# REFERENCE VALUES FOR DISTAL MOTOR CONDUCTION OF THE TIBIAL NERVE: EFFECTS OF DEMOGRAPHIC AND ANTHROPOMETRIC MEASURES

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# REFERENCE VALUES FOR DISTAL MOTOR CONDUCTION OF THE TIBIAL NERVE: EFFECTS OF DEMOGRAPHIC AND ANTHROPOMETRIC MEASURES


## ABSTRACT

Introduction: We collected reference values for the across-tarsal-tunnel conduction of the motor tibial nerve (mTN).

Methods: mTN compound muscle action potentials (CMAPs) from the abductor hallucis muscle were obtained by stimulating below/above malleolus, and the popliteal fossa. The effect of weight, height, body mass index (BMI), foot and leg length, sex, and age were evaluated using univariate and multivariate correlation analyses, and predictive equations for each mTN conduction parameter were developed.

Results: Based on data from 185 subjects, there were differences between females and males in all anthropometric parameters and for some nerve conduction values. Through multivariate analysis, age, but not sex, was found to have a significant impact. Height affected both distal and proximal conduction velocity. BMI affected CMAP amplitude.

Discussion: mTN conduction is influenced by various demographic and anthropometric factors.. Between all intrinsic factors, height demonstrated the greatest effect on mTN conduction across the tarsal tunnel.



Key words: anthropometric factors; demographic factors; predictive equations; reference values; tarsal tunnel; tibial nerve

## INTRODUCTION

Motor tibial nerve (mTN) conduction to the abductor hallucis (AbH) muscle is a commonly performed electrodiagnostic technique, and normative reference values for latency, amplitude, and motor nerve conduction velocity (MCV) have been derived by numerous investigators.[1] In most of these papers, the conduction is investigated in the proximal part of the mTN, stimulating above the tarsal tunnel and recording over the AbH or abductor digiti quinti muscle. The studies of Felsenthal et al.[2] and Troni et al.[3] were exceptions, stimulating the mTN above and below the tarsal tunnel in twenty healthy subjects.

The lack of large studies of mTN distal conduction on normal individuals is a significant clinical gap, because the tarsal tunnel is a well known compression site. This is especially true in subjects affected by diseases of the peripheral nervous system. For example, Watanabe et al.[4] in a diabetic population reported that both the mTN in the tarsal tunnel and the median nerve in the carpal tunnel had morphologic alterations that correlated with reduced MCV and delayed latency.

It is known that intrinsic/biological factors such as age, height, sex, and body mass index (BMI) may affect nerve conduction parameters.[5-14] The effects of multiple demographic and anthropometric factors on distal mTN conduction have not been systematically investigated. Therefore, the first aim of this study is to collect reference values for the distal conduction parameters of the mTN from disease-free individuals. The second aim is to develop equations for predicting the reference limits as a function of both these factors.

## METHODS

### Study Subjects

The prospectively recruited participants were consecutive subjects referred to public outpatient EMG laboratories between June 2016 and June 2017 for a variety of symptoms / conditions such as low back pain, lower limb pain, diffuse paresthesia, cramps, weakness, fatigue, asymptomatic creatine kinase elevation, and fibromyalgia. Eligible subjects all had normal neurological examinations and no history of disorders of the peripheral nervous system, normal conduction study of the deep peroneal and sural nerves, and standard needle electromyography of the lower limb muscles. Nerve conduction studies were considered abnormal if they differed by more than two standard deviations (SD) from the mean of normative data of each EMG lab. In addition, we excluded subjects with any other type of neurological diseases, diabetes, connective and thyroid disorders, renal failure, history of alcoholism, trauma or surgery of the lower limb, malignancy in the previous 5 years or previous intake of drugs considered toxic to the peripheral nervous system.

Two neurophysiologists and one neurophysiological technician performed all neurophysiological studies. All were experienced, received the same neurophysiological training, and used standardized electrophysiological techniques.

