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LATERAL ASYMMETRY IN GRIP STRENGTH: UTILITY OF THE TEN PER CENT RULE

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ABSTRACT

Objective: **To measure asymmetry in grip strength between hands in left, right and mixed handers and to test utility of the ten per cent rule.**
Design: **A cross sectional study.**
Setting: **Queen Elizabeth Central Hospital, Blantyre, Malawi.**
Subjects: **One hundred and seventy six healthy volunteers (102 males and 74 females) aged 15 to 66 years were selected from visitors to the patients admitted at the hospital.**
Main outcome measures: **Bilateral measurements of maximal grip strength, assessment of handedness using a questionnaire incorporating questions on hand preferred for six habitual activities.**
Results: **In about 70% of males and females, the right hand was stronger than the left hand while frequency of left, mixed, and right handers was 5.7%, 4.5% and 89.2%, respectively. Significant association ($\chi^2 = 6.43$, n=2, $p<0.05$) was found between handedness and stronger hand with preferred hand being stronger in most subjects. However, for about 40% of left and mixed handers and 27% of right handers, the non-preferred hand was stronger. The mean differences between grip strengths varied between 10% and 20% in different categories of handers when stronger hand was taken into consideration. Without considering the stronger hand, the mean bilateral difference in maximal grip strength in the three categories of handedness was between three and six per cent..**
Conclusion: **Distinction between stronger hand and hand preferred for skilled activities should be made and considered when assessing limitations in hand strength in clinical practice.**

INTRODUCTION

Limitations of hand functions due to hand and arm injuries, stroke, cerebral palsy and other conditions are among the serious medical and socio-economic problems leading to considerable restrictions in professional, social and every day activities of the patients. A number of procedures have been designed for evaluation of hand sensory and motor capabilities under pathological conditions as well as for rehabilitation of hand functions(1). Hand strength measurements have been used for a long time for assessment of disability ratings, setting strength goals for patients with damaged hands and evaluation of effectiveness of various types of treatment(2). When both hands are involved in pathological process, hand strengths of a patient might be compared with reference values, which give only approximate degree of hand weakening due to high variability of normal values within reference populations(3). In many patients only one hand is damaged and hand strengths of the injured and intact hands might be compared. However, the strengths of the two hands are not equal and some guidance is required to make a correct conclusion on degree of functional impairment of a damaged hand. The ten per cent rule serves such purpose. The rule states that grip strength of the dominant hand is 10% higher than that of the nondominant hand(4).

Reported data on utility of the 10% rule are controversial. Some authors(4,5) have demonstrated that the 10% rule is valid only for right handers while grip strengths of both hands of left handed persons are equal. Recent studies(6) confirmed lateral asymmetry in grip strength in right handers but showed a smaller than 10% difference between the grip strength of the two hands. Some studies(7,8) have not found significant difference between strengths of dominant and non-dominant hands. Such discrepancy in reported data on utility of the 10% rule can be explained, at least partly, by different methodological approaches in evaluation of grip strength, different sample sizes as well as superficial application of the concept of lateralisation of functions in assessment of dominant and non-dominant hands. In many studies the hand used for writing is classified as the dominant hand and subjects are divided into left and right handers. However, hand dominance is not consistent in some of the people because a person might prefer to use different hands for different behavioural activities or equally prefer both hands for certain manipulations. Therefore, three categories of handedness: namely right, left and mixed

handers are well recognised(9,10). Due to inconsistency in hand use the term hand preference is more accurate than hand dominance.

Hand preference can be determined using several methods such as questionnaires incorporating questions about habitual activities, personal impression, and manual dexterity tests(10-12). Some authors(13,14) used lateral differences in grip strength as an index of lateral dominance. However, strongest hand assessed on the basis of grip strength measurements does not necessarily mean that is a hand preferred for a particular behavioural activity such as writing. The aim of the present study is to measure asymmetry in grip strength between hands in left, right and mixed handers and to test the utility of the 10% rule.

MATERIALS AND METHODS

The study was conducted at Queen Elizabeth Central Hospital, Blantyre, Malawi. One hundred and seventy six adult males and females were selected from visitors to the patients admitted at the hospital. In selection of the subjects, sex, socio-economic status, education or occupation was not considered but subjects under 15 years were excluded. Persons with previous history of neuro-muscular or skeletal disorders of the upper limbs and trunk and with current medical problems and those under medication were excluded from the study population. The purpose and procedure of the study was explained and informed consent was obtained from each subject.

