The effect of handedness on grip strength in older adults with intellectual disabilities

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Abstract

Grip strength is an important predictor of several health outcomes in the general older population. Grip strength assessment is feasible and reliable in older adults with intellectual disabilities (ID), which makes it a valuable measurement for application in this population. The purpose of this study was to investigate the effect of handedness on grip strength in the older population with ID. Handedness and grip strength were assessed in a sample of 1050 older adults (≥ 50 years) with borderline to profound ID. Results showed that 26.2% of the study sample was left-handed. In right-handed participants the dominant hand (right) was on average 8.7% stronger than the non-dominant hand ($p < 0.001$). For left-handed participants there was no significant difference between the dominant hand (left) and non-dominant hand. However, more detailed analyses revealed that 34.5 % of the participants were stronger with their non-dominant hand, (on average 16.6% stronger for right-handed and 16.3% stronger for left-handed participants). Because of the large strength ratios, distributed in favor of both the dominant as the non-dominant hand, it is recommended to assess both hands to get a valid result of grip strength in older adults with ID.

Keywords: Handedness, grip strength, intellectual disabilities, older adults

1. Introduction

Grip strength is not only a measurement of hand functioning, but also characterizes overall upper extremity muscle strength (Bohannon, 1998) and correlates with lower extremity strength and power (Cruz-Jentoft et al., 2010; Lauretani et al., 2003). It is an important marker in the assessment of sarcopenia (Cruz-Jentoft et al., 2010), nutritional status (Norman, Stobaus, Gonzalez, Schulzke, & Pirlich, 2011), frailty (Syddall, Cooper, Martin, Briggs, & Aihie Sayer, 2003), and muscular strength as a component of physical fitness (Bouchard & Shephard, 1994; Dwyer & Davis, 2005). Grip strength is a predictor of premature mortality, earlier onset of disability, postoperative complications, increased length of hospital stay (Bohannon, 2008), fractures, and cognitive decline in older adults (Alfaro-Acha et al., 2006; Cooper et al., 2011).

Because of the simple, inexpensive, non-invasive, and quick measurement of grip strength by the use of a hand dynamometer, it is increasingly being used in clinical settings, such as in geriatric practice (Cruz-Jentoft et al., 2010). Measuring grip strength with a hand dynamometer was found to be feasible and reliable in older adults with intellectual disabilities (ID) (Hilgenkamp, van Wijck, & Evenhuis, 2012a). Therefore, it might be valuable to introduce this measurement into this population as a marker for sarcopenia, nutritional status, frailty, and physical fitness.

In assessing grip strength it is important to consider possible differences between the strength of the dominant and the non-dominant hand. By dividing the strength of the dominant hand by the strength of the non-dominant hand, the resulting strength ratio describes the differences between both hands. The ‘10% rule’ states that the dominant hand is generally 10% stronger than the non-dominant hand (Bechtol, 1954; Petersen, Petrick, Connor, & Conklin, 1989). Clerke & Clerke (2001) reviewed the literature regarding handedness (which hand is the dominant hand) and grip strength. They found a wide individual variation in reported strength ratios of 0% to 40%. Also, strength ratios were often larger for right-handed individuals than for left-handed individuals (Clerke & Clerke, 2001; Incel, Ceceli, Durukan, Erdem, & Yorgancioglu, 2002). Thus, the ‘10% rule’ does not seem to hold as a general guideline (Clerke & Clerke, 2001). Bohannon (2003) reported that right-handed individuals were stronger on the dominant side, but for left-handed individuals results were equivocal (Bohannon, 2003). These results suggest that it is important to consider handedness in the assessment of grip strength.