The following anthropometric measures were recorded for each subject: weight, height, BMI, length of the leg (from fibular head to lateral malleolus), and length of the foot (from the tip of the heel to the tip of the big toe).

The local ethics committee approved the study, and all participants gave written informed consent.

Electrophysiology

We performed motor conduction studies of the deep peroneal and sural nerves bilaterally in most, and the tibial nerve bilaterally in all participants. Motor nerve conduction studies were performed

with surface Ag/AgCl disc recording electrodes, 9 mm in diameter, placed in the 'tendon-belly' configuration. Electrical stimuli consisted of rectangular pulses of 0.2-0.3-ms duration. Compound muscle action potential amplitude (CMAPa) was measured from baseline to the following negative peak. The latency was measured at the onset of the negative deflection of the CMAP.

The active electrode for the medial plantar nerve study was placed over the medial belly of the AbH muscle while the reference electrode was placed on the proximal phalanx of the big toe. The mTN was stimulated at the popliteal fossa (S3), proximal to the upper border of flexor retinaculum (S2) and just distal to the distal border of the thickest portion of the flexor retinaculum (S1). The S1 point was localized about halfway along an imaginary line drawn from the apex of the heel to midway between the navicular tuberosity and the prominence of the medial malleolus, per Troni et al.[3] Inching the cathode distally through the tarsal tunnel also helped to localize this point. Placement of the cathode was adjusted until a supramaximal response was obtained. The S2 electrode was located 5-8 cm proximal to S1. The range of distance between the S2 and S3 recording electrodes was 26-39 cm depending on the leg and foot length of the subject. Examination was performed with the subject lying prone and the ankle in a neutral position. Inter-examiner variability was not tested.

Conductions in the below-above malleolus segment (distal MCV, S2-S1), and proximally, in the popliteal fossa-above malleolus segment (proximal MCV, S3-S2) were analyzed. The terminal motor latency index (TmLI) was calculated as follows: distal conduction distance (cm)/MCV (m/s) × DML (ms). We calculate two different types of TmLI: (1) S1 distal conduction distance/MCV between S2 and S1 x DML at S1; (2) S1 distal conduction distance/MCV between S3 and S2 x DML at S1.

The deep peroneal nerve was studied from the lateral border of the popliteal fossa to below the fibular head, and from below the fibular head to the flexor retinaculum, 9 cm from the extensor digitorum

brevis muscle. The sural nerve was stimulated along the posterior aspect of the leg immediately lateral to midline recording slightly above and posterior to the lateral malleolus at a fixed distance of 13-14 cm. Sensory conduction velocity (SCV) and sensory action potential amplitude were measured from the first positive peak (where latency was calculated) to the following negative peak. For motor and sensory conduction study, the low- and high-frequency filters were set at 10 Hz–10 kHz and 20 Hz–2 kHz, respectively.

We maintained the temperature of the sole of the foot at ≥ 32°C with an infrared lamp. The neurophysiologists performed standard needle EMG in the muscles of the lower limbs on almost all subjects based on the history and symptoms.

## STATISTICAL ANALYSIS

We only used the results from one foot (randomly chosen). After testing for normality using the Kolmogorov-Smirnov test with Lilliefors correction, we found that the data were not normally distributed and therefore we used the Mann Whitney *U* test to analyze continuous variables. The statistical methods which focus on the extremes (ends) of the distribution are markedly influenced by skewness.[15] Because our electrophysiological values showed a skewed distribution (between +0.5 and +1), we transformed the values logarithmically (base 10) to bring positively skewed data into a more Gaussian shape for setting normal limits . We then took the mean ± 2SD of the transformed data and converted these end points back to original units, to derive the normative limits.[15] In addition, we present the data as $2.5^{th}$, $5^{th}$, and $95^{th}$ percentile of the values. We employed Spearman's coefficients for univariate correlation analysis to assess the differences between females and males. Effects of the demographic and anthropometric measures on nerve conduction parameters were

estimated by correlation and linear regression analyses. The goodness of fit of the models was checked by the determination of coefficient $R^2$. To avoid collinearity, when we constructed the multivariate models, if an independent variable that was considered a proxy of another had a similar correlation coefficient to a dependent variable, we included in the model only the independent variable with the higher r value. Based on multivariate analyses, nerve conduction values were expressed with derived regression equations.

