



Non-invasive assessment of the gracilis muscle by means of surface EMG electrode arrays

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1. INTRODUCTION

Several techniques for the treatment of the end-stage faecal incontinence are available nowadays. One of the widely accepted procedures is graciloplasty, both stimulated and non-stimulated. Graciloplasty consists of the transposition of one or both (for total anorectal reconstruction) gracilis muscles from their natural location in the medial part of the thigh into the perineum. During that procedure the distal tendon is divided, the muscle body is freed from the surrounding tissues and the muscle is brought up to the perineum and wrapped around the anal canal forming alpha or gamma loop and finally sutured to uni- or ipsi-lateral ischial tuber or skin, depending on the preferences of the surgeon and technical possibilities. The crucial part of the procedure is the preservation of the most proximal neurovascular bundle which in normal conditions provides most and after transposition all vascular and neural supply to the body of the muscle. Since the point where innervation enters the body of the muscle will become the point which limits the dissection, the localisation of the proximal bundle determines the length of the body muscle available for the creation of a neosphincter. This is why the innervation point matters so significantly for the technical feasibility of surgery.

At the moment, the incision of the thigh to expose the gracilis is performed only on the basis of standard anatomical data, experience and the surgeon's preference. The authors suggest that a more accurate knowledge of the anatomical characteristics of the muscle before the incision would provide useful information to the surgeon. A precise localization of the innervation zone (IZ) of the muscle would give us some significant advantages.

2. METHODS

Non adhesive arrays carrying 16 equally spaced electrodes (10 mm interelectrode distance) were used in this study on 15 healthy male volunteers (age: 24.1 ± 2.8 years, height: 176.4 ± 2.8 cm, weight: 69.8 ± 2.8 kg, mean \pm SD) recruited at LISiN. The subjects were laying supine on a bed with the legs opened at an angle of 15° with respect to the medial sagittal plane (30° between the legs), and were asked to contract the gracilis against a resistance placed between the knees.

A line was drawn between the medial epicondylis of the tibia and the palpated edge of the gracilis to help electrode placement. Only the most proximal muscle portion (16 cm) was investigated. The electrode array was placed parallel to this line, with the first electrode most proximal to the inguinal fold (Fig. 1). The distance between the IZ location and the inguinal fold (referred to from now on as AbsDist) was measured for each of three maximal contractions performed by each muscle. This distance was also divided by the thigh length in order to obtain a percentage value of the IZ position with respect to the total thigh length (referred to from now on as RelDist).

The EMG signals were amplified (EMG-16 amplifier, OT Bioelettronica, Rivarolo, Torino, Italy), sampled at a rate of 2048 Hz per channel and stored on a PC after 12 bit A/D conversion. A visual inspection of the identified MUAPs was performed in order to find the location of the IZ of the motor units (MUs). The statistical analysis was performed with a two way analysis of variance (ANOVA) with Student Neuman-Keuls (SNK) post-hoc comparison with side and trial as factors. A matched pairs Wilcoxon test was performed to compare the mean IZ distances over the three MVC trials. In all cases the probability of having type 1 errors (α) was set to 0.05.

