEDLINE, CINAHL and Cochrane Register of Clinical Trials. Peer-reviewed intervention studies detailing the functional outcome measures used for any treatment for distal radius fracture were selected. Participant characteristics, outcome measures reported and the trends in their use over time and geographical locations were extracted.

Results: This review analysed 119 studies. Thirty-one functional outcome measures were used across 36 countries. Ninety-two percent of studies measured both the Body Function/Structure and Activity/Participation domains of the ICF. The most frequently used measures were the Disabilities of the Arm, Shoulder and Hand Questionnaire, Range of Motion and Grip Strength. There is a lack of measures on successful return to meaningful occupation.

Conclusion: The outcome measures identified were equally spread across the ICF domains. There is a growing importance of Patient-Reported Outcome Measures to supplement performance-based measures, but a lack of measure on successful return to meaningful occupation.

Keywords

Distal radius fractures, disability evaluation, functional outcome measures, patient-reported outcome measures, systematic review

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Introduction

Distal radius fractures (DRFs) are the most common type of fracture of the upper extremity that affect the person's occupational performance. Radius and/or ulna fractures comprised 44% of the overall emergency department visits due to hand and forearm fractures in the United States (Chung & Spilson, 2001). Amongst the adult population aged from 18 to 65, the incidence is largely attributed to an increase in sport-related activity, with the current leading causes of DRF's being sports and car accidents (Meena et al., 2014).

The goal of treatment (conservative or operative) in DRFs is the restoration and a return to normal daily occupations (Meena et al., 2014). Measuring and comparing

the effectiveness of interventions require the use of functional outcome measures to assess a person's ability to perform activity (Ikpeze et al., 2016). Functional outcome measures can be defined as performance-based or

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patient-reported. Performance-based measures assess a person's physical ability and are not subject to a large degree of individual interpretation, such as Range of Motion (ROM) and Grip Strength (Grip). These are categorised in the Body Function/Structure domain according to the International Classification of Functioning, Disability and Health framework (ICF) model. Patient-Reported Outcome Measures assesses outcomes directly based on the opinion of the patient, such as pain and functional ability, and are commonly assessed using questionnaires such as the Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH) (Kleinlugtenbelt et al., 2016). They can be classified in the Activity/Participation domain of the ICF.

Selecting an appropriate outcome measure is considered good clinical practice as it allows for the comparison of a patient's status between intervention (Sullivan et al., 2013). It also contributes to a more comprehensive assessment and analysis, assists in the development of care-plans, increases efficacy in practice and facilitates communication between the client and clinician (Sullivan et al., 2013).

The standardised use of outcome measures is essential for both researchers and practitioners in assessing the effectiveness of interventions (Herzberg, 2013). Homogeneity enhances the synthesis of evidence and pooling of data from studies for the purpose of meta-analysis and assist in the comparison of interventions and outcomes within studies and between trials across treatment groups not only locally, but across the globe (Kleinlugtenbelt et al., 2016). A consensus may furthermore assist clinicians and researchers in the prediction of objective and subjective outcomes and facilitate the tracking and continuous examination of the quality, performance, and costs of outcome measures (Herzberg, 2013).

This systematic review aims to identify and describe the utility of the functional outcome measures reported in intervention trials between 2010 and 2020 for people aged 19–64 years with a DRF. Furthermore, this research paper will map the outcome measures to the ICF model, and identify their frequency and combined use and their use over time and between countries.

Method

This systematic review is registered on the Open Science Framework (OSF; <https://doi.org/10.17605/OSF.IO/8EKP2>).

Search strategy

Three databases were systematically searched using these search terms and headings: MEDLINE, CINAHL and Cochrane. The search keywords were “distal radius fracture” AND “outcome measure” AND “function” OR “performance” (Refer to Supplemental Appendix I for an example search strategy and Supplemental Appendix II for the final search terms).