We performed all analyses using SPSS.23 software package and accepted an alpha error of 0.05.

## RESULTS

The demographic and anthropometric characteristics from 185 subjects are reported in table 1. There were differences between females and males in all anthropometric parameters: males were taller and heavier than females. Table 2 shows the reference values of the mTN conduction parameters by sex and sides. Females had faster conduction velocities and shorter DMLs than males, whereas the CMAP amplitudes showed no statistically significant difference between groups. The CMAPa drop across tarsal tunnel (5.9%) was much smaller than that observed between popliteal fossa and ankle stimulus sites (12.8%).

No difference was found between right and left sides. Table 3 shows the extremes (ends) of the distribution of the values with the normative limits, according to sex. In table 4, results of the univariate correlation analysis of the mTN nerve conduction data, demographic and anthropometric measures are reported. All nerve conduction data were found to be negatively correlated with age. CMAPa at S1 andS2 were significantly correlated with all nerve conduction data and other measures except for DML, foot length and weight. The proximal MCV parameters were significantly correlated

with all the nerve conduction and demographic/anthropometric values. The distal MCV parameters were significantly correlated with age, foot length and all conduction data.

Using multivariate analyses, we explored the power and effect size of each of the seven multivariate models (Table 5). The power was very high in each case (in 5 of 7, it was 100%) and the effect size was medium or large. Based on the multivariate analyses, nerve conduction values were expressed as regression equations (table 6). Gender was not entered into the model because the electrophysiological differences initially attributed to sex disappeared once the other factors were included in the analysis.

Age was found to be an independent factor influencing both proximal and distal MCV and DML, with an approximately 1.1 m/s decrease in MCV and 0.13 ms increase in DML per decade. Proximal and distal MCVs were influenced by height and distal MCV by foot length. For across-tarsal tunnel MCV, there was about a 0.2 m/s decrease for each centimeter increase in height, and a 1.13 m/s increase for each centimeter increase in foot length. ML and TmLI were related to the distal distance from the stimulation electrode located on S1 point. Terminal motor latency index was the only parameter for which age did not enter in the model.

The negative relationship of age and BMI with CMAP amplitude was a significant finding in all three points of recording. Older subjects with higher BMIs had smaller CMAP amplitudes both across the tarsal tunnel and at the popliteal fossa. However, the magnitude of the effect of BMI on CMAPa was less prominent below the flexor retinaculum than that more proximally.

DISCUSSION

Difficulty in determining the onset and different CMAP configurations with distal vs. proximal stimulation across the tarsal tunnel are the most frequent challenges encountered. However, defined mTN CMAPs were obtained from all subjects from below and above the malleolus. Moreover, mTN MCV across the tarsal tunnel may not always be accurate because of the short distance between the stimulation sites.

Our electrophysiological method is similar to that utilized by Felsenthal et al.[2] and Troni et al.[3], although the latter used needle recording. Despite the numerical and demographic differences of the samples analyzed, the mean values relative to the mTN MCV and CMAPa are quite similar between the three studies. These similarities demonstrate the feasibility of the across-tarsal-tunnel motor-conduction technique. We believe that slight adjustment of the recording electrode location and the intensity of the stimulus to avoid electrical current spread is usually sufficient to minimize technical errors.