ID has been linked to atypical distribution of right- and left-handedness in comparison to the general population (Carlier et al., 2006; Leconte & Fagard, 2006; Pipe, 1988). Handedness was less skewed to the right in children (Carlier et al., 2006; Grouios, Sakadami, Poderi, & Alevriadou, 1999; Leconte & Fagard, 2006; Pipe, 1988) and adults with ID (Di Nuovo & Buono, 1997; Lewin, Kohen, & Mathew, 1993; Lucas, Rosenstein, & Bigler, 1989). Furthermore, the incidences of left- and mixed-handedness are about twice those reported for samples with normal intellectual capabilities (Pipe, 1988). The frequency of right-handedness decreased with the severity of ID (Carlier et al., 2011; Lucas et al., 1989). No studies concerning the effect of handedness on grip strength measurements in adults with ID have been performed, to the knowledge of the authors.

In clinical practice, it is not standard to consider the strength of both hands to be different. The American Medical Association (AMA) states in its *Guides to the Evaluation of Permanent Impairment*

that “little evidence exists that there is a significant difference in grip strength between the dominant and non-dominant hand” (American Medical Association, 1993). If one of both hands is affected, the AMA recommends comparison of grip strength scores of the affected hand with the uninjured hand, thereby assuming both hands could be equally strong (American Medical Association, 1993). This is also recommended by The American Society of Hand Therapists (ASHT) (American Society of Hand Therapists, 1992).

Before introducing grip strength measurement into routine diagnostic work-up of older adults with ID, more information is required about the effect of handedness on grip strength in this population to give recommendations about the best way to measure grip strength and interpret the results. Questions to be answered were whether it is sufficient to measure a single hand, whether the dominant hand needs to be determined, or if it is necessary to always measure both hands. Because of the association of left-handedness with more severe ID (Carlier et al., 2011; Lucas et al., 1989) it is important to take different levels of ID into account. Therefore, the aims of this study were to investigate (a) the distribution of handedness, (b) the grip strength ratios between the dominant and non-dominant hand, (c) the distribution of the strongest hand with regard to handedness, and (d) the relation between handedness and the severity of ID.

2. Methods

2.1 Study design and participants

This study was part of the large Dutch cross-sectional study 'Healthy ageing and intellectual disabilities' (HA-ID), executed by a consort consisting of three ID care provider services in the mid, west and south of the Netherlands in collaboration with two university departments (Intellectual Disability Medicine, Erasmus Medical Center at Rotterdam; Center for Human Movement Sciences, University Medical Center at Groningen). All 2150 clients with ID, aged 50 years and over, of the three care provider services were invited to participate, resulting in a near-representative sample of 1050 clients. Details about design, recruitment, and representativeness of the sample have been presented elsewhere (Hilgenkamp et al., 2011). Data collection took place between February 2009 and July 2010.

Ethical approval was provided by the Medical Ethical Committee of the Erasmus Medical Center (MEC 2008-234) and by the ethical committees of the participating ID care provider services. Informed consent was obtained from all participants; however, unusual resistance was a reason for aborting measurements at all times. This study followed the guidelines of the Declaration of Helsinki (Helsinki, 2008).

2.2 Procedure

Data were collected as part of an extensive physical fitness assessment, which was conducted on locations familiar or close to participants: a large room within their home, a familiar daycare center, or a gym. Assessments were guided by test instructors, who all were physiotherapists, occupational therapists, or physical activity instructors with experience with individuals with ID. They all received an instruction manual and followed two days of training for the execution of all assessments.

Standardized encouragement provided by test instructions for testing individuals with normal intellectual capabilities is unsuitable for individuals with ID. To keep this motivational aspect as equal as possible, we prescribed 'maximal motivation' to the test instructors for all tests. In some cases, this meant that participants were motivated to engage in the assessments by constant verbal encouragement and verbal rewarding, in other cases the test instructor had to remain very calm and quiet to motivate the participant as much as possible and to prevent stress or anxiety. The specific background, knowledge, and experience of the test instructors were important conditions to ensure the most suitable 'maximal motivation' for every participant, while regarding safety as well.

2.3 Measurements

2.3.1 General information

To describe the study population in detail, the following information was collected.

