Isokinetics and Exercise Science 11 (2003) 219–223
IOS Press

Effects of dominance, body mass index and age on grip and pinch strength

Kadir Ertem[a,*], Muharrem Inan[a], Saim Yologlu[b], Nurzat Elmali[a], Ahmet Harma[a], Sükrü Sahin[a] and Arslan Bora[a]

[a]*Department of Orthopaedics and Traumatology, Inonu University, Turgut Ozal Medical Center, Malatya, Turkey*
[b]*Department of Biostatistics, Inonu University, Turgut Ozal Medical Center, Malatya, Turkey*

Abstract. Measurement of grip and pinch strength is an important component in hand evaluation. It assesses the patient's initial limitations and provides a quick reassessment of patient's progress throughout the treatment. This investigation was conducted to examine the effects of hand dominance, body mass index (BMI) and age on grip strength (GS) and pinch strength (PS) tasks. Subjects were 365 apparently healthy young male adults (19–33 years). No correlation was found between the BMI hand strength measures. Grip and pinch strength were measured instrumentally. The rule "dominant hand (DH) is approximately 10% stronger than the nondominant hand (NDH)" was found to be valid for left handed persons only (11.2%), otherwise these measures should be considered equivalent in both hands in clinical practice.

Keywords: Dynamometry, muscle strength, grip, pinch

1. Introduction

Reliable and valid evaluation of hand strength is of paramount importance in determining the effectiveness of various surgical or treatment procedures. In addition, normative data are needed to interpret evaluation data, to set realistic treatment goals, and to assess a patient's ability to return to employement [1]. Besides, grip strength tests convenient, safe and reliable and without require large or expensive equipment [2]. Therefore, grip strength has been used as an indicator of overall muscle strength. Rantanen et al. [4] emphasized that higher strength itself may provide greater physiologic and functional reserve that protects against mortality [3,4]. Many factors including fatigue, hand dominance, age state of nutrition, pain, cooperation of the patient and presence of amputations, restricted motion, and sensory loss can influence the strength of the grip and pinch.

With increasing age, muscle strength decreases and may eventually reach a level at which weakness starts to restrict the ability to perform usual activities [5]. Ager [6] pointed out that GS and PS increased from early childhood towards adolescence in a population of 474 children aged 5 to 12 years [6]. Mathiowetz [7] studied a sample of 310 men and 318 female adults, aged 20 to 94 and the highest grip strength scores coincided in the 25 to 39 age groups. Though a high correlation was seen between grip strength and age, a low to moderate correlation between was indicated between pinch strength and age [7]. Rantanen et al. [8] pointed out that among healthy 45–68 year old men, GS was highly predictive of functional limitations and disability 25 years later. It was also suggested that good muscle strength in midlife could protect people from old age disabilities [8]. On the other hand, Hanten et al. [9] indicated weak correlation between age and grip-pinch strengths [9] while Lowe [10] pointed out that hand functions were not significantly affected by age [10].

Neu et al. [11] studied a population comprising of 366 cases of children, adolescents and young adults from 6 year of age to 23 year of age (185 female) and 107 adults (88 female) aged 29 to 40 year for

*Address for correspondence: Kadir Ertem, MD, Department of Orthopaedic and Traumatology, Inonu University, Turgut Ozal Medical Center, 44069 Malatya, Turkey. Tel.: +9 0422 3410660/5110; Fax: +9 0422 3410728; E-mail: kertem@inonu.edu.tr.

ISSN 0959-3020/03/$8.00 © 2003 – IOS Press. All rights reserved

Table 1
Descriptive statistics for the strength measures according to the group

Measurement	RD ($n = 338$) (93%)			LD ($n = 27$) (7%)			Bilateral
	Average	SD	range	Average	SD	range	($n = 0$)
RGS	49.93	7.94	62.70	47.88	8.29	29.00	–
LGS	48.76	7.45	45.00	53.25	7.29	36.00	–
RPS	12.27	1.33	6.50	12.12	1.42	9.80	–
LPS	12.10	7.50	8.00	12.44	1.52	9.40	–

SD: Standard deviation; n: No of cases.

Table 2
The comparisons according to GS and PS for RDH and LDH

Measurement	RDH ($n = 338$) (93%)				LDH ($n = 27$) (7%)			
	t	p		%	t	p		%
RGS-LGS	2.01	<0.05	DH>NDH	2.4	2.07	<0.05	DH>NDH	11.2
RPS-LPS	0.41	>0.05	DH>NDH	1.4	0.82	>0.05	DH>NDH	2.6

analyzing the relationship between cross-sectional area of forearm muscles and maximal isometric grip force with age and pubertal stage. He concluded that the increase in GS was similar in both genders and appeared to be independent of sex hormones [11].