Since most of the conduction velocity data in this study showed small deviations from Gaussian distribution, we reported the mTN reference values with the most used method for nerve conduction studies: mean ± 2 SD.[15] However, the distribution of other nerve conduction parameters in the healthy population does not always follow a Gaussian distribution.[15] The amplitude histograms in this study were positively skewed with an asymmetric tail extending toward higher amplitudes. We dealt with this by using logarithmic transformation.[16-18] We also used other statistical methods and found little or no difference. The lower limits were slightly different depending on whether we used 2SD of the mean of log-transformed data, the 2.5$^{th}$ or the 5$^{th}$ percentile.

The decrease of 12.8% in the mTN CMAPa with stimulation at the popliteal fossa compared to that with stimulation at the ankle (above the malleolus) is similar to what is commonly seen in routine

mTN conduction studies. Temporal dispersion and phase cancellation are the most plausible explanations for this.[19] The smaller CMAPa drop (5.9%) observed between stimulation below and above the malleolus (with shorter conduction distance), is in keeping with this. Using univariate correlation analysis we found that increasing age was associated with diminished CMAPa and MCV (both proximal and distal), and increased DML. Similarly to Rivner et al,[12] CMAPa of our sample showed a larger negative correlation than conduction velocity.

In the literature, negative correlations between motor nerve conduction parameters and height have been reported.[6,7,12,20] In contrast, there is much debate about the correlation between BMI and MCV/CMAPa.[11,13,21-22] In our sample, MCV across the tarsal tunnel was not correlated with BMI or height. Conversely, the across-tarsal tunnel CMAP amplitudes and proximal MCV correlated with height and BMI. The considerably shorter nerve segment studied could explain the lack of correlation of the distal MCV with both height and BMI.

To detect possible interactions among the various factors influencing the conduction data, multiple linear regression analysis was performed. This type of analysis for mTN was performed by Fong et al.[23] and Robinson et al.[10] who studied the popliteal-above malleolus TN segment. Fong et al.[23] demonstrated that age was an independent variable affecting all conduction parameters, whereas BMI affected CMAPa. Robinson et al.[10] showed that height influenced MCV but not CMAPa.

Our study showed that the effects of the demographic and anthropometric factors on the conduction parameters of mTN were different. The effects of increasing age on distal MCV and CMAPa, and of increasing BMI on CMAPa were much less significant than the effects of the height on MCV. For example, an increase in age of 20 years causes a decrease in distal MCV of about 2 m/s and a decrease in amplitude of 0.2 mV. In contrast, an increase of 20 cm in height causes a decrease of about 4.3 m/s

in distal MCV. In addition, the effects of intrinsic factors on the conduction parameters of mTN were similar in distal and proximal segments. The only exception was that foot length influenced only distal MCV

The major limitation of our study is the population enrolled. For convenience, instead of healthy volunteers, we collected data from subjects referred with suspected neuromuscular disorders. However, we excluded all subjects having medical conditions that could be associated with neuromuscular diseases and those having signs and symptoms suggesting disorders of the peripheral nervous system. Because all eligible subjects also had normal nerve conduction studies of the deep peroneal and sural nerves, and normal needle electromyography results, the possibility that they had disorders influencing the mTN electrophysiological results is likely small. Other limitations of the study are that we did not test the inter-examiner reliability of the measurements of nerve conduction parameters, and that the selected population is older that the general population and therefore the results may not be generalizable to a younger age group. Finally, although multivariate analysis is a useful tool for increasing diagnostic sensitivity of NCS, the possibility of errors should be considered.[15]

In summary, we evaluated the impact of anthropometric variables on mTN conduction and found that height had a greater effect than other intrinsic factors on conduction parameters across the tarsal tunnel. The use of the across-tarsal tunnel mTN conduction in routine clinical evaluations could facilitate the diagnosis of tarsal tunnel syndrome and of early or subclinical polyneuropathies..

