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Does level of load affect relative activation levels of vastus medialis oblique and vastus laterialis?

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Abstract

The purpose of the study was to evaluate the effect of different relative loading levels on the EMG activity of Vastus Medialis Oblique (VMO) and Vastus Laterialis (VL). Previous research into the EMG temporal and spatial relationship between VMO and VL has increased the controversy surrounding the topic, due to the majority of studies failing to be consistent in electrode placement, level of loading and subject selection. It is generally believed that the nature of the loading task will significantly affect results; despite this few studies have controlled relative load level between subjects. EMG activity of VMO and VL was measured at four load levels (MIVC, 75%, 50% and 25% of MIVC) in 10 asymptomatic male subjects. No difference in onset of activity was found between VMO and VL ($p > 0.05$) and onset of activity was not affected by level of load ($p > 0.05$). The relative level of load had a significant effect both on overall activity of VMO and VL, and the ratio of their activity. The study has shown that relative level of load can have significant effects on the parameters measured and if this variable is not controlled for within the study design it becomes a potential confounding effect.

Keywords: EMG; Onset time; RMS, VMO VL

1. Introduction

Patellofemoral pain syndrome (PFPS) is a group of conditions represented by pain, inflammation, muscle imbalance and instability of any component of the extensor mechanism of the knee [14]. This disturbance of the extensor mechanism of the knee has been regarded as one of the most common disorders of the knee [28], with approximately 25% of the general population [6,28] and up to 60% of an athletic population [9,28] is being affected at some stage. Despite the high incidence of PFPS, its aetiology and patho-physiology remain poorly understood [12].

The mechanism most widely accepted as causing PFPS is abnormal tracking of the patella as it moves through the trochlear groove [14]. The abnormal tracking generates excessive stress on both the peripatellar retinacular supports and the patellar articular cartilage [13]. McConnell [18] suggests that a primary cause of patella mal-tracking was an alteration in the force or onset of the contraction of the dynamic (muscular) stabilisers of the patella. The muscles primarily responsible for this are the Vastus Medialis Oblique (VMO) medially and Vastus Laterialis (VL) laterally. A number of authors believe that an imbalance occurs between the force of contraction of VMO and VL, with VL generating the greater force causing the patella to be drawn laterally in the trochlear groove creating abnormal stresses [18,25]. Alternatively, it is believed asynchronous activation of the VMO muscle occurs, with the VL muscle

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being the first to activate in patients with PFPS [30]. It is believed that in asymptomatic subjects, the onset of VMO is first during quadriceps contraction [29]. Whereas, were VMO is has its onset of activity after VL it facilitates a lateral pull of the patella by VL, which it cannot adequately counter and the patella is drawn further laterally into the trochlear groove [8].

There is however, some discrepancy between the majority of the available research findings and the clinical hypothesis of VMO action highlighted above [5]. This discrepancy is in part related to the controversy surrounding the normal EMG temporal and spatial relationships between VMO and VL [4]. The lack of clarity in the research literature is reflected in the disparate methods used to investigate VMO and VL interaction in patella control [17]. The majority of studies have failed to be consistent in electrode placement, level of loading and subject selection all of which can have a significant bearing on the nature and quality of the EMG data collected and how it can be interpreted [21].

It is generally believed that the nature of the loading task will significantly affect muscle activity parameters [17]. Despite this few studies have controlled relative load level between subjects. A number of studies have examined the temporal and spatial EMG parameters whilst ascending and descending stairs [3,4,7,19,24] all these studies failed to control for either velocity of stair ascent/descent or load level. A number of studies have used an isometric quadriceps contraction to establish EMG activity levels in VMO and VL [1,2,17,22] but the patient in all these cases worked at a self selected level of load. A limited number of studies have had their subjects work at prescribed levels of loading established against a standardised norm (usually maximal isometric voluntary contraction (MIVC)) for example Grabiner et al., [8] and Worrall et al., [31]. Of these studies only Worrall et al., [31] reported on the effect of load on EMG parameters, they found load (100 or 60% of MIVC) failed to have a significant effect on VMO:VL activity ratio's. Unfortunately this study had large between individual variations in the ratio's reported.

The aim of this study therefore was to: (1) assess the effect of different relative loads on VMO and VL EMG activity; (2) examine the effect of loading on EMG activity onset.

2. Method

2.1. Subjects

Electromyographic activity (sEMG) of VMO and VL muscles was measured in 10 healthy asymptomatic male subjects (31.8 ± 1.6 years). Subjects were excluded if they had any current or previous history of knee or lower limb injury. The tests were performed in agreement with the declaration of Helsinki and all subjects gave informed written consent to participate in the study. The study was approved by the institutional research ethics committee.

2.2. EMG recording

Simultaneous recording of the sEMG activity from the VMO and VL muscles were made during a 5-s isometric quadriceps contraction of the right quadriceps. Prior to mounting the recording electrodes, the skin surface was prepared by light abrasion (Nuprep, SLE Ltd) and cleaning with alcohol swabs. Two silver/silver chloride bipolar electrodes (Medicotest UK, type N10A), with a 20-mm inter-electrode distance (centre to centre) were placed midline on muscle site in the location outlined below. A ground electrode (Medicotest, UK, type Q10A), was placed at an electrical neutral site, (anterior border of the tibia) of the contra-lateral limb. The sEMG was high and low pass filtered between 10 and 500 Hz (Neurolog filters NL 144 and NL 134, Digitimer, UK), preamplified (1000×), (Neurolog remote AC preamplifier NL 824, Digitimer, UK), amplified (2×) (Neurolog isolation amplifier, NL 820, Digitimer, UK) and A/D converted at a rate of 2000 Hz (KPCI 3101, Keithley instruments, UK). To determine the sEMG signal on/off, a computer aided algorithm was used (Testpoint, Keithley instruments, UK) to allow a threshold value to be calculated from three standard deviations above baseline [11]. To ensure the validity of the computer derived EMG onsets each trace was also visually inspected in order to ensure that movement artefact or other interference was not incorrectly identified as a muscle onset [4,11]. To quantify the sEMG amplitude, (RMS), epochs were taken at 20 ms intervals and a mean value calculated for a standardised period (4 s from onset). All dynamic RMS values of sEMG were standardised to static RMS values of the maximal isometric contraction (at 30° knee flexion) and expressed as a percentage of maximal activity.

2.3. Electrode placement

VMO: 2 cm superior to and 2 cm medial to the superiomedial patella border, orientated 50° to the vertical (femoral axis).

VL: 10 cm superior to, 6 cm lateral to the superiolateral border of the patella, orientated 15° to the vertical (femoral axis).

2.4. Procedure

Prior to examination the subjects undertook a 5 minute sub-maximal effort warm up in a cycle ergometer. Subjects sat on a Kin-Com™ isokinetic dynamometer with hips flexed to 90° and knee flexed to 30° (knee fully