Selection criteria

This systematic review included peer-reviewed intervention studies detailing the use of functional outcome measures for DRFs. The search was limited to studies written in English or included an accessible English translation, full-text, and published between January 2010 and January 2020. The mean age of participants within the studies had to be between 19–64 years (male and/or female) who had experienced a DRF. Studies had to report on at least one intervention to treat a DRF, including operative and/or non-operative interventions. They must have reported on at least one functional outcome measure to assess a person's physical ability to perform a task and to determine the intervention(s) effectiveness. Articles were excluded if:

1. they were duplicated,
2. an English publication was not available,
3. there was no full text.
4. the study was not intervention-based, or
5. a medication/supplement was used as the intervention.

Two independent reviewers (BN and KL) were involved in the study selection. The abstracts of each article were screened against the selection criteria. In the case of an abstract which did not provide detailed information, the full text was accessed to assess eligibility. The full text of the articles which met the selection criteria in the initial screening was then accessed to determine final eligibility. Disagreements relating to eligibility were resolved by discussion between the two reviewers to reach a consensus (Figure 1 - Prisma Flowchart).

Data extraction

The same two independent reviewers (BN and KL) were involved in the data extraction. Disagreements were resolved by discussion between the two reviewers to reach a consensus. Data was extracted from the articles using a customised data extraction table (Supplemental Appendix III). The data collected and analysed included background information relating to the article's authors, title, year, and country of publication. The participant characteristics were also gathered, and included the sample size, age range, mean age, gender distribution and the percentage of fractures occurring in the dominant hand. The type and number of functional outcome measures used in each article were also collected and analysed.

Data synthesis

This study included all outcome measures which measured a person's function and/or performance of the hand and wrist. Measures were grouped if there was a standard and a

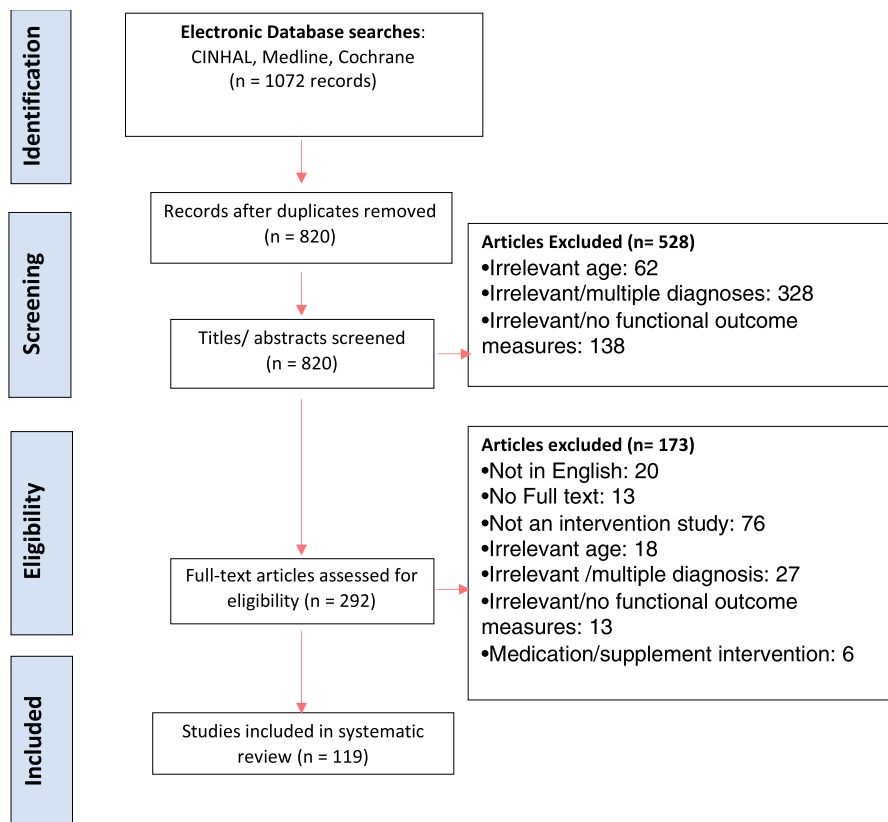


Figure 1. Prisma Flowchart.

