THE EFFECTS OF VISUAL FEEDBACK AND AGING ON FORCE OSCILLATIONS WITHIN 0-1 Hz

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INTRODUCTION

Oscillations in motor output change in specific frequency bins and have important implications for understanding healthy aging and pathological motor control. Force output primarily comprises of oscillations from 0-4 Hz; however, most of the modulation comes from 0-1 Hz and the power within this bin is associated with force control [1,2]. Despite this, prior studies have assumed that the oscillations from 0-1 Hz respond uniformly rather than considering the presence of sub-frequencies within 0-1 Hz.

It is important to examine the modulation of sub-frequencies within 0-1 Hz because these sub-frequencies may originate from physiological processes, such as those associated with visuomotor integration and aging. For example, manipulation of visual feedback, either by removing it or changing the magnification, alters force oscillations from 0-1 Hz [1]. Additionally, age-associated differences in force control may be due to modulation of force from 0-1 Hz [2]. Furthermore, the age-associated differences in force control are exacerbated when visual feedback is magnified [3].

Our purpose was to determine whether modulation of specific sub-frequencies within 0-1 Hz contribute to changes in force control associated with manipulation of visual feedback and aging.

METHODS

Ten young adults (25± 4 yrs, 5 men) and ten older adults (71± 5 yrs, 4 men) participated and performed the following: 1) MVC with abduction of the index finger; 2) Constant force task with abduction of the index finger; 3) repetition of the MVC task. During the constant force task, we manipulated visual feedback by changing the visual angle or removing it. Changing the visual angle altered the amplitude of the force fluctuations viewed by the subject [3].

Each subject performed three trials at each visual angle (0.05°, 0.5°, 1.5°) at 2% MVC. We counterbalanced the order for the visual feedback conditions (vision and no vision) and the order of the three visual angles was random. The 2% MVC force was chosen because age-associated differences in force control are consistently evident at low-force levels [4].

Subjects were instructed to increase their force (blue line) to match the target force (red line) within 5 s, and then to maintain their force on the target as accurately as possible for 30 s. During the no visual feedback condition, visual feedback was removed after 15 s.

The middle 6 s of force data were used to calculate the mean force and the coefficient of variation. The frequency data were divided into seven bins: 0, 0.16, 0.33, 0.50, 0.66, 0.83, and 1.00 Hz and the percent of power was calculated for each bin, relative to the total power from 0-1.0 Hz.

RESULTS AND DISCUSSION

To determine whether modulation of force output within 0-1 Hz is different with and without visual feedback we compared the no visual feedback condition with the visual feedback condition at the highest visual angle (1.5°). During the no visual feedback condition, both groups exhibited greater force oscillations from 0 to 0.33 Hz and lesser oscillations from 0.66 to 1.0 Hz. In contrast, magnification of visual feedback (visual angles of 0.50° and 1.5°) decreased force oscillations from 0-0.16 Hz and increased force oscillations from 0.86-1.0 Hz (Figure 1).
Older adults demonstrated a greater increase in the variability of force with magnification of visual feedback compared with young adults (P=0.05). Furthermore, older adults exhibited differential force modulation within 0-1 Hz compared with young adults (P<0.05). Specifically, older adults exhibited greater power from 0-0.16 Hz and lesser power from 0.66-0.83 Hz (Figure 2).

We used multiple linear regression models to predict the change in CV of force at the highest visual angle (relative to the no visual feedback condition) from the change in power of the seven frequency bins within 0-1 Hz. The change in CV of force was predicted by a multiple-regression model that included the modulation at 0.16 Hz, 0.33 Hz, 0.5 Hz, 0.66 Hz, and 0.83 Hz ($R^2 = 0.8$, $P = 0.01$).

Our findings suggest that sub-frequencies in force output within 0-1 Hz are modulated with changes in visual feedback and aging. Modulation of these low-frequency oscillations may be associated with underlying processes such as central drive to the motor unit pool or breathing. The age-associated changes in low-frequency oscillations may be related to increases in motor unit discharge rate variability [5]. Additionally, our results suggest that alterations in visuomotor integration may underlie the age-associated differences in force modulation with magnification of visual feedback. This finding may be related to age-related changes in neuroanatomic structures [6] as well as the increased attentional demands associated with magnification of visual feedback.

CONCLUSIONS

Overall, examination of force oscillations within 0-1 Hz is critical for understanding the effects of visual feedback and aging on force control. Our findings have important implications for identifying underlying mechanisms associated with force control and may potentially influence the development of training strategies for individuals with motor impairments.

REFERENCES


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