Original article (short communication)

Technical application and the level of discomfort associated with an intramuscular electromyographic investigation into gluteus minimus and gluteus medius.

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Abstract (181/250 words)

Our current theoretical understanding of gluteus minimus (GMin) and gluteus medius (GMed) function is primarily based on cadaveric studies and biomechanical modelling. There is an absence of electromyographic (EMG) research that aims to verify this understanding, particularly in relation to the potentially unique functional roles of structurally distinct segments within GMin (anterior and posterior) and GMed (anterior, middle and posterior). The aim of this paper is to provide a comprehensive technical description for inserting intramuscular EMG electrodes into uniquely oriented segments of GMin and GMed; and to report the levels of discomfort associated with gluteal intramuscular electrode insertions. Fifteen healthy volunteers took part in a series of walking trials after intramuscular EMG electrodes were inserted into segments of GMin (x2) and GMed (x3) according to previously verified guidelines. Visual analogue scores following walking trials at comfortable and fast speed indicate that discomfort levels associated with these insertions were low (2.4 ± 1.4 and 1.6 ± 0.7 respectively). The technical descriptions and illustrations provided in this paper will allow trained intramuscular electromyographers to insert electrodes into these muscle segments with confidence.

Keywords

Electromyography; buttocks; hip; gluteal; pain measurement.

Introduction

Gluteus medius (GMed) and minimus (GMin) have commonly been described in anatomical studies as having three (anterior, middle and posterior) and two (anterior and posterior) segments respectively with uniquely oriented fibres [1], supporting previous descriptions of functional differentiation within these muscles [2]. However, the ability of these segments to function independently and their role in function and dysfunction at the hip joint has not been established due to a paucity of electromyographic (EMG) studies [1, 3]. This lack of research is largely due to the technical expertise required to insert intramuscular needles into relevant segments of these muscles, particularly given the proximity of posterior GMin to the superior gluteal neurovascular bundle (NVB) [4], and the perceived pain, discomfort or anxiety that may be associated with fine wire electrode insertions [5]. It is only recently that guidelines for electrode placement have been validated in cadaveric specimens [3]. The aim of this paper was to provide a comprehensive description of fine wire electrode insertions in segments of GMed and GMin *in-vivo* and to report participant discomfort levels.

Methods

Approval was obtained from the University Human Ethics Committee to recruit 15 healthy young adults (9 male, 6 female, mean age 22.5 years) for this study.

Bipolar intramuscular electrodes were prepared from two stainless steel, Teflon® coated wires (A-M Systems, Washington, USA) according to the method of Basmajian and Stecko [6], and inserted into a 23 gauge hypodermic needle. Needle (and wire) lengths were 5cm (20cm) for

GMed anterior and GMed middle, 7cm (20cm) for GMed posterior and GMin anterior and 9cm (25cm) for GMin posterior. After manufacture, electrodes were sterilized in an autoclave.

For all measurements and electrode insertions subjects were placed in a side lying position on a plinth, with hips and knees in 45° flexion, and pillow between the knees for comfort. This allows for greatest access to all insertion sites without having to change positions. Electrode insertions guidelines were developed with reference to real time ultrasound (RTUS) imaging *in-vivo*; anatomical texts and papers and examination of cadaver specimens as described previously (Fig. 1) [3].

Insert Figure 1 here

RTUS imaging was used to determine the location of each segment, the path of the needle and the depth of the insertion. Ultrasound imaging has been previously reported as a valid method for judging the depth of electrode insertions into a desired muscle belly [7]. Color Doppler was used for viewing the NVB prior to posterior GMin insertions (Fig. 2B). The electromyographer stood posterior to the participant and the RTUS transducer was aligned in the transverse plane, and placed slightly anterior to the insertion site. A sterile environment was maintained around electrode insertion sites through the use of sterile gloves, cleansing of the insertion site and RTUS transducer with an alcohol swab and application of sterile ultrasound gel. The insertion path was then scanned to ensure that all relevant muscles, fascial and bony planes and NVBs at each site were identified prior to insertion. The investigator inserted the wire and needle unit until the tip of the needle was observed on the RTUS monitor to be resting in the desired muscle belly.

Electrodes were inserted from anterior to posterior (see sequence below) to avoid subsequent displacement of previously inserted electrodes. Insertion paths for each of the electrodes as visualized on RTUS for GMed and GMin are illustrated in Figure 2. Technical notes regarding insertion paths are described in Table 1.

Insert Figure 2 here

Insert Table 1 here

Following insertions, wires were taped to the skin and connected to the EMG recording apparatus. Participants then completed a series walking trials (6 x comfortable walking speed, 6 x fast walking speed) along a 9m walkway. After each series of trials they were asked to rate their level of discomfort on a visual analogue scale (VAS) of 0-10 where 0 = no discomfort and 10 = maximum possible discomfort. Discomfort data were averaged for each set of comfortable and fast walking trials. Finally participants completed a series of 18 maximum voluntary isometric contraction (MVIC) trials [8] for amplitude normalization purposes.

