

EFFECTS OF GRIP SPAN AND SHOULDER POSTURE ON ENDURANCE LIMIT OF FORCE

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This study investigated the effects of shoulder posture and grip span on endurance limit (EL) of continuous isometric hand-grip force. The results indicate that grip span, thus, muscle contractile length is an important parameter that should be considered in modeling of EL and relaxation allowances in addition to hand tool design.

Objective. The aim of this study was to investigate the effects of the combinations of three grip spans and two shoulder postures on EL (maximum holding time of force) for sustained isometric hand-grip force, thus, localized forearm muscle fatigue.

Background. EL may provide critical information for determining relaxation allowances. It was hypothesized that the time of exhaustion to fatigue for sustained hand-grip contractions is correlated with required rest pauses for intermittent contractions; thus, work/rest cycles. EL for isometric sustained contractions was studied by number of researchers (e.g., Rohmert, 1973; and Corlett and Manenica, 1980). In these studies, EL was found merely a function of applied force and independent of other variables such as age, gender, tool specifications, etc. In this study, it was hypothesized that EL is also a function of posture and grip span; i.e., muscle contractile length.

Criteria. (1) Subjectively determined exhaustion limit (the point at which the subject can no longer maintain the required force), (2) objective measure of significant EMG sign of fatigue and (3) high subjective ratings of perceived exertion (RPE).

Methods. Twelve male volunteers took part. A span adjustable handgrip dynamometer was utilized for span setting and grip force generation. Three selected grip spans were relative optimum grip span (ROGS) and two additional spans that were 2 cm greater (ROGS+2) and 2 cm lower (ROGS-2) than ROGS. ROGS previously was found to be a function of one's modified thumb crotch length (Eksioglu, 1996; Eksioglu, 1999). Shoulder postures studied were neutral and 25° flexion. The grip force level for six experimental conditions were kept constant at 30% MVC across twelve subjects. A two-factor experiment in a randomized complete block design with subjects serving as blocks was utilized. The subject was seated in a specially designed station giving solid support to the arm. The forearm was kept horizontal with the wrist in a neutral position. The hand-grip contractions were performed by dominant hand using the hand-grip dynamometer. The dynamometer had a built in potentiometer. The exerted grip force level was displayed on a PC monitor utilizing a software developed for the purpose. The force level

(30% MVC) was constantly monitored by the subjects and the researcher to keep the target level in continuance. EMG of forearm muscles (flexor carpi radialis and extensor digitorum) was recorded continuously. The time to exhaustion was recorded as EL for each test condition for each subject. RPE of subjects for various body segments were also recorded using 10-point Borg scale (Borg 1982) immediately after each session.

Results. Posture, and interaction between posture and span had no significant effect on EL; however, grip span had a significant effect: $EL_{ROGS} > EL_{ROGS-2} > EL_{ROGS+2}$. This may be an indication that the biomechanical advantage of ROGS is delaying fatigue for 30% MVC. EMG analysis showed that median frequency shifts to lower values were not significantly different among experimental conditions indicating that localized forearm muscle fatigue levels were consistent for all experimental conditions. There was a significant span effect on normalized EMG_{RMS} values (muscular activity levels). Neither posture nor span had significant effect in variation of RPE for palm, wrist, forearm and upper arm.

Conclusion. Based on the results of this study, one may infer that grip span, thus, muscle contractile length or biomechanical advantage, may be an important parameter that should be considered in EL modeling, therefore, rest allowances modeling, in addition to hand tool design.

NOT: this study was conducted at Wichita State University, Wichita, Kansas, USA.

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PROCEEDINGS OF THE
XIVth Triennial Congress of the
International Ergonomics Association
and
44th Annual Meeting of the
Human Factors and Ergonomics Society
"Ergonomics for the New Millennium"

July 29 through August 4, 2000
San Diego, California, USA

Volume 5

Manual Work



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Published by the
Human Factors and Ergonomics Society
P.O. Box 1369
Santa Monica, CA 90406-1369 USA
310/394-1811, FAX 310/394-2410
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ISBN 0-945289-13-8

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HFES Annual Meeting Proceedings ISSN 1071-1813