It is evident that the relationship between body mass index and strength is controversial: Jette et al., Chong et al. and Kritz-Silverstein et al., Rantanen et al., Pedersen et al. and Butterfeld et al. reported a positive relationship [12–17] while Davis et al. found an inverse link [18]. Still, Apovian et al. reported no relation between body mass index and strength [19].

In this study, we investigated the effects of hand dominance, body mass index and age on grip and pinch strength.

2. Methods

2.1. Subjects

365 healthy male students at the Police School of Malatya, ages ranging from 19 to 33 years (mean 22.7±3 years) took part in the study. Criteria for inclusion were no restriction of movement in the upper limbs and no history of any disease or injury to the upper limbs. All participants gave informed written consent and dominant hand was defined as the one used for writing. 338 participants were RDH and 27 were LDH. No participants reported ambidexterity.

2.2. Tester

Three testers performed all measurements. Prior to the initiation of the study, a pilot study was conducted in order to allow the testers to become familiar with the standard procedure of measurements as well as the use of the instruments. An assistant recorded all the data from the dynamometers and pinchmeters. The data were not revealed to the subjects or the testers.

2.3. Instrumentation

The standard, adjustable-handle Jamar dynamometer (Asirnow Engineering Co., Los Angeles, CA, USA), reported as the most accurate for measuring grip strength was used. For uniformity, it was set at the second handle position for all subjects. However for borderline acromegaly patients it was set at the third or fourth position which previous subjects informed to be more suitable [20]. For pinch strength, the B&L pinch gauge (B&L Engineering, Tustin, CA, USA) was used. This specific instrument had the highest calibration accuracy of all instruments tested [21].

2.4. Procedure

A brief interview preceded all testing in order to determine if subjects met the above criteria. We performed all measurements in a standardized arm position for hand strength tests as suggested by the American Society of Hand Therapists [22]. Subject sat with his shoulder adducted and neutrally rotated, elbow flexed at 90° and the forearm and wrist in neutral position. Subject was instructed to take two to three seconds to reach the maximum effort and then verbal encouragement was given consistently throughout all measurements. For each strength test the scores of three successive trials recorded for each hand. The highest grip and pinch strength for each hand was used for analysis. The trials for each measuement were seperated by a rest of at least one minute to minimize fatigue. Body

Table 3
Correlations between BMI , weight, height, age, GS and PS for the RHD cases ($n = 338$)

	BMI		Weight (kg)		Height (m)		Ages	r	p
	r	p	r	p	r	p			
RGF	0.072	0.189	0.319	0.000	0.216	0.000	RGF	0.203	0.000
LGF	0.048	0.378	0.246	0.000	0.194	0.000	LGF	0.123	0.024
RPF	0.094	0.083	0.266	0.000	0.169	0.002	RPF	−0.040	0.459
LPF	0.059	0.276	0.131	0.016	0.057	0.293	LPF	0.018	0.735
Ages	0.082	0.130	0.139	0.010	−0.80	0.142			

Table 4
Correlations between BMI, weight, height, age, GS and PS for the LHD cases ($n = 27$)

	BMI		Weight (kg)		Height (m)		Ages	r	p
	r	p	r	p	r	p			
RGS	0.321	0.102	0.436	0.023	0.331	0.092	RGS	0.199	0.320
LGS	0.331	0.092	0.493	0.009	0.441	0.021	LGS	0.414	0.032
RPS	0.262	0.187	0.298	0.131	0.163	0.418	RPS	0.190	0.344
LPS	0.293	0.138	0.335	0.088	0.193	0.334	LPS	0.222	0.265
Ages	0.357	0.067	0.358	0.066	0.160	0.424			

Table 5
Studies relating to bilateral comparison of grip and pinch strength

Study	Year	Grip strength	%						
Smidt and Toews [12]	1970	DH>NDH	**10.3**						
Thorngren and Werner [9]	1979	DH>NDH	7.0						
Mathiowetz et al. [4]	1985	DH>NDH	Min						
		Grip Strength				Pinch strength			
		RD	%	L D	%	RD	%	L D	%
Swanson [14]	1970	DH>NDH	5.4	DH< / =DH	**58**	DH>NDH	4	–	–
		DH<NDH	6.9						
Petersen [13]	1985	DH>NDH	**12.7**	DH<NDH	**48**	–	–	–	–
Reikeras [10]	1983	No significant difference between DH and NDH							
Crosby [15]	1994	DH>NDH	6	DH<NDH	2	DH>NDH	3	DH<NDH	5
Armstrong and Oldham [11]	1999	DH>NDH	0.1-3	No significant difference between DH and NDH					
Incel [2]	2002	DH>NDH	8.2	DH>NDH	3.2	DH>NDH	**9.43**	DH>NDH	5.31
Present study	2003	DH>NDH	2.4	DH>NDH	11.21	DH>NDH	1.4	DH>NDH	2.6

weight and height were measured during the exam and values were expressed as kilograms and centimeters, respectively. To calculate BMI, height was converted into meters (BMI = weight/height^2).