Maximal grip strength (MGS) of both hands was measured using hand grip dynamometer and procedure as described by Weiner and Lourie(15) was followed. To facilitate understanding of the test, the method was demonstrated to each subject and any question answered. Subjects were allowed to practice and familiarise themselves with the apparatus. The handle on the dynamometer was accordingly adjusted to suit the size of the subjects' hands. Grip strength of each hand was measured three times and recorded to the nearest 0.1 kg. The highest reading was taken as MGS of that hand and the hand with higher value of MGS was classified as the stronger hand. The difference in MGS between hands for each subject was calculated. The percentage difference in MGS of the two hands of each subject was calculated using the following equation:

$$\frac{\text{Difference in MGS between two hands}}{\text{MGS of the weaker hand}} \times 100\%$$

Two groups of subjects were identified according to a stronger hand: subjects with stronger right hand (SRH) and subjects with stronger left hand (SLH). Each group was also subdivided into several sub-groups according to age, gender and level of bilateral differences in MGS. Ten years were used as a unit for groupings of persons on the basis of age and ten percent difference in MGS between the two hands served as a unit for groupings of subjects according to the level of bilateral asymmetry in MGS.

Handedness was detected using questionnaire listing six questions on hand preferred for writing, drawing, cutting with scissors, threading a needle (for women) or hammering (for men), striking a match and brushing teeth. Subjects were classified as left or right handers if they preferred left or right hand respectively for all activities and as mixed handers if hand preference was inconsistent. The instruction allowed a person to select use of both hands for specific activity if he was forced to change from left to right hand use. These individuals were classified as mixed handers.

Statistical analysis was carried out with software Epi Info 2000. Results are presented as means and standard errors of means. The Student's paired and un-paired t test was used to compare means and the Chi-squared test was used to compare proportions. Non-parametric test was used to compare small sub-groups of persons. The level of statistical significance was fixed at $P<0.05$.

RESULTS

The mean MGS values had normal distribution for all groups. Table 1 shows number of volunteers, the mean age and the mean MGS values of the four groups of subjects. In 69.9% of subjects, the right hand exhibited higher MGS than left hand and frequency of SRH among males and females was similar. The mean MGS values of the stronger hand were significantly higher than those of the other hand in all groups. The mean values of percentage difference in bilateral measurements of MGS varied non-significantly from group to group. High values of standard errors from the means indicated considerable variability of differences in MGS between hands within each group of subjects. However, differences between groups in variability of analysed parameter were non-significant.

Table 1

Statistical parameters of groups of subjects with stronger right hand and stronger left hand.

Stronger hand	Gender	No. of subjects	Age (years)	Maximal grip strength		
				Left hand (kg)	Right hand (kg)	Bilateral difference (%)
Right	Males	71	29.8±1.1	38.1±8.6	43.0±1.0*	12.9±1.6
	Females	52	28.3±1.2	27.8±0.9	32.1±0.9*	15.5±1.6
	Total	1 23	29.2±0.8	33.7±0.7	38.4±0.8*	13.9±1.1
Left	Males	31	26.3±2.0	43.7±1.5	39.5±1.7*	10.7±2.4
	Females	22	27.3±2.1	31.2±0.9	27.7±1.3**	12.6±1.7
	Total	53	26.7±1.5	38.5±1.0	34.6±1.2*	11.3±1.6

Values are Mean ± SEM

*P<0.001; **P<0.01 compared to corresponding values for left hand

Table 2 demonstrates proportions of males and females with different levels of bilateral asymmetry in MGS. About half of the differences in MGS values of the two hands in overall sample of males were less than 10%. In females, 30-40% of the relative differences between hands fell within 10% category. The overall distributions of the bilateral differences among persons with SRH and SLH of the same sex were similar. The gender differences were only present between subjects with SRH (χ^2=10.00, n=4, p = 0.041). Proportions stratified by age indicated that there were no significant associations between the distributions of the bilateral differences in MGS values and age of the subjects.