ABBREVIATIONS

AbH: abductor hallucis

BMI: body mass index

CMAP: compound muscle action potential

DML: distal motor latency

mTN: motor tibial nerve:

MCV: motor nerve conduction velocity

SCV: sensory conduction velocity

TmLI: terminal motor latency index

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**Table 1:** Demographic characteristics of the enrolled subjects

| Subjects | AGE (years) | HEIGHT (cm) | WEIGHT (kg) | BMI (kg/m$^2$) | FOOT length (cm) | LEG length (cm) |
|---|---|---|---|---|---|---|
| Total n= 185 | 60.1±14.5 | 164.6±9.5 | 71.1±16.8 | 26.1±4.9 | 22.3±1.8 | 34±2.7 |
| Females n= 110 | 59.8±14.8 | 159.4±6.6 | 64.5±13.1 | 25.4±5.2 | 23.3±1.3 | 32.8±2 |
| Males n= 75 | 60.6±14 | 172±7.8** | 80.9±16.7** | 27.1±1.5** | 25.8±1.5** | 36.0±2.4** |

BMI: body mass index; n: number; Values are reported as mean ± SD; **: p<0001 (males vs. females)

**Table 2:** Tibial nerve. Electrophysiological values

| | MCV distal tract (m/s) | MCV proximal tract (m/s) | DML (ms) | TmLI (1) (ms) | TmLI (2) (ms) | CMAPa at S1 (mV) | CMAPa at S2 (mV) | CMAPa at S3 (mV) | difference CMAPa S2-S1 | difference CMAPa S3-S2 |
|---|---|---|---|---|---|---|---|---|---|---|
| All subjects (185 feet) | 44.3±7.6 | 45.9±3.7 | 4.52±0.7 | 0.79±0.3 | 0.76±0.3 | 7.24±2.7 | 6.85±2.7 | 6±2.5 | 5.7% | 14,2% |
| Females (110 feet) | 45.5±8.1 | 46.6±3.6 | 4.39±0.7 | 0.72±0.2 | 0.68±0.2 | 7.3±2.9 | 6.93±2.8 | 6.17±2.8 | 5.1% | 11% |
| Males (75 feet) | 44.1±6.5 | 44.9±3.7* | 4.72±0.6** | 0.9±0.3** | 0.88±0.2** | 7.17±2.4 | 6.74±2.4 | 5.77±2.1 | 6.4% | 14.4% |
| Right side all subjects (185 feet) | 44.3±7.6 | 45.9±3.7 | 4.52±0.7 | 0.81±0.3 | 0.77±0.2 | 7.24±2.7 | 6.85±2.6 | 6.01±2.5 | 5.7% | 12.3% |
| Left side all subjects (185 feet) | 45.7±6.3 | 45.8±3.4 | 4.5±0.7 | 0.78±0.2 | 0.76±0.22 | 7.12±2.5 | 6.74±2.5 | 5.83±2.3 | 5.6% | 13.5% |

Values are reported as mean ± SD. CMAPa: compound muscle action potential amplitude; Distal MCV: motor conduction velocity in the above-below malleolus (S1-S2) tract; DML: distal motor latency; Proximal MCV: motor conduction velocity in the above malleolus-knee (S2-S3) tract; S1: point of stimulation at the ankle, below malleolus; S2: point of stimulation at the ankle, above malleolus; S3: point of stimulation at the knee; TmLI: terminal motor latency; TmLI 1 was calculated with distal MCV, TmLI 2 was calculated with proximal MCV; TmLI 1 and 2 were not statistically different. *p=0.001 (males vs. females); **p<0001 (males vs. females)

