The impact of foot angle on lower limb muscles activity during the back squat and counter movement jump

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ABSTRACT

Background. Squatting is a core exercise for many purposes. However, there is still controversy surrounding the practice of targeting specific muscle groups when performing the back squat with different stance widths or foot positions. Therefore, this study aimed to assess lower limb muscle activation during different form of back squat when adopting three different foot angles. **Methods.** Eight male active participants (age 24.0±0.8 years, height 1.80±0.63m and mass 85.8±8.7kg) performed maximal isometric squat, back squat with an overalod of 80% of 1 repetition maximum, and countermovement jump (CMJ) when adopting three foot rotation angles: parallel (0°); +10° outward (external rotation); +20° outward (external rotation). We calculated the root mean square of the electromyographic signals recorded from eight participant's dominant leg muscles. **Results.** During the descending phase of the back squat, the 20° external foot rotation elicited greater activation of the biceps femoris (+35%; $p = 0.027$) and gastrocnemius medialis (+70%; $p = 0.040$) compared to parallel foot. There were no significant differences among the other muscles and exercise conditions. **Conclusion.** The +20° foot position increased BF and GasM muscle activity only during the downward phase of the back squat. Strength coaches should consider the present findings when selecting specific resistance exercises aiming to improve athletes' strength and physical fitness.

KEY WORDS

Electromyographic activity, resistance training, rehabilitation, foot position; strength

INTRODUCTION

The biomechanical variation of the physical exercises can modify joint mechanics and associated muscular activity influencing responses to exercise [2]. Foot positioning is one of the variables that strength coaches often modified during the execution of lower body exercises. It is supposed that changes in foot position can generate different activation of involved muscles. Even more importantly, modifying the foot rotation is supposed to modify the relative contribution of one muscle with respect to the other synergistic muscles. One of the most popular examples in the literature and in the real world of clinical practice was the supposed preferential activation of vastus medialis obliquus when performing lower body exercises (e.g. leg press or leg extensions) with rotated feet (REF). This hypothesis has been widely studied in clinical settings because of the important role of vastus medialis obliquus in controlling the patella's tracking (REF). Despite this specific hypothesis being denied by some experimental evidence (REF), the topic of feet rotation during lower body exercise is still under investigation (REF).

In the sport context, previous studies paid particular attention to the modification of foot rotation angles and initial stance widths adopted during the back squat [4–6,8–11]. The back squat is one of the most investigated exercises in resistance training. Thanks to its multi-joint movement, it involves several muscle groups that are used daily during locomotion activities [12–14]. Due to its biomechanical and neuromuscular similarities to a wide range of athletic movements, the back squat is probably the most frequently recommended and used exercise for increasing overall power, muscular size, speed, and explosiveness in the low limbs [10,15,16]. Dynamic squat have been proved to increase acute performances thanks to post activation potentiation processes (REF).

Previous investigations studying the assessment of thigh muscle activation during back squat have generally found no significant differences in myoelectrical activity across different foot angles or stance widths conditions [4,5,10,15]. Boyden et al. [8] evaluated muscle activity of the vastus medialis, vastus lateralis, and rectus femoris of six experienced lifters during the execution of three squats with four different foot positions (-10° inward , 0°, + 10° outward, + 20° outward) and they observed that the foot rotation position did not influence the mean peak activity or thigh muscles [8]. Similarly, Escamilla et al. [17] tested ten experienced male lifters: the subjects performed the squat, and a high-foot and a low-foot placement leg press too, employing two-foot angle positions (0°, + 10° outward) but no differences were detected in muscle activity or knee forces between foot angle variations [17]. Coratella et al. [11] did not found difference between sumo squat and sumo squat with externally rotated feet. However, results are still not completely clear and the issue related to the angle of the feet has not been fully clarified yet.

One of the most obvious limitations of the previous studies on this topic was that they were conducted adopting a narrow range of overweight, typically from 65 to 80% of 1 repetition maximum (REF). Whilst those overweight ranges were practically relevant, it is reasonable to state that the differences among various feet positions have been measured in a narrow zone of the force-velocity curve of the involved muscles. Therefore, the muscle activation at higher force and at higher velocity is unknown. The activation's distribution across muscles may change because each individual muscle act in different zone of the force-velocity profile (REF) and therefore the changes in external resistance may affect muscle activation inhomogeneously. Therefore the muscle activation recorded in one condition may not necessarily transfer to higher force or higher velocity. Since squat (or squat jump) exercise is used in real-world practice adopting different external load and velocity, investigating a wider portion of the force (or load)-velocity curve might be necessary to provide more relevant data to coaches.

