A standardised protocol for the assessment of lower limb muscle contractile properties in football players using Tensiomyography

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ABSTRACT

Tensiomyography is used to measure skeletal muscle contractile properties, most notably muscle displacement (Dm) and contraction time (Tc). Professional football medical departments are currently using the equipment to profile the muscle function of their squad and subsequently evaluate change due to injury or intervention. However, at present there are no published standardised operating procedures for identifying probe position for muscle assessment. In this technical report we propose standardised operating procedures for the identification of precise probe position as part of an on-going study in male professional footballers.

KEY WORDS: Muscle, Tensiomyography, Injury, Football

INTRODUCTION

Tensiomyography (TMG) is a non-invasive technique used to measure the contractile properties of superficial skeletal muscles [1]. The technique, specifically contraction time (T_c), has previously been validated against muscle fiber type [2] and has been used to report the muscle contractile profiles of professional male football players [3,4,5]. TMG uses a probe containing a sensor to measure radial displacement (D_m) in response to electrical stimulation, which is a single biphasic pulsed electrical current delivered through surface electrodes at a rate of 1 milli-second [6]. The properties of muscle contraction, which can be estimated from the displacement-time curve, include contraction time (T_c), delay time (T_d), sustain time (T_s), relaxation time (T_r) [7]. It is recommended that the probe is positioned perpendicular to the muscle belly, as this has suggested to be the largest cross sectional area of mass and the region for maximal fibre recruitment [1] and force production [8,9]

Measurement of Dm using TMG, has been reported to have excellent intra-session reliability (Intra-class correlation coefficient (ICC) >0.86) [10], between day reliability (ICC >0.95) [11] and inter-rater reliability (ICC 0.96-0.97) [7]. However, probe position has been largely based on operator anatomical knowledge or electromyography (EMG) reference points, for example the popliteal crease and measurements such as fingerbreadths for gastrocnemius muscle belly identification [3,4,5]. Inconsistencies in EMG electrode placement positioning have previously been reported [12] and therefore there is a need to standardise the approach taken to locate the muscle belly, in order to enable the comparison of muscle contractile parameters as measured by TMG.

The aim of this technical report is to describe a standardised protocol for probe placement in relation to superficial lower extremity muscles of professional football players.

METHODS

The following standard operating procedure was developed for use in ninety-eight healthy male professional football players during the pre-season period of the 2016/17 season. All players were free of musculoskeletal injury and had adhered to a strict inclusion criteria, which included no exercise for 48 hours and no caffeinated drinks 12 hours before testing. Each player was initially marked up using a dermatological pen; highlighting specific regions for muscle belly identification (Figure 1-6). A trained TMG operator, who had knowledge of anatomical landmarks and human muscle architecture, performed this initial procedure. The specific muscles selected for testing were rectus femoris, bicep femoris, adductor magnus, gastrocnemius medialis and gastrocnemius lateralis. This was based these muscles being most commonly injured in previous injury surveillance data of male professional football [13,14]. The gluteus maximus was also tested because of the relationship between hip extensor contraction and hamstring injury risk [15,16]. The marking procedure for probe placement on the rectus femoris was adapted from Wilson et al [17] and similar reasoning was used to develop the procedure for all other muscles (Table 1).

DISCUSSION

This report details a new standard procedure for muscle belly identification i.e. probe placement on selected lower limb muscles related to football injury. As described in the methods, identification of the muscle belly was performed by measuring the length of the muscle; a common method reported in previously published studies [7,11]. Toward the aim of identifying the muscle belly, the newly developed protocol measures muscle width from the borders of the muscle identified from a manually resisted isometric contraction. This enhances the possibility of obtaining D_m not just from the midpoint of the muscle, but from the muscle belly itself. This approach proved straightforward for the rectus femoris, bicep femoris, adductor magnus and gluteus maximus muscles because the midpoint of the muscle is between its origin and insertion, also tends to be the area of largest contractile mass [18, 19] However, in the case of gastrocnemius, where the muscle belly is located more proximal to its origin, a different approach was required. Instead, the widest girth of the calf was identified in accordance with procedures used for the measurement of skinfolds [20].

CONCLUSION

We propose the use of the described standardised TMG protocol for the measurement of selected lower limb muscles in male professional football players, particularly for repeat measures multiple operator use. Future research measuring the intra and inter-rater reliability of TMG measures would be of value to further establish the efficacy of the protocol within clinical and research practice.

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TABLES

TABLE 1: Standardised protocol for probe position

Muscle	Protocol
Rectus Femoris	a) Locate two anatomical landmarks and mark with a dermatological pen i. Proximal point – greater trochanter ii. Distal end of the femur – lateral condyle b) Measure the distance between 2.a.i and 2.a.ii. along the vertical plane c) Using a dermatological pen, draw the transversal line at 50% of the total length (the muscle belly) d) Ask the participant to contract their quadriceps and palpate rectus femoris e) Using a dermatological pen, draw onto the skin the lateral and medial muscle boundaries. f) Using the transversal (2.c.), and lateral and medial muscle boundaries (2.e.), measure half way between the muscle boundaries and mark an ‘X’ on the transversal line. g) ‘X’ landmarks the most central point of the rectus femoris muscle belly which we can measure, and the point at which the TMG probe will be positioned.
Bicep Femoris	a) Locate two anatomical landmarks and mark with a dermatological pen i. Proximal point – ischial tuberosity ii. Distal end of the femur – lateral condyle b) Measure the distance between 2.a.i and 2.a.ii. along the vertical plane c) Using a dermatological pen, draw the transversal line at 50% of the total length (the muscle belly) d) In a prone position, ask the participant to flex their knee, then resist and palpate rectus femoris e) Using a dermatological pen, draw onto the skin the lateral and medial muscle borders. f) Using the transversal (2.c.), and lateral and medial muscle boundaries (2.e.), measure half way between the muscle boundaries and mark an ‘X’ on the transversal line. g) ‘X’ landmarks the most central point of the bicep femoris muscle belly which we can measure, and the point at which the TMG probe will be positioned.
Adductor Magnus	a) Locate two anatomical landmarks and mark with a dermatological pen i. Proximal point – pubic tubercle ii. Distal point – medial femoral condyle