modified version, such as the Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH) and Quick-DASH. The frequency of outcome measures used across the study was calculated as a percentage, based on the number of articles using each outcome measure divided by the total number of articles. Given the wide variety of outcome measures identified in the studies, an in-depth analysis of the 15 most commonly used measures was conducted. These 15 measures were analysed and categorised according to the domains of Body Function/Structure and/or Activity/Participation of the International Classification of Functioning, Disability and Health framework (ICF) (World Health Organization, 2001). The percentage of articles which covered either or both ICF domains was calculated. The number of patient-reported measures compared to performance-based measures was also evaluated, as well as the combination of measures within each article. Trends in the use of the six most frequently used outcome measures over time (2010–2020) were established by dividing the number of articles reporting each outcome measure used in a specific year, by the total number of articles reported that year. Finally, the number of articles published in each country was calculated. The top 16 countries were further analysed regarding the use of the six most frequently used outcome measures in each

country. This data was presented as a percentage of the number of articles which used an outcome measure in a specific country, divided by the total number of articles published in that country.

Results

A total of 119 articles were included in this study, with a cumulative total of 9408 participants across all studies (Supplemental Appendix IV). Forty articles had a sample size under 50, 49 between 50 and 99, 19 between 100 and 149, and 11 between 150 and 500. Sixty-eight percent of participants were female, and 32% of participants were male. Three articles had a mean age of participants between 19 and 34 years, 28 between 35 and 49 years, and 87 between 50 and 64 years. One article did not report the mean age. Forty-eight percent of articles reported on the dominance of the injured hand. Of those noted, 48% of participants injured their dominant hand. One participant was reported as ambidextrous.

Grouping of outcome measures

The DASH included the full version and the Quick-DASH and the Spanish and Danish versions. The Patient-Rated

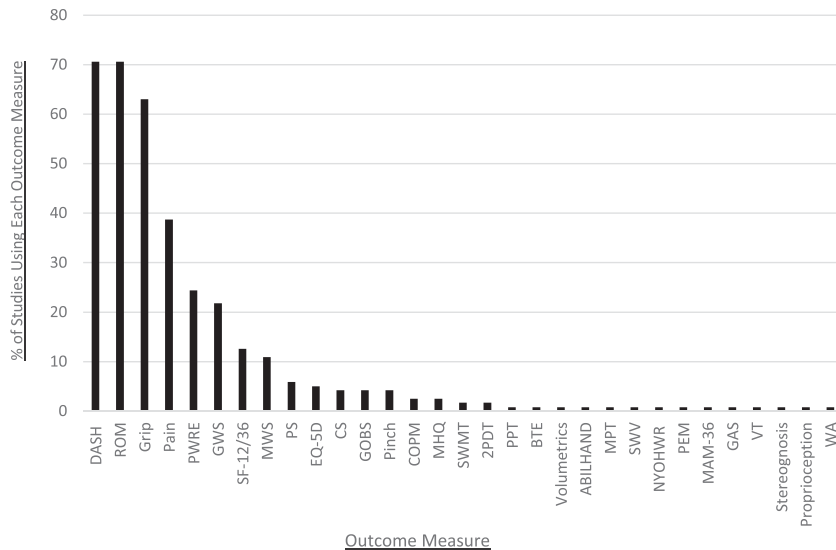


Figure 2. Frequency of the use of different functional outcome measures (in % of studies).