For this reason, we aimed to evaluate the effect of three feet positions (angles) on muscle activation in different parts of the force-velocity curve. To do that, we selected three different conditions that might cover almost the full range of force-velocity relationship in the squat exercise: i) the maximal isometric back squat, representing the highest-force limit; ii) the back squat with 80% of 1RM, representing an intermediate-high load previoulsly adopted in the literature; iii) a counter movement jump (CMJ), representing a highest-velocity limit. Far from being exhaustive, this approach represents an expansion and an improvement with respect to the previous literature. Furthermore, the inclusion of CMJ, which is a commonly used exercise in assessing and training lower limb explosive strength in different sports [18,19] would make our finging even more directly related to the sport context. Based on the existing literature, it was hypothesized not to observe significant differences in muscles activation among different foot positions neither for maximal isometric back squat, dynamic back squat and CMJ.

MATERIALS AND METHODS

Study design and participants

Participants were informed about benefits and potential risks of the project and the testing procedures involved before submitting a written informed consent form. The study protocol was approved by the institutional ethics review committee of the Leeds Beckett University (Ref. N. 36175) in compliance with current national and international laws and regulations governing the use of human subjects (Declaration of Helsinki II).

Resistance trained individuals (n=8) performed a randomized and counterbalanced design, to examine the effects of three different foot angles during maximal isometric back squat exercise, dynamic back squat and CMJ exercises. This involved three foot variations (0°, + 10° outward, + 20° outward) along with three different exercises, therefore nine different conditions in total, examined by a within-subjects repeated measures design, used to analyse muscle activation levels. Participants attended one short session of familiarization, and two sessions for data collection which took place in the Carnegie Research Institute at Leeds Beckett University (United Kingdom). Therefore, data collection was divided into: 1) analysis of maximum voluntary isometric contraction (MVIC) for the selected five lower limb muscles and the maximal isometric back squat; 2) dynamic back squat and CMJ exercise. The intent of the research was to measure activation of five muscles: rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM), biceps femoris (BF) and gastrocnemius medialis (GasM).

Eight male active participants (age 24±0.8 years, height 1.80±6.3m and mass 85.8±8.7kg) were recruited in the study. To determine the sample size of the study an a-priori power analysis on the basis of the scientific literature was performed. The main outcome was to determine if there was a difference in lower limb EMG activity during squat exercises over three different foot positions. With the following parameters: alpha = 0.05, statistical power = 85%, expected correlation = 0.5, effect size = 0.6, it was calculated that a sample of N=8 participants would be suffice to detect a significant change in EMG activity between +0° and + 20° outward foot positions. To calculate the sample size, the GPower software (Universitat Dusseldorf-Germany) was used.

To participate in this study, participants had to meet the following inclusion criteria: 1) at least 3 years of resistance training experience; 2) Demonstration of good technique in the back squat exercise, determined by the lead researcher, following the United Kingdom Strength & Conditioning Association (UKSCA) general instructions [20] and the ability to: (i) squat with 85% of their estimated 1RM and (ii) to a depth where thigh segments were parallel to the ground, for at least two repetitions during each of the three different foot positions; (iii) possession of sufficient strength levels required to perform a back squat of at least 1.5 times their bodyweight. Exclusion criteria were: use of medications, and medical conditions contraindicating physical exercise as diagnosed by a sports medicine physician.

Experimental procedures

Foot rotation angle

The three foot rotation angles were the following: parallel (0°); +10° outward (external rotation); +20° outward (external rotation). The angles were determined by a goniometer and tape attached on floor (standardized for every participant). Width stance was automatically selected by each participant, based on a comfortable position to squat using the parallel foot position. From it, tape was attached onto individual force platforms to mark each foot positions (Figure 1).