2.5. *Data analysis*

All statistical analyses were performed with SPSS for Windows version 10.0. Unpaired t test was used to determine the effects of hand dominance, body mass index and age on the grip and pinch strength task. The level of significance was set at $p = 0.05$. Pearson correlation test was used for testing the correlation between the variables. Each test was considered separately. The data were analyzed with all participants included, then separately, for right- and then left-hand dominant participants.

3. Results

Descriptive statistics for the strength measures about the group presented on Table 1. Table 2 summarizes the dominance-based comparison of grip and pinch strength. Although the GS of the DH was slightly stronger then the NDH (by 2.4%) when DH was also the right hand, this discrepancy was more evident when the left hand was the DH (11.2%). With respect to PS, the strength of DH was stronger then NDH for both hands but the difference failed to reach significance. Tables 3 and 4 summarize the correlations of BMI, weight, height and age with the GS and PS.

4. Discussion

Our study group was limited to 365 apparently healthy young male adults (age range 19–33 years).

One handicap was the lack of a female study group. However, Neu et al. have concluded that the increase in GS was similar in both genders and appeared to be independent of sex hormones [11].

There was a good statistically significant relation between ages and grip strength especially for RDH, in agreement with the Mathiowetz et al. and Ager et al. studies [6,7]. The lack of a significant relation between ages and pinch strength was supported by the Ager et al., Hanten et al. and the Lowe studies [6–10] (Tables 3,4).

Table 5 summarizes a number of comparative studies relating to GS and PS. In some studies the authors concluded that the DH was just stronger than the NDH and thus the hands could be regarded as having equivalent strength [7,23–25]. On the other hand, a general 'rule' which is often used suggested that the DH hand was approximately 10% stronger than the NDH [26]. It was later argued that this 'rule' was valid for right handed subjects only whereas for left handed persons, grip strength should be considered equivalent in both hands [27]. The present study points to the opposite supporting the 'rule' in left handed persons only. Interestingly in a number of studies NDH was found to be stronger than the DH [27–30].

With respect to the lack of relationship between body mass index and strength, our results are in agreement with those of Apovian et al. [19] and in variance with those by Jette et al. [12], Chong et al. [14], Kritz-Silverstein et al. [13], Rantanen et al. [15] Pedersen et al. [16] and Davis et al. [18].

5. Conclusion

No correlation was found between the BMI hand strength measures. The rule which states that "the dominant hand is approximately 10% stronger than the non-dominant hand" was found to be valid for left handed persons only, otherwise GS and PS should be considered equivalent in both hands. This difference may be attributed to the fact that the world we live is designated more to suit right handedness. As a result the left handed people exercise their DH more often for daily activities. Thus the finding relating to the superiority of the left hand in LDH people probably reflects the overuse imposed on this select group.

References

[1] N.A. Incel, E. Ceceli, P.B. Durukan, H.R. Erdem and Z.R. Yorgancigil, Grip strength: Effect of hand dominance, *Singapore Med J* **43**(5) (2002), 234–237.

[2] E.J. Bassey, Measurement of muscle strength and power, *Muscle Nerve* **5** (1997), 44–46.

[3] E.J. Bassey and U.L. Harries, Normal values in hand grip strength in 920 men and women aged over 65 years and longitudinal changes over 4 years in 620 survivors, *Clin Sci* **84** (1993), 331–337.

[4] T. Rantanen, T. Harris, S.G. Leveille, M. Visser, D. Foley, K. Masaki and J.M. Guralnik, Muscle strength and body mass index as long-term predictors of mortality in initially healthy men, *J Gerontol Med Sci* **55A**(3) (2000), 168–173.

[5] M.M. Porter, A.A. Vandervoort and J. Lexell, Aging of human muscle: structure, function and adaptability, *Scand J Med Sci Sports* **5** (1995), 129–142.

[6] C.L. Ager, B.L. Olivett and C.L. Johnson, Grasp and pinch strength in children 5 to 12 years old, *Am J Occup Ther* **38**(2) (1984), 107–113.

[7] V. Mathiowetz, N. Kashman, G. Volland, K. Weber, M. Dowe and S. Rogers, Grip and pinch strength: Normative data for adults, *Arch Phys Med Rehab* **66** (1985), 69–72.