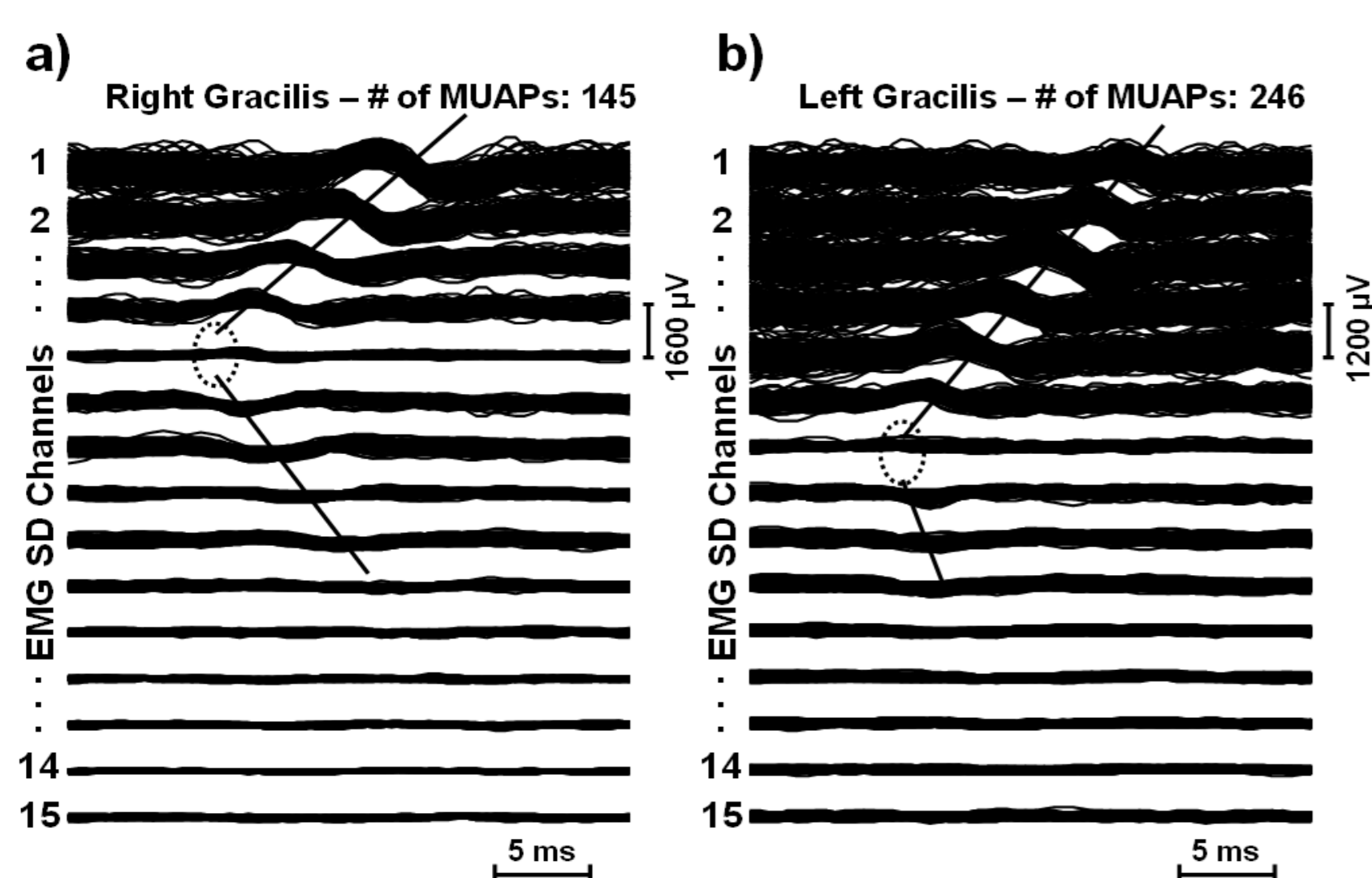


Figure 3. Examples of MUAPs extracted, classified as belonging to the same MU and superimposed. The innervation zones are indicated. a) Right side, b) Left side.