Table 3 shows proportions of left, mixed and right handers among subjects. Gender differences in the distribution of the three categories of handedness were non-significant. There was significant association (χ^2 = 8.74, n = 2, p = <0.012) between handedness and stronger hand (Table 4). For most of the left and right handers, the MGS of the preferred hand was highest while most of mixed handed subjects exhibited higher MGS of the left hand.

Table 2

Distribution (%) of values of bilateral differences in maximal grip strength among subjects with stronger right hand (SRH) and stronger left hand (SLH)

Bilateral difference (%)	Age of subjects (years) 15-25		26-35		36-45		46+		Total	
	SLH	SRH	SLH	SRH	SLH	SRH	SLH	SRH	SLH	SRH
Males										
0-9.9	63.6	61.5	63.6	37.0	20.0	55.6	50.0	55.6	54.8	50.7
10-19.9	9.1	26.9	18.2	33.4	40.0	44.4	0.0	22.2	16.2	31.0
20-29.9	18.2	7.7	18.2	18.5	20.0	0.0	50	0.0	22.4	9.9
30-39.9	9.1	3.9	0.0	3.7	20.0	0.0	0.0	11.1	6.6	4.2
40+	0.0	0.0	0.0	7.4	0.0	0.0	0.0	11.1	0.0	4.2
Females										
0-9.9	33.4	29.0	60.0	37.5	40.0	28.6	33.3	33.3	41.2	31.0
10-19.9	33.3	25.8	20.0	50.0	40.0	28.6	66.7	33.3	35.3	31.0
20-29.9	11.1	32.3	20.0	12.5	20.0	42.8	0.0	16.7	11.7	28.5
30-39.9	11.1	9.7	0.0	0.0	0.0	0.0	0.0	16.7	5.9	7.1
40+	11.1	3.2	0.0	0.0	0.0	0.0	0.0	0.0	5.9	2.4

Table 3

Proportions of left, mixed and right handers among subjects

Category of handedness	Gender		
	Males	Females	Total
Left handers	7 (6.9)	3 (4.1)	10 (5.7)
Mixed handers	5 (4.9)	3 (4.1)	8 (4.5)
Right handers	90 (88.2)	68 (91.8)	158 (89.8)
Total	102 (100)	74 (100)	176 (100)

Values are numbers of subjects with percentages in brackets.

Table 4

Relations between stronger hand and hand preference.

Stronger hand	Hand preference Left	Mixed	Right	Total
Right	4 (40)	3 (37.5)	115 (72.8)	123 (69.9)
Left	6 (60)	5 (62.5)	43 (27.2)	53 (30.1)
Total	10 (100)	8 (100)	158 (100)	176 (100)

Values are numbers of subjects with percentages in brackets.

Table 5

Maximal grip strength of left, mixed and right handers with stronger left hand and stronger right hand

Handedness	Stronger hand	Maximal grip strength Left hand (kg)	Right hand (kg)	Bilateral difference (%)
Right	Right	34.4±0.9	37.8±0.9*	9.9±0.8
	Left	39.1±1.4	34.6±1.6*	13.1±2.1
	Total	35.7±0.7	36.9±0.7*	3.4±0.4
Left	Right	27.3±4.5	28.8±3.8	5.5±1.2
	Left	45.9±2.4	38.4±2.2*	19.5±1.7
	Total	34.7±1.4	32.6±1.4**	6.4±0.7
Mixed	Right	25.9±7.0	29.9±9.3	15.4±12.1
	Left	39.8±12.1	35.8±12.5***	11.4±6.2
	Total	34.6±10.6	33.6±11.7	3.0±4.8

Values are Means±SEM
*P<0.001, **P<01, ***P<0.02 comparing to corresponding value of left hand.

Table 5 shows bilateral asymmetry in MGS in right, left and mixed handed subjects. Without considering the stronger hand, the level of bilateral differences in MGS was between three and six per cent for all categories of handedness and differences between the three groups of

subjects were non-significant. Stratification of left, right and mixed handers by stronger hand increased the levels of bilateral differences in MGS in all sub-groups but not in left handed persons with stronger right hand. However the differences in the level of bilateral asymmetry between the three groups remained non-significant.