Note. Abbreviations of the above outcome measures in alphabetical order: ABILHAND = ABILHAND Questionnaire, BTE = Baltimore Therapeutic Equipment, COPM = Canadian Occupational Performance Measure, CS = Castaing Score, DASH = Disabilities of the Arm, Shoulder and Hand Questionnaire, EQ-5D = EuroQol- 5 Dimension Questionnaire, GAS = Global Assessment Scale, GOBS = Green and O'Brien Score, Grip = Grip Strength, GWS = Gartland and Werley Score, MAM-36 = Manual Ability Measure-36, MEPS = Mayo Elbow Performance Score, MHQ = Michigan Hand Questionnaire, MPT = Moberg's Pick-up Test, MWS = Mayo Wrist Score, NYOHWR = New York Orthopedic Hospital Wrist Rating, PEM = Patient Evaluation Measure, PPT = Purdue Pegboard Test, PS = Patient Satisfaction, PRWE = Patient-Rated Wrist Evaluation, ROM = Range of Motion, SF-12/36 = Short Form 12 or Short Form 36, SWMT = Semmes-Weinstein Monofilament Test, SWV = Subjective Wrist Value, VT = Vibration Test, WA = Working Ability, 2PDT = 2-point discrimination Test.

Wrist Evaluation (PRWE) included the PRWE and the PRWE (Danish version). The Gartland and Werley Score (GWS) included the original score and Sarmiento's Modified GWS, whilst the Green and Obrien Score and Mayo-Wrist Score both included their original and modified versions.

Range of Motion (ROM) included passive and active ROM measured by a goniometer, Neutral-zero-method, inclinometer, N-K Computerised Evaluation System, and unidentified measures. Grip Strength (Grip) included measurements made by dynamometers, Martin-Vaporimeters, grip meters and unspecified measures. Measures of pain through a visual analogue scale or an unknown source were grouped into one measure of Pain.

The Short Form 12/36 (SF 12/36) included the SF-12 and SF-36. Patient Satisfaction, which measures a patient's level of satisfaction regarding the intervention's effectiveness, included measurements on a visual analogue scale and dichotomous (yes/no) scale.

Frequency use of outcome measures

Thirty-one functional outcome measures were used across 119 studies. The frequency of use ranging between 0.8-70.6% of studies (Figure 2). The DASH, ROM, and Grip were the most commonly used measures and were each used almost twice as much as the other measures. The DASH and

ROM were found in 71% of the studies and Grip was used in 63%. Pain followed in frequency at 39%, followed by the PRWE at 24% and the GWS at 22%.

ICF domains

Of the 15 most commonly used outcome measures, seven measures were categorised in both the Body Function/Structure and Activity/Participation domains of the ICF (Figure 3). Thirteen analysed the ICF Body Function/Structure domain, and nine analysed the Activity/Participation domain of the ICF. The DASH was the most commonly used measure for Activity/Participation; used almost three times as much as the next most frequently used measure, the PRWE.

Patient-reported versus performance-based outcome measures

Of the 15 most commonly used outcome measures, 10 were solely Patient-Reported Outcome Measures (DASH, Pain, PRWE, SF-12/36, Patient Satisfaction, Mayo-Wrist Score, EuroQol- 5 Dimension, Green and O'Brien Score, Canadian Occupational Performance Measure and Michigan Hand Questionnaire). Performance-based outcome measures included ROM, Grip, Pinch and Castaing Score. The GWS incorporated both patient-reported and performance-based areas of measurement.