< insert Figure 1 about here >

Familiarization and warm-up protocol

A week before the testing sessions, each participant completed a familiarization session to the involved demands. It served to assess the participants' foot rotation angle and the predicted 1RM based on the 5RM, using the 1RM-Repetition table created by Baechle and Earle [21]. Additionally, the session allowed the lead researcher to note the isometric squat rack heights for each participant (Jordan fitness, USA), reducing time consumption in the following session. All squat exercises were performed barefoot. In fact, as reported in various studies [22–24] wearing different shoes can highly affect the kinematic and performance output, affecting also muscle activation. For this reason, in order to avoid limitations, the suggestion of Sinclair et al. [22], who supports anecdotal evidence indicating that athletes generally prefer to train barefoot or in barefoot-inspired footwear, was followed. Prior to each data collection, participants completed a standardized warm up consisting of: a 5-minute RAMP warm-up protocol following guidelines described by Pearcey et al. [25], 6 minutes of cycling (60RPM) on a stationary ergometer (Monark, Ergomedic 828E, Sweden), and 10 back squats repetitions of at 35% 1RM.

First session Testing

The first session was used to determine the EMG amplitude during MVIC for the five muscles considered and to assess MVIC back squat for each of the three foot positions. Participants were advised to avoid any leg exercises and consequent fatigue at least two days prior to testing.

Firstly, the dominant leg was identified using the protocol described by Maulder [26]. After the warm-up, participants' skin of the dominant leg before was shaved, debrided, and cleaned. Wireless surface electrodes (Delsys, Trigno) were located according to well-established guidelines [27]. The electrodes have a bipolar Ag/AgCl surface (Delsys Inc., Boston, MA, USA) with a fixed inter-electrode distance of 1 cm and are 10 × 1 mm. EMG signals were recorded with a sampling frequency of 4000 Hz using the EMGworks software (Version 4.3, Delsys, MA) and stored on a computer for the following analysis.

MVIC Testing: Individual muscle groups

EMG signals were recorded during MVIC of RF, VL, VM, BF and GasM. The MVIC was necessary to normalize muscle activation between different muscle groups or between different trials are made [28]. MVICs were performed against immovable resistance [29–31]. For RF, VL, and VM MVIC was obtained during a leg extension with the knee in a position of a 60°±10 of flexion. For GasM, MVIC was obtained during an isometric standing calf raises executed in the rack cage with knee fully extended. For BF, participants were positioned prone and executed a leg curl with the knee in 60°±10 of flexion. Participants were instructed to give maximal effort during three repetitions lasting 5 seconds. A 60-second rest period occurred between repetitions and three minutes were permitted between different exercises.

MVIC Testing: Back Squat

The MVIC back squat was performed barefoot on two force platforms (Kistler 9287BA, Winterthur, Switzerland), operating at 1000 Hz, within a secure squat rack. A trigger module (Delsys, MA) was used to syncronize signals coming from EMG and force plates. Following a randomised order, two maximal repetitions lasting 5 seconds were collected for each foot position. Rest periods of 60 seconds were used between repetitions at each foot angle, and 3 minutes between different foot positions. Participants were instructed to place equal weight on both lower extremities and force plates on the ground, while pushing their shoulders into a crossbar exerting maximal force. A knee angle of 110°±10 was chosen based on previous research [32] which found that 110° of knee flexion provide the greatest level of reproducibility for use during separate sessions.

Second session Testing

This session was used to analyze and record data for the CMJ and dynamic back squat exercises. A minimum of two days apart from the previous session was assured. As done in the first session also this slot commenced with a RAMP warm up protocol. After skin preparation, the surface electrodes were placed over five investigate muscles, and CMJ exercise over the three different feet position was assessed.

CMJ Testing

The CMJ was assessed according to the protocol established by Bosco et al. [33]. Participants were asked to keep their hands on their hips throughout the entire jump, bend their knees up to 90°, and to take off and land maintaining the same body posture. Similarly to the isometric squat and the dynamic one, both the left and the right foot positions were marked on the squatting cage floor over the two force plates, and EMG activity was recorded from the same five sites identified earlier. The three different foot positions were assessed in a randomised order and the protocol consisted of 2 repetitions of countermovement jump for every foot position, providing always with 60 seconds of rest between jumps.

