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Endurance time of grip-force as a function of grip-span, posture and anthropometric variables

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ABSTRACT

The time to volitional exhaustion (endurance time) for sustained contractions is considered as a valid parameter to quantify fatigue and to determine the required rest pauses between two successive contractions. In this study, the effects of grip-span, shoulder posture and anthropometric characteristics on endurance time of grip-force during sustained 30% of maximal voluntary grip-force were investigated. Both subjective and objective measures of fatigue were used in determining the endurance times. Twelve male subjects performed sustained isometric handgrip contractions using a handgrip dynamometer at the combinations of three different grip span settings and two shoulder postures. The investigated three grip spans were the optimal, 2 cm narrower than the optimal, and 2 cm wider than the optimal. The investigated two shoulder postures were neutral and 25° flexion. The outcome measures were: endurance time, surface electromyography of related forearm muscles, heart rate, blood pressure, and ratings of perceived discomfort/pain. The results indicate that the endurance time decreases significantly as the grip span deviates from the optimal in both directions. On the other hand, the considered shoulder postures did not have a significant effect on the endurance time. Further analysis indicated a significant negative correlation between endurance time and rest pause and a marginal positive correlation between maximum voluntary grip-force and rest pause. Body mass index, and volume of forearm and hand had also significant negative correlation with endurance time. The comparisons are made with a number of existing endurance models and the impact of findings are discussed.

Relevance to industry: In accurate establishment of the time standards, muscular fatigue allowances need to be taken into account. The endurance time for sustained isometric contractions is correlated with the required rest allowances (pauses) for intermittent static contractions; and therefore, required muscular fatigue allowances can be estimated from the endurance times.

1. Introduction

The endurance time of force, T_E, is the maximum voluntary holding time of force until the failure to maintain the required or expected force level due to fatigue/pain. In general, there are two uses of T_E: (i) to quantify muscular fatigue, and (ii) to estimate recovery times (relaxation allowances) for muscular force exertion. Since T_E is related to fatigue, the factors that contribute to fatigue buildup naturally also contribute to T_E. These factors that cause metabolic changes within muscle, and impaired central nervous and neuramuscular activation contibuting to the decline in muscle power output with fatigue primaily are: magnitude of contraction force, muscle fiber composition (slow or fast twitch fibers), load type (e.g.; holding or pushing a static load), posture, individual differences, strength, gender, age, motivation and training (Gendevia et al., 1995; Hunter and Enoka, 2003; Hunter et al., 2005; Chaffin et al., 2006). For intermittent static contractions, the contraction duration and rest pause between successive contractions become additional factors affecting T_E. Biomechanical advantage of muscles during contraction, vibration and environmental factors such as heat or cold stress should also be added to these factors.

It is hypothesized by a number of researchers that the endurance time for sustained isometric contractions is correlated with the required rest-pauses (relaxation allowances) for intermittent static contractions (e.g., Mundale, 1970; Rohmert, 1973a, 1973b; Corlett and Manenica, 1980; Milner, 1985; Rose et al., 1992). According to these researchers, the required rest-pauses that allow recovery from muscular fatigue may be estimated from the endurance time of sustained isometric force. Providing rest-pauses of sufficient duration ensures the restoration of normal blood flow

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