4. CONCLUSIONS

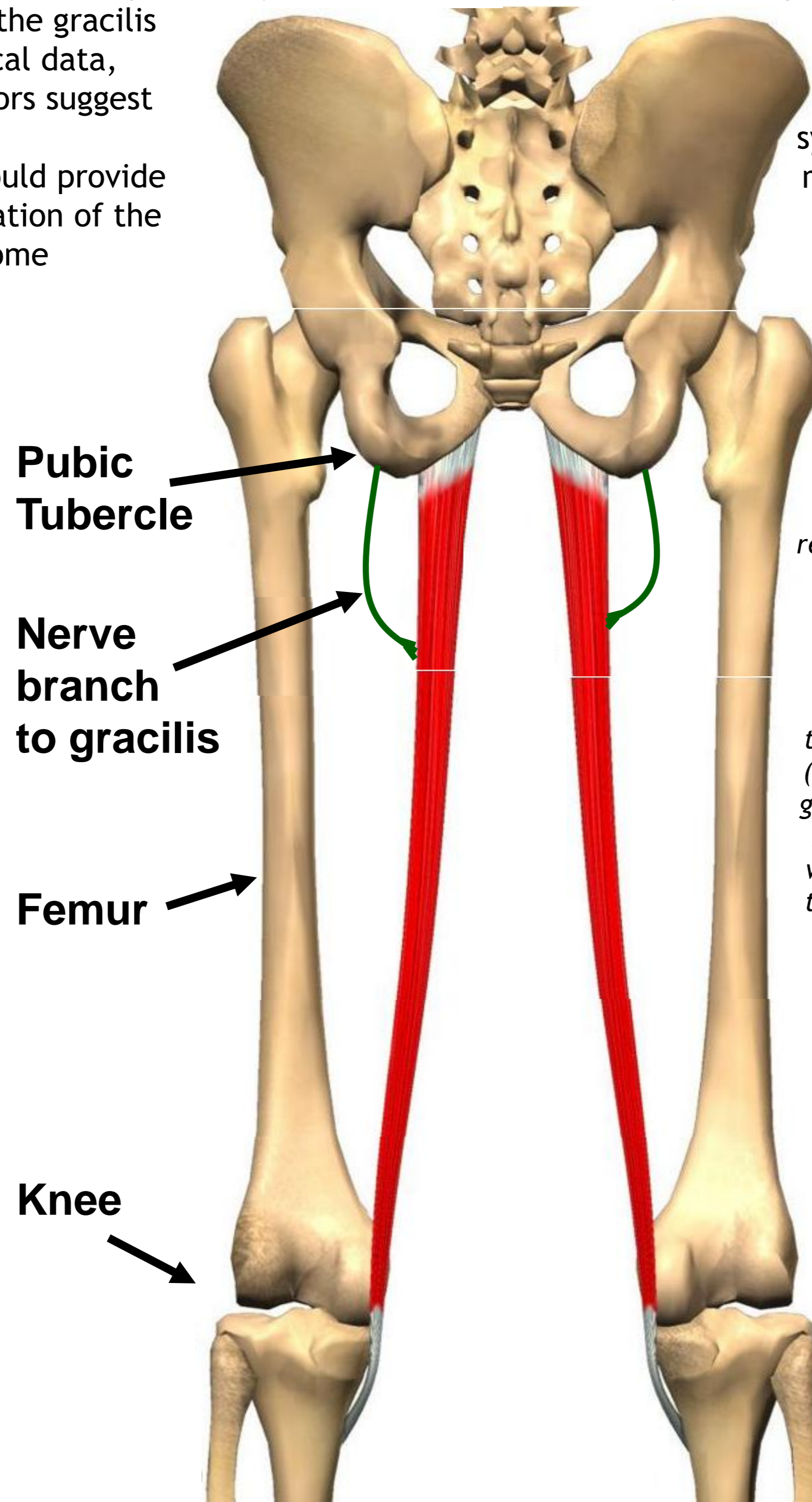
The main objective of this study was to demonstrate asymmetry between the IZ locations of the right and left gracilis muscles and thus justify preoperative evaluation of innervation zones. It is also important to notice that such differences (up to 3.6 cm) were detected in highly homogeneous group of subjects. Surface EMG allows the localisation of the innervation zones of gracilis muscle. We suggest that sEMG performed preoperatively would give information helpful in planning gracilis muscle transposition. Direct impact of that method on final outcome of dynamic graciloplasty remains to be investigated.

5. REFERENCES

- [1] Bottin A, Cescon C, Nowakowski M, Herman RM. Non-invasive Assessment of the Gracilis Muscle by Means of Surface Electromyography Electrode Arrays. J Surg Res. In press
 [2] Gazzoni M, Farina D, Merletti R. A new method for the extraction and classification of single motor unit action potentials from surface EMG signals. J Neurosci Methods. 2004 Jul 30;136(2):165-77.

6. ACKNOWLEDGEMENTS

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A preliminary localisation of the muscle IZ would shorten the intraoperative time by faster isolation of structures of interest.

Moreover, the localisation of the most proximal IZ is not symmetrical, it might be very important to choose the muscle with more proximal localisation to have more muscle body available for the creation of a neosphincter. In this study the multichannel surface EMG technique was applied to localize the IZ of both gracilis muscles in a number of subjects [Bottin et al., 2006].

Figure 1. Anatomical representation of the gracilis muscles; the pubic tubercle (origin of the gracilis), the tibial tuberosity (insertion of the gracilis), and the nerve branches which innervate the two muscles are shown.