Results

Electrode insertions were completed as described for all 15 participants. There were no adverse reactions during the insertion of electrodes although some subjects experienced transient lightheadedness when they first stood up after insertions. Mean discomfort scores (± standard deviation) were 2.4 ± 1.4 and 1.6 ± 0.7 on the VAS for normal and fast walking trials respectively.

Up to 2 - 4 cm of ‘electrode sliding’ (drawing more of the external wire length into the muscle) was noted during dynamic and static manoeuvres. However, loss of data due to electrode dislodgment only occurred in 1 of the 15 participants (6.7%) for GMin posterior and GMed anterior segments.

Discussion

Intramuscular electrodes were successfully located in the three segments of GMed and two segments of GMin previously verified in a cadaveric study [3]. Very few electrodes were displaced during walking trials, adverse events were minor and participants experienced relatively low levels of discomfort. The needle and wire lengths used were suitable for the sample of young active participants in this study. Alternative wire and needle lengths may be considered for other populations.

It has been over thirty years since EMG research was reported on GMin [9]. Processing and analysis techniques have advanced since then, and there are now cadaverically verified guidelines for assessing the function of multiple GMin segments [3]. Similarly, prior research into unique regions of GMed are based on unverified electrode insertion guidelines [2]. As a consequence, our theoretical understanding of segmental GMed function, and the function of

GMin is principally based on inferences from cadaveric studies and biomechanical modelling [1].

This study aimed to address the paucity of segmental GMin and GMed EMG research by providing a comprehensive technical guide (see Table 1 and Fig. 1 and 2) for inserting EMG electrodes into segments of GMin (x2) and GMed (x3). Secondly, we have reported the level of discomfort associated with gluteal insertions. The minor discomfort levels are not expected to alter the recruitment patterns in these muscles [10, 11], and may be referred to in order to facilitate participant recruitment, ethical approval or grant applications associated with intramuscular EMG research for these muscles.

Conflict of interest

None declared.

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Table 1

Technical notes for gluteus minimus and gluteus medius intramuscular EMG insertions.

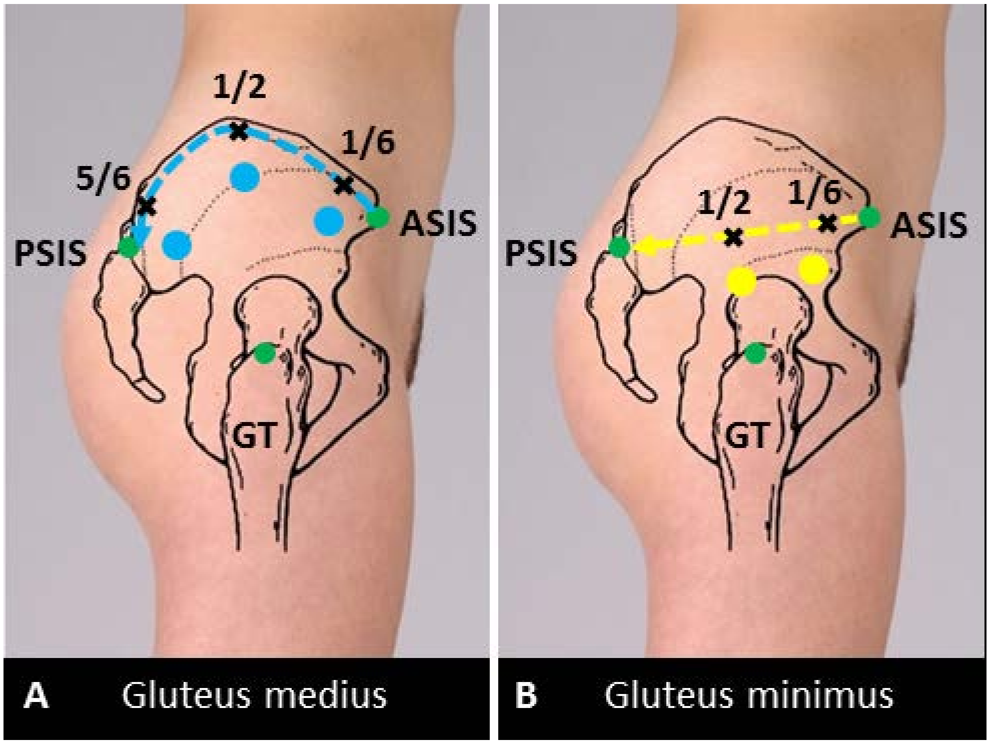
Muscle	Segment	Order of insertion	Depth	Notes
GMin	Anterior	2	Deep to GA and GMed anterior	GMin has a hyper-echoic superficial tendon
	Posterior	3	Deep to GMax and GMed	Must use color Doppler to view safe path adjacent to NVB. May require slight movement away from marked insertion sight
GMed	Anterior	1	Deep to GA	Located superior to the belly of TFL, which does not reach the iliac crest
	Middle	4	Deep to GA	Occasionally deep to some GMax fibers
	Posterior	5	Deep to GMax	An intramuscular tendon appears as a hyper-echoic fascial plane within the posterior GMed muscle belly

GA, gluteal aponeurosis; GMax, gluteus maximus; GMed, gluteus medius; GMin, gluteus minimus; NVB, superior gluteal neurovascular bundle; TFL, tensor fascia lata.

