CORRELATION BETWEEN GUIDED GRIP FORCE AND PERCEIVED EXETION FOR MALES

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INTRODUCTION

The study of perceived effort has long been dominated by Borg's concept of perceived exertion [1]. Borg's ratings of perceived exertion (RPE) scale (ranged from 6 to 20) have been widely used in analyzing various manual tasks as well as in many physical works [1] as a supplementary measure in addition to physiological measures. In addition to the RPE scale, Borg [2] has constructed another subjective scale, called CR-10 scale. Borg [2] claimed that the advantage of the CR-10 scale over the RPE scale is that the former lacks of an inter-subjective unit for direct determinations of intensity levels while the latter provides direct level estimates for determinations of ratio relationships between perceptual responses. Both the RPE and the CR-10 scales may be used to measure muscular exertion and physical workload for whole body or specific body segment.

Even though the Borg's RPE and CR-10 scales have been claimed function well, investigations and discussions on the design, function, and requirement of calibration are still continued. Buchholz *et al.* [3] examined the agreement of subjective ratings of upper extremity exposures with corresponding direct measurements obtained simultaneously from workers. Psychophysical ratings of exposure, based on the Borg CR-10 scale, were obtained for the period of time in which direct measurements were acquired using electro-goniometers, electro-inclinometers and electromyography. Subjects from workers at two automobile manufacturing plants were selected. Significant relationships between subjective ratings of wrist position and measured wrist posture or motion and between ratings of shoulder position and measured shoulder posture were not found.

In the study of Spielholz [4], twenty subjects applied power grip forces corresponding to their perceptions of different Borg CR-10 scale levels using both ''grip-to-scale'' and ''guided-grip'' procedures. These data were used separately to define relationships between scale ratings and actual force application. Two gripping tasks were performed and corresponding subjective hand force ratings were calibrated using the grip-to-scale calibration data. The results showed that the mean estimation error for a 44.5 N power grip task was significantly reduced from 142.8 to 62.3 N. The guided-grip calibration method also significantly reduced rating error for the power grip task. Spielholz's [4] study indicated that calibration of hand force ratings using the grip-to-scale procedure may improve the accuracy of hand exertion measurements using the Borg CR-10 scale.

Handgrip is a fundamental element in performing many tasks. The Borg's CR-10 has been discussed in the literature [1,2,3]. The objective of this study were to examine the relationship between the grip force of the dominant hand and the Borg's CR-10 ratings and to report the deviation of predicted grip force from measured force based on a linear regression model developed in the study.

METHODS

Twenty males were recruited as human subjects in the study. All the subjects were free from musculoskeletal injuries. Their age, gender, stature, and body weight were 22.1 (±2.5) yrs, 172.3 (±5.3) cm, and 69.8 (±12.5) kg, respectively. All the subjects received payment and had signed informed consent forms for their participation in the study. All the subjects, except one, were right-handlers.

In the experiment, each subject was required to grip a dynamometer under one of the four Borg CR-10

scale levels: 2, 5, 7, and 10. The scores of 2, 5, 7, and 10 on the CR-10 scale were assumed to represent 20%, 50%, 70% and 100% of perceived maximum voluntary contraction (MVC), respectively. The grip forces of the dominant hand of the subjects were measured. The upper arm of the subject was straight down and the lower arm was horizontal, or at 90° with the upper arm. The span of the dynamometer was 5 cm. Each subject will take a break for five minutes or more after he finished one measurement at the 5, 7, or 10 levels so as to avoid the effects of fatigue on the measurement.

Descriptive statistical analysis was performed. In addition, a linear regression model was built to describe the relationship between the grip force and the Borg's CR-10 scale. The statistical analyses were performed using the SPSS® 12.0 computer software.

RESULTS AND DISCUSSION

The means (±standard deviations) of the grip force corresponding to the scores of 2, 5, 7, and 10 on the CR-10 scale were 10.0 (±2.8), 23.5 (±4.2), 32.8 (±3.5), and 43.3 (±5.3) N, respectively. The Pearson's correlation coefficient between the CR-10 rating and the grip force was 0.95 (p<0.0001). A linear regression model was established to describe the relationship between the CR-10 score and grip force:

$$\text{Grip force} = 2.29 + 4.18 \times \text{CR-10 score} \qquad (1)$$

This model is statistically significant at p<0.0001 with an R^2, or coefficient of determination, of 0.90 and a root mean square error of 4.11. The intercept (2.29) and the slope (4.18) of the regression model were statistically significant at p<0.032 and p<0.0001, respectively. The scatter plots and regression line of (1) are shown in Figure 1. To assess the deviations of the measured grip force and the predicted values using (1), a mean absolute deviation (MAD) was defined using the following equation:

$$\text{MAD} = \frac{1}{n}\sum_{i=1}^{n} |\text{measured value} - \text{predicted value}|$$

where n is the sample size. The MAD was 3.02 N.

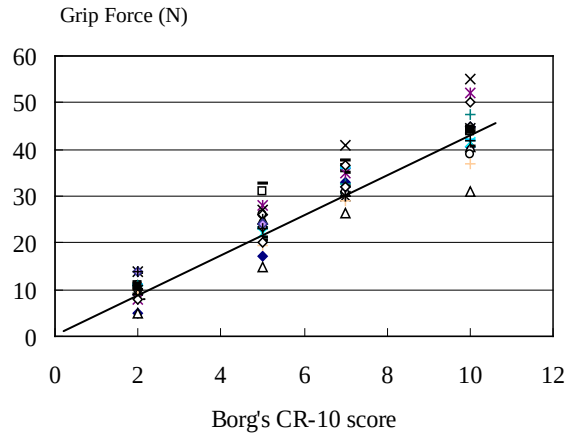

Figure 1: Scatter plots and regression line

In the regression model, the CR-10 score was highly correlated with the grip force. The linear regression model in (1) may be used to describe and predict the grip force of the dominant hand for the male subjects. The results of this study were consistent with the findings in the literature [4].

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ACKNOWLEDGEMENTS

This research was financially support by the National Science Council of the ROC under grant NSC 98-2221-E-216-01.