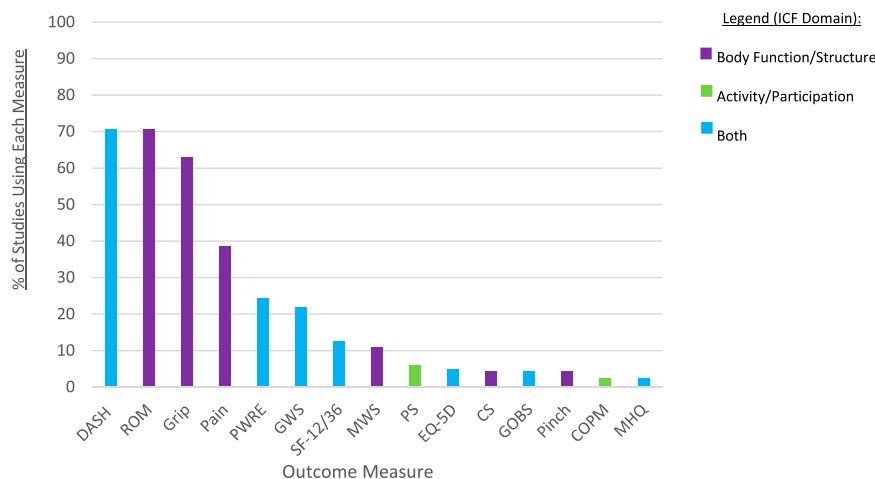


Figure 3. Frequency of the use of outcome measures according to ICF domains (in % of studies).

Note. Abbreviations of outcome measures: COPM = Canadian Occupational Performance Measure, CS = Castaing Score, DASH = Disabilities of the Arm, Shoulder and Hand Questionnaire, EQ-5D = EuroQol- 5 Dimension Questionnaire, GOBS = Green and O'Brien Score, GWS = Gartland and Werley Score, MHQ = Michigan Hand Questionnaire, MWS = Mayo Wrist Score, PS = Patient Satisfaction, PRWE = Patient-Rated Wrist Evaluation, ROM = Range of Motion, SF-12/36 = Short Form 12 or 36, 2PDT = 2-point discrimination Test.

Combined use of outcome measures

Most studies (89%) used more than one outcome measure. Sixteen percent of studies used two outcome measures and 18% of studies used three measures. The most common number of measures used in a study was four (26%), followed by a combination of five measures (20%). Nine percent of studies used six to eight outcome measures. Over half (55%) of all studies used both ROM and Grip, and 52% of studies used the DASH and ROM together. The four most common outcome measures (DASH, ROM, Grip and Pain) were combined in 20% of studies, whilst the DASH, ROM and Grip were simultaneously used in 42% of studies. Ninety-two percent of studies measured both Body Function/Structure and Activity/Participation domains of the ICF.

Use of outcome measures over time

An increase in the use of the DASH was evident from 2012 to 2018 (from 55% to 85%) with a slight decrease to 73% in 2019, despite having dropped from 100% to 55% between 2010 and 2012 (Figure 4a). A similar trend was found in the use of Pain as its use peaked in 2010 (at 80%) but decreased to 18% the following year. However, between 2011 and 2018, its use increased from 18% to 70%, following a sharp decrease in 2019 down to 36%. The PRWE and the GWS showed opposite trends in use over the 10 years. Whilst the PRWE was used in 0% of studies in 2010, it had increased to 55% by 2011. The GWS was used in 33% of studies published in 2010 but dropped to 9% in 2011. Between 2011 to 2014, the use of the PRWE showed a

consistent decline in use (55%–7%), whilst the GWS showed a constant incline in use (9%–57%) over the same period. The PRWE showed an overall increase between 2014 to 2019 (7%–64%), whilst the GWS showed a decrease (57%–9%). ROM and Grip varied in use across the 10 years but showed an overall declining trend. In 2010, they were both used in 89% of studies, followed by a respective drop to 55% and 36% in 2019.

Geographical patterns of use

Thirty-six countries were reported in the studies reviewed. The DASH was the most commonly used measure in the USA (92%), Sweden (87.5%), the Netherlands (83%) and China (80%). It was among the top three measures in 12 of the 16 countries (Figure 4(b)).

The DASH, ROM and Grip were all used throughout each of the top 16 countries (excluding the DASH in Iran), and were the three most commonly used measures in 10 of these countries. ROM and the DASH had a relative homogenous pattern of use across the 16 countries. Grip was used in 100% of studies from four countries (Sweden, Austria, Japan, and Turkey), and ROM was used in 100% of studies in Australia, Austria, and Turkey. Contrary to the high use of ROM, the DASH and Grip in the top 16 countries, Pain, the PRWE and GWS were not reported at all in several countries.