	b) Measure the distance between 3.a.i and 3.a.ii. along the vertical plane c) Using a dermatological pen, mark measured point at 50% of the total length (the muscle belly) d) In a side-lying position, with the leg closest to the bed being marked, ask the participant to adduct their hip, then resist and palpate adductor longus e) Using a dermatological pen, draw onto the skin the lateral and medial muscle borders. f) Using the transversal (3.e.), and lateral and medial muscle boundaries (3.b.), measure half way between the muscle boundaries and mark an 'X' on the transversal line. g) 'X' landmarks the most central point of the adductor magnus muscle belly which we can measure, and the point at which the TMG probe will be positioned.
Gastrocnemius Medialis (Medial head)	a) Locate the widest girth of the lower leg (gastrocnemius muscle belly). b) Trace down from the medial border of the popliteal crease. a) Using a dermatological pen, mark measured point where 2 measurements meet c) In a prone position, ask the participant to plantarflex their ankle, then resist and palpate the gastrocnemius (medial head) d) Using a dermatological pen, draw onto the skin the proximal and distal muscle borders. e) 'X' landmarks the most central point of the gastrocnemius medial head muscle belly which we can measure, and the point at which the TMG probe will be positioned.
Gastrocnemius Lateralis (Lateral head)	b) Locate the widest girth of the lower leg (gastrocnemius muscle belly). c) Trace down from the lateral border of the popliteal crease. d) Using a dermatological pen, mark measured point where 2 measurements meet e) In a prone position, ask the participant to plantarflex their ankle, then resist and palpate the gastrocnemius (lateral head) f) Using a dermatological pen, draw onto the skin the proximal and distal muscle borders. g) 'X' landmarks the most central point of the gastrocnemius lateral head muscle belly which we can measure, and the point at which the TMG probe will be positioned.
Gluteus Maximus	a) Locate two anatomical landmarks and mark with a dermatological pen i. Proximal point – Right or left PSIS (depending on side)

	ii. Distal point – Ischial Tuberosity b) Measure the distance between 3.a.i and 3.a.ii. along the transverse plane c) Using a dermatological pen, mark measured point at 50% of the total length (the muscle belly) d) In a prone position, ask the participant to extend their hip, then resist and palpate the gluteus maximus e) 'X' landmarks the most central point of the gluteus maximus belly which we can measure, and the point at which the TMG probe will be positioned.

FIGURES

FIGURE 1: Probe placement marking for rectus femoris

FIGURE 2: Probe placement marking for bicep femoris

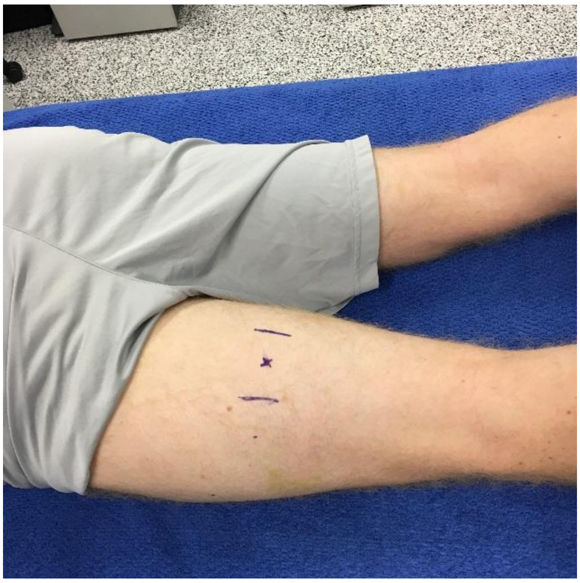

FIGURE 3: Probe placement marking for adductor magnus

FIGURE 4: Probe placement marking for gastrocnemius medialis

FIGURE 5: Probe placement marking for gastrocnemius lateralis

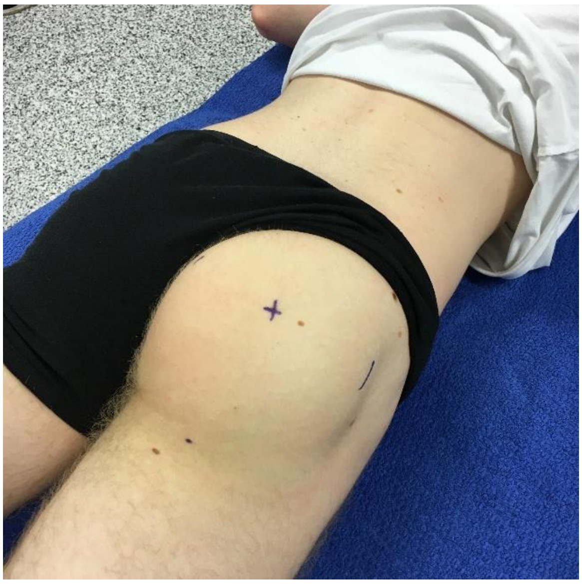

FIGURE 6: Probe placement marking for gluteus maximus