Abstract

Introduction:

Handgrip strength (HGS) is commonly measured to assess hand function, however, little is known about how and why occupational therapists assess and interpret HGS. This study aimed to explore the experiences of occupational therapists who work with HGS. Additionally, the study explored what biological and functional factors occupational therapists believe influence adult HGS.

Method:

A qualitative study design utilising purposive sampling identified occupational therapy clinicians within Queensland, Australia who assess HGS. Data were collected from 19 participants using a semi-structured interview process. The interviews were transcribed verbatim and analysed using thematic analysis.

Results:

Variations of the American Society of Hand Therapists HGS testing procedure were used by the participants based on experience. When evaluating HGS, comparison to normative data was not always completed or seen to be valuable. Biological and functional factors such as height, hand length, occupation and lifestyle factors were considered to influence HGS.

Conclusion:

The results of this study provide insight into the various ways occupational therapists assess and evaluate HGS according to experience and practice context. These variations in assessment and evaluation of HGS along with the influence of an individual's biological and functional factors need to be considered when interpreting HGS results.

Introduction

Measurement of handgrip strength (HGS) using a dynamometer is a common assessment tool in many occupational therapy practice settings (Reuter et al., 2011). HGS is a simple, quantifiable measure to aid in the assessment and evaluation of hand function (Günther et al., 2008). HGS may be measured as an initial baseline from which to track rehabilitation progression, as a tool to assess work capacity and to compare to normative data (Innes, 1999; Reuter et al., 2011). The comparison of HGS scores to normative data allows hand function and rehabilitation progress to be quantified. Reference values are significant for HGS as they describe the status of the hand and overall upper limb strength in comparison to the population (Bhat et al., 2021; Bohannon et al., 2006). To allow for an accurate comparison, reliable and valid testing protocols which are consistent with the protocols utilised within the normative data set are required (Reuter et al., 2011; Wang et al., 2018).

The interpretation of HGS normative data can be difficult due to the influence of various biological (age, gender, anthropometric characteristics) and functional (hand dominance, occupation, lifestyle) factors. It has been widely acknowledged that age and gender influence HGS with men found to be stronger than women and younger adults being stronger than older adults (Agnew and Maas, 1982; Dodds et al., 2016; Günther et al., 2008; Massy-Westropp et al., 2011; Mathiowetz et al., 1985; Wang et al., 2018). Previous studies have also discussed the potential influence other biological and functional factors have on HGS including hand dominance (Bohannon et al., 2006; Günther et al., 2008; Wang et al., 2018) different types of occupation (Günther et al., 2008; Josty et al., 1997; Lo et al., 2021; Rostamzadeh et al., 2019; Rostamzadeh et al., 2020; Saremi and Rostamzadeh, 2019) and anthropometric characteristics (Angst et al., 2010; Eidson et al., 2017; Lo et al., 2021; Massy-Westropp et al., 2011; Mohammadian et al., 2015; Rostamzadeh et al., 2019; Rostamzadeh et al., 2020; Saremi and Rostamzadeh, 2019; Shim et al., 2013; Wang et al., 2018). The

correlation between HGS and these additional functional and biological factors has been found to be varied.

HGS assessment has a wide range of applications across the diverse practice contexts where occupational therapists work. Despite having clear guidelines from The American Society of Hand Therapists (ASHT) describing how HGS testing should be performed, little is known about how occupational therapists from a variety of practice settings apply their knowledge and experience to assess and evaluate HGS. A study by Roberts et al. (2011) concluded that the use of various testing protocols can lead to confusion among clinicians regarding best practice. Innes (1999) agreed by suggesting a common approach to HGS testing is important for not only research purposes, but also application in clinical practice. An improved understanding of how occupational therapists conduct HGS testing and interpret the HGS results will assist in understanding how hand function is monitored and evaluated by the profession. The aim of this research was to explore the experiences of occupational therapy clinicians working across a range of practice contexts in Australia who assess adult HGS. The research questions were: What are the experiences of occupational therapists working with HGS normative data? and What are the factors that influence Australian adult HGS?

Methods

Design

An exploratory qualitative design utilising focus groups and semi-structured interviews was chosen for this study which sought to understand the experiences of the participants when assessing and evaluating HGS.