[8] T. Rantanen, J.M. Guralnik, D. Foley, K. Masaki, S. Leveille, D. Curb and L. White, Midlife hand grip strength as a predictor of old age disability, *JAMA* (281) (1999), 558–560.

[9] W.P. Hanten, W.Y. Chen, A.A. Austin, R.E. Brooks, H.C. Carter, C.A. Law, M.K. Morgan, D.J. Sanders, C.A. Swan, A.L. Vanderslice, Maximum grip strength in normal subjects from 20 to 64 years of age, *J Hand Ther* **12**(3) (1999), 193–200.

[10] B.D. Lowe, Precision grip force control of older and younger adults, revisited, *J Occup Rehabil* **11**(4) (2001), 267–279.

[11] C.M. Neu, F. Rauch, J. Rittweger, F. Manz and E. Schoenau, Influence of puberty on muscle development at the forearm, *Am J Physiol Endocrinol Metab* **283**(1) (2002), 103–107.

[12] M. Jette, K. Sidney and W. Lewis, Fitness, performance and anthropometric characteristics of 19,185 Canadian Forces personnel classified according to body mass index, *Mil Med* **155**(3) (1990), 120–126.

[13] D. Kritz-Silverstein and E. Barrett-Connor, Grip strength and bone mineral density in older women, *J Bone Miner Res* **9**(1) (1994), 45–51.

[14] C.K. Chong, C.H. Tseng, M.K. Wong and T.Y. Tai, Grip and pinch strength in Chinese adults and their relationship with anthropometric factors, *J Formos Med Assoc* **93**(7) (1994), 616–621.

[15] T. Rantanen, K. Masaki, D. Foley, G. Izmirlian, L. White and J.M. Guralnik, Grip strength changes over 27 yr in Japanese-American men, *J Appl Physiol* **85**(6) (1998), 2047–2053.

[16] A.N. Pedersen, L. Ovesen, M. Schroll, K. Avlund and P. Era, Body composition of 80-years old men and women and its relation to muscle strength, physical activity and functional ability, *J Nutr Health Aging* **6**(6) (2002), 413–420.

[17] S.A. Butterfeld, R.A. Lehnhard and T. Coladarci, Age, sex, and body mass index in performance of selected locomotor and fitness tasks by children in grades K-2, *Percept Mot Skills* **94**(1) (2002), 80–86.

[18] J.W. Davis, P.D. Ross, S.D. Preston, M.C. Nevitt and R.D. Wasnich, Strength, physical activity, and body mass index: relationship to performance-based measures and activities of daily living among older Japanese women in Hawaii, *J Am Geriatr Soc* **46**(3) (1998), 274–279.

[19] C.M. Apovian, C.M. Frey, G.C. Wood, J.Z. Rogers, C.D. Still and G.L. Jensen, Body mass index and physical function in older women, *Obes Res* **10**(8) (2002), 740–747.

[20] J.M. Hunter, E.J. Mackin and A.D. Callahan, *Rehabilitation of the hand: Surgery and therapy*, Missouri: Mosby, 1995.

[21] V. Mathiowetz, K. Weber, G. Volland and N. Kashman, *Reliability and validity of hand strength evaluation* **9A** (1994), 222.
[22] E.E. Fess and C. Moran, Clinical assesment recomendations, indianapolis. American Society of Hand Therapists, 1981.
[23] K.G. Thorngren, Werner CO: Normal grip strength, *Acta Orthop Scand* **50** (1979), 255–259.
[24] O. Reikeras, Bilateral differences of normal hand strength, *Arch Orthop Trauma Surg* **101** (1983), 223–224.
[25] C.A. Armstrong and J.A. Oldham, A comparison of dominant and non-dominant hand strengths, *J Hand Surg* **24B** (1999), 421–425.
[26] R.T. Schmidt and J.V. Toews, Grip strength as measured by the Jamar dynamometer, *Arch Phys Med Rehab* **51** (1970), 321–327.
[27] T. Petersen, G.P. Smith, J.A. Oldham, T.E. Howe and R.C. Tallis, The use of patterned neuromuscular stimulation to improve hand function following surgery for ulnar neuropathy, *J Hand Surg* **19B** (1994), 444–447.
[28] A.B. Swanson, I.B. Matev and G. DeGroot, The strength of the hand, *Bulletin of Prosthetics Research* **10** (1970), 145–153.
[29] C.C. Crosby and M.A. Wahbé, Hand strength: normative values, *J Hand Surg* **19A** (1994), 665–670.
[30] C.Y. Su, K.F. Cheng, T.H. Chien and Y.T. Lin, Performance of normal Chinese adults on grip strength test: a preliminary study, *Gaoxiong* **10**(3) (1994), 145–151.