Discussion

This systematic review identified the functional outcome measures and their trends of use in intervention studies



Figure 4. (a) Frequency (%) of studies which used the top six outcome measure over the past 10 years. (b) Frequency in the use of outcome measures in the top 16 countries.

following a DRF. A total of 31 functional outcome measures were recorded across 119 studies. The DASH and ROM were the most frequently used measures. Ninety-two percent of studies measured both the Body Function/Structure and Activity/Participation domains of the ICF, and 91% of studies used more than one outcome measure. There was a positive trend toward an increased use of the DASH and a decreased use of ROM and Grip over the past 10 years. Whilst the DASH and ROM had the highest overall use, the DASH was the most commonly used measure in only

seven out of the top 16 countries, and ROM was the top measure in only three countries. Despite these commonly used outcome measures, there is a clear heterogeneity in general in the use of functional outcome measures across intervention studies.

The DASH, ROM and Grip were the most commonly used outcome measures. The high frequency of the DASH's utility verifies previously established studies with the DASH as the most commonly self-reported outcome measure following a DRF (Cheema et al., 2020). Similarly,

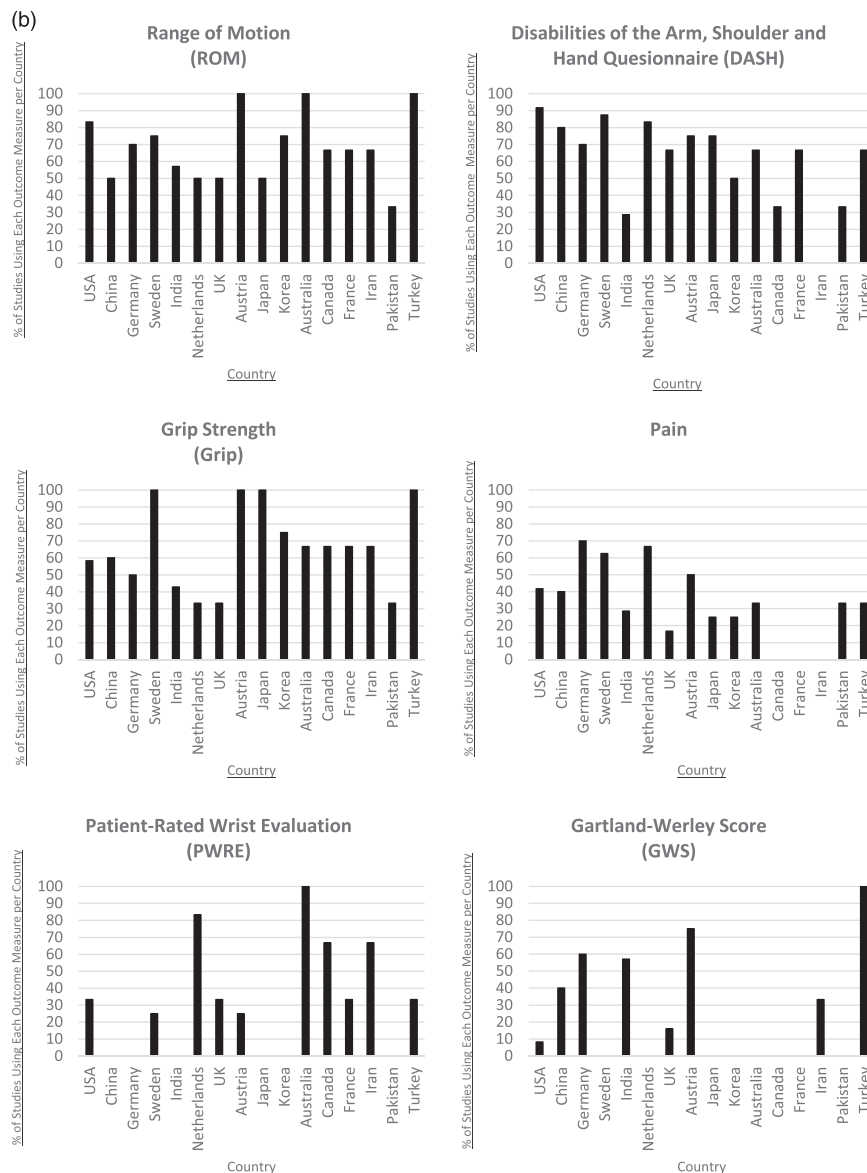


Figure 4. Continued.

