Age-related differences in fMRI during weighted arm lifting

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Introduction

Functional neuroimaging in normal aging tends to show a similar pattern of age-related changes in brain activity during both motor and cognitive task, consisting in an increase and bilateralization of activation in older as compared to young subjects.[1][2] These changes have been widely interpreted as increased neural recruitment by old brain to compensate for the neurobiological effects of aging. Regarding the motor system, most neuroimaging studies have assessed the effects of normal aging on primary motor(M1) or sensorimotor(SM1) cortex activation during simple or complex motor task. There has been no study of the effects of aging on the simple daily-life motor task such as forearm lifting with and without weight.(ex. dumbell exercise). In this study, we investigated neural correlates of human brain between weighted and none-weighted arm lifting. Also we studied age-related alterations in normal aging brain when the task involves similar performance levels as in younger subjects.

Material and Methods

Subjects: We studied nineteen healthy old subjects(7 male, 12 female ; age 59~75years ; mean age 66years; all RH) and twelve young subjects (5 male, 7 female ; age 21~25years ; mean age 22.8years; all RH). Non-weighted task is right arm(dominant) lifting and weighted task is right arm lifting with 1.0kg wood object during MRI scanning.

Functional MRI: All subjects were imaged on a 3.0T clinical whole body magnet with 8ch head-coil(VHi; General Electric Medical, USA). Multi-slice BOLD images with T2*-weighted EPI sequence imaging was performed, the fMRI imaging parameters were as follows: 240×240-mm field of view, 64×64 matrix size, 31 axial slices, 4-mm slice thickness, repetition time=3000 ms, echo time = 40 ms.

Statistical Analysis: Statistical parameter map software (SPM2, Wellcome Department of Cognitive Neurology, London, UK) was used to generate activation map. One-sample and two-sample t-test for within group analysis was performed with voxel-wise intensity threshold of $P<0.01$ (FDR, corrected) and cluster size 64.

Results

Young group showed increased contralateral sensorimotor(SM1) activation during weighted arm lifting task compared to non-weighted condition (Fig. 1; (a),(b)). For old group, both contralateral and ipsilateral sensorimotor (SM1) areas showed the increased activation (Fig. 2; (a),(b)) during weighted condition. In addition, two-sample t-test between young and old group revealed significant subcortical activation (ipsilateral basal ganglia) in aging brain when performing weighted movement (Fig. 3). The voxel counts of activation area in SM1, insular, and cerebellum well demonstrated increased involvement of ipsilateral motor network in older group when the weighted task involves similar performance levels as in younger subjects (Fig. 4).

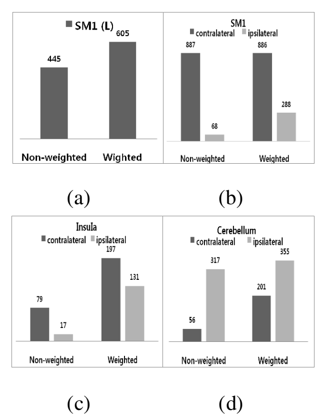

Fig. 4. Activation voxel counts of contralateral sensorimotor area in young group (a). Both contralateral and ipsilateral activation voxel counts of older subjects in SM1, insular, and cerebellum(b),(c) and (d) are shown in (b)-(d).

Discussion

Our findings demonstrate age-related alterations of brain activation which is related to weighted arm lifting. For younger group, only difference is a slight increase of activation area in contralateral SM1 cortex between none-weighted and weighted task. Activated regions of old subjects involve widespread motor areas even in none-weighted task and strong increase in activation on ipsilateral subcortical motor network in weighted task. Age-related alterations of brain activation shown during weighted arm lifting task suggest functional compensation of motor network to maintain performance level by recruiting both contralateral and ipsilateral motor areas. Especially, ipsilateral subcortical brain activations suggest that these areas are crucial circuit involved in force production. We found that age-related alterations in motor system occur to produce same force as younger subjects. These alterations in older subjects are necessary to compensate declined motor function and force production in older subjects

(a)

(b)

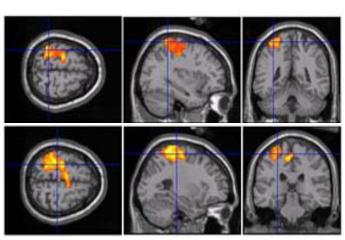

Fig. 1. Brain activation maps for arm lififting task in younger subjects. (a) non-weighted condition and (b) weighted condition

(a)

(b)

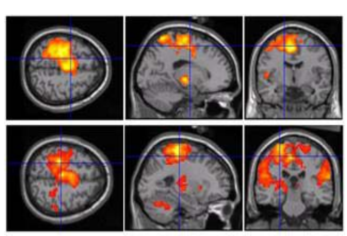

Fig. 2 Brain activation maps for arm lifting task in older subjects. (a) non-weighted and (b) weighted condition.

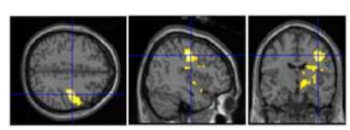

Fig. 3. Two sample t-test map between younger and older subjects for weighted arm lifting movement.

References

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