A thematic analysis was utilised to identify and explore the participant's experiences and opinions relating to the research questions (Braun and Clarke, 2013).The analysis of the participants' experiences led to the identification of common themes and sub-themes. Ethical approval (H7200) was granted by the James Cook University Human Research Ethics Committee.

Participants

Participants were recruited using purposive sampling methods. The inclusion criteria were registered occupational therapists; available for face to face interview or telephone interview who assess and evaluate HGS as a standard part of their clinical practice withing Queensland, Australia. The exclusion criteria were any health professionals other than occupational therapists and occupational therapists who do not assess HGS. Health professionals other than occupational therapists who also assess HGS were not included in the study as the research aims were focused on the experiences of occupational therapists. The primary researcher sent information via email about the study to occupational therapists who met the inclusion criteria and they were invited to participate in focus groups or a semi-structured interview based on their availability.

Participants from a wide variety of practice settings who assess HGS were approached to participate in the study to ensure a strong representation of occupational therapists in the study. Rather than utilising individual invites, all occupational therapists working at workplaces which met the inclusion criteria were invited to participate in the study, however not all occupational therapists from each workplace approached were available to attend. Nineteen participants consented to take part in the study.

The setting for the focus groups and one-on-one interviews was determined based on the most convenient location for the participants. Two focus groups were held on the James Cook University campus within the Rehabilitation Sciences building with another two focus groups and one interview facilitated at local occupational therapy practices within the Townsville community. One remaining interview was conducted via phone.

Data collection

Participants were provided with an information sheet detailing the research aims and consent form. Participants took part in a single focus group or semi-structured interview depending upon their availability to participate. A semi-structured interview guide was developed based off a prior systematic review exploring the factors which influence Australian adult HGS. The interview

guide detailed open-ended questions which were utilised to frame the discussion with clinicians and provided the opportunity for participants to explore their views and opinions around the research aims and questions (Braun and Clarke, 2013). Lead questions and prompts were also utilised to ascertain more detail (Liamputtong, 2020). A pilot of the interview guide was carried out prior to the recruitment of participants with an occupational therapists experienced with HGS to refine the development of the interview structure and questions included (Table 1).

Table 1. Sample interview guide for participants

Two individual interviews and four focus groups were conducted for 19 participants over a 6 month period in 2019. The sessions ranged from 60 to 90 min and were all conducted by the first author who has over 17 years of experience working with HGS. The interviews and focus groups were facilitated either over the phone (n=1) or face-to-face (n=5), where suitable. All interviews were audio-recorded, de-identified and then transcribed verbatim. Transcriptions from the interviews were provided to participants for review to ensure accuracy of the data, and no changes were identified. Data saturation was reached when participants were found to provide no new information with the data collected fitting within the emerging themes (Padgett, 2008).

Data analysis

Analysis of the data was conducted by the first author using inductive thematic analysis, as described by (Braun and Clarke, 2013). This form of analysis was adopted to identify and analyse themes identified across the data sample (Braun and Clarke, 2013). Following a familarisation with the data in general, frequently occurring key ideas were identified as initial codes. A more detailed review of the transcripts was then undertaken to search for broad initial themes (Braun and Clarke, 2013). Themes were identified by grouping like ideas and words from the participants' discussions (Liamputtong, 2020). Transcripts were imported into QSR International Nvivo12 software, which is appropriate for qualitative research analysis (Welsh, 2002). Re-examination of these initial themes

by a second researcher, FB, who was independent of the focus groups/interviews and the use of mind-mapping allowed for refinement and identification of key themes.

To ensure the trustworthiness and rigor of this qualitative research the checklist for thematic analysis developed by Braun and Clarke (2013) was reviewed as a guide. This 15-point checklist examines thematic analysis and follows the process through the stages of transcription, coding, analysis and includes an overall review and the development of the written report. Prolonged engagement of the authors lead to emersion in the data to ensure coding all stages of the thematic analysis were inclusive and comprehensive. Additionally, transcripts of each session and audio records were utilised. Member checking was also completed to allow participants the opportunity to comment on the trustworthiness of the information collated (Braun and Clarke, 2013). To address researcher bias and ensure credibility of the findings, reflections and observations were noted by the first author following each interview to ensure accurate representation of the participants' experiences.

