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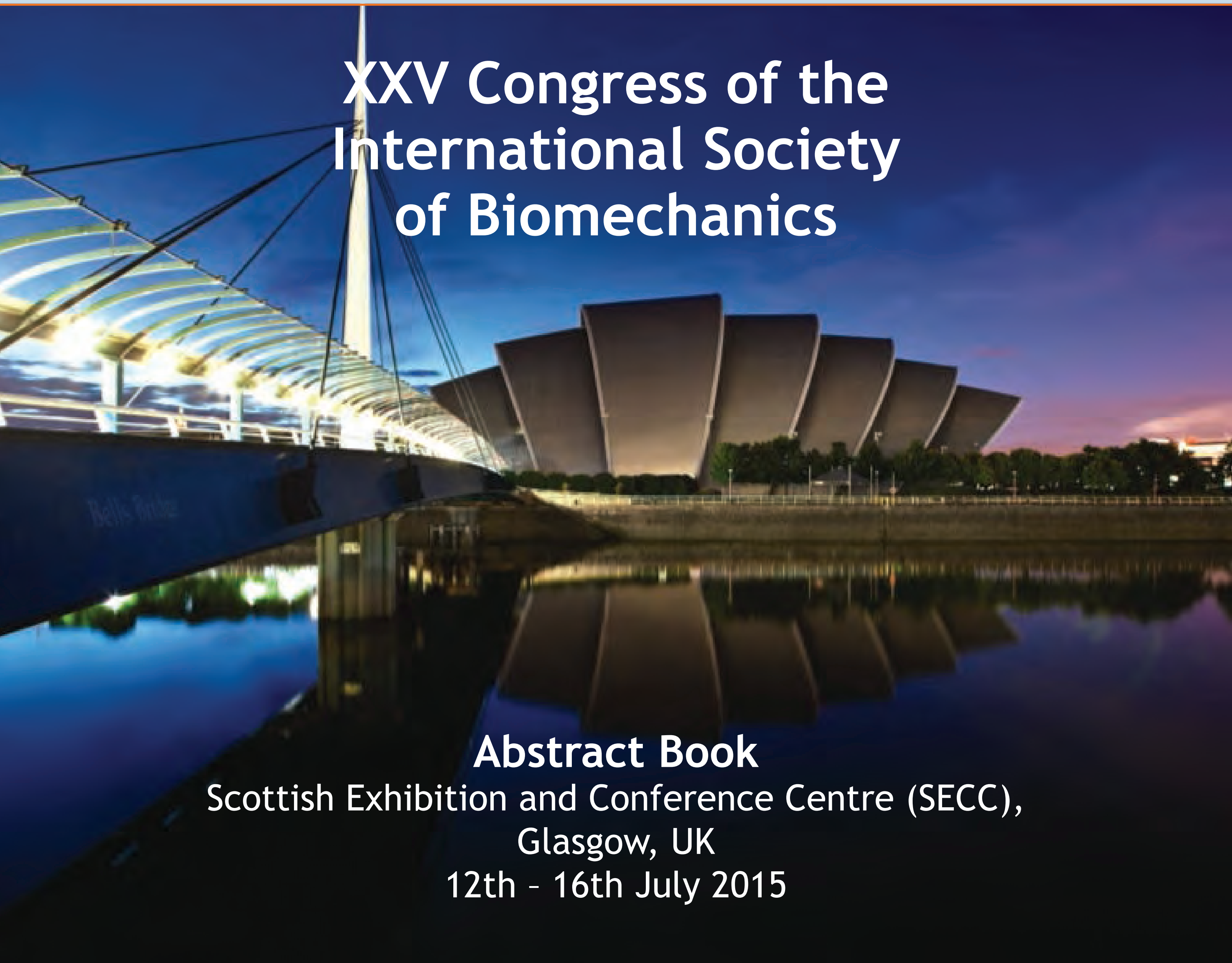

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Balance

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IMPORTANCE OF BIARTICULAR LEG MUSCLES FOR BALANCE DURING UPRIGHT HUMAN STANDING.

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Introduction and Objectives: Human bipedalism is characterized by an upright trunk posture and straight knee configuration during stance phases. The trunk must be balanced during movements like walking and running. This is an ongoing task also in standing as the body sways and has to be balanced. In order to keep an upright posture, humans can employ different control strategies such as the ankle or the hip strategy [2, 6, 7, 8]. Alternatively, they can also use the stepping strategy [4].

Ground reaction forces (GRF) during human walking intersect in a virtual pivot point (VPP) above the centre of mass. Here, simulations with a simple gait model tuning the GRFs to intersect a body-fixed VPP lead to postural stability [3]. Through activation of biarticular leg muscles humans are able to manipulate leg forces perpendicular to the leg axis with appropriate leg segment lenghts and muscle moment arms [5]. In this study we assess the relevance of this concept for humans by perturbed standing experiments.

