Hand grips strength effect on motor function in human brain using fMRI: a pilot study

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Abstract: Several methods of motor tasks for fMRI scanning have been evolving from simple to more complex tasks. Motor tasks on upper extremity were applied in order to excite the increment of motor activation on contralesional and ipsilateral hemispheres in brain. The main objective of this study is to study the different conditions for motor tasks on upper extremity that affected the brain activation. Ten healthy right handed with normal vision (3 male and 7 female, age range=20-30 years, mean=24.6 years, SD=2.21) participated in this study. Prior to the scanning, participants were trained on hand grip tasks using rubber ball and pressure gauge tool outside the scanner. During fMRI session, a block design with 30-s task blocks and alternating 30-s rest periods was employed while participants viewed a computer screen via a back projection-mirror system and instructed to follow the instruction by gripping their hand with normal and strong grips using a rubber ball. Statistical Parametric mapping (SPM8) software was used to determine the brain activation. Both tasks activated the primary motor (M1), supplementary motor area (SMA), dorsal and ventral of premotor cortex area (PMA) in left hemisphere while in right hemisphere the area of primary motor (M1) somatosensory was activated. However, the comparison between both tasks revealed that the strong hand grip showed the higher activation at M1, PMA and SMA on left hemisphere and also the area of SMA on right hemisphere. Both conditions of motor tasks could provide insights the functional organization on human brain.

1. Introduction
Since the number of various studies relates to usage of functional Magnetic Resonance Imaging (fMRI) has been increasing owing to non-ionization modality, it implies an importance in accommodating the enhancement of motor action for clinical research such as reorganization of motor recovery and plasticity for stroke patients [1]. Several methods of motor tasks for fMRI scanning have been evolving from simple to more complex tasks such as finger tapping [1-4], hand grip [5-8] and wrist extension [9-10]. Motor tasks on upper extremity were applied in order to excite the increment of motor activation in the brain [5-9]. These motors action usually revealed the activated areas and connectivity not only in the contralateral hemisphere but also in the ipsilateral hemisphere [11-12].
The common areas which activated in the brain for motor task are the primary motor (M1) [1], supplementary motor (SMA) [13-15], premotor cortex (PMA) [16-18], and somatosensory areas.

The importance of the study is to highlight the tasks which suitable for stroke patient and the information about functional specialization of motor activation might appropriate task to be use in the rehabilitation of strokes patients and pave the way for future studies in fMRI. The aim of this study was to identify the brain areas (activation) of motor and brain activation (% percentage of signal changes) of functional areas between normal and strong hand grips. We hypothesized that different strength of hand grips would give different activation areas of motor in brain.

2. Material and methods

2.1. Subject
This quasi-experimental study was done using the fMRI of 3 Tesla (3T) at Department of Radiology, Universiti Kebangsaan Malaysia Medical Centre (UKMMC). This study was approved by the Universiti Kebangsaan Malaysia (UKM) Ethics Committee (IEC) (NN-051-2013). Ten healthy volunteers participated in this study (3 males and 7 females, age range=20-30 years, mean=24.6 years, SD=2.21) with no neurological or physiatrist diseases. All participants were right-handed tested by Edinburg handedness inventory [19]. They were given written consent and screening forms prior to scanning.

2.2. Experimental Paradigm
Participants were trained outside the scanner to perform the hand grip exercise using a rubber ball and pressure gauge tool. This is to measure their normal and strong grip before entering the MRI. This task is important for participant in order to make sure they know and familiar with the tasks given during the scanning. Overall, pressure for normal grip are between 3-5 psi and for strong grip are approximately between 5-10 psi.

The participants performed a grip task with the right hand in the presence of visual cues by applying normal and strong grip to a rubber ball. The block design paradigm (Figure 1) consists of 12 active (normal and strong grips) and 12 rest blocks, 30s each was used in the experiment.

![Figure 1. Block paradigm for hand grips motor task.](image_url)
2.3. fmRI Data Analysis
All the functional (T2*-weighted) and structural (T1-weighted) images were analysed using Matlab R2012a (Mathworks Inc. Natrick, MA, USA) and Statistical Parametric Mapping (SPM8) software package shown in Figure 2.

Activated voxels were identified by pre-processing (realignment, normalization, and smoothing) by deriving the appropriate test statistic (T statistic) with corrected p-value = 0.05 and post processing.

Percentage of signal changes (PSC) for regions of interest (ROIs) with sphere of 5mm were analyzed using Marsbar toolbox [20].

![Figure 2. fmRI data analysis using SPM software.](image)

3. Results
Brain map analysis (Figure 3 and Figure 4) of both tasks normal and strong grips showed activation in the primary motor (M1), supplementary motor area (SMA), dorsal and ventral of premotor cortex area (PMA) in left hemisphere and primary motor (M1) somatosensory in right hemisphere.

![Figure 3. ROI of brain activation for normal grip (NG) on right and left hemispheres.](image)

![Figure 4. ROI of brain activation for strong grip (SG) on right and left hemispheres.](image)
The percentages of signal changes (PSC) in Table 1 revealed that on left hemisphere the value of activated voxels were slightly significant between normal with strong grips. The areas of activation of M1 are higher followed by area of SMA and PMA on left hemisphere shown in Figure 4.

**Table 1.** The percentage signal changes (PSC) from group analysis in the ROI at M1, PMA and SMA for normal and strong grips on left hemisphere.

| Left hemisphere | Normal Grip | Strong Grip |
|-----------------|-------------|-------------|
| M1              | 2.053       | 2.460       |
| SMA             | 1.876       | 2.269       |
| PMA             | 1.887       | 1.728       |

**Figure 5.** Percentage of signal change (%) of activated on motor areas for normal and strong grips on left hemisphere.

4. Discussion
From Figure 3 and Figure 4, it is interesting to see that both tasks normal and strong grips shown activation at the areas of M1, SMA and PMA in left hemisphere while in right hemisphere the area of M1 somatosensory was activated. This indicated the existence of ipsilaterality on right hemisphere accompanying the expected contralaterality on left hemisphere while doing the strong and normal grips task.

However, the comparison between both tasks revealed higher number of activated voxels and higher activation intensity in M1 and SMA for strong grip compared to the normal grips.

The strength of both tasks indicated that normal participants were able to do it at the range of 4 - 5 psi for normal hand grips while for strong grips were between 7-10 psi. Review from all participants stated that these simple task are easily and comfortable to be applied during the scan for about 30 sec per block. Hence, simple tasks like these may provide suitable task for stroke patient.

From Table 1 and Figure 5, PSC were higher observed in the left M1 followed by SMA and PMA for strong grip task. This was due to higher demand of force doing the strong grip task compared to the normal grip task.

5. Conclusion
Strong grip task has higher percentage of signal changes compare to normal grip. This can verify that different strength of hand grips have affected motor areas of brain activation on left and right hemispheres. Both conditions of motor tasks could provide insights the functional organization on human brain and could contribute to medical decision making in neurological and rehabilitation treatment for stroke patient.
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