Findings

Nineteen occupational therapists participated in the research project (female n=18, male n=1). All participants worked within Queensland however they were trained at various universities in Australia and had worked across Australia and internationally. All participants regularly assessed and evaluated HGS within their role despite working across broad practice contexts. These contexts included specialised hand therapy within both public and private practice (n= 6), occupational rehabilitation (n= 6), inpatient rehabilitation (n=1) and private practice across the community rehabilitation setting (n= 6). Professional experience assessing HGS ranged from less than five years (n=7), five to ten years (n=6), ten to 20 years (n=4) to more than 20 years (n=2) (Table 2).

Table 2. Participant demographic information

Thematic data analysis revealed three overarching themes: The HGS testing protocol; Interpretation and evaluation of HGS scores: the influence of biological and functional factors on HGS.

Theme 1: HGS testing protocol

The ASHT HGS testing protocol outlines that the client is: seated upright with both the hips and knees in 90° flexion with feet flat on the floor; testing arm at side, not touching the body; elbow flexed at 90°, forearm in neutral, wrist slightly extended between 0° and 30° and ulnar deviation between 0° and 15°; With the non-testing arm relaxed at side. Using the dynamometer on the second handle position, 3 alternating trials on each hand are recorded with an average of the 3 trials used to compare with the norms (MacDermid et al., 2015). Participants described various iterations of the ASHT testing protocol. When discussing why they utilised certain testing procedures, participants reported it was how they were instructed at university with P6 stating "that's how I was taught 25 years ago". P4 and P18 stated they know it is the standardised process, or "that's the way that all the clinicians I've ever worked with… we've always done it".

Handle position

One variation to the testing protocol was to change the handle position from the second handle position for comfort or dependent upon the hand size of the client. P18 stated "I guess the average person we would usually have it on the second rung… If they've got quite a large hand then possibly out a bit further and likewise if their small then having it on the um, smaller size". Multiple participants reported if they do change the handle position, they would document this change to the procedure in their clinical notes. Other participants spoke of changing the handle position when using HGS as a test of sincerity within legal contexts.

Trials

Another variation included using the maximum score of the three trials instead of the mean score or only taking one trial of each hand. One participant reported that referrers will request the highest of the three trials. P4 stated “if they’ve done a really bad one, I’ll just ignore that and I’ll just take the maximum”.

Duration

The maximal contraction duration also varied with P18 stating “I would ask the person just squeeze as hard as they can… but squeezing as hard as they can and stopping as opposed to squeezing and continuous squeezing hard”. By contrast, P6 stated “sustained is much better” while P9 agreed, “the longer that you ask them to do something gives you way more insights”.

Clinical expertise

Participants reported that they used clinical reasoning to guide their assessment protocol with P1 stating I “don’t follow the standard protocol, but it’s a fairly anecdotal one. It’s how I feel on the day. You might do three standard measures on each side, or sometimes I don’t. Sometimes I just do one and it depends on that patient. If, when they go to squeeze, it hurts them – you know, you stop”. Another highly experienced clinician P19 reported “in my early years, I always did three on each hand…and take the average” but now “I also do the abbreviated version where it’s just one on each side, and that’s a clinical judgement, whether I do one on each side or three and take the average”.

Theme 2: Interpretation and evaluation of HGS scores

When evaluating HGS, comparison to normative data was not always completed or seen to be valuable while the normative data set used for interpretation of the HGS scores varied. Instead, clinicians reported they would compare affected to unaffected or right to left sides as a more accurate representation of an individual's ability with P8 stating “I wouldn’t even refer to norms. I’d just be comparing them against themselves”.

Practice context

Practice context influenced the use of normative data with P6 stating "In medico-legal world, we definitely need to use normative data". This same participant reported they prefer to use normative data to examine where a client sits in comparison to the normal population particularly if they are documenting the HGS results for reporting purposes and the audience is not clinicians, stating "I like just to have a reference point …this is just numbers to the readers… I think we need to provide a context for what that means". This was supported by P9 who noted "when you do compare it to the norms and document that, I think it's also important to specify further".

