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# Muscular activity and torque of the foot dorsiflexor muscles during decremental isometric test: a cross-sectional study

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# HIGHLIGHTS

- The foot dorsiflexor muscle activation explains over 75% of the torque variance during maximal isometric foot dorsiflexion intensity.
- The muscle contributions to the torque variance increase with the isometric foot dorsiflexion intensity.
- Tibialis anterior muscles are always the main muscles during isometric foot dorsiflexion.

**Abstract**

Purpose: To analyse the torque variation level that could be explained by the EMG amplitude (muscle activation) of the three major foot dorsiflexor muscles (tibialis anterior (TA), extensor digitorum longus (EDL), extensor hallucis longus (EHL)) during isometric foot dorsiflexion at different intensities.

Methods: Cross-sectional study. Forty-one subjects (22 women) performed foot dorsiflexion at 100%, 75%, 50% and 25% of maximal voluntary contractions (MVC) with the hip and knee flexed 90º and the ankle in neutral position (90° between leg and foot). Three foot dorsiflexions were performed for each intensity. Outcome variables: maximum (100% MVC) and relative torque (75%, 50%, 25% MVC), maximum and relative EMG amplitude. A linear regression analysis was calculated for each intensity of the isometric foot dorsiflexion.

Results: The degree of torque variation (dependent variable) that independent variables explain (EMG amplitude of the three major foot dorsiflexor muscles) increases when the foot dorsiflexion intensity is increased, with values of R2 that range from 0.194 (during 25% MVC) to 0.753 (during 100% MVC). The reliability of the outcome variables was excellent.

Conclusion: The EMG amplitude (muscle activation) of the three main foot dorsiflexors explains more variance in the dependent variable (torque) when foot dorsiflexion intensity increases.

**ABBREVIATIONS**

BMI: Body mass index.

EDL: Extensor digitorum longus.

EHL: Extensor hallucis longus.

FD: Foot dorsiflexion.

IFD: Isometric foot dorsiflexion.

MVC: Maximal Voluntary Contraction.

sEMG: Surface electromyography.

SENIAM: Surface Electromyography for the Non-Invasive Assessment of Muscles.

TA: Tibialis anterior.

Keywords: Ankle; Electromyography; Force; Tibialis Anterior; Extensor Digitorum Longus, Extensor Hallucis Longus

## BACKGROUND

Walking, running and climbing stairs are activities of daily living, and their proper implementation has a definite impact on an individual's level of independence [1]. The implementation of a comprehensive movement is the sum of the execution of all the minor movements that it comprises [2-4]. When studying a step, it is important to analyse the component bending movements: hip extension, knee flexion and plantar flexion of the foot [5,6].

Foot dorsiflexion (FD) is the gesture by which the anterior surface of the foot approximates the anterior surface of the leg [7]. The three major foot dorsiflexor muscles are the tibialis anterior (TA), extensor digitorum longus (EDL) and extensor hallucis longus (EHL) [8]. FD is an analytical gesture much less studied than plantar flexion of the foot [7]. However, FD is critical to the control of balance (adjusting the position of the foot in both single-leg as well as bipedal stances) in human dynamic motion. Correct execution of the FD during ambulation allows the individual to take a step with the foot during the swing phase, prepares the foot to support the heel, and prevents the foot from dropping at the beginning of the stance phase. While poor execution of the FD causes altered gait pattern, generating a slower and inefficient gait. In addition FD with some variation in the range of motion or force required for repeated gestures, is used when climbing stairs or running [1]. These factors could explain why proper execution of the FD reduces the risk of falls and increases an individual's balance and therefore independence [9-11].

To analyse the muscle behaviour, surface electromyography (sEMG) recordings provide information on several aspects of muscle function such as muscle fatigue [12-15] and forces [16]. In addition, load cells are one of the most objective, reliable and sensitive instruments for measuring torque and joint movements [1,13]. Torque, defined as the product of the force generated during a movement and the distance between the point of application of the force and the axis of rotation, is the variable that is most frequently recorded by load cells during isometric contractions [17,18].