Table 3: Limits of distal tibial nerve conduction

| | **CMAPa at S1, mV (below malleolus)** | **CMAPa at S2, mV (above malleolus)** | **Distal MCV, m/s** |
|---|---|---|---|
| **Females (n = 110)** | | | |
| - 2SD of the mean of log-transformed data | 2.91 | 2.69 | 30.7 |
| 2.5$^{th}$ percentile of the values | 2.57 | 2.58 | 32.3 |
| 5$^{th}$ percentile of the values | 3.44 | 2.85 | 33 |
| 95$^{th}$ percentile of the values | 12.96 | 13 | 60.9 |
| **Males (n = 75)** | | | |
| - 2SD of the mean of log-transformed data | 3.38 | 3.06 | 32.8 |
| 2.5$^{th}$ percentile of the values | 3.09 | 2.8 | 34 |
| 5$^{th}$ percentile of the values | 3.9 | 3.3 | 35.3 |
| 95$^{th}$ percentile of the values | 11.12 | 10.78 | 58.1 |

CMAPa: compound muscle action potential amplitude; Distal MCV: motor conduction velocity in the above-below malleolus (S1-S2) tract; n: number; S1: point of stimulation at the ankle, below malleolus; S2: point of stimulation at the ankle, above malleolus; SD: standard deviation.

**Table 4.** Correlation analyses of the conduction parameters of the tibial nerve in 185 subjects (110 females and 75 males)

| SPEARMAN'S RHO | Age | Height | Weight | BMI | Foot length | Leg length | Proximal MCV | Distal MCV | DML | CMAPa at S1 | CMAPa at S2 | CMAPa at S3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | | r=-0.25 *p*=0.0008 | n.s. | n.s. | r=-0.18 *p*=0.0174 | r=-0.36 *p*<0.0001 | r=-0.34 *p*<0.0001 | r=-0.19 *p*=0.0093 | n.s. | r=-0.51 *p*<0.0001 | r=-0.52 *p*<0.0001 | r=-0.52 *p*<0.0001 |
| Height | r=-0.25 *p*=0.0008 | | r=0.5 *p*<0.0001 | n.s. | r=0.71 *p*<0.0001 | r=0.74 *p*<0.0001 | r=-0.23 *p*=0.0015 | n.s. | r=0.18 *p*=0.0146 | r=0.15 *p*=0.0415 | n.s. | n.s. |
| Weight | n.s. | r=0.5 *p*<0.0001 | | r=0.83 *p*<0.0001 | r=0.56 *p*<0.0001 | r=0.52 *p*<0.0001 | r=-0.22 *p*=0.0029 | n.s. | n.s. | n.s. | n.s. | n.s. |
| BMI | n.s. | n.s. | r=0.83 *p*<0.0001 | | r=0.22 *p*=0.0036 | n.s. | r=-0.15 *p*=0.036 | n.s. | n.s. | r=-0.2 *p*=0.007 | r=-0.25 *p*=0.0007 | r=-0.26 *p*=0.0004 |
| Foot length | r=-0.18 *p*=0.0174 | r=0.71 *p*<0.0001 | r=0.56 *p*<0.0001 | r=0.22 *p*=0.0036 | | r=0.73 *p*<0.0001 | r=-0.2 *p*=0.0074 | r=0.15 p=0.043 | r=0.2 *p*=0.008 | n.s. | n.s. | n.s. |
| Leg length | r=-0.36 *p*<0.0001 | r=0.74 *p*<0.0001 | r=0.52 *p*<0.0001 | n.s. | r=0.73 *p*<0.0001 | | r=-0.17 *p*=0.022 | n.s. | n.s. | r=0.24 *p*=0.0011 | r=0.22 *p*=0.0033 | r=0.2 *p*=0.0082 |
| Proximal MCV | r=-0.34 *p*<0.0001 | r=-0.23 *p*=0.0015 | r=-0.22 *p*=0.0029 | r=-0.15 *p*=0.036 | r=-0.2 *p*=0.0074 | r=-0.17 *p*=0.022 | | r=0.25 *p*=0.0005 | r=-0.3 *p*<0.0001 | r=0.29 *p*<0.0001 | r=0.3 *p*<0.0001 | r=0.36 *p*<0.0001 |
| Distal MCV | r=-0.19 *p*=0.0093 | n.s. | n.s. | n.s. | r=0.15 *p*=0.043 | n.s. | r=0.25 *p*=0.0005 | | r=-0.26 *p*=0.0003 | r=0.23 *p*=0.0018 | r=0.21 *p*=0.0047 | r=0.2 *p*=0.0078 |
| DML | n.s | r=0.18 *p*=0.0146 | n.s. | n.s. | r=0.2 *p*=0.008 | n.s. | r=-0.3 *p*<0.0001 | r=-0.26 *p*=0.0003 | | n.s. | n.s. | r=-0.16 *p*=0.0349 |
| CAMPa at S1 | r=-0.51 *p*<0.0001 | r=0.15 *p*=0.0415 | n.s. | r=-0.2 *p*=0.007 | n.s. | r=0.24 *p*=0.0011 | r=0.29 *p*<0.0001 | r=0.23 *p*=0.0018 | n.s. | | r=0.97 *p*<0.0001 | r=0.94 *p*<0.0001 |
| CAMPa at S2 | r=-0.52 *p*<0.0001 | n.s. | n.s. | r=-0.25 *p*=0.0007 | n.s. | r=0.22 *p*=0.0033 | r=0.3 *p*<0.0001 | r=0.21 *p*=0.0047 | n.s. | r=0.97 *p*<0.0001 | | r=0.97 *p*<0.0001 |
| CAMPa at S3 | r=-0.52 *p*<0.0001 | n.s. | n.s. | r=-0.26 *p*=0.0004 | n.s. | r=0.2 *p*=0.0082 | r=0.36 *p*<0.0001 | r=0.2 *p*=0.0078 | r=-0.16 p=0.0349 | r=0.94 *p*<0.0001 | r=0.97 *p*<0.0001 | |