Gender, age, and residential status (central setting providing intensive care and support, community-based setting, independent living with ambulatory support, or with relatives) were collected from the administration systems of the ID care provider services.

The presence of Down syndrome and spasticity of the arms was collected through the medical files. Professional caregivers provided information about mobility impairments (independent, walking

with an aid, or wheelchair-bound). Daily functioning was assessed with the Barthel Index (Mahoney & Barthel, 1965) for basic activities of daily living (BADL), scores ranging from 0 (completely dependent) to 20 (completely independent) and the Lawton IADL Scale (Lawton & Brody, 1969) for Instrumental activities of daily living (IADL), scores ranging from 8 (completely dependent) to 24 (completely independent). The questionnaires were completed by professional caregivers of the participants.

Level of ID was categorized by psychologists or behavioral therapists as: borderline (IQ = 70 – 84), mild (IQ = 50 – 69), moderate (IQ = 35 – 49), severe (IQ = 20 – 34) or, profound (IQ < 20) based on International Classification of Diseases (ICD-10) criteria (World Health Organization, 1996).

2.3.2 Handedness

Handedness is defined as the relative preference for one hand in the execution of unimanual tasks (Annett, 1970; M. Peters, 1998). It was determined by asking the participant, who was sitting down, to pick up a block (2.5 cm^3) which was put on the table in front of him or her. This was part of the Box and Block test, assessed in the extensive physical fitness assessment of the HA-ID study (Hilgenkamp et al., 2011).

2.3.3 Grip strength

Grip strength (Mathiowetz et al., 1985) was measured with the Jamar Hand Dynamometer (#5030J1, Sammons Preston Rolyan, USA). Reliability and validity in the general population was good (Abizanda et al., 2012; Stark, Walker, Phillips, Fejer, & Beck, 2011). Test-retest reliability in older adults with ID was good (ICC 0.94 [same day interval] and 0.90 [two-week interval]) (Hilgenkamp et al., 2012a). In a previous report from the HA-ID study, selective loss to participation was reported. Older adults with severe or profound ID, Down syndrome or wheelchair users were underrepresented (Hilgenkamp, van Wijck, & Evenhuis, 2012b).

The handle of the dynamometer was put in the second smallest position according to the instruments' instructions. The middle phalanges had to rest on the handle, if not, the position was adjusted. An example of the test was provided by squeezing a rubber ball by the test instructor. Subsequently, the participant was allowed to squeeze the ball, to assure understanding of the task. The participant squeezed the dynamometer to his or her maximum ability in seated position, according to the recommendations of the ASHT (Fess & Moran, 1981). The best result of three attempts for both the left and right hand (with a one-minute pause between attempts) was recorded, in kilogram (kg). The test instructor had to be convinced that the participant squeezed with maximal effort; otherwise the result was not recorded. In order to check this, test instructors looked at facial expressions, contracting muscles of the arm and hand, turning white of the phalanges, and the consistency of the three attempts.

2.4 Statistical analysis

Characteristics of the study sample, completion rates of the tests, and distribution of handedness were described first.

Consequently, differences in strength between the dominant and non-dominant hand were analyzed with paired *t* tests for the total study sample and subgroups according to level of ID. Because eight *t* tests were performed, Bonferroni correction was used to correct for the inflated familywise error rate. *P*-values smaller than 0.00625 (0.05/8) were considered statistically significant.

Grip strength ratios were expressed as a percentage difference between the dominant and non-dominant hand. Individual grip strength ratios were calculated following the formula ((*strength dominant hand* / *strength non-dominant hand*) - 1) x 100%). Subsequently, the mean grip strength ratios were calculated for the total study sample and the subgroups according to level of ID.

To tell which of both hands was the strongest hand, a categorical variable was made from the grip strength scores, with the categories right, left, and equal strength for both hands. A grip strength difference of 1 kg was used to divide the scores in these categories. Pearson's chi-square test was used to analyze the relationship between handedness and the strongest hand. *P*-values smaller than 5% ($p < 0.05$) were considered statistically significant.