Studies have demonstrated a relationship between the level of muscle activation and the degree of force generated by muscles [19]. However, an analysis of the degree of torque variance generated during isometric foot dorsiflexion (IFD) at various intensities, explained by the activation of the three major foot dorsiflexor muscles (TA, EDL, EHL), was not found in the availably published research.

The objective of the present study was to analyse the torque variation level that could be explained by the EMG amplitude (muscle activation) of the three major foot dorsiflexor muscles (TA, EDL, EHL) during isometric foot dorsiflexion at various intensities.

The hypothesis of the present study was that more than 60% of the torque variation experienced during isometric FD at various intensities (100%, 75%, 50% and 25% of MVC) could be explained by the EMG amplitude (muscle activation) of the three major dorsiflexor foot muscles.

## METHODS

## Study design and participants

Forty-one subjects (22 female and 19 male) participated in this cross-sectional study conducted within a laboratory of human movement analysis. The subjects in this study were selected based on the following inclusion criteria: aged between 18 and 40 years, body mass index (BMI) <30 kg/m$^2$ and no musculoskeletal or neurological pathology diagnosed. The following exclusion criteria were used: having undergone a surgical intervention of the ankle in the past six months or in the legs previously at baseline, participants whose FD was less than 10º, cognitive impairment from any cause, or pregnancy for women.

The present study was conducted following the principles of the Accordance with Ethical Principles for Medical Research Involving Human Subjects [20]. Ethical approval for the study was granted by the local ethics committee.

Prior to obtaining informed consent from each participant, he or she was presented with an information sheet outlining the protection of personal data according to the Spanish Organic Law of Protection of Personal Data 19/55, the aim of the study, the voluntary nature thereof and the participant's ability to leave the study at any time.

## Protocol

*Participant position.*

All participants, during FD, were seated with hips and knees flexed at 90º. Additionally, the dominant foot was supported on a specifically designed instrumentation tool composed of two perpendicular wooden platforms. The wooden platforms only allowed FD, and ensured that the movement was linear due to two hinges fixing the wooden platforms together, avoiding any movement of the foot during isometric foot dorsiflexion. The heel of the foot rested on the corner formed by the two platforms; through straps, the leg was fixed on the vertical table and the foot was fixed on the horizontal table. The instrument was designed to allow the FD to commence only from the ankle in a neutral position (90° between leg and foot) (Figure 1). The bisection of the knee joint and the centre of the rotation axis of the load cell had an angle of 0° in the frontal and sagittal planes, as measured using a dual-axis goniometer.

*Surface EMG (sEMG)*

The EMG amplitude of the TA, EDL and EHL muscles was measured using a Biomonitor ME6000 electromyograph [21] with a sampling frequency of 2000 Hz.

The electrodes were positioned, and the skin was prepared in accordance with the recommendation of Barbero *et al.* (2012) and SENIAM (Surface Electromyography for the Non-invasive Assessment of Muscles – European concerted action in the Biomedical and Health Research Programme (BIOMED II)) [22,23]. Nine propelled Al/AgCl electrodes (3 cm diameter) for each subject and the complete procedure were used (three electrodes for each muscle). The distance between electrodes was 1 cm.

Electrode placement after palpation of the belly muscles was as follows: TA: first third of the line connecting the fibula and the medial malleolus; EDL: medial third of the line joining the tuberosity of the tibia and the lateral malleolus; EHL: distal third of the line connecting the tibial tuberosity to the lateral malleolus.

To minimise the proper limits of sEMG (such as crosstalk, skin impedance and subcutaneous fat), the size and positioning of the electrodes were carefully considered, the skin was shaved and cleaned with alcohol, and participants with a BMI ≥ 30 kg/m$^2$ were excluded.

EMG amplitude (muscle activation) was recorded, processed by Megawin 3.0.1. software. Following the recommendation of the Surface EMG for Non-invasive Assessment of Muscles (SENIAM) and the recommendations of the International Society of Electrophysiology and Kinesiology, a low-pass corner filter (20 Hz) was used to remove high-frequency noise from the sample.

