Neural Correlates of archery Motor Imagery

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Introduction

Motor imagery was defined as the metal rehearsal of simple or complex motor acts that is not accompanied by physical movement[1]. Previous studies provide evidence that motor imagery is associated with dynamic changes between performance and the mental rehearsal period that precedes the voluntary movement as an important difference between highly trained athletes and beginners. [2]. However, static sports such as motor imagery of archery and rifle shooting are seldom studied[2]. In the present study, we compared the neural correlates of expert archers and nonarcher during mental rehearsal of archery and observed whether the neural networks of expert archers are more focused and efficiently organized than those of nonarcher.

Subjects and methods

Subjects: Eighteen elite archers (6 males, 12 females) and 18 non-archers (8 males, 10 females) were included in this study. The mean age was 27.2 years (± 7.9 years, standard deviation) for the elite archers and 24.0 years (± 3.2 years) for non-archers. The mean educational level was 14.7 ± 1.4 years for the elite archers and 14.7 ± 1 years for non-archers. There were no significant differences between the non-archers and elite archers regarding age or education ($P = 0.9$, $P = 0.9$, respectively).

Task: The imagery task was designed in a block manner. For the active imagery paradigm, the participants were instructed to mentally rehearse their archery shooting from a first person perspective, as they would on a practice field, with each shot including six phases: bow hold, drawing, full draw, aim, release, and follow-through, with the cycle repeated every 7 to 8 s. The active imagery condition was tested against the control condition. For the rest control condition, the participants were told to project themselves into a restful state, such as sitting quietly on a beach, and taking care not to wander mentally or move physically during the study. Participants were told to image the requested movement kinesthetically when they heard the pre-recorded voice say “start,” and to change to the resting imagery when they heard the voice say “rest.” The sound cues were presented through sound-insulated earphones (Silent Scan, Avotec, Jensen Beach, FL) connected to the computer audio output. The dB level of the tones, as heard from the earphones, was checked before each session, and was approximately 80 dB in each case. The participant would alternate the imagery as follows: rest, archery, rest, archery, etc., with each condition repeated 4 times during one run. The entire functional scanning run lasted approximately 4 min.

fMRI: The fMRI task paradigm was used imagery task with block design. Functional magnetic resonance images were acquired using a 3.0T GE HD scanner(EPI, TR=3000ms, TE=40ms, matrix=64x64, Thickness=3.0mm, FOV=192mm, no gap). Anatomical images were acquired using 3D-FSPGR sequence(TR=7.8ms, TE=3ms, matrix=256x256, no gap).

Data analysis: Statistical parametric map software (SPM2, Wellcome Department of Cognitive Neurology, London, UK) was used to generate activation map. In fMRI data within-group analysis, the resulting statistical maps were entered into a second-level random effects combining all single-subject data for each group, and t-test were performed to assessed differences within (one-sample t-test) and between groups (two sample t-test). Correction for multiple comparisons was carried out at the voxel level using false discovery rate (FDR) of 0.05. Clusters of fewer than 20 voxels were ignored. A one-sample t-test was used to calculate the main effect within the group of subjects. Two-sample t-test was used to calculate the difference of group (novice vs expert athletes).

Results and Discussion

In non-archers, motor imagery showed the premotor areas, and supplementary motor areas (SMA) including the pre-SMA and inferior parietal cortex bilaterally. The left inferior frontal cortex (IFC) was also activated. In contrast, elite archers displayed significant activation in SMA bilaterally. Elite archers showed significant asymmetry in SMA, with left dominance compared with the non-archer group (Fig1). Between-group analysis of the imagery task revealed that the non-archer group exhibited significantly higher activation than did the elite archer group in the primary motor cortex, parietal cortex, basal ganglia, and cerebellum (Fig. 2). No region was significantly more activated in the elite archers group than in the control group. The present study demonstrates an important difference between brain activation in non-archers and elite archers during mental rehearsal of archery. the current study demonstrates an important difference between brain activation in novices and elite archers during mental rehearsal of archery. Our results show that the neural networks of expert archers is more focused and efficiently organized than those of nonarchers. That is, the motor programs of experts are more efficiently organized and thus they require less energy to execute. These results are consistent with the notion of relative economy in the cortical processes of expert athletes such as golfers and marksmen, relative to controls, during the specific challenge with which they are highly practiced. Therefore, the relative economy of motor planning at the level of central neural programs in the skilled group could contribute to greater consistency of the involved cognitive and motor processes over a much wider range of stressful environment such as Olympic game.

References

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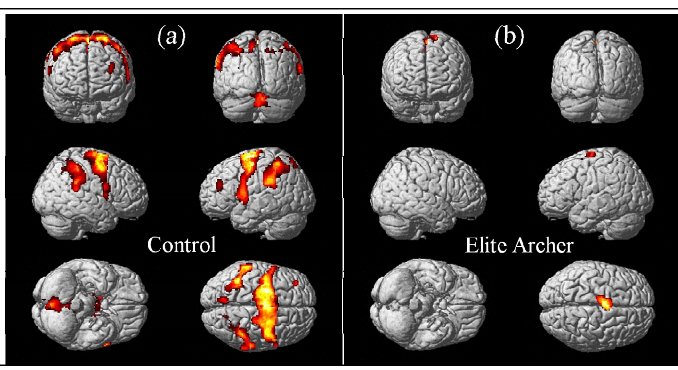

Fig 1. Brain activation maps contrasted from archery imagery minus control task for nonarchers (a) and elite archers (b) (p<0.05, FDR)

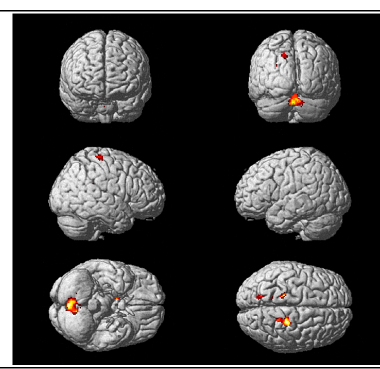

Fig 2. Brain activation maps derived from direct comparison between non-archers and elite archers (p<0.05, FDR)