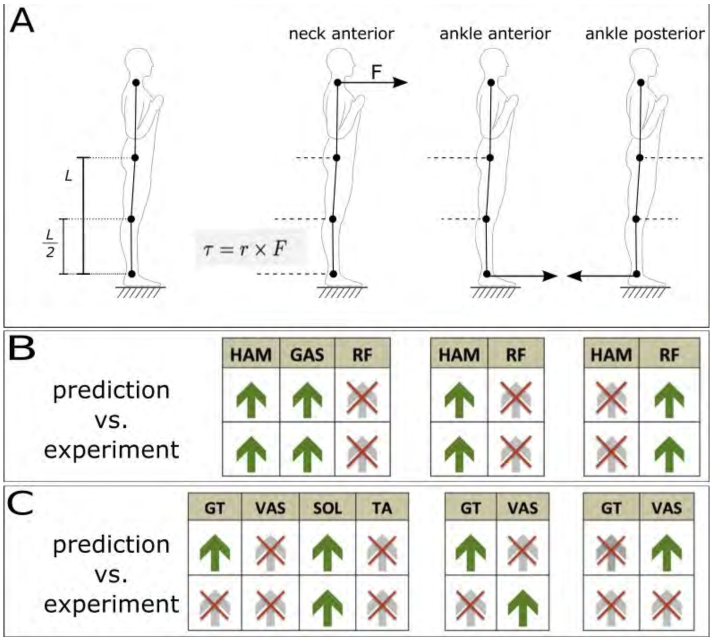
Methods: Nine healthy male subjects (24.3 ± 1.82 years, 77.6 ± 7.5 kg and 182.1 ± 7.5 cm) took part in this study. Human upright standing was perturbed by introducing constant external pulling forces (Fig. 1A – arrows; 10, 20 and 30N) at different body locations (ankle and neck) that created external torques (Fig. 1A – dashed lines) according to the pulling direction (anterior or posterior). Subjects were instructed to maintain their upright posture resulting in re-orientation of leg forces via muscles to compensate for the external perturbation. Kinematic, kinetic and electromyographical (EMG) parameters of selected mono- and biarticular leg muscles were recorded.

EMG signals were demeaned, filtered and normalized to MVC-signal (maximal voluntary contraction) as suggested by Konrad [1]. One-second means of unperturbed and perturbed standing were calculated in order to compare EMG differences under these circumstances.

Results: Figure 1 presents the results of the data analysis for selected bi- (Fig. 1B) and monoarticular (Fig. 1C) muscles. Upper rows show predicted change (green arrow up – increase; grey, crossed out arrow – no increase) in muscle activation, lower rows show the measured muscle activation. Muscle abreviations can be found in Table 1.

In contrast to monoarticular muscles, predicted changes in EMG for biarticular muscles largely comply with measured EMG changes. Moreover, seven out of ten biarticular muscles with predicted EMG increase revealed a significant positive linear relation between pulling force and EMG increase. For monoarticular muscles, this was only the case for two out of eight muscles.

Figure:



Caption: Figure1: Experimental design and results. A: experimental design with introduced external forces (black arrows), lever arm ratios (L and L/2) and resulting external torques (dashed lines) according to the perturbation location and direction (anterior or posterior). B+C: predicted (upper row) and measured (lower row) muscle activation (green arrow up – increase; grey, crossed out arrow – no increase) of biarticular (B) and monoarticular (C) muscles.

Conclusion:

Our static perturbation experiments (Fig. 1A) suggest, that upright posture can be maintained by manipulating GRF via perpendicular leg forces that are created by biarticular leg muscles. This indicates the relevance of the presented concept from Rode and Seyfarth [5] for humans.

Further data analysis comprising more sophisticated comparisons such as assessing the influence of knee angles during perturbation or a comparison with axial perturbation experiments will be done. Moreover, investigating the dynamic changes of leg force and muscle activation in response to a sudden release of the quasi static pulling force is scheduled.

Table:

Abbreviation	Muscles
HAM	Hamstrings: *Biceps Femoris long head* and *short head, Semitendinosus*
GAS	*Gastrocnemius lateralis and medialis*
RF	*Rectus femoris*
GT	*Gluteus Maximus*
VAS	*Vastus lateralis* and *medialis*
SOL	*Soleus*
TA	*Tibialis anterior*

Caption: Table 1: Explanation for abbreviations of muscles-names shown in Figure 1 (B+C).

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Disclosure of Interest: None Declared