Normative data

Mixed responses were received when discussing the normative data sets utilised with many participants stating they did not know the name of the normative data set used within their workplace. Some participants reported using normative data linked to specific Functional Capacity Evaluation assessments whilst P6 stated "The normative data we're using at the moment is Bohannon, which is a meta-analysis". Reasoning behind why participants chose not to use normative data to evaluate HGS included the categorisation of the data sets with P11 stating "there's men and women, and then there's the age… there's not age characteristics". P8 stated "the normative data is really good, but also, there's so many other factors you need to take into consideration".

Theme 3: The influence of biological and functional factors on HGS

Biological factors

Biological factors such as height and hand size were seen by many participants to have an influence on HGS. P6 identified that normative data "doesn't take into account the size of the person". Hand size was identified by 5 individual participants (P10, P11, P12 & P4) as an influencing factor on HGS with P11 stating "I guess people who are really tall generally do have bigger hands

anyway. So, they'll find it easier". In regards to weight, P19 noted "people that are lean seem to be stronger".

Functional factors

Functional factors including a person's employment, their roles outside of work including hobbies and physical fitness and hand dominance were also identified as potential influencers. P4 stated that "lifestyle impacts grip strength… a lot more than age and the norms group it in age".

Several participants identified employment or job role as an influencing factor with P6 stating, "knowing the type of job… that changes your expectations about the norms you're comparing back to". For example "you know they are working on a computer, so their grip strength is adequate for that task". This was supported by P8 who stated "assessment for her grip strength on paper actually looks very good for a female, but her job which is very physical …it wasn't sufficient".

The discussions around hand dominance and its influence on HGS were varied. Some participants reported they often see clients with stronger HGS in their non-dominant hand and suggested this may correlate to the person's employment if they performed manual work and had to use their hands bilaterally along with the impact of the individual's lifestyle. Another suggestion was that the type of work tasks they perform may influence which hand is stronger. P11 stated "if you're going to do a task and it has a gross and more intrinsic part to it, you'll use your dominant hand for the intrinsic part, and your non-dominant one… holds things and requires strength".

Discussion

This study explored the experiences of occupational therapists within Queensland, Australia who assess adult HGS. The specific research questions of What are the experiences of occupational therapists working with HGS normative data? and What are the factors that influence Australian adult HGS? were explored with a number of themes identified. Identified themes included the HGS

testing protocol utilised, the interpretation and evaluation of HGS scores and the influence of biological and functional factors on HGS.

Theme 1: HGS testing protocol

When assessing and evaluating HGS the testing protocol utilised was a significant point of variance. This inconsistency in testing protocol may impact reliability. Reasons for variance in the testing protocol included the clinician's training and their clinical experience. Clinicians with more years of practice used their professional experience and prior interactions with HGS to inform the adopted testing protocol based on a case-by-case scenario. In contrast, less experienced clinicians were more likely to adopt and adhere to the testing protocol they were trained to use as a routine procedure with no variations.

The variations from the standardised testing protocol included only taking one measurement on each hand, recording the score of a sustained squeeze technique and only recording the maximal contraction of the 3 trials completed. These variations in testing procedure are likely to influence the overall HGS score of an individual. The variations also influence the evaluation and interpretation of HGS results regardless of whether the clinicians is comparing to normative data.

Theme 2: Interpretation and evaluation of HGS scores

The interpretation and evaluation of the HGS scores elicited mixed responses. Participant's experiences included comparison to normative data sets, comparison to unaffected upper limbs and comparison to previous scores for the same individual to track progress. It has been noted that "the identification of grip-strength impairments requires normative reference values to which an individual's grip-strength measurements can be compared" (Wang et al., 2018: 685). Whereas Reikeras (1983) suggested that the uninjured hand serves as a control. Regardless of the type of

comparison, for the comparison to be accurate the testing protocol utilised must be consistent each time. Any variations to the testing protocol need to be identified and documented to allow for consistency in the testing procedure. If HGS was not obtained using the same standarised testing protocol as the normative data set identified for comparison, the interpretation of the HGS scores would be impacted. This is supported by (Innes, 1999: 122) who stated "to compare results with normative data, then the same position used to develop the norms is required".