Mellstrand-Navarro et al. (2011) supported the high frequency use of ROM and Grip.

The DASH is classified as a Patient-Reported Outcome Measure as it requires a person to provide a self-evaluation of their perceived ability to engage in different activities that involve their injured upper extremity (Ikpeze et al., 2016). It requires the person to assess their injury by answering a 30-question survey on their ability to complete different activities and the severity of their symptoms. This measure involves both ICF domains of Body Function/Structure and Activity/Participation, with seven items categorised as assessing symptom severity, which falls under Body Function/Structure, and 23 items related to the person’s ability to

engage in different activities, falling under Activity/Participation. The DASH is a valid and reliable Patient-Reported Outcome Measure in the assessment of function and disability in people following a DRF (Ikpeze et al., 2016; Kleinlugtenbelt et al., 2016; Ritting & Wolf, 2012). Multiple studies have validated its high responsiveness to change when assessing function following a DRF, with additional research suggesting its correlation with clinical measures of wrist function and deficits in ROM (Tsang et al., 2017).

The PRWE is another Patient-Reported Outcome Measure which assesses wrist pain and function following a DRF. The PRWE is a 15-item questionnaire made up of a

five-question subscale regarding pain (rated from 1 to 10) and a 10-item function subscale divided into a 6-item section for specific activities and a 4-item section for unusual activities (MacDermid et al., 1998). The pain subscale falls under the ICF domain of Body Function/Structure, whilst the specific activity and unusual activity subscales fall under the ICF domain of Activity/Participation (Harris et al., 2005). The PRWE has demonstrated a high ability to detect change over time and has been described as the most responsive score for DRFs, as it was designed for this specific type of injury (Cheema et al., 2020; MacDermid et al., 1998). Multiple studies have also established that the PRWE has high validity and reliability (Kleinlugtenbelt et al., 2016; Ritting & Wolf, 2012).

ROM, measured by a goniometer, is a performance-based outcome measure and a clinical standard for the measurement of hand and wrist ROM following a DRF (Nizamis et al., 2018; Yang et al., 2018). ROM measures only the Body Function/Structure of the ICF domain. Similarly, Grip is a performance-based outcome measure of the Body Function/Structure. It is most commonly measured using a dynamometer (Massy-Westropp et al., 2011). Both ROM and Grip are valid outcome measures to measure hand and wrist function following a DRF (Ikpeze et al., 2016). Research has reported on the correlation between reduced extension and ulnar deviation and grip strength with a poorer DASH score, with researchers additionally reporting on the good predictive value that Grip has for patient satisfaction regarding intervention effectiveness (Goldhahn et al., 2008; Wilcke et al., 2007). Both ROM and Grip measures can be completed in a short time frame with relative ease.

The results of this study have confirmed that ROM and Grip were two of the three most commonly used outcome measures over the past 10 years. Both ROM and Grip were used at their peak in 2010 but have since demonstrated an overall decrease in their use. Contrary to this decrease in performance-based outcome measures used over time is the use of the DASH and PRWE, which have shown (on average) an increasing trend in use most notably since 2012. The reason for these varying trends in the use of different outcome measures over time could be the result of a change in the goals of rehabilitation amongst patients. Recent studies have established that there is an increase in a patient's interest in their ability to engage in and complete daily functional activities (Ikpeze et al., 2016). This increase has resulted in increased attention on the psychosocial effects of injury, and thus the development of Patient-Reported Outcome Measures which measure the engagement of function (Chung & Pusic, 2013; Shauver et al., 2014).