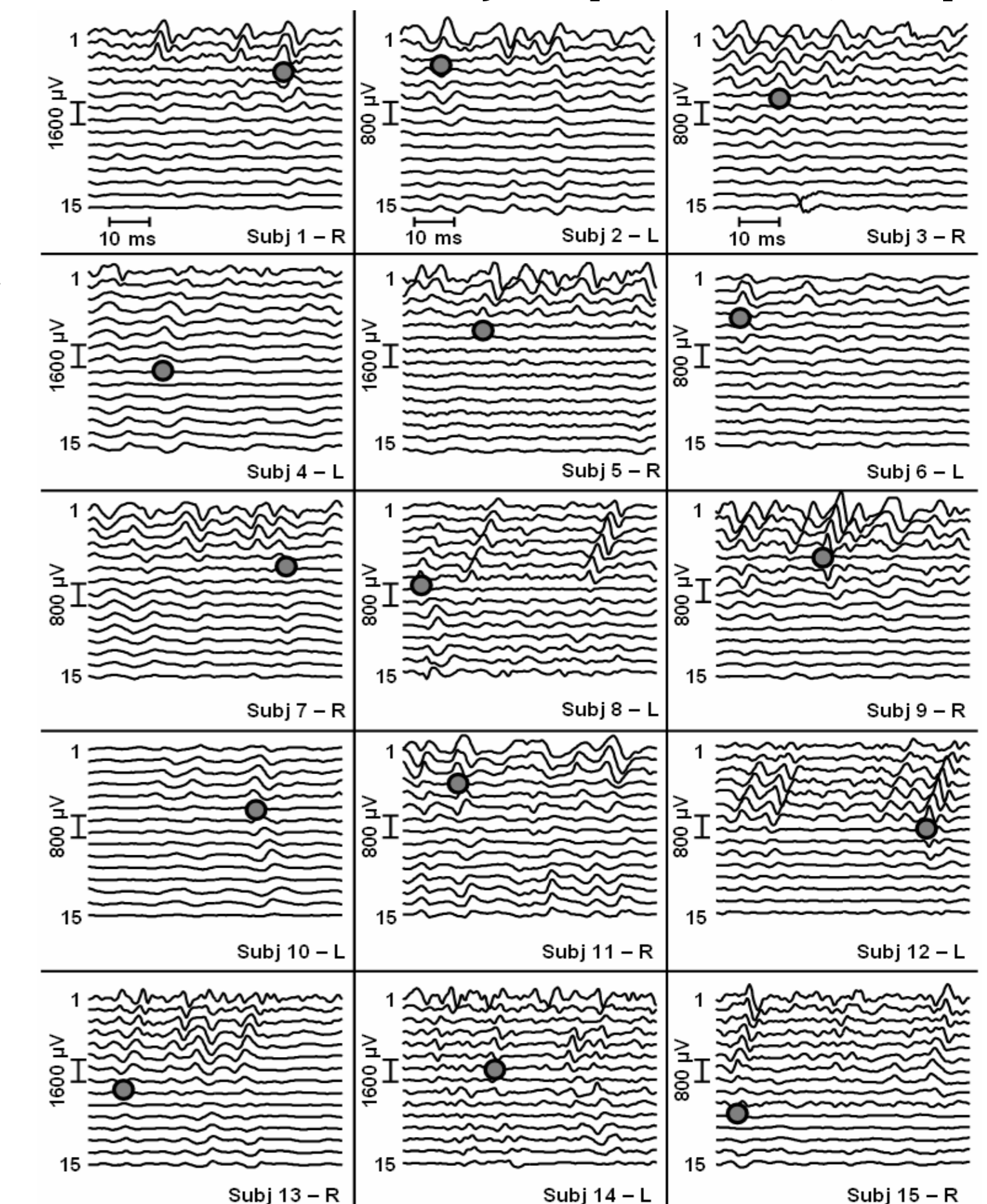


Figure 2. Examples of EMG signals detected from the 15 tested healthy male subjects. In all cases it is possible to visually identify the innervation zone location, as the position where the potentials start their propagation towards the pubis and the knee, with opposite polarity (indicated in each panel as a dark circle for a representative MUAP). Electrode 1 was the most proximal, as it was placed at a distance of 0.5 cm from the inguinal fold. I.E.D = 10 mm.

3. RESULTS

Some examples of the detected signals are shown in Fig. 2, showing the good quality of the acquisitions for all the tested subjects. Fig. 3 shows examples of single MUAP firings identified, extracted and superimposed by means of a decomposition algorithm [Gazzoni et al. 2004]. A two-way ANOVA was performed on the IZ distance (both absolute and in percentage of the thigh length) from the inguinal fold, with the side (left or right) and the trial as fixed effects. No statistically significant differences were found among the distances in the three trials, which is an index of good repeatability, while the effect of the side was significant (post-hoc SNK: $p < 0.05$ for both RelDist and AbsDist). Since the effect of the trial was not relevant, a Wilcoxon matched pairs test was performed on the mean values of the distances over the three trials. The results showed that there was a statistically significant difference between the sides (more proximal IZs on the left side, $p < 0.05$ for both RelDist and AbsDist; Fig. 4) with a difference of about 2-3% of the left leg with respect to the right leg (corresponding to about 10 mm; see Fig. 4).

