INTRODUCTION

The ability of human subjects to control the variability of force about a target is a reflection of the integration of afferent input and the online correction of the ongoing motor command. This ability has been studied in aging, disease, and training [1]. In studies of muscle force variability, or steadiness, the experimental protocol often involves tasks during which the motor output of an isolated muscle group is maintained on a constant, submaximal target force [1]. In order to orient a subject to the task, minimize the contribution of immediate learning, and obtain a stable outcome measure, it is common to require at least one practice trial before two or more test trials. There is little definitive information to support the validity of that strategy during simple, submaximal force steadiness tasks. Furthermore, there is little information available on any potential differences in immediate learning effects between men and women. The purpose was to determine the extent of the immediate reduction in variability when young men and women perform repeated discrete trials of a constant-force (CF) steadiness task.

METHODS

Healthy young men (N=20, 23 ± 3yrs) and women (N=20, 22 ± 2yrs) underwent steadiness testing of the ankle dorsiflexors. The maximum voluntary contraction (MVC) force for dorsiflexion was first determined by performing 3-5 slow ramping trials until the maximal forces from two trials were within 5% of each other. The target force for the steadiness trials was set at 10% MVC. No practice trials were given. Subjects performed a sequence of ten 20s isometric constant-force trials with 40s rest between trials. Subjects had visual feedback of the exerted force and target force as bold horizontal lines on a large monitor and were instructed to match the target as steadily as possible for the whole trial. They rested completely during the 40s between trials. The first two seconds of the trials were discarded. The force fluctuations were quantified as the coefficient of variation of force (CV=SD force/mean force*100) for the first 3s, last 3s, and entire trial (15s). This allowed a within-trial and whole trial characterization of the normalized amplitude of the force fluctuations. Statistics: The CV of force was compared between the first 3s and last 3s for all trials, and across the ten consecutive trials using repeated-measures comparisons. The CV of force was also compared between the sexes (between subjects comparison).

RESULTS AND DISCUSSION

The linear trend across trials was significant, indicating a slight overall reduction in the CV across the ten trials (1.32% for trial 1 vs. 1.12% for trial 10, P=0.008, Fig. 1). Although trial 1 produced the highest average CV value, the reduction in CV from trial 1 to trials 2, 3, 4 or 5 was not significant (all P>0.15). The CV values for trials 6, 7, 9, and 10, however, were reduced compared with trial 1 (P<0.05). There were no differences in the across-trial effect between men and women (P=0.5, Fig. 2). Pooled across the ten trials, the CV of force was lower for women than men (1.03 vs. 1.36%, P=0.049, Fig. 2). Within trial effects: Pooled across all trials, the CV of force was lower in the last 3s of the trial compared with the first 3s of the trial (1.07 vs. 1.24%, P<0.001, Fig. 3). This within-trial effect was not different across trials (P=0.86) or between sexes (P=0.12).

The incremental reduction in the normalized amplitude of the fluctuations across a sequence of ten discrete trials performed over a 10 minute period suggests a small but relatively consistent effect of repeated performance of this simple task.
It appears that the amplitude of the force fluctuations are reduced, albeit slightly, even over the course of an 18s segment of a single trial. This effect does not diminish significantly over ten trials. Although the extent of the reduction in fluctuations is similar between young men and women both across and within trials, the normalized force variability overall is significantly less for women than men.

The results suggest that even for a simple, constant-force visuomotor task there is a quite rapid but subtle improvement in the ability to minimize the variability of force around a static submaximal target force, both within brief trials and across exposure to multiple trials performed in minutes. This is presumably the result of acute adjustments in brain function that rapidly minimize the difference between the force produced and the intended target force on a moment to moment basis [2].

Young women exhibited significantly better force control of the dorsiflexors than young men as evidenced by the lower CV values. This was consistent enough to be statistically significant. This is a new finding in the area of force steadiness. Although there is some information that suggests better force control for women than men [3], the small amount of literature cannot strongly suggest an unequivocal direction.

CONCLUSIONS

Young healthy adults exhibit subtle improvements in force steadiness during single trials and across multiple trials. These findings suggest the need for several practice trials in order to obtain a stable outcome measure in these subjects, and a careful selection of data segments within a trial to produce a representative outcome.

REFERENCES