Practice context also influenced the interpretation and evaluation of HGS scores by clinicians. Clinicians in practice settings including occupational rehabilitation or community settings require external parties to understand an individual's HGS scores. Consequently, these clinicians tended to rely on the use of normative data to situate scores and allow for comparison to the general population. This was less common in hospital and private hand therapy practice settings where evaluation of HGS was more commonly done through comparison to previous HGS scores and injured versus uninjured limbs. HGS scores within these practice settings are likely to be reviewed by other health professionals who are more familiar with these types of assessments. This may explain the variance in evaluation of HGS scores across practice settings. These insights also built on the concept that the evaluation of HGS is more than a comparison to normative data and requires context and clinical reasoning to interpret and evaluate the results.

Theme 3: The influence of biological and functional factors on HGS

It is widely accepted that the biological factors of age and gender directly influence HGS. Whilst these influencing factors are well established, conjecture remains as to the influence of other biological factors such as height, weight, body shape and size along with functional factors including hand dominance, occupation, and lifestyle factors. This linked with one of the study's key aims to examine the participants' beliefs regarding variables previously identified through a systematic review as potential influences on HGS.

When discussing potential influencing factors on HGS a wide range of biological and functional factors were reported. Clinical experience allowed participants to speak regarding assumptions related to biological factors such as a person's build or body type. Hand size, followed by height being the anthropometric characteristics they believed most closely correlated to HGS. The correlation between anthropometric characteristics and HGS has been examined in numerous studies. Height has been found to have the strongest correlation to HGS (Angst et al., 2010; Mohammadian et al., 2015; Moy et al., 2015; Spruit et al., 2013; Wang et al., 2018). Hand length has been identified as a prime criterion to estimate height (Agnihotri et al., 2008). Therefore, the larger their hand size, the taller someone is predicted to be. The standardised HGS testing protocol has the handle position set at number 2 with no variation allowed based on personal preference or hand size. Consequently, hand length may provide a mechanical advantage when squeezing the dynamometer. This was supported by Saremi and Rostamzadeh (2019) who stated individuals with larger hands were more likely to have stronger HGS due to their increased muscle mass. There were mixed findings regarding the correlation between HGS and weight or Body Mass Index (BMI). It is known that BMI correlates strongly with weight but is independent of height (Sperrin et al., 2016). Therefore, height and hand size are both likely independent of BMI and this may explain why BMI is not a consistent predictor of HGS.

Currently, HGS normative data is only categorised using age and gender with no allowances for hand dominance. Currently there is debate as to whether hand dominance has a reliable correlation to HGS. Previous studies have suggested a 10% rule stating the dominant hand is 10% stronger (Petersen et al., 1989), however this does not seem to apply for left dominant individuals (Bohannon, 2003). A study by De Andrade Fernandes et al. (2014) found not only was right HGS stronger than left, dominant HGS was stronger than non-dominant. Rostamzadeh et al. (2020) also identified hand dominance as having a significant influence on HGS suggesting that as the dominant hand is used more frequently and with increased force which may increase HGS of the dominant hand. The study by Wang et al. (2018) identified HGS values were not statistically different by hand

dominance. The findings from the later study aligned with the beliefs of the participants in this study who reported that an individual's dominant hand was not always their stronger hand. Instead, participants suggested that an individual's employment or activities performed within their lifestyle were more likely associated with HGS than hand dominance. An understanding of the impact of hand dominance may improve a clinician's interpretation and evaluation of HGS results in comparison to not only normative data sets, but also when comparing affected versus unaffected limbs.

Functional factors such as employment and activities including sports and hobbies all influence HGS. Participants discussed how knowing an individual's employment influenced their expectations regarding HGS. Employees who performed work with high physical demands were anticipated to achieve higher HGS scores. This was confirmed in the studies by Lo at al. (2020) and Rostamzadeh et al. (2020b) who found HGS of manual workers was significantly stronger than non-manual workers or healthcare workers. The findings by Moy et al. (2015) identified men who performed heavy manual had higher HGS, but this trend did not apply to women. In contrast, the study by Mohammadian et al. (2015) found no significant difference between physical demand levels and HGS for both genders.