Dynamic Back Squat Testing

Following the CMJ and a 5-minute rest period, the dynamic back squat was performed. Again, each foot position was assessed in a randomized order. Participants were considered to be already warmed up from the previous exercise, however a self-selected ramping of back squat exercise has occurred in order to reach a good RM% of roughly 85%, the percentage required and utilized for every squat during this test. This percentage value was calculated through the use of a table created by Baechle and Earle [21]. This specific percentage value was chosen after careful consideration of the data collected during the evaluation of the athletic capabilities of the participants, and its use in prior studies with a similar focus [34,35]. Participants were visually assessed to squat barefoot, to a minimum depth of parallel (i.e. greater trochanter in line with the knee joint centre), as instructed during the familiarization sessions. The protocol consisted of 1 set of 2 repetitions at 85% RM for every foot position (parallel, +10°, +20°). A rest period of 120-seconds was provided between repetitions while 3-minutes rest [36] occurred between different foot positions.

Data analysis

EMG analysis

EMG signals were band-pass filtered (20-450Hz) and the root mean square (RMS) were calculated over a moving windows of 1-s length. During the MVICs the RMS was calculated as the highest RMS value over the 5-s contractions, while during the Dback squat the window was centred in each phase of the movement (downward or upward). The RMS values were averaged over two repetitions of dynamic back squat and then normalized to the RMS recorded during the MVIC of individual muscle group (nRMS).

Statistical Analysis

The EMG data (nRMS for downward and upward phases) for each foot position were entered into SPSS (version 24, IBM). A Kolmogorov-Smirnov test for normality was completed to ensure all data were normally distributed and Mauchly's test was used to check sphericity. If the test of sphericity was not assumed (not significant >0.05), the Epsilon value was checked and either the Greenhouse-Geisser or the Huynh-Feldt method was used to report the F value, based on corrected degrees of freedom. Differences in levels of muscle activity were assessed for statistical significance ($p< 0.05$) and then, if appropriate, a pairwise comparison procedure was performed. The repeated measure ANOVA within condition was selected due to testing the difference between 3 variables. The F value, significance, was noted for each result and each foot position was compared for muscle activation using a repeated measures model. This was done to illustrate the differences in muscle activation between the different positions.

Data availability

The data associated with the paper are not publicly available but are available from the corresponding author on reasonable request;

RESULTS

A significant main effect of foot positioning was not identified during the upward phase of the back squat for any of the five muscles investigated ($p>0.05$). However, for the downward phase, a significant main effect was identified for both the BF ($F=6.25$; $p<0.01$) and GasM ($F=6.67$; $p<0.01$). Pairwise comparisons identified a significant difference between parallel (0°) and 20° foot positions, with an increase in activity at 20° within both the BF (+35%; $p=0.027$) and GasM (+70%; $p=0.040$). The analysis of muscle activty during the CMJ did not show any significant main effect for both the upward and downward phases ($p>0.05$). Similarly to that, the isometric back squat also did not show any significant main effect in EMG activity over the different foot positions ($p>0.05$). Table 1 shows the within participant's analysis of differences of muscle activation (Mean ± SD of nRMS values) over different foot positioning for the back squat exercise.

< insert Table 1 about here >

Table 2 reports the within each participant's analysis of differences of muscle activation (Mean ± SD of nRMS values) over different foot positioning for the CMJ; while Table 3 shows the ones for the isometric back squat. Both of them showed no significant differences.

< insert Table 2 about here >

< insert Table 3 about here >

Figure 2 shows an increase in muscle activation during +20° foot position of the down phase of the back squat, and a decrease in muscle activity at 0°. Specifically, BF had 0.397±0.2 nRMS at 20° and 0.294±0.14 at 0° while GasM registered 0.293±0.35 nRMS at 20° and 0.172±0.26 at 0° (BF: +35%; p = 0.027 and GasM: +70%; p=0.040).

< insert Figure 2 about here >

DISCUSSION

The aim of the current study was to determine the effect of foot position on muscle activity on five different thigh muscles. Data on EMG were collected during different dynamic and static strength exercises: dynamic back squat, maximal isometric back squat and CMJ were performed by well-trained male participants, familiarized with all resistance exercise. EMG data suggest that foot positions, during dynamic back squat, maximal isometric back squat and CMJ, did not have a significant effect on the muscle activity. However, during the downward phase of the Dback squat significant differences were observed for BF (+ 35%;p = 0.027) and GasM (70%; p = 0.040) activation, with an increased muscle activity at +20° foot position compared to a parallel foot position (0°). No significant differences were recorded for the RF, VM, or VM. Our initial hypotheses were only partially confirmed.

