

# THE RELATIONSHIP OF BORG CR10 RATINGS OF PERCEIVED EXERTION TO GRIP FORCE DURING HAND TOOL TASKS

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## INTRODUCTION

Grip forces applied when using hand tools or grasping objects are difficult to quantify without sophisticated or expensive instrumentation. Often subjective methods are used to obtain estimates of force exposure for use in assessments such as the Hand Activity Limit (HAL) Threshold Limit Value (TLV) [1]. One tool used for this purpose is the Borg CR10 Scale [2]. The purpose of the study was to evaluate how well individuals utilize the Borg scale to estimate grip forces applied in gripping tasks where forces or moments are applied in different ways. Correlation analyses was used to guide exploration of factors that may affect subjective ratings of grip force during hand tool use.

## METHODS

Sixteen male participants were recruited, (43.9 (12.9) years, 181.1 (8.2) cm, 91.3 (41.7) kg). A sensor composed of a 16 mm diameter stainless steel core instrumented with strain gauges was used measure grip force and reactive moments during hand tool use [3]. A 30 mm diameter handle was fitted to the core. Task-specific end effectors were attached to the handle, for each of three experimental tasks (Figure 1). The lift-carry task with a suspended weight produced loading along the handle long axis. The ratcheting task simulated nut tightening and produced a moment that is

opposed along one side of the palm. The screwdriver task produced a rotational torque about the handle. Each task was performed at four force levels. Ten cycles of the ratchet and screwdriver tasks and two cycles of the lift and carry task were performed at each force level (Table 1). Grip force MVCs were recorded for each participant prior to data collection. A Borg CR10 rating of exertion followed each trial. Additional grip force measures were calculated: force integration over each trial and the mean, peak and integrated grip forces normalized by the respective grip MVC. Pearson correlation coefficients were determined for the Borg ratings and the corresponding force measures.

## RESULTS AND DISCUSSION

The correlations for all conditions were significant at the  $p < 0.05$  level (Table 2). Based on this data several observations can be made. Borg scale ratings more closely reflected grip exertion while performing the screwdriver task than the lift-carry or ratchet task. This suggests that how force/torque is applied with a tool influences perceived grip, perhaps due to tactile cues. Borg ratings were more closely correlated with integrated grip force than mean or peak values, indicating perception may be related to duration of exposure. When adjusted by normalization correlations improved for all but the screwdriver task, suggesting that individual perceptions are scaled to individual capacities. Further research will investigate how factors such as force level and relative grip force capacity influence Borg ratings.

Table 1. Ensemble mean (s.d.) and peak grip forces for three tasks for the four force levels

Task	Set Resistance	Mean Grip Force (N)	Peak Grip Force (N)
Screwdriver n = 191	0.34 (.02)	39.4 (14.4)	52.6 (21.1)
	0.63 (.03)	51.5 (11.0)	73.9 (17.4)
	1.07 (.06)	70.3 (12.3)	106 (20.8)
	1.57 (.06)	91.5 (14.1)	138 (24.6)
Ratchet n = 128	2.1 (0.5)	65.2 (17.2)	89.9 (29.1)
	2.9 (0.7)	74.3 (15.2)	109 (28.2)
	4.0 (1.0)	84.9 (12.5)	129 (22.8)
	5.3 (1.2)	98.3 (17.3)	153 (32.5)
Lift & Carry n = 64	38 (0)	57.5 (28.7)	98.9 (39.1)
	56 (0)	67.4 (25.6)	105 (35.4)
	73 (0)	82.7 (22.1)	124 (33.8)
	91 (0)	94.0 (29.7)	136 (41.8)

Table 2. Correlation coefficients of Borg CR10 compared to the grip force variables.

	Grip force			Normalized grip force		
	Mean	Peak	Integrated	Mean	Peak	integrated
Lift and Carry	0.35	0.26	0.56	0.56	0.50	0.71
Ratchet	0.43	0.44	0.53	0.62	0.63	0.70
Screwdriver	0.76	0.75	0.79	0.68	0.67	0.70

## REFERENCES

1. ACGIH Worldwide. Hand Activity Level TLV, 2007.
2. Borg G. *Med Sci Sports Exercise*, **14**, 377-381, 1982.
3. McGorry RW et al. *Applied Ergon*, **32**, 271-279, 2001.

Figure 1.