*Load Cell*

A load cell (rated capacity: 0 – 500 kg; maximal excitation: 15 VDC; accuracy: 0.001%) [Mega Electronics Ltd] was used to measure torque. The load cell was located between the ground and the horizontal foot support platform, blocking the ankle movement during FD in the neutral position (90° between leg and foot).

The load cell was placed at a distance of 15 cm from the axis of rotation (stub). This distance was considered to calculate the torque record whose formula is $M=F \cdot d$, where M is the torque, F is the force and d the distance. The strap that fixed the forefoot of each participant onto the horizontal table was placed at the same distance as the load cell (15 cm from the rotation axis). Depending on the foot size, straps of between 5 and 8 cm wide were used, to ensure that the metatarsophalangeal joints of all participants were fixed by the strap to the horizontal table.

*Synchronization of data acquisition*

A trigger device [Mega Electronics Ltd] was used for the integration of the signals from the load cell and electromyography to synchronize the start and end of the record of the variables recorded during the IFD (EMG and torque) at various intensities.

**Procedure**

Before starting the procedure, each participant signed informed consent, and basic anthropometric data (weight, height, BMI and foot size) were recorded. Together with age and gender, these factors were used to characterise the sample. Subsequently, each participant, after conducting a 15 min warm-up to familiarise with the procedure, was seated in an adjustable chair with the hip and knee positioned at 90° of flexion. The foot rested on the instrument created for the implementation of the IFD. The heel was positioned at a 90° angle created by the vertical and horizontal platform where the foot was supported. During IFD, the leg and foot were then fixed in this position with straps. A researcher explained to each participant the maximum IFD to be undertaken. Each participant was free to perform all repetitions as deemed necessary to achieve a perfect execution of the movement. Once both the participant and the researcher understood what was expected, the maximal IFD was implemented to record the outcome variables. Every IFD was performed three times. The maximum torque used as a reference was the maximum value recorded after the three maximum IFDs.

Using maximum torque as the reference value and a trigger device to synchronise the variables recorded, the exact moment when the participant reached various relative intensities (75%, 50% and 25% MVC) during the IFD could be used to extract the EMG amplitude of the three muscles monitored (EHL, EDL and TA). Participants performed the IFD relative to the torque indicated on the record. On a computer screen, the torque was shown so participants could see the force they needed to exert during relative intensities of IFD. During execution of the IFD at 100%, 75%, 50% and 25%, the recorded EMG amplitude of each muscle was analysed (EHL, EDL and TA). The protocol consisted of 12 IFDs, with three IFD intensities requested. Each IFD was performed for 5 seconds with 90 seconds between as rest.

*Variables*

Using electromyography and the load cell, the outcome variables analysed during IFD were: *Maximum Torque*: Maximum torque recorded. For this formula, $M = F \cdot d$ , where F was the force recorded by the load cell and d the distance from the registration point of the force (load cell) until the rotation axis (ankle). This value was used to obtain the reference FD relative at 75%, 50% and 25%. *Maximum EMG amplitude (Maximum Muscle Activation)*: Peak muscle activation recorded in each of the three muscles was analysed (TA, EHL, EDL) during maximal IFD. *Relative EMG amplitude (Relative Muscle Activation)*: Muscle activation recorded for each muscle tested (TA, EHL, EDL) for the execution of IFD at 75%, 50% and 25% relative to the maximum torque registered. For each muscle, the variable value used was the average of the maximum value recorded in each intensity of the IFD analysed. The data extraction and statistical analysis were performed by two external researchers who were unrelated to this study.

**Statistical Analysis**

Descriptive statistical analysis was carried out with means and standard deviations for anthropometrics and result variables. Kolmogorov-Smirnov test was then used to analyse the distribution of the sample. Multivariate non-linear regression models were established. Torque was used as the dependent variable while the independent variables were the activations of each muscle (TA, EHL and EDL).