The current data are partially in line with previous studies [4,5,7,8,17,37] that observed that performing the squat exercise with either different stance widths or foot angles did not lead to any difference in muscle activation across conditions. To confirm this, Escamilla et al. [17]observed no differences in muscle activity and knee forces between a parallel and +10° outward foot angle during the squat and, in line with this, it was highlighted that VM, VL, and RF muscle activy was similar in experienced lifters performing the squat exercise with -10° inward , 0°, + 10° outward, and+ 20° foot position [8]. Furthermore, many studies tested subjects that performed strength exercises both with an internal foot rotation (i.e. leg medially rotated) and during open kinetic chain exercises [5,7]. In detail, Stoutenberg et al., [7] studied variations in EMG responses of VL, VM, and RF due to foot position during leg extension performed at 70% (leg medially or laterally rotated, and neutral) in twenty-four young subjects; the data indicated that the highest nRMS for the VM and VL occurred with medial rotation whereas the highest nRMS for the RF occurred with lateral rotation [7]. Nevertheless, it is important to underline that in an open kinetic chain exercise, such as the leg extension, the distal portion of the leg is free to move in space leading to a greater tibial movement in relation to the femur as a result [38] and, therefore, it is likely these data are partially influenced by this factor. In the present study, the internal foot position was avoided as it is very challenging to force participants into a position that is uncommon in daily practice. However, the selection of different exercises, performed both in static and dynamic conditions, allowed for a better analysis and rationale around EMG activity.

The inclusion of maximal isometric back squat represents a peculiar added value of the present study with respect to previous ones. While the standard modality of performing exercises in the gym is the dynamic one, the inclusion of the isometric back squat allows comparing feet position more robustly. Indeed, the drawback of analysis EMG signals in dynamic contractions, e.g. the shift of electrodes above the conduction volume and the signals' non-stationarity, are removed adopting static contractions. However, even the foot position did not affect the relative activation of investigated muscles even in isometric conditions (Table 3). This makes our results more robust compared analyzing only the dynamic back squat.

Another key aspect of the present study, that makes the herein finding particularly relevant, was the fact that the participants were trained men with a predicted 1RM of back squat of at least 1.5 times their body weight. The recruitment of such experienced participants allowed to utilize a high intensity load (85% of 1 RM) during the dynamic back squat. The extra-weights and loads utilized during the exercises in the current study reflect a resistance training level that could be realistically employed in a typical training program for different sport disciplines. Differently, many previous studies tested participants without requiring any specific baseline physical condition [5,7,37] and this may represent a limit for the homogeneity of the sample and to address possible practical applications too.

Torque and force generation may change as a function of several variables such as the position of the external load, the lifter's anthropometric proportions or body orientation, and foot position too. This is one of the reasons why trained individuals tend to converge towards an exercise execution style which best fits their biomechanics, resulting in a stratification of performance characteristics, with remarkable uniformity of lifting characteristics and development of individual technique.

The main limitation of the present study was that the MVICs of individual muscle groups were performed were performed in a different experimental session with respect to the dynamic squat testing. Executing the set of maximal contractions (individual muscles and squats) in separate days was a choice needed to avoid the cumulative muscle fatigue due to repetitive maximal contractions. Nevertheless, the electrode replacements in separate days may have reduced the reproducibility of our EMG estimates. However, since this trend did not bias the results towards one foot rotation over the others (0° vs. 10° vs. 20°), we believe that our findings are reasonably reliable. The second main limitation regards the adoption of bipolar EMG montage. While this means is the easiest way to estimate muscle activation, we appreciate that the accurate assessment of muscle activation would require multiple EMG detection [39]. For this reason, the scope of our findings is limited to the portion of muscles (conduction volume) that we were able to record with the bipolar arrangements that we adopted.