The DASH and the PRWE may also have gained popularity due to the depth in which they cover areas within the ICF domains. Performance-based measures, like ROM and

Grip, are single-item measures and only measure one area of the Body Function/Structure domain of the ICF. In comparison, the DASH and the PRWE, as well as most other Patient-Reported Outcome Measures, cover both the Body Function/Structure and Activity/Participation domains, therefore increasing their coverage of areas affecting hand and wrist performance and participation. For example, Item 1 in the DASH asks the person to rate their ability to "Open a tight or new jar", which falls under the Activity/Participation domain of the ICF. Item 24 of the DASH asks the person to rate their "Arm, shoulder or hand pain", which falls under the Body Function/Structure domain of the ICF. Similar coverage happens in the PRWE.

Whilst there is both a growing interest in the self-reported measurement of engagement in activities following a DRF and a decline in the use of performance-based measures, a significant number of recent studies have continued to use measures such as ROM and Grip. One reason for the sustained popularity in these performance-based measures may come from the suggestion that a number of outcome measures should be used to maximise the domains and subcategories of the ICF (Goldhahn et al., 2008). Whilst this may sound contradictory, given the evidence previously discussed showing that the DASH and the PRWE cover both Body Function/Structure and Activity/Participation domains of the ICF, there are in fact areas within Body Function/Structure which they fail to measure. Most notably, and perhaps unsurprisingly, range of motion and grip strength.

The analysis of the combined use of measures across the studies used in this systematic review corroborates the idea that researchers are combining outcome measures used to maximise the coverage in the ICF domains. The majority (89%) of studies used more than one outcome measure, with a total of 46% of studies using at least four measures. The trend of combining multiple outcome measures suggests that, in the absence of a single outcome measure capable of assessing sufficient ICF domains, researchers are compelled to use a variety of measures to assess the effectiveness of an intervention. From the results of this systematic review, it appears that a combination of ROM, Grip and the DASH may offer the best coverage in the ICF domains.

The use of outcome measures varied widely across different geographic regions. The DASH was the most commonly used outcome measure in USA, China, Germany, Netherlands, UK, France, and Pakistan; and was among the top three measures in 12 out of the 16 countries. However, ROM had the most homogenous geographic pattern of use and was used in at least 50% of the studies published in 15 of the top 16 countries, compared to both the DASH and Grip used in more than 50% of studies published in only 12 countries. A trend in the popularity of an outcome measure and number of countries using the measure was also apparent. All countries included at least one study

which used the ROM and/or Grip as an outcome measure, and all but one country included the DASH. However, there were multiple countries which did not include Pain, the PRWE or GWS as an outcome measure. Whilst an international consensus may assist researchers to compare the outcome of their study, there may be some for why heterogeneity in use of outcome measures exist. Some of the reasons might include: (a) new outcome measures being developed such as more focus on quality of life; (b) some outcome measures may not have been psychometrically evaluated and validated in different languages or cultures; and (c) costs involved in using some instruments for research purposes.

There are several limitations in this systematic review. Studies were limited to those published between 2010 and 2020 to allow for an up-to-date collection of data that could still be compared with one another over time. Furthermore, the selection of studies published in English only had almost certainly led to the omission of studies from certain countries where English was not the primary language of academic publication. The quality of the studies was not rated. Although this systematic review focused on the outcome measures used, the lack of study quality rating might create bias. Additional parameters which may have influenced outcome measure selection were not analysed in detail due to the lack of data provided from studies and the lack of relevance to this study, including the cause of injury, occupation, age, gender, and hand dominance of participants.

Conclusion

This systematic review examined the use of functional outcome measures across intervention studies in the rehabilitation of people with a DRF in the recent 10 years. ROM, Grip, and the DASH were most commonly used. There is a growing importance of Patient-Reported Outcome Measures to supplement performance-based measures. The result of this systematic review recognised the need to combine a number of measures in order to cover important domains of the ICF. We may also see the move to measure the successful return to meaningful occupation in the future.

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Systematic review registration

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Supplemental Material

Supplemental material for this article is available online.

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