Further analysis of the internal consistency of the measures was performed to calculate the reliability for all outcome variables in all intensities of IFD. Reliability was considered as a test-retest SD of differences such as the 95% limits of agreement [24-25]. Each outcome variable was measured three times, and internal consistencies were measured by Cronbach's alpha (95% CI). Levels of reliability were poor (ICC $< 0.40$), moderate ($0.40 \leq$ ICC $<0.60$), good ($0.60 \leq$ ICC $<0.80$) or excellent (ICC $\geq 0.80$) [26].

Statistical analysis was carried out using SPSS 15.0 statistical package for Windows. The confidence level was established with a statistically significant *p*-value of less than 0.05.

## RESULTS

There were 41 subjects who participated in this study (22 female and 19 male), with a mean age of 27.8 years (±5.9), a mean height of 1.72 m (±0.11), a mean weight of 69.69 kg (±13.12), a BMI of 23.24 (±2.19 kg/$m^2$) and a foot size of 23.8 cm (±3.29). In addition, the descriptive values of the output variables separated by gender are shown in Table 1. All outcome variables were parametric.

The reliability values for all outcome variables are presented in Table 2. It can be seen in all outcome variable measures for all intensities of FD that reliability is excellent [26], presenting a range of reliability from 0.897 (EMG EHL 25%) to 0.988 (100% torque).

The degree of torque variance explained by each independent variable (EMG TA, EHL and EDL) for the four intensities of IFD analysed in the present study (100%, 75%, 50% and 25% MVC) increased progressively with the intensity of the contraction from 0.194 (25% MVC) to 0.753 (100% MVC). Also, it is possible to see how, in all contraction intensities, the EMG amplitude of TA explained more variance of the dependent variable (torque) (standardised β values: 0.519 (MVC), 0.441 (75% MVC), 0.337 (50% MVC), 0.289 (25% MVC) than the other two independent variables (EMG amplitude of the EHL and EDL). However, the standardised β values (standardised partial regression coefficients, which define the regression equation when it is obtained after the original variables were standardised) were only significant for the high IFD intensities (100% – 75% MVC).

A similar behaviour is observed in the other two analysed muscles, which have standardised β values, mainly for the highest IFD intensities, with the exception of EHL (50% MVC) and EDL (25% MVC). Finally, it is also possible to see how the standard error of the estimation (which is the standard deviation of the residuals, i.e. the standard deviation of the distances between the scores of the dependent variable and the forecasts made with the regression line) is progressively reduced as the intensity of FDI increases: 906.383 (25% MVC) to 601.581 (100% MVC). The remaining data on the torque variance explained by the independent variables can be seen in Table 3.

## DISCUSSION

The aim of this study was to analyse the torque variation level that could be explained by the EMG amplitude of the three major foot dorsiflexor muscles during isometric foot dorsiflexion at various intensities. These results confirm that the aim of the present study has been fulfilled and the hypothesis partially confirmed.

The results indicate that only for high intensities of IFD (100% and 75% of MVC), the variance explained by the EMG amplitude is over 60%, while during lower intensities of IFD, however, the percentage of the torque variance explained during low intensities (50% – 25%) explained by EMG amplitude is 38.3% and 19.4% respectively.

The results observed in this study are consistent with previous studies that have analysed the relationship between the torque and EMG amplitude during foot plantar flexion [27] or knee extension [28]. In all the studies consulted it is possible to see how, during maximal or submaximal muscle contractions, a high percentage of the variance in the level of force generated is explained by muscle activation [15,27-29]. However, during mild or moderate muscle contraction intensity, the variance in the force generated by the muscle is poorly explained by the muscular activity [15,28,29], with values for corrected $R^2$ of 0.383 (50% MVC) and 0.194 (25% MVC). Thus, the results of the present study are consistent with previous studies that suggest that in normal subjects (without specific training), the EMG-torque relationship may be reasonably considered as curvilinear [15,28,29], following an increase in the muscular co-activation, a limited cortical adaptation and a limited activation of motor unit capacity [28]. In addition, previous studies suggested that the difference in torque variance explained by EMG amplitude observed for high and low intensities may be due to neural and anatomical mechanisms [15,29] justified by the centre responsible for controlling muscle contraction as the intensity. Thus, at low intensities, neuromuscular control is central, whereas with increasing amounts of contraction, the neuromuscular control is peripheral [12]. In addition, it is necessary to consider that the position of the load cell is always the same for all participants, independently of foot size. It could condition the accuracy of the relationship between dependent variable (torque) and independent variables (EMG variables). Finally, it is important to consider that the muscle activation analysed is the average maximum activations registered when the maximum or relative torque occurs. It is important to consider this aspect as it could be a minor influence when interpreting the results obtained in the present study.

