Clinical Neurophysiology 124 (2013) 346–353

Contents lists available at SciVerse ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

An age-related change in the ipsilateral silent period of a small hand muscle

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ARTICLE INFO

Article history:
Accepted 11 July 2012
Available online 9 August 2012

Keywords:
Ageing
Transcranial magnetic stimulation
Ipsilateral silent period
Motor cortex
Transcallosal inhibition

HIGHLIGHTS

- This study reports a strong and reproducible effect of ageing on ipsilateral silent period as an index of transcallosal inhibition.
- iSP onset latency is delayed in older adults and transcallosal conduction time is lengthened.
- Laterality may interfere with iSP onset latency in young adults but not in older adults, whereas women display shorter latencies than men.

ABSTRACT

Objective: To establish the presence or absence of an age effect on the ipsilateral silent period (iSP) for the abductor pollicis brevis (APB) muscle in healthy subjects.
Methods: Twenty young adults (10 men, 10 women; age range: 20–40) and 20 older adults (10 men, 10 women; age range: 50–70) were matched by age (+30 years), gender and height (±5 cm). All were right-handed. We investigated the iSP for the APB by applying transcranial magnetic stimulation (TMS) and recording surface electromyograms. The contralateral motor-evoked potential (MEP) onset latency, the iSP onset and end latency (iSPOL and iSPEL) were measured and the iSP duration (iSPD) and transcallosal conduction time (TCT) were calculated. We evaluated the correlation between age and iSP, the latter's intra- and intersession reproducibility and potential influencing factors.
Results: Mean iSPOL, iSPEL and TCT values were significantly greater in older adults (both men and women) than in young adults. Intra- and intersession reproducibility was good. The mean left-side iSPEL and iSPD were longer than the right-side mean values in young adults but not in older adults. In both age groups, women displayed shorter latencies than men.
Conclusions: There is a strong effect of age on iSP parameters.
Significance: Our iSP results may evidence a decrease in transcallosal excitability with age, rather than slowing of the transcallosal interneuron conduction velocity.

1. Introduction

The corpus callosum is known to be an essential structure in bimanual motor coordination (Bonzano et al., 2008; Eliassen et al., 2000). Indeed, Meyer et al., (1995; 1998) have shown that patients with agenesis or alteration of the corpus callosum present mirror movements and are unable to perform unilateral arm movements (Hübers et al., 2008). As with any central nervous system (CNS) structure, the corpus callosum changes with age. By using magnetic resonance imaging (MRI), Takeda et al. (2003) demonstrated significant thinning of the corpus callosum in the sagittal plane in over-65 subjects. Likewise, Ota et al. (2006) reported a significant, age-related diffusion tensor imaging change centred on the genu, the rostral body and the isthmus of the corpus callosum. By investigating the effect of age on a visuomotor task with the Poffenberger paradigm, Jeeves and Moes (1996) reported greater interhemispheric transfer time differences in the elderly. Moreover, Ryberg et al. (2006) and Thomann et al. (2006) have pointed out the clinical significance of corpus callosum atrophy in a mixed elderly population, with a decline in cognitive and motor performances. Regarding the physiological basis of transcallosal motor coordination, studies using transcranial magnetic stimulation (TMS) have reported that it is possible to elicit transcallosal inhibition (Ferbert et al., 1992). With paired-pulse stimulation on the two primary motor cortices, a conditioning shock over the originating hemisphere and a delayed test shock on the contralateral target, several researchers have reported a significant reduction

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1388-2457/$36.00
http://dx.doi.org/10.1016/j.clinph.2012.07.006

in motor-evoked potential (MEP) amplitude - an indication that inhibitory interneurons had been recruited (Chen et al., 2003; Ferbert et al., 1992; Gerloff et al., 1998; Hanajima et al., 2001). By using this neurophysiological technique, Talelli et al. (2008) found that task-related increases in interhemispheric inhibition appeared to diminish with advancing age. Investigation of the ipsilateral silent period (iSP) evoked by unilateral TMS and superposed on a mild, ipsilateral voluntary contraction constitutes another means of evaluating inhibitory, transcallosal pathways. The iSP onset latency and duration are measured, rather than the percentage MEP decrease. Moreover, the transcallosal conduction time (TCT) can be calculated by subtracting the MEP latency obtained for contralateral stimulation from the iSP onset latency. It has been reported that the TCT is lengthened in various white matter pathologies, such as multiple sclerosis (Boroojerdi et al., 1998; Höppner et al., 1999; Jung et al., 2006; Manson et al., 2006). Although several studies have sought to determine the effects of ageing on intracortical inhibitory or facilitatory circuits (Avanzino et al., 2007; Chen et al., 2003; Oliviero et al., 2006; Peinemann et al., 2001; Smith et al., 2009; Talelli et al., 2008; Todd et al., 2010), the effect of age on the iSP has been poorly documented. To the best of our knowledge, the study by Lo and Fook-Chong (2004) is the only one to have addressed this matter. By evoking an iSP in leg muscles, Lo and Fook-Chong compared the iSP onset latency in three groups of healthy subjects (20–40, 41–60 and 61–80 years of age) and noted a slight (but not statistically significant) reduction in the mean iSP onset latency. However, motor control and corticospinal pathways for leg muscles are very different from those of the arm muscles in general and hand muscles in particular. In view of the lack of data concerning hand muscles and the importance of transcallosal motor coordination in bimanual movements (Eliassen et al., 2000), we sought to determine how age may impact the iSP in older adults in comparison with young adults.

