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The effect of handedness on electromyographic activity of human shoulder muscles during movement

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Abstract

The aim of the study was to investigate whether there was a difference in the electromyographic (EMG) activity of human shoulder muscles between the dominant and nondominant side during movement and to explore whether a possible side-difference depends on the specific task. We compared the EMG activity with surface and intramuscular electrodes in eight muscles of both shoulders in 20 healthy subjects whose hand preference was evaluated using a standard questionnaire. EMG signals were recorded during abduction and external rotation. During abduction, the normalized EMG activity was significantly smaller on the dominant side compared to the nondominant side for all the muscles except for infraspinatus and lower trapezius ($P \leqslant 0.002$). In contrast, during external rotation, higher EMG activity was seen in the supraspinatus, infraspinatus, lower and upper trapezius and latissimus muscles of the dominant side ($P \leqslant 0.01$). We demonstrated a side-difference in shoulder muscle activity, which was dependent on the type of motion carried out, suggesting a qualitative difference in the activation of muscles during the two types of movement. Dynamic abduction has the characteristics of a dominant arm task (i.e., task performed almost exclusively by the dominant arm) and reduced muscle activity for the dominant side during abduction indicates a dominance-related advantage in arm dynamics.

Keywords: Electromyography; Shoulder joint; Handedness

1. Introduction

Handedness is a well-known behavioural phenomenon, defined as the tendency to prefer the use of a consistent hand in performing selected tasks.

Physiological and anatomical asymmetries at different levels of the central nervous system controlling the upper extremity have been established. Handedness-related asymmetries exist in the motor cortex (Volkmann et al., 1998) and authors have reported functional asymmetries in some cervical spinal pathways, including the corticospinal tract (Semmler and Nordstrom, 1998; Tan, 1989a; Tan, 1989b). Also, differences in peripheral nervous pathways have been found such as higher sensory detection thresholds and higher conducting velocities for the motor nerve in the dominant arm (Friedli et al., 1987; Sathiamoorthy and Sathiamoorthy, 1990), although results have not been consistent (Tan, 1985).

In addition to asymmetries in the nervous system, side-differences exist in the muscles. Long-term preferential use of muscles of the dominant side of the body may result in changes of muscle fiber composition with a higher prevalence of slow twitch type I fibers (Fugl-Meyer et al., 1982). The shift towards slow twitch fibers is associated

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with changes in motor unit control properties, which results in reduced firing rates of motor units on the dominant side (Adam et al., 1998, 1989). In line with these results, some authors have demonstrated differences in EMG manifestations of muscle fatigue in the upper trapezius muscle with the dominant side showing less fatigue (Farina et al., 2003).

Although several authors have assessed EMG activity of the shoulder muscles with different approaches in normal subjects, effects of side-dominance have remained largely undetermined (Arwert et al., 1997; Bagg and Forrest, 1986; Inman et al., 1944; Jobe et al., 1983, 1984; Kronberg et al., 1990; Nuber et al., 1986; Pearl et al., 1992; Ryu et al., 1988; Saha, 1956; Shevlin et al., 1969). To our knowledge, the only study on EMG amplitude and side-dominance in the upper extremities is by Bagesteiro and Sainburg in which they examined kinematics and EMG from the upper arm during reaching movements (Bagesteiro and Sainburg, 2002). With equal kinematics, they found side-differences in torque patterns and EMG profiles. However, the study was restricted to assessment from just two shoulder muscles.

From a clinical point of view, knowledge of possible dominant-related differences in EMG activity of shoulder muscles from healthy subjects could be useful in studies on motor patterns in subjects with and without shoulder problems. In some previous studies, results have been pooled from dominant and nondominant side and in others information about hand preference has not been included at all. Some of the diversity in the results of EMG studies on shoulder patients may be due to the lack of attention to handedness (Alpert et al., 2000; Ludewig and Cook, 2000; Michaud et al., 1987; Peat and Grahame, 1977; Reddy et al., 2000).

In accordance with the evidence of physiological and anatomical asymmetries associated with side-dominance, the purpose of the present study was to investigate whether there was a handedness-related difference in the EMG activity of different shoulder muscles between the dominant and nondominant side during different standardized movements in healthy subjects. Moreover, we aimed to explore whether a possible side-difference may depend on the specific task.