**Reliability**

The reliability of the observed variables in this study can be categorised as excellent [26]. All outcome variables analysed in this study show a reliability above 0.897 (extensor hallucis longus at 25% MVC). These values are shown to be in line with previous studies, specifically with torque; the reliability values observed in the present study ranged between 0.907 and 0.988, which are consistent with the reliability of the torque during the FD analysis, which had a value of 0.94 (95% CI ICC) [30] and 0.946–0.997 [31]. This is in addition to other changes made with the foot, such as plantar flexion of 0.88 (ICC 95% CI) [30] or eversion investment, which had values of 0.870 and 0.960, respectively [32].

Furthermore, the reliability of the electromyographic recording was excellent based on the range of values offered in all three muscles analysed: 0.904–0.974 (TA), 0.901–0.970 (EDL) and 0.897–0.967 (EHL). These results are consistent with the assurance provided in some muscles analysed in this study, such as the TA, with values of 0.812–0.827 (subject barefoot), 0.859–0.862 (subject wearing footwear) [33], 0.99 (peak activation) [34] and 0.97 (mean activation during a complete stride cycle) [35]. In addition, the medial gastrocnemius, soleus and lateral gastrocnemius (reliability of 0.94, 0.93 and 0.84 respectively) [34] are also shown to be consistent with the reliability of the measured sEMG of other leg muscles that are essential to complete the gait cycle.

The reliability of sEMG was measured in various situations as isometric contractions at various intensities (present study) or throughout the entire stride [34]. Various patient profiles were analysed: healthy subjects (this study) [34] and patients with rheumatoid arthritis [33]. The last results obtained in this study yielded more robust results suggesting that the sEMG is reliable and valid for analysing the EMG amplitude of superficial muscles in various situations involving the use of different instruments.

**Results of the measures**

The value observed in the present study showed a mean FD torque of 49.87 Nm, which was slightly higher than with the results obtained by Baudry *et al.* [35], Billot *et al.* [36] and Moraux *et al.* [30], with values of 38.30 Nm, 34.15 Nm, 36.56 Nm and 31.97 Nm, respectively, and was not consistent with the value presented by Kemertzis *et al.* (20.3 Nm) [37].

The discrepancies in the results may be due to a different leg position during the execution of IFD. In all studies, the ankle was in a neutral position (90° between leg and foot); however, the position of the lower limb and the trunk varied between studies. In the present study the hip and knee were flexed at 90º, compared to full knee extension [37] or 120º knee extension (maximal extension 180º) [36], or a slightly reclined position [35]. In addition, there are differences in warm-up periods that could also influence the maximum IFD recording. In the present study, participants performed a 15 min global warm-up (cycle ergometer), while other studies proposed 5 min of global warm-up [37], or local warm-up (repeated submaximal foot dorsiflexion) [35,36].

In the present study, the results obtained for mean FD torque in both gender groups (53.64 Nm and 45.16 Nm for males and females, respectively) were consistent, although slightly higher than values reported previously (38.2 Nm and 25.75 Nm for males and females, respectively) [30]. For the submaximal contractions, the mean FD torque reduced according to the decrease in the intensity of the contraction. The 75%, 50% and 25% contractions were always higher in males (41.74, 25.57 and 10.95, respectively) than in females (26.04, 22.41, 5.07 respectively). The differences between both studies could be explained due to the fixed position of the load cell conditions so that the resistance offered was determined by the foot size and, consequently, by the insertion point of the muscle. The relationship between the position of the resistance (load cell) and the point of muscle attachment could generate a mechanical advantage that would explain the higher values in the present study regarding the comparative study [30].