CONCLUSIONS

During dynamic back squat and CMJ exercises, the changes in foot positioning did not substantially alter muscle activity of lower limb muscles; however, during the downward phase of the Dback squat, significant differences were observed for BF and GasM with an increased muscle activity at +20° foot position compared to a parallel foot position (0°). Therefore, the current findings suggest a possible increase in muscle activation of the posterior kinetic chain muscles with wider foot angles and this is partially in line with previous studies that showed the effects of wider stances in increasing the muscle activity of gluteus maximus, which is part of the posterior chain [3,4] while, on the contrary, different foot angles seem not to influence muscle activity of individual muscles of the quadriceps [4,7,8,37,38]. No differences were observed in the CMJ performed with different foot positions. Strength coaches should consider that attempting to change the contribution of tight muscles via different foot rotation does not seem to be a viable strategy.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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AUTHORS' CONTRIBUTION

F.R. L.P. and A.L.T. designed the present study. F.R. and L.P. conducted the experimental procedures. J.A.V performed the statistical analysis and wrote with F.R. the first draft of the manuscript. G.B. and L.P. critically revised the manuscript. All authors read and approved the final version of the manuscript

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Table 1: Mean ± SD of muscle activation (nRMS) during phases of the dynamic back squat.

Downward	**0°**	**10°**	**20°**
RF	1.07 ± 0.13	1.20 ± 0.41	1.05 ± 0.63
VM	1.78 ± 0.98	1.90 ± 0.66	1.67 ± 0.47
VL	2.16 ± 1.67	2.35 ± 2.75	2.45 ± 2.83
BF *	0.29 ± 0.14	0.34 ± 0.18	0.40 ± 0.20
Gas M *	0.17 ± 0.26	0.21 ± 0.32	0.29 ± 0.35
Upward			

RF	0.93 ± 0.57	0.92 ± 0.80	0.69 ± 0.32
VM	1.80 ± 1.70	1.80 ± 1.70	1.32 ± 1.06
VL	2.00 ± 2.32	1.66 ± 1.40	1.78 ± 2.55
BF	0.46 ± 0.25	0.52 ± 0.17	0.50 ± 0.19
Gas M	0.29 ± 0.24	0.26 ± 0.21	0.49 ± 0.59

* = significantly different ($p < 0.05$); RF, Rectus Femoris: VL, Vastus Lateralis; VM, Vastus Medialis; BF, Biceps Femoris; GasM. Gastrocnemius Medialis (GasM).

Table 2: Mean ± SD of muscle activation (nRMS) during phases of the CMJ.

Downward	**0°**	**10°**	**20°**
RF	0.97 ± 0.62	0.77 ± 0.36	1.21 ± 0.79
VM	1.82 ± 0.82	1.19 ± 0.53	1.58 ± 0.58
VL	2.18 ± 1.66	1.88 ± 1.77	2.41 ± 2.52
BF	0.41 ± 0.21	0.29 ± 0.12	0.31 ± 0.13
Gas M	0.64 ± 0.21	0.43 ± 0.25	0.66 ± 0.59
Upward			
RF	1.76 ± 1.06	2.05 ± 1.03	2.08 ± 1.22

VM	2.60 ± 2.41	2.19 ± 0.72	2.15 ± 1.07
VL	2.78 ± 2.00	3.36 ±2.71	2.91 ± 2.31
BF	0.59 ± 0.36	0.90 ± 0.96	0.41 ± 0.22
Gas M	0.97 ± 0.45	1.14 ± 0.58	1.08 ± 0.49

CMJ, Counter Movement Jump; RF, Rectus Femoris: VL, Vastus Lateralis; VM, Vastus Medialis; BF, Biceps Femoris; GasM. Gastrocnemius Medialis (GasM).

Table 3: Mean ± SD of muscle activation (nRMS) during maximal isometric back squat.

	0°	**10°**	**20°**
RF	0.55 ± 0.44	0.41 ± 0.29	0.54 ± 0.37
VM	1.97 ± 2.49	1.15 ± 0.66	1.41 ± 1.11
VL	1.59 ± 1.32	1.44 ± 1.32	1.57 ± 1.43
BF	0.80 ± 1.32	0.34 ± 0.13	0.49 ± 0.59
Gas M	0.77 ± 1.64	0.17 ± 0.20	1.08 ± 0.49

RF, Rectus Femoris: VL, Vastus Lateralis; VM, Vastus Medialis; BF, Biceps Femoris; GasM. Gastrocnemius Medialis (GasM).

FIGURE CAPTIONS

Figure 1. Foot positioning setup with the individually calculated positions (0°; +10°; +20°). Personalized stance for the participant where specific points were marked in order to correctly place big toes and hells.

Figure 2. Changes in nRMS (Mean ± SD) of BF and GasM for each foot position during the down phase of the back squat.