2. Materials and methods

2.1. Subjects

Twenty healthy subjects without any reported shoulder problems participated in the study. There were 3 females and 17 males, aged 23–57 years (median = 37 years). Seventeen out of 20 were right-hand dominant. The hand preference of each subject was determined using a modified Edinburgh handedness inventory (Oldfield, 1971), resulting in a laterality quotient (LQ) ranging from −100 (complete

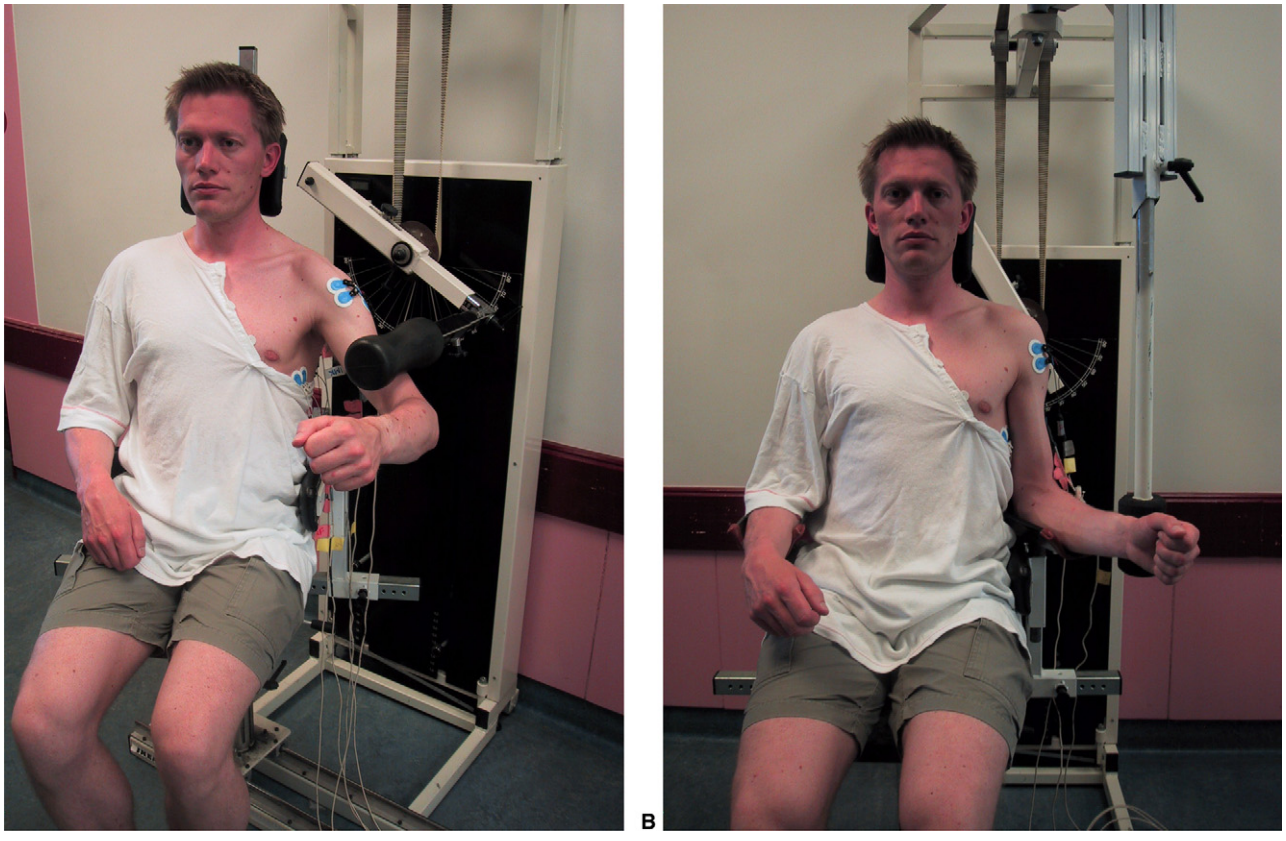

Fig. 1. *Experimental set-up*. Subjects make A: dynamic abduction (0–110°) or B: dynamic external rotation (−80 to 40°) in a custom-built shoulder machine adjustable to different loads and designed to record force and position during motion.