DISCUSSION

The present study differs from previously published works(2,4,7,8) in the way that it considers the effect of handedness as well as stronger hand of subjects on pattern of bilateral asymmetry in maximal grip strength. This methodological approach seems to have at least two advantages. Firstly, it allows investigation of relations between handedness and stronger hand of subjects. Secondly, it provides more accurate values of mean differences between hand strengths since subjects with stronger right hand and stronger left hand are analysed separately. Another important feature of the study is that the three categories of handedness were analysed, contrary to other investigations which considered only right and left handers(4,6-8). Since different methods used for assessment of handedness produce different proportions of right, left, and mixed handers and some tests give inconsistent results from one performance to another(16), we selected a questionnaire that provides a high degree of redundancy and produces consistent responses(9). The frequency of left and mixed handers measured using a questionnaire in this study is lower than that reported for Western countries(9,10,12), which might be explained by differences in social acceptance of non-right handedness. While in Western countries social pressure on non-right handers has been considerably reduced over the last few decades, it is still strong in Malawi. Lack of information on handedness in African countries did not allow us to compare our results with those from other African regions.

In the present study, right handers and persons with stronger right hand were the most numerous groups of subjects. This fact is consistent with literature, which suggest that upper limb is often laterally dominant on the right side(3,17). Our data also revealed significant association between handedness and stronger hand. Hand preferred for selected habitual activities in most cases tended to be stronger. However, this association seems to be weak since non-preferred hand was stronger in about 40% of left and mixed handers and 27% of right handers. Hand preference is a multi-dimensional phenomenon with skilled activities being more lateralised than "less skilled" activities that involve strength(18). Pressing on a handle of a dynamometer with maximal strength represents latter type of activities. Therefore, it is not surprising that stronger hand and hand preferred for skilled activities did not correspond in all cases.

The central purpose of this study was to investigate the lateral asymmetry in maximal grip strength in different categories of subjects. According to the per cent rule, hand dominance is one of the major factors affecting differences in strength between hands(4). At the same time, some published data indicate that handedness does not significantly affect bilateral asymmetry(3). The data on the mean level of bilateral asymmetry in maximal grip strength is also contradictory. Our findings are at variance with the 10% rule and some other investigations(4,6-8) on the utility of this rule. Firstly, hand preferred for skilled activities is stronger in most but not all subjects. Therefore it is more accurate to consider bilateral asymmetry in MGS between stronger and the other hand rather than between preferred and non-preferred hands for skilled activities. Stronger hand might be identified with questions on hand preferred for activities which require strength such as lifting heavy weights or stirring ingredients when cooking ugali. However, further research is required to assess association between stronger hand and hand preferred for manipulations that require strength. Secondly, in the present study the mean values of the bilateral differences between hands in males and females varied from 11 to 16% when stronger hand of the subjects was considered and handedness was not taken into consideration. About the same levels of bilateral asymmetry was obtained when both handedness and stronger hand of subjects were considered. At the same time, calculation of the mean differences between grip strength of the hands regardless of stronger hand of subjects gave mean values of three to six per cent. The distinction between stronger hand and hand preferred for skilled activities might explain discrepancy in reported data on the level of bilateral asymmetry in maximal grip strength. Thirdly, contrary to some previously published studies(4-6), our investigation provides evidence that bilateral differences exist in all three categories of handedness. However, for left and mixed handers with stronger right hand, the differences were statistically non-significant. Fourthly, the level of bilateral asymmetry varied considerably from person to person and from one category of subject to another. Some authors(3,17,19) showed that age, gender, environmental stress and mental normality affect morphological and functional asymmetries. Particularly it has been demonstrated that bilateral asymmetry between hands increases with age with a considerable increment during adolescence(3,17). Since subjects younger 15 years did not participate in this study, association between age and asymmetry between hands was not found. Results of the present study also indicated that gender related side differences in grip strength were non-significant when stronger hand of subjects was considered. We can only suggest that other factors such as general level of physical fitness, occupation, e.g. unilateral work might contribute to high variability of asymmetry in grip strength between hands in this study.

In conclusion, bilateral asymmetry in MGS varies from 10% to 20% in different groups of subjects. Distinction between stronger hand and hand preferred for skilled activities should be made and considered when assessing limitations in hand strength in clinical practice.

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