**Strengths and weaknesses**

This is the first study to analyse the degree of torque variance that is experienced by the three main foot dorsiflexors (TA, EDL and EHL) at various foot dorsiflexion intensities. However, it has weaknesses. The registration of EMG amplitude was done with sEMG; this instrument has its own limitations, such as crosstalk, skin impedance and subcutaneous fat that could alter the myoelectric signal. To minimise these limitations, the following recommendations by SENIAM were followed: belly muscles were identified, shaved the skin, limited the alcohol application to prevent skin impedance, and excluded participants with a BMI equal to or higher than 30 kg/m$^2$. Furthermore, the distance between the load cell and the rotation axis was the same for all subjects; foot size varied among the participants. This distance is related to the foot size and also to the insertion points of the investigated muscles. To use external distance between the device joint and the load cell to estimate the torque could determinate a possible inaccuracy in torque estimation and it could affect the relationship between torque and EMG variables. To increase the accuracy in the relationship between dependent and independent variables, future studies should consider a protocol where the load cell will be located at the same relative point on the foot. This study was conducted on the dominant leg and it is recommended that future studies should examine whether the degree of torque variance experienced during maximal and submaximal IFD is experienced by the three major foot dorsiflexor muscles similarly in the non-dominant leg.

## CONCLUSION

The main conclusion reached in this study is that muscle activation of the three main foot dorsalflexors could explain up to 75.3% of the variance suffered during a maximal-torque IFD. Similarly, during a sub-maximal IFD (75% MVC), the percentage of torque variance that could be experienced by the same variables reached 60.6%.

However, during IFD at mild and moderate intensities, torque variance experienced by activation of the three major dorsiflexor muscles was 38.3% (50% MVC) and 19.4% (25% MVC). These results are potentially useful in the evaluation and management of patients in the clinical field and research. They should also be considered in planning preventive as well as therapeutic intervention strategies. Moreover, the reliability of electromyographic recording of the three main dorsiflexor foot muscles (TA, EDL and EHL) was excellent, as was the torque recorded during isometric foot dorsiflexion at various intensities.

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**FIGURE LEGENDS**

Figure 1. Experiment set-up: scheme of the participant's position during protocol execution. Includes: measuring instruments (electromyography, load cell, trigger); methods of attaching the leg and foot are included in the platform.