Furthermore, mean grip strength ratios were then calculated for the group of participants with the dominant hand as the strongest hand and for the group of participants with the non-dominant hand as the strongest hand, for right- and left-handed participants separately. Again this was done for the total study group and the subgroups according to level of ID.

All analyses were performed with the Statistical Package for Social Sciences (SPSS) version 17.0 (IBM Corporation, New York).

3. Results

3.1 Participants

Of the 1050 clients that participated in the HA-ID study, 652 (62.1%) had successful measurements of handedness and grip strength for both hands. Reasons for drop-out were mainly attributable to limited understanding (13.6%), physical disability (3.1%), and non-cooperation (2.9%).

The groups of participants with borderline ($n = 30$) and profound ($n = 3$) ID were relatively small. Because the borderline and mild ID group did not differ significantly on grip strength scores and gender, and neither did the severe and profound ID group (data not presented), these groups were combined in the analysis.

Characteristics of the study sample are shown in Table 1.

Table 1. Participant characteristics of the study sample.

Characteristics		***n* (%)**
Total		652
Age	Years (*m* ± *sd*)	61.7 ± 8.0
Gender	Female	324 (49.7)
	Male	328 (50.3)
Type of setting	Central setting	254 (39.0)
	Community-based	345 (52.9)
	Ambulatory support	41 (6.3)

	With relatives	5 (0.8)
Level of ID	Borderline	30 (4.6)
	Mild	184 (28.2)
	Moderate	353 (54.1)
	Severe	63 (9.7)
	Profound	3 (0.5)
	Unknown	19 (2.9)
Down syndrome	Yes	69 (10.6)
	No	440 (67.5)
	Unknown	143 (21.9)
Spasticity	Right hand	25 (3.8)
	Left hand	23 (3.5)
	Unknown	126 (19.3)
Mobility	Independent	493 (75.6)
	Walking aid	103 (15.8)
	Wheelchair	26 (4.0)
	Unknown	30 (4.6)
ADL	BADL (*m* ± *sd*)	16.0 ± 4.1
	IADL (*m* ± *sd*)	13.3 ± 4.9

m = mean; *sd* = standard deviation; *n* = number of participants;
ID = intellectual disability; ADL = activities of daily living;
BADL = basic activities of daily living (0 – 20);
IADL = instrumental activities of daily living (8 – 24).

3.2 Handedness and grip strength

The study sample consisted of a large number of left-handed participants (*n* = 171, 26.2%) (Table 2). A trend towards an increase in left-handedness with the severity of the ID was found.

Table 2 shows the mean grip strength scores and strength ratios for right-handed and left-handed participants, respectively. For right-handed participants the right hand was significantly stronger than the left hand, on average 8.7%. In the subgroup analysis for level of ID this significant difference was only present in the moderate ID group. The strength ratio was highest in the severe to profound ID group. For left-handed participants there was no significant difference in strength between the dominant and non-dominant hand, but the strength ratios were large.

Table 2. Handedness, mean grip strength and strength ratios for the total study sample and ID level subgroups.

	Total	**Borderline-mild ID**	**Moderate ID**	**Severe-profound ID**
Right-handed *n* (%)	**481 (73.8)**	**167 (78.0)**	**255 (72.2)**	**44 (66.7)**
Mean strength right hand (kg)	24.2 ± 10.1	28.1 ± 10.9	22.7 ± 8.9	19.0 ± 9.1