Some studies examined not only the influence of employment but also lifestyle factors and sports in relation to HGS. Günther et al. (2008) identified no significant variation in HGS for working men or women based on their employment and instead hypothesized that lifestyle factors and personal fitness may be more closely related to HGS. Participants from this study identified the influence of physical fitness and leisure pursuits on HGS not just the tasks they perform at work. Hobbies, sports or unpaid work which requires increased physical demands may lead to stronger HGS despite performing sedentary tasks when employed. The physical demands required within various forms of employment also vary from country to country based on cultural differences. Therefore, caution must be taken when examining the correlation between employment and HGS

(Rostamzadeh et al., 2020a). An understanding of the impact of an individual's employment and lifestyle factors may improve a clinician's interpretation and evaluation of HGS results.

Implications for practice

Consideration must be given as to the uniformity of the testing protocol utilised when testing, interpreting and evaluating HGS. The use of a consistent testing protocol as guided by clinical reasoning and practice experience is required for all HGS tests regardless of the intention to compare to normative data. This consistency in testing protocol can only be achieved if the AHTA standardised protocol is adopted for any trials which are intended to be compared to normative data. If a modified testing protocol is utilised, it must be documented so it can be replicated for future assessment to ensure consistency. This will allow for a reliable comparison of an individual's score with themselves or their unaffected limb.

Normative data sets are required to provide an informed evaluation of HGS test findings to various professional audiences. The wide scope of occupational therapy practice contexts means having a standard reference point for comparison is valuable. Basic evaluation strategies such as comparing affected to unaffected sides or tracking the progression of trials over time may be applicable in certain practice contexts.

The inclusion of other functional and biological factors including height, hand length, occupation and lifestyle factors when assessing an individual will improve the clinician's ability to interpret and evaluate HGS results and consider the use of these scores to quantify hand function, track progression and assess for work capacity.

Limitations and future research

While this study offers insight into the ways in which occupational therapists assess and evaluate HGS, some limitations were evident. This study focused on clinicians working in Queensland, Australia and despite some clinician's providing services to regional areas of

Queensland, all participants were based in Townsville, Queensland. Therefore, the experiences of occupational therapists working in other practice contexts may not have been captured. The conclusions drawn from this study are applicable to the specific context of the study.

Future research with occupational therapists and other health professionals working throughout Australia using a tailored online survey is underway to identify commonalities and variances in assessment and evaluation of HGS and clinician's perceptions on what functional and biological factors influence HGS. This larger study will allow for improved transferability of the findings to the broader profession.

Conclusion

This study provided insight into the various ways occupational therapists assess and evaluate HGS according to clinical experience and their practice context. How these variations are likely to influence the interpretation and evaluation of HGS results was also provided.

These variations in assessment and evaluation of HGS and the influence of biological and functional factors should be considered when interpreting HGS results to best evaluate an individual's hand function.

Key findings

- Occupational therapists use clinical reasoning and practice context to guide the HGS testing protocol
- Assessment and interpretation of HGS is impacted by clinical experience and biological and functional factors

What the study has added

Occupational therapists from a range of practice settings use clinical reasoning and practice context as opposed to explicit instructions or a consistent protocol to guide HGS testing and interpretation of results.

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Declaration of conflicting interest

The authors confirm that there is no conflict of interest.

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Table 1. Sample interview guide for participants

Questions for participants	
1.	For what reasons do you assess clients grip strength?
2.	What testing procedure do you utilise? *Possible prompts:* • Handle position? • Testing position (sitting/standing/arm position) • How many trials? • Rest breaks? Alternating sides right to left? • Scoring (average or maximal)? • - Do you provide prompting/motivation/encouragement?
3.	Why do you choose this position? *Possible prompts:* • Do you always use the same position?
4.	How do you evaluate the client's results? *Possible prompts:* • Do you compare the client's results to normative data sets? • What normative data sets do you utilise to evaluate HGS? • Why do you choose to utilise that specific normative data set? • Do you think these data sets are adequate for your needs?
6.	What are the advantages/disadvantages to using your chosen data sets?
7.	How do the results of the HGS testing guide your practice/intervention? *Possible prompts:* • How do you interpret the results?
8.	What factors do you believe influence HGS? *Possible prompts:* • Do you believe hand dominance influences HGS? • Do you believe the person's job influences their HGS? • Do you believe psychosocial factors influence assessment of HGS?
9.	Is there anything else that we haven't discussed in this session that you would like to add about this topic?