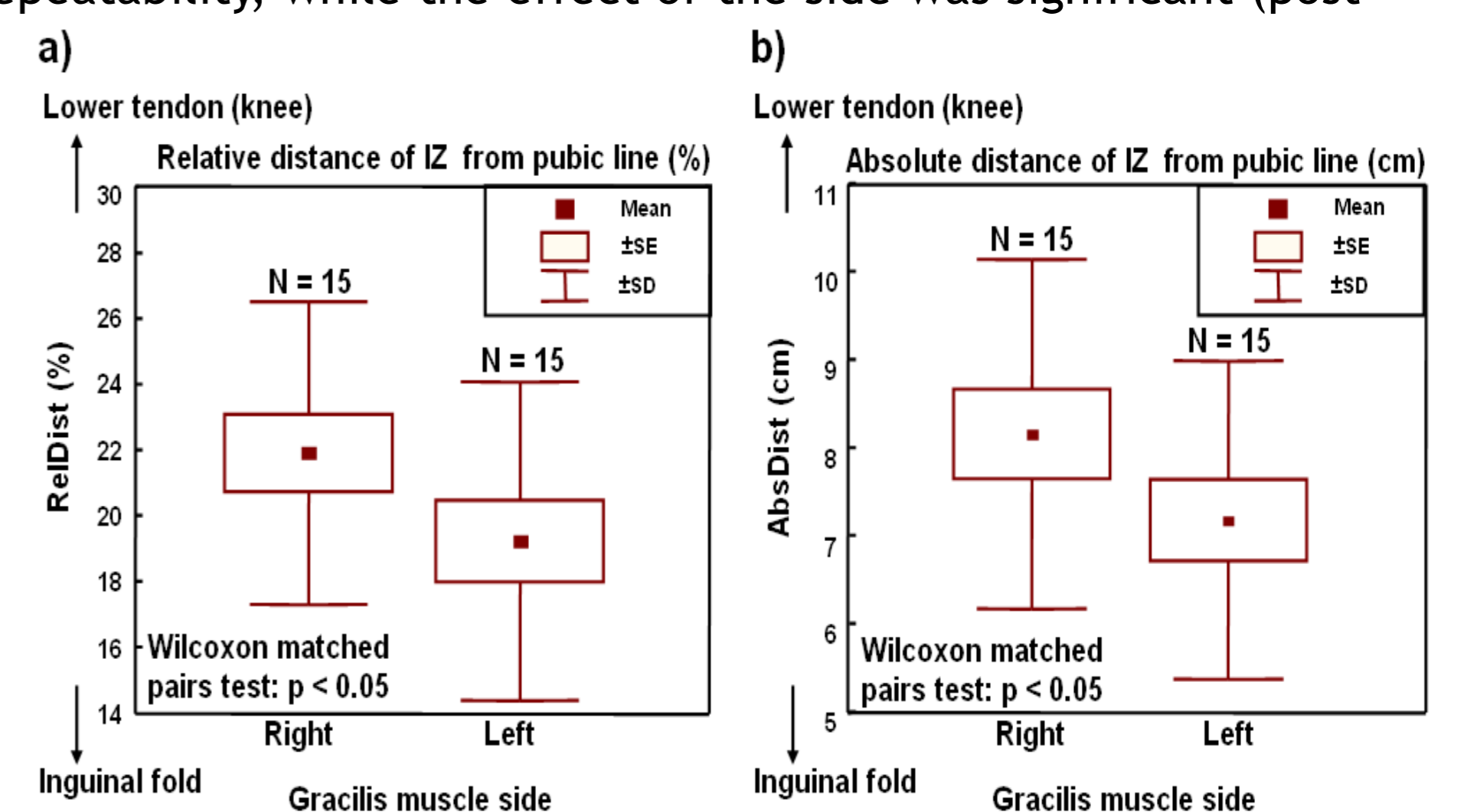


Figure 4. Distributions of the distance of the IZ from the inguinal fold in the left and right gracilis muscles for the 15 subjects. The percentage (with respect to the total thigh length; RelDist) and absolute values (AbsDist) of this distance for the three different trials are shown for the 15 subjects (panels a and b respectively). Mean, standard error (SE) and standard deviation (SD) are shown. More proximal IZs were found on the left side (Wilcoxon matched pairs test, $p < 0.05$ for both AbsDist and RelDist).