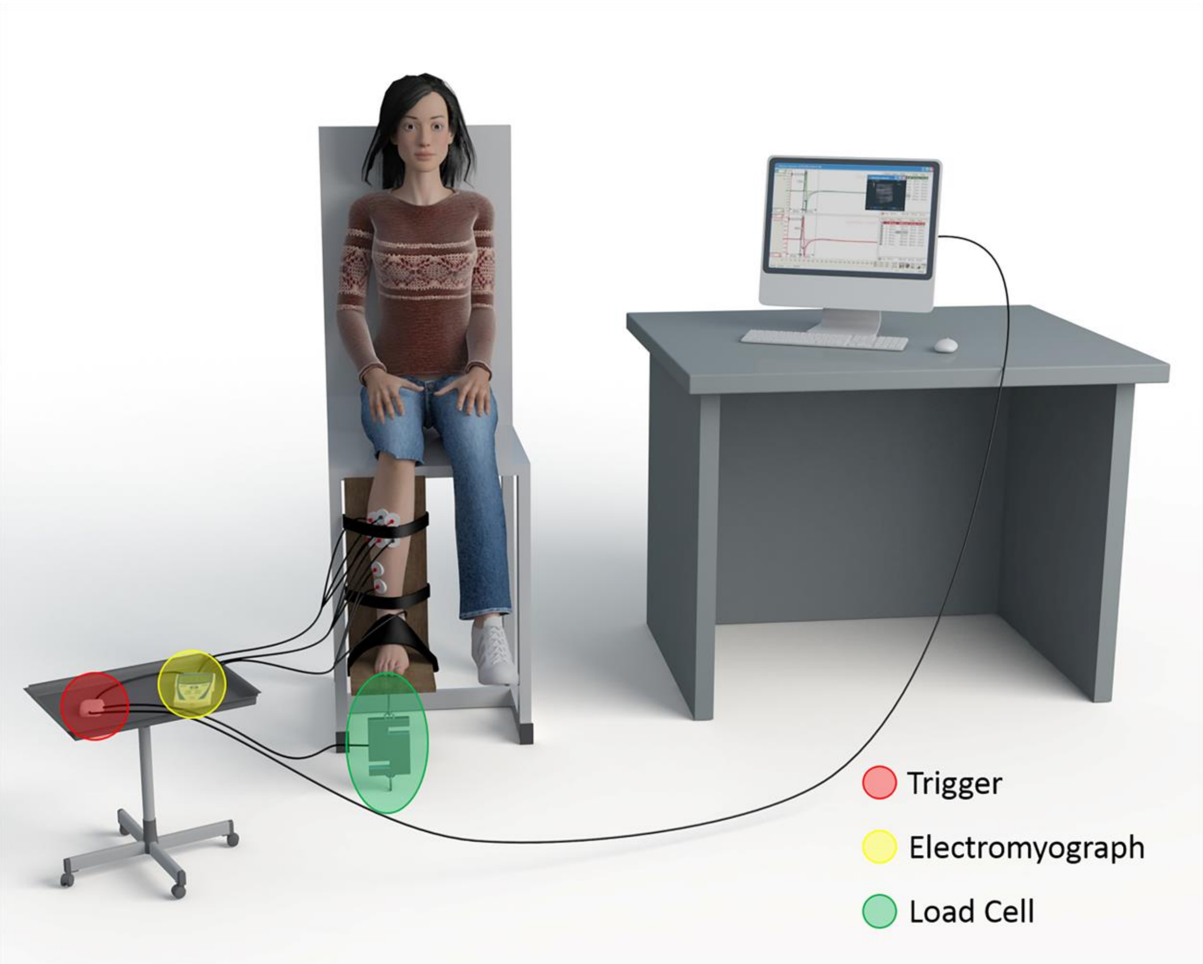

**Table 1**. Descriptive statistics of torque and EMG amplitude (muscle activation) during isometric FD at various intensities.

| | | | Mean (SD) | Male (SD) | Female (SD) |
|---|---|---|---|---|---|
| **Torque** (N.m) | | MCV 100% | **49.87** (±3.87) | **53.64** (±3.32) | **45.17** (±4.59) |
| | | 75% | **34.49** (±3.00) | **41.74** (±3.05) | **26.04** (±2.84) |
| | | 50% | **24.23** (±2.56) | **25.57** (±2.21) | **22.41** (±3.10) |
| | | 25% | **8.34** (±1.04) | **10.95** (±1.14) | **5.07** (±0.84) |
| **EMG amplitude** (uV) | Tibialis Anterior | MCV 100% | **617.26** (±71.70) | **628.83** (±90.11) | **589.55** (±60.56) |
| | | 75% | **483.71** (±63.29) | **565.94** (±73.72) | **444.69** (±41.07) |
| | | 50% | **368.11** (±54.09) | **400.39** (±64.56) | **335.19** (±46.74) |
| | | 25% | **229.83** (±41.19) | **247.91** (±45.92) | **200.55** (±38.15) |
| | Extensor Digitorum Longus | MCV 100% | **376.88** (±43.11) | **437.56** (±48.60) | **350.19** (±42.58) |
| | | 75% | **257.91** (±38.39) | **287.53** (±43.91) | **237.13** (±34.85) |
| | | 50% | **198.30** (±34.72) | **214.16** (±39.05) | **179.34** (±31.60) |
| | | 25% | **149.27** (±31.71) | **163.87** (±35.24) | **135.97** (±28.00) |
| | Extensor Hallucis Longus | MCV 100% | **342.60** (±42.74) | **398.37** (±47.64) | **315.38** (±38.59) |
| | | 75% | **243.19** (±37.41) | **279.08** (±41.74) | **219.99** (±36.95) |
| | | 50% | **183.77** (±32.62) | **206.11** (±37.77) | **167.42** (±30.30) |
| | | 25% | **129.55** (±27.60) | **147.02** (±29.31) | **120.35** (±24.97) |