Illustrations

Fig. 1. Location of insertion sites for gluteus medius (A) and gluteus minimus (B) segments. Gluteus medius measurements are proportions of the length along the iliac crest from anterior (ASIS) to posterior (PSIS) superior iliac spines. GMin measurements are proportions of a direct line from the ASIS to PSIS. All insertions sites are 3cm inferior to the measured point along a line directed towards the apex of the greater trochanter (GT). Fig. 1 has been modified with permission from [12].

Fig. 2: Transverse RTUS images *in-vivo* taken with a 7.5 MHz linear transducer of needle insertions into anterior (A) and posterior (B, C) GMin; as well as anterior (D), middle (E) and posterior (F) GMed. Doppler imaging is used to view the NVB (B) prior to needle insertion into posterior GMin (C). GMax, gluteus maximus; GMed, gluteus medius; GMin, gluteus minimus; IT, intramuscular tendon; N, needle; NVB, superior gluteal neurovascular bundle.


1/2
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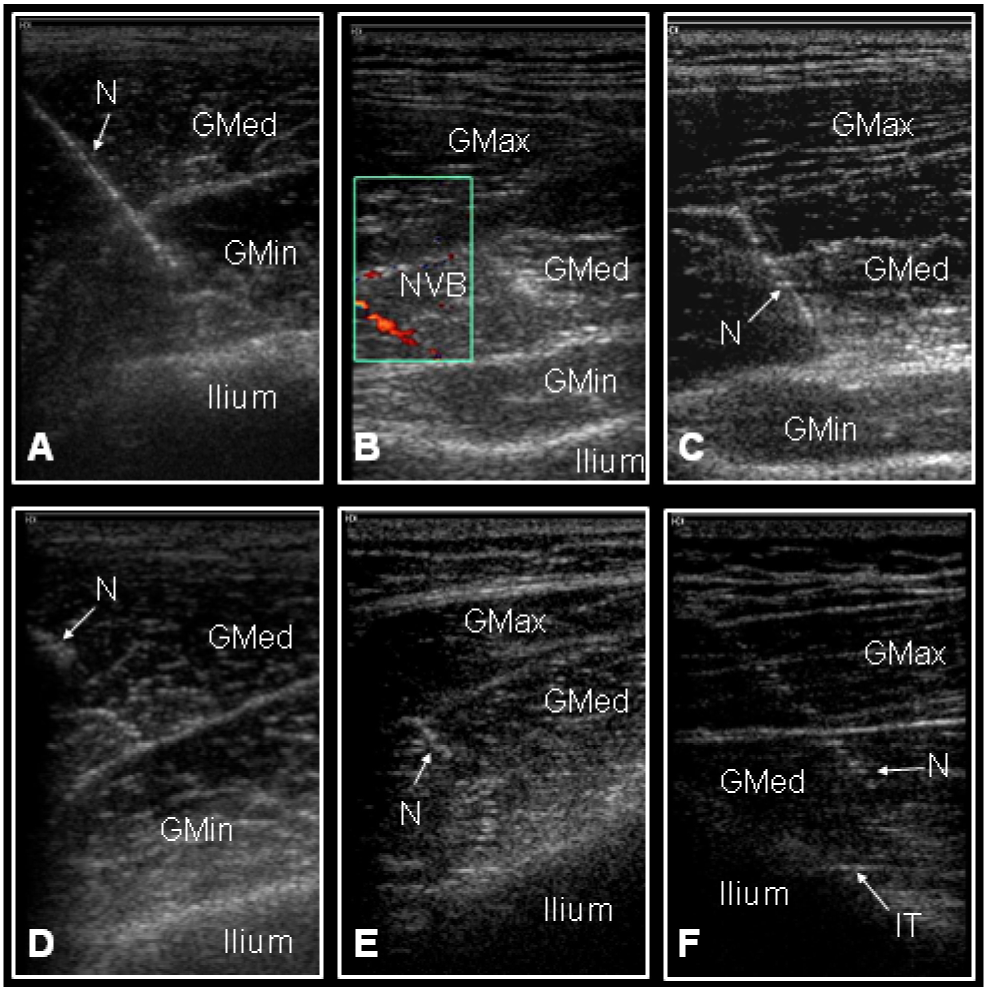
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