(*m* ± *sd*)				
Mean strength left hand (kg) (*m* ± *sd*)	23.2 ± 10.0	27.3 ± 10.6	21.6 ± 8.8	17.5 ± 8.2
t-value	4.53**	1.95	3.67**	2.47
Strength ratio (% difference)	8.7	4.8	10.7	11.9
Left-handed *n* (%)	**171 (26.2)**	**47 (22.0)**	**98 (27.8)**	**22 (33.3)**
Mean strength left hand (kg) (*m* ± *sd*)	22.2 ± 9.5	25.5 ± 10.0	21.3 ± 8.7	18.4 ± 8.5
Mean strength right hand (kg) (*m* ± *sd*)	21.6 ± 10.6	24.8 ± 11.5	20.1 ± 9.7	20.5 ± 10.8
t-value	1.55	1.06	2.06	- 1.79
Strength ratio (% difference)	27.2	25.6	35.4	- 5.9

m = mean; *sd* = standard deviation; *n* = number of participants; ID = intellectual disability.

** $p < 0.001$

3.3 Distribution of the strongest hand

However, when analyzing which hand (dominant or non-dominant) was actually the strongest hand, the dominant hand proved to be the strongest only in 54.7% of the right-handed participants and in 46.2% of the left-handed participants ($p = 0.001$) (Table 3). For 13% of the participants, both hands were equally strong. This means that in 34.5% of the participants ((65 + 160) / 652) the non-dominant hand was the strongest hand.

Table 3. Distribution of handedness and the strongest hand for the total study sample (*n* = 652).

			Strongest hand		
		***n* (%)**	**Right**	**Left**	**Equal**	**Total**
Handedness	**Right**	263 (54.7)	160 (33.3)	58 (12.1)	481 (100)
	Left	65 (38.0)	79 (46.2)	27 (15.8)	171 (100)
	Total	328 (50.3)	239 (36.7)	85 (13.0)	652 (100)

n = number of participants

The strength ratios for the selection of participants with the dominant hand and participants with de non-dominant hand as the strongest hand, for right- and left-handed participants are presented in Table 4.

For right-handed participants with their right hand as the strongest hand, the strength ratio was on average 26%. The highest strength ratio was found in the severe to profound ID group. For the right-handed participants with their left hand as the strongest hand, the strength ratio was on average – 16.6 %. Again the highest strength ratio was found in the severe to profound ID group.

For left-handed participants with their left hand as the strongest hand, the strength ratio was on average 72.1%. The highest strength ratio was found in the moderate ID group. For the left-handed

participants with their right hand as the strongest hand, the strength ratio was on average - 16.3 %, the highest strength ratio was found in the severe to profound ID group.

Table 4. Strength ratios of subgroups of right- and left-handed participants.

	Total	**Borderline-mild ID**	**Moderate ID**	**Severe-profound ID**
Right-handed				
Strength ratio – selection right hand strongest	26.0	18.3	29.8	32.1
Strength ratio – selection left hand strongest	- 16.6	- 16.8	- 16.1	- 17.5
Left-handed				
Strength ratio – selection left hand strongest	72.1	72.3	80.3	16.7
Strength ratio – selection right hand strongest	- 16.3	- 11.7	- 17.2	- 22.5

ID = intellectual disability.

4. Discussion

This first study into the effect of handedness on grip strength in older adults with ID shows that 26.2% was left-handed. When looking at handedness alone, the dominant hand (right hand) of right-handed participants was on average 8.7% stronger ($p < 0.001$). For the left-handed participants there was no significant difference between both hands. However, more detailed analyses revealed a large percentage of participants (34.5%) in which the non-dominant hand was the strongest hand, the non-dominant hand proved to be on average 16.6% stronger for right-handed and 16.3% stronger for left-handed participants. This influenced the strength ratios calculated for the dominant versus non-dominant hand. Therefore, we recommended that both hands are tested in grip strength measurements in this population.