BMI: body mass index; CMAPa: compound muscle action potential amplitude; Distal MCV: motor conduction velocity in the above-below malleolus (S1-S2) tract; DML: distal motor latency; n.s.: not significant; Proximal MCV: motor conduction velocity in the above malleolus-knee (S2-

S3) tract; S1: point of stimulation at the ankle, below malleolus; S2: point of stimulation at the ankle, above malleolus; S3: point of stimulation at the knee.

**Table 5:** Multivariate linear regression results

| Neurographic parameters | Estimate (beta) and (C.I.) | Standard Error | p-value | Adjusted $R^2$ | Effect Size (C.I.) |
|---|---|---|---|---|---|
| **Proximal MCV (m/s)** | | | | 0.22 | 0.23 (0.13-0.32) |
| -Intercept | 76.31 (66.8 / 85.9) | 4.830.017 | <0.0001 | | |
| -Age (years) | -0.11 (-0.15 / -0.08) | 2.7 | <0.0001 | | 0.18 (0.09-0.28) |
| -Height (m) | -14.43 (-19.8 / -9.1) | | <0.0001 | | 0.14 (0.06-0.23) |
| **Distal MCV (m/s)** | | | | 0.076 | 0.09 (0.02-0.17) |
| -Intercept | 59.48 (38.4 / 80.5) | 10.67 | <0.0001 | | |
| -Age (years) | -0.12 (-0. 2 / -0.05) | 0.039 | =0.002 | | 0.05 (0.01-0.13) |
| -Height (m) | -21.36 (-37.5 / -5.24) | 8.17 | =0.002 | | 0.04 (0.01-0.11) |
| -Foot length (cm) | 1.13 (0.33 / 1.93) | 0.41 | =0.006 | | 0.04 (0.01-0.11) |
| **DML (ms)** | | | | 0.17 | 0.18 (0.09-0.27) |
| -Intercept | 1.98 (1.17 / 2.78) | 0.41 | <0.0001 | | |
| -Age (years) | 0.013 (0.007 / 0.02) | 0.003 | <0.0001 | | 0.08 (0.02-0.16) |
| -Distal distance (cm) | 0.23 (0.15 / 0.31) | 0.039 | <0.0001 | | 0.16 (0.08-0.26) |
| **TmLI (ms)** | | | | 0.57 | 0.57 (0.48-0.64) |
| -Intercept | -0.67 (-1.06 / -0.29) | 0.2 | =0.001 | | |
| -Height (m) | 0.3 (0.02 / 0.57) | 0.14 | =0.033 | | 0.02 (0.01-0.08) |
| -Distal distance (cm) | 0.13 (0.1 / 0.15) | 0.011 | <0.0001 | | 0.43 (0.33-0.52) |
| **CMAPa S1 (mV)** | | | | 0.32 | 0.32 (0.21-0.42) |
| -Intercept | 15.41 (13.3 / 17.5) | 1.07 | <0.0001 | | |
| -Age (years) | -0.01 (-0.12 / -0.08) | 0.011 | <0.0001 | | 0.29 (0.19-0.39) |
| -BMI ($kg/m^2$) | -0.084 (-0.15 /-0.017) | 0.034 | =0.014 | | 0.03 (0.01-0.10) |
| **CMAPa S2 (mV)** | | | | 0.34 | 0.35 (0.24-0.44) |
