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Temporal sequence of muscle activation in the glute bridge exercise

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Introduction

The glute bridge (GB) is a foundational exercise strengthening lower posterior muscles and valuable for fitness, strength training, rehabilitation, and physical therapy. While the contributions of the muscles involved in GB have been investigated (Gasibat et al., 2023; Lehecka et al., 2017; Youdas et al., 2017), the temporal sequence of their activation remains unexplored.

Research Question

To address this gap, we conducted a statistical analysis of 1,272 muscle onsets from surface electromyography (EMG) data.

The central research question is: What insights can be gained from the statistical analysis of muscle onset timings in lower posterior muscles during glute bridges?

Methods

We recruited five healthy participants (age 29–38, three male, two female). EMG data were collected using a FREEEMG system (BTS Bioengineering) at 1,000 Hz. Electrodes were attached to left and right rectus femoris (RF), gluteus maximus (GM), erector spinae (ES), and biceps femoris (BF), following the SENIAM guidelines (http://seniam.org/). Participants completed 1–4 cycles of 20 GBs, contributing a total of 159 GBs. The study was approved by the Ethics Committee at Setanta College Ltd.

We processed EMG data and determined muscle onsets following Schuermans et al. (2017). Noise levels for each test cycle were estimated as the standard deviation of a three-second resting period with all eight muscles at rest. Muscle onsets were defined as the first 0.1 s with signal consistently above 3× noise level. The resulting 1,272 muscle onsets, shown in Fig. 1, were analysed with a linear mixed effects model (Bates et al., 2015) of the form `Onset ~ Muscle * Side + (1|Participant/Rep)`.

Results

The fixed effects from Table 1 with confidence intervals (CIs) that do not span zero show that the typical GB is initiated by the left BF and both ESs and GMs, all of which activate in the first 0.1 s. The right BF activates 0.1 s later, followed within 0.25 s by the left and finally, <0.1 s later, the right RF. Random effects (Table 2) revealed that 13.4% of variance in onset timing was due to participants, 22.1% to repetitions, and 64.5% remained as residual variance (SD = 0.127 s).

Discussion

Findings indicate that GB muscle activation sequence is remarkably consistent both within and across individuals. This contrasts with other posterior muscle exercises, such as prone hip extension (Bonacci et al., 2009; Carlos et al., 2024; Kiseljak & Medved, 2022; Lirio-Romero et al., 2021; Suehiro et al., 2014) where onset timing varies and has been controversially linked to low back pain or hamstring injury risk (Emami et al., 2014; Ryan & Bruno, 2024; Schuermans et al., 2017). The consistency in GB activation timing suggests it may provide a more stable basis for injury risk modelling and clinical assessment compared to other posterior chain exercises.

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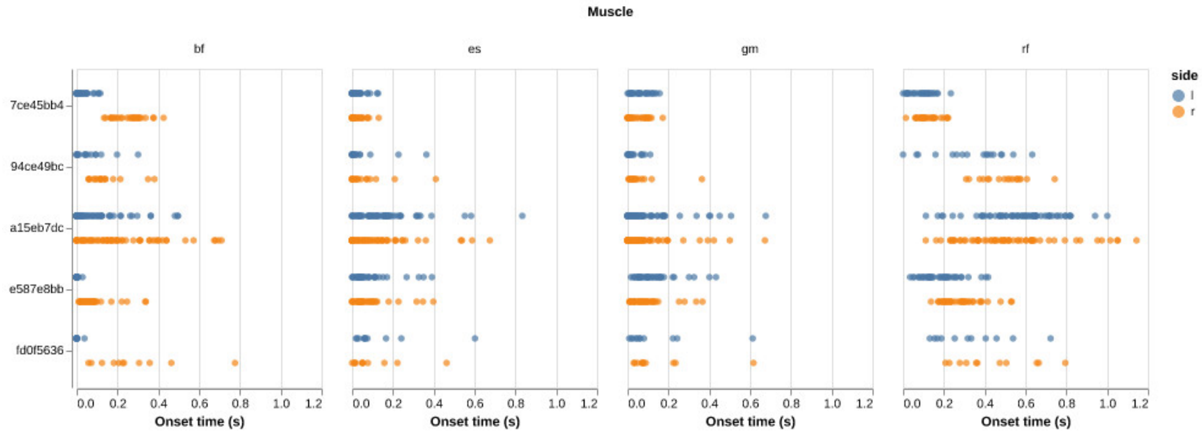

Figure 1: Muscle onset time (s) by participant, muscle, and side

Table 1: Fixed effect estimates, standard errors (SE), t statistic, and 95% confidence intervals (CI), rounded to three significant digits

Effect	Estimate	SE	t	95% CI Lower	95% CI Upper
Intercept	0.0734	0.0288	2.55	0.0169	0.13
ES	0.00285	0.0143	0.199	−0.0251	0.0308
BF	0.101	0.0143	7.08	0.0731	0.129
RF	0.296	0.0143	20.7	0.268	0.324
Left	0.0131	0.0143	0.917	−0.0149	0.0411
ES:Left	0.00235	0.0202	0.116	−0.0372	0.0419
BF:Left	−0.146	0.0202	−7.24	−0.186	−0.107
RF:Left	−0.0478	0.0202	−2.37	−0.0874	−0.00824

Table 2: Random effects variance and standard deviation (SD), rounded to three significant digits

Effect	Variance	SD
Participant:Rep	0.00556	0.0746
Participant	0.00338	0.0582
Residual	0.0162	0.127