The high percentage of left-handedness found in this study is in agreement with previous research showing high percentages of left-handedness in the population with ID, ranging from 17.3% up to 32.0% as compared to 9.3 % to 16.7% of the nondisabled controls (Carlier et al., 2011; Carlier et al., 2006; Groen, Yasin, Laws, Barry, & Bishop, 2008; Grouios et al., 1999; Lewin et al., 1993; Lucas et al., 1989; Van Strien et al., 2005). The cause of this increased prevalence of left-handedness is not well understood. Carlier et al. (2011) suggested that the atypical laterality could be related to the general cognitive level; they found a trend for increased left- and mixed-handedness with lower IQ scores (Carlier et al., 2011), as did Lucas et al. (1989). In this study, left-handedness also increased from 22.0% in the group with borderline or mild ID up to 33.3% in the group with severe or profound ID. Another explanation may be that atypical laterality is associated with language, which is often compromised in individuals with ID (Groen et al., 2008; Lucas et al., 1989).

Research in the general population has shown that the dominant hand was more often the strongest hand (Clerke & Clerke, 2001; Incel et al., 2002), with grip strength ratios ranging from 0% to 11% (Crosby, Wehbe, & Mawr, 1994; Incel et al., 2002; M. J. Peters et al., 2011; Petersen et al., 1989; Werle et al., 2009). The results for right-handed participants in this study are in line with these findings; the right hand was significantly stronger than the left hand with a strength ratio of 8.7%. However, for left-handed participants this was not the case. This result is in line with the finding of Bohannon (2003) who reported that right-handed individuals are stronger with their right hand, but for left-handed participants results were equivocal. These results would suggest that it is sufficient to measure only one hand, the dominant hand in right-handed participants, and either hand for left-handed participants.

However, in this study 34.5% of the participants had higher grip strength in their non-dominant hand. In comparison, in adults without ID only 14.1% had higher or equal grip strength with their non-dominant hand (Incel et al., 2002). The strength ratios of this selection show that if grip strength is measured for only the dominant hand, an error up to 22.5% can be made. These results stress the need to always measure both hands when assessing the maximal grip strength of an individual with ID. The wide distribution of grip strength ratios (both positively and negatively) for these subgroups, is likely to cause the low grip strength ratios of the dominant versus the non-dominant hand of the first analyses.

Norm-referenced values for grip strength are available for the general population (Bohannon, Bear-Lehman, Desrosiers, Massy-Westropp, & Mathiowetz, 2007; Bohannon, Peolsson, Massy-Westropp, Desrosiers, & Bear-Lehman, 2006; M. J. Peters et al., 2011). These normative values are either presented for left and right hands (Bohannon et al., 2007; Bohannon et al., 2006) or as one value for both hands (M. J. Peters et al., 2011), thus causing difficulties for use in this population. No norm-referenced values for the population of ID are currently available. Until these normative values are developed, the existing values of the general population can be used by comparing the highest grip strength value, regardless from which hand, to the values of M.J. Peters et al. (2011) or right-hand values (the strongest hand in these values) of Bohannon et al. (2006) and Bohannon et al. (2007).

A limitation of this study is that handedness was measured by performing just one unimanual task and was categorized in right- or left-handedness with that information, not in mixed-handedness. A more precise way to assess handedness would have been by assessing the preferred hand used in several tasks, for example based on the Annett hand preference questionnaire (AHPQ) (Annett, 1970). This would provide information about the consistency of the use of one preferred hand, by which a distinction could be made not only between right- and left-handed but also mixed-handed individuals. A thorough assessment of handedness is therefore recommended for future research. The fact that mixed-handedness was not identified could contribute to the large proportion which had the non-dominant hand as the strongest hand.

Older adults with borderline or mild ID without any form of registered professional support or care are not included in the HA-ID population and results are therefore not generalizable to this group. Participants with severe and profound ID were underrepresented through selective drop out during grip strength assessment. A higher percentage of left-handedness was found in this group. We

conclude that the proportion of left-handedness presented here is likely to be an underestimation rather than an overestimation.

In summary, this study provides guidelines for grip strength assessment in older adults with ID and recommendations how to use existing normative values. Further research is necessary to provide normative values for the older population of ID.

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Conflict of interest

None.

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