2. Materials and methods

2.1. Subjects and ageing model

After successful completion of the French legal and ethical procedures for the approval of biomedical research in human volunteers, we recruited 40 right-handed subjects: 20 men and 20 women, distributed equally between young adult (20–40) and older adult (50–70) age groups. Each young adult was matched with an older adult by gender, age difference (30 ± 3 years) and height (height ± 5 cm). All subjects were given detailed information on the study's objectives and procedures and provided their written, informed consent. Right handedness was assessed by using a modified Edinburgh inventory (Oldfield, 1971), with a special focus on consistency/inconsistency. Great care was taken when assessing the health status of the volunteers (especially for the older adult group). Cognitive decline (known to interfere with corpus callosum functioning (Ryberg et al., 2006)) and memory disturbance were excluded by use of a French-language adaptation (Derouesné, 2001) of the Mini Mental State Examination (MMSE) (Folstein et al., 1975); a score below 27 out of 30 was a major exclusion criterion, as was the presence of metallic implants known to interfere with transcranial magnetic stimulation (Rossi et al., 2009). Before inclusion in the study, each subject's medical history was screened for any treatments or neurological diseases that could potentially modify motor cortex excitability. Bearing in mind the influence of the ovarian hormone cycle on motor cortex excitability (Smith et al., 2002; Hausmann et al., 2006), experiments in young adult women were carried out during the early phase of their menstrual cycle, following the menses. All the young women used a physical contraceptive. All the women in the older adult group were menopaused and were not undergoing hormone replacement therapy.

2.2. Electromyographic recordings

Surface electromyograms (EMGs) were recorded bilaterally for the abductor pollicis brevis (APB) muscle with a silver-silver chloride self-adhesive electrode (9013SO24, Alpine Biomedical Inc, Villebon sur Yvette, France) in a belly-tendon montage, with the active electrode over the belly of the muscle. The APB was chosen because previous work (Jung and Ziemann, 2006) had suggested that its iSP corresponds better to transcallosal inhibition than that of the first dorsal interosseous muscle (FDI), with almost no contamination from ipsilateral corticospinal descending pathways. A ground electrode was also affixed close by each recording site. Surface EMG signals were amplified, bandpass-filtered (10–2 kHz), sampled at 10 kHz (enabling time measurement with a precision of 0.1 ms) and stored for later analysis using an in-house customized electrophysiological signal conditioner (Keypoint, Dantec Medical Inc., Copenhagen, Denmark).

2.3. Transcranial magnetic stimulation

Transcranial magnetic stimulation (TMS) was generated by a Magpro X100 (Magventure Inc, Farum, Denmark) delivering a biphasic single pulse. Preliminary experiments performed in our lab had revealed that an iSP occurred more frequently with biphasic pulse than with a monophasic one. The magnetic field was applied by using a figure-of-eight coil (2×7.5 cm diameter, CB-60, Magventure) positioned perpendicular to the central sulcus and flowed in a posterior-to-anterior direction, in accordance with Brasil-Neto et al. (1992) and Balslev et al. (2007). The coil was moved over the scalp until the site eliciting ABP MEPs with the largest amplitude was found. This ‘‘hot spot'' was marked on the tight silicone pool cap and strapping was applied in order to avoid slippage. Maintenance of the coil over the hot spot was checked after each experimental session by comparing the MEP amplitude in response to a single pulse shock with the reference amplitude obtained at the beginning of the session. The resting motor threshold (rMT) was defined as the percent of maximal stimulator output intensity needed to evoke MEPs with an amplitude >50 μV in at least five out of ten trials with the muscle relaxed. Lastly, 160% of the individual rMT value was chosen to evoke the iSP, in accordance with Sommer et al. (2006).

2.4. Experiment protocol

The subject sat in a comfortable chair with a headrest and straps to maintain the general posture and arm posture. The room was quiet and air conditioned at 21 °C. Although a previous study (Strutton et al., 2003) has reported that motor cortex excitability might not be subject to circadian variation, all experiments were performed during the afternoon, in order to prevent any potential chronobiological effects on the iSP. During the first session (day 1), the ethics procedures, clinical examination, handedness questionnaire and MMSE were administered prior to the TMS and iSP measurements. In order to record the iSP, subjects had to maintain a slight, unilateral, voluntary muscle contraction by means of an EMG visual feedback system and an maximum EMG peak-to-peak amplitude of 1 mV. Next, magnetic stimulation was performed over the ipsilateral motor cortex. Stimulation was applied so as to obtain 9 consecutive iSPs (defined as a true electrically silent period, i.e. without any detectable EMG activity). Subjects rested between each contraction in order to prevent the occurrence of muscle fatigue. To test the reproducibility of all data, a second session (day 2) was performed one week later (and about one month