**Table 2.** Reliability values of the results.

| | | | SEM (Stand. Error. Measu.) | Cronbach's α | IC (95%) | |
|---|---|---|---|---|---|---|
| | | | | | Min. | Max. |
| **Torque** (N.m) | | **MCV 100%** | **3.795** | **0.988** | 0.970 | 0.993 |
| | | **75%** | **2.929** | **0.960** | 0.943 | 0.975 |
| | | **50%** | **2.472** | **0.931** | 0.910 | 0.949 |
| | | **25%** | **1.834** | **0.907** | 0.891 | 0.923 |
| **EMG amplitude** (uV) | Tibialis Anterior | **MCV 100%** | **62.126** | **0.974** | 0.951 | 0.986 |
| | | **75%** | **38.942** | **0.933** | 0.918 | 0.947 |
| | | **50%** | **31.476** | **0.911** | 0.894 | 0.927 |
| | | **25%** | **20.846** | **0.904** | 0.883 | 0.917 |
| | Extensor Digitorum Longus | **MCV 100%** | **34.198** | **0.970** | 0.949 | 0.983 |
| | | **75%** | **22.976** | **0.928** | 0.929 | 0.973 |
| | | **50%** | **17.243** | **0.951** | 0.909 | 0.941 |
| | | **25%** | **16.742** | **0.901** | 0.883 | 0.918 |
| | Extensor Hallucis Longus | **MCV 100%** | **32.597** | **0.967** | 0.953 | 0.981 |
| | | **75%** | **21.512** | **0.922** | 0.922 | 0.967 |
| | | **50%** | **19.241** | **0.946** | 0.900 | 0.939 |
| | | **25%** | **13.844** | **0.897** | 0.873 | 0.906 |

**Table 3:** Analysis of the degree of torque variance (dependent variable) explained by the TA, EHL and EDL EMG amplitude (independent variables) during isometric foot dorsiflexion at various intensities.

| FD Intensity | Independent variables (EMG amplitude) | β-stand | p value | SEE | $R^2$ | Sig |
|---|---|---|---|---|---|---|
| 100% | | | | 601.581 | **0.753** | 0.002 |
| | Tibialis Anterior | 0.519 | 0.036 | | | |
| | Extensor Digitorum Longus | 0.306 | 0.025 | | | |
| | Extensor Hallucis Longus | 0.294 | 0.007 | | | |
| 75% | | | | 738.673 | **0.606** | 0.013 |
| | Tibialis Anterior | 0.441 | 0.042 | | | |
| | Extensor Digitorum Longus | 0.274 | 0.039 | | | |
| | Extensor Hallucis Longus | 0.253 | 0.045 | | | |
| 50% | | | | 796.781 | **0.383** | 0.054 |
| | Tibialis Anterior | 0.337 | 0.058 | | | |
| | Extensor Digitorum Longus | 0.233 | 0.069 | | | |
| | Extensor Hallucis Longus | 0.208 | 0.031 | | | |
| 25% | | | | 906.383 | **0.194** | 0.047 |
| | Tibialis Anterior | 0.289 | 0.061 | | | |
| | Extensor Digitorum Longus | 0.206 | 0.046 | | | |
| | Extensor Hallucis Longus | 0.187 | 0.067 | | | |

FD: Foot dorsiflexion; SEE: Standard error of the estimation .