| -Intercept | 15.41 (13.37 / 17.45) | 1.03 | <0.0001 | | |
| -Age (years) | -0.01 (-0.12 / -0.08) | 0.011 | <0.0001 | | 0.31 (0.20-0.40) |
| -BMI ($kg/m^2$) | -0.1 (-0.165 /-0.036) | 0.03 | =0.002 | | 0.05 (0.01-0.12) |
| **CMAPa S3 (mV)** | | | | 0.38 | 0.39 (0.28-0.47) |
| -Intercept | 14.66 (12.8 / 16.52) | 0.94 | <0.0001 | | |
| -Age (years) | -0.097 (-0.117 / -0.077) | 0.01 | <0.0001 | | 0.36 (0.23-0.43) |
| -BMI ($kg/m^2$) | -0.11 (-0.168 / -0.051) | 0.03 | <0.0001 | | 0.07 (0.02-0.15) |

BMI: body mass index; C.I.; confidential interval; CMAPa: compound muscle action potential amplitude; Distal MCV: motor conduction velocity in the above-below malleolus (S1-S2) tract; DML: distal motor latency; Proximal MCV: motor conduction velocity in the above malleolus-knee (S2-S3) tract; S1: point of stimulation at the ankle, below malleolus; S2: point of stimulation at the ankle, above malleolus; S3: point of stimulation at the knee; TmLI: terminal motor latency calculated with MCV in distal tract.

**Table 6:** Nerve conduction values expressed as regression equations.

| **Regression equations** |
|---|
| **Proximal MCV (m/s) =** 76.31-0.11*age (years)-14.43*height (m) |
| **Distal MCV (m/s) =** 59.48-0.11*age (years)-21.36*height (m)+1.13*foot length (cm) |
| **DML (ms) =** 1.98+0.013*age (years)+0.23*distal distance (cm) |
| **TmLI (ms) =** -0.67+0.3*height (m)+ 0.13*distal distance (cm) |
| **CMAPa S1 (mV) =** 15.41-0.01*age (years)-0.084*BMI ($kg/m^2$) |
| **CMAPa S2 (mV) =** 15.41-0.01*age (years)-0.1*BMI ($kg/m^2$) |
| **CMAPa S3 (mV) =** 14.66-0.097*age (years)-0.11*BMI ($kg/m^2$) |

BMI: body mass index; CMAPa: compound muscle action potential amplitude; Distal MCV: motor conduction velocity in the above-below malleolus (S1-S2) tract; DML: distal motor latency; Proximal MCV: motor conduction velocity in the above malleolus-knee (S2-S3) tract; S1: point of stimulation at the ankle, below malleolus; S2: point of stimulation at the ankle, above malleolus; S3: point of stimulation at the knee; TmLI: terminal motor latency calculated with MCV in distal tract.