FACTORS INFLUENCING GRIP STRENGTH TESTING IN TEENAGERS

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B.App.Sc.O.T.

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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2006
STATEMENT OF AUTHORSHIP

The work presented in this thesis is the original work of the author except where as acknowledged in the text. I hereby declare that I have not submitted this material either in whole or in part for any degree at this or any other institute.

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ABSTRACT

The aims of the Thesis were: to investigate and quantify the factors influencing the production of maximum isometric grip strength force in a sample of Australian teenagers when using Jamar™-like handgrip dynamometers; to determine the reliability of this measure over long and short retest intervals; to establish a database of anthropometric and strength values for this group and prediction equations for premorbid strengths to aid assessment of recovery in those with upper limb pathologies.

The history of these handgrip dynamometers demonstrates that they have been employed in one form or another for over three hundred years and are still widely used today in hand rehabilitation and medical examinations. Many new types of dynamometers have been constructed subsequent to the ubiquitous Jamar™ and have all been briefly reviewed here.

Handedness (dominance) was thought to be a possible factor influencing grip strength performance and was later evaluated. But first, the Edinburgh Handedness Inventory was tested with 658 teenagers and 64 adults and confirmed to be a valid tool for assessing handedness. Its validity was improved by substituting the tasks of sweeping and opening the lid of a box for hammering and use of a screwdriver. Its excellent reliability \((ICC = .78, p < 0.01)\) was confirmed with 45 teenagers and 45 adults.

There were 235 teenagers who performed maximal isometric grip strength tests and from the results a local database was created. It was confirmed that the grip strength difference in males and females becomes significant after the age of 13 years, and that the average teenaged male is stronger than the average teenaged female by 11.2 Kg force \((p < .01)\). Height, weight, BMI, hand dimensions, past upper limb injuries, degrees of handedness and exercise levels were measured and compared with known norms to establish that the grip strength tested sample of teenagers was representative of urban teenagers in Australia.

The influence of handedness on maximal grip strength in dominant and non-dominant hands was unable to be completely ascertained due to the vast majority of the sample
of teenagers being right-handed. Only 13 of the 235 teenagers used their left hand for most tasks, with another 20 using their left hands for a small majority of tasks. There was a grip strength bias towards the dominant hand of 2.63 kg force ($p < .01$).

The most accurate way to predict the grip strength of one hand is by knowing the grip strength of the other hand. Prediction models found that 90% ($R^2_{adj} .902$) and 70% ($R^2_{adj} .702$) of the variance in one hand could be accounted for by the grip strength of their other hand for male and female teenagers, respectively. Prediction equations were also created to assist in estimating the pre-morbid grip strength of teenagers suffering from bilateral hand injuries. If for the males, measurements for height and hand surface area were entered into these models, the grip strength of the dominant and non-dominant hands could be estimated with 62.6 and 63.5% of the variance between the real and predicted scores accounted for, respectively. For the females the prediction models using height and hand surface area could only account for 33.9 and 42.8% of the variances, with no other independent variables improving the prediction equations.

The reliability of the maximal grip strength performance of 154 of these teenagers was retested after one or four weeks. A number of sub-group permutations were created for age, gender, retest time interval and handedness groups. The measures of grip strength for males were highly reliable with $ICC (3,1)$ values ranging from .91 to .97. These measures were significantly higher than that obtained from the females, where reliability values ranged from .69 to .83. Handedness played a significant part in grip strength reliability. The dominant hand of right-handed teenagers achieved an $ICC (3,1)$ of .97, as contrasted with the non-dominant hand of left-handers who attained a very poor $ICC (3,1)$ of .27.

The shape of the hands of the males did not influence their grip strength or their reliability values, which ranged from .954 to .973. The shape of female hands did not affect their ability to generate maximal grip strength, only its reliability. The females with hands shaped squarer-than-average had mean grip strength reliability values of $ICC (3,1)$ at only .48, in contrast to those with longer-than-average hands who achieved a mean $ICC (3,1)$ of .92. The handle shape of the dynamometer may disadvantage square-handed females, and this should be further investigated.