Original Contribution

A Cross-Sectional Study of the Normative Data of the Side-To-Side Soleus Hoffmann Reflex from the Calf Muscle in Healthy Individuals in the Lying Down Position

***Gupta A[1], *Chouhan S[2], Arya V[3], Singh R[4], Shrivastava R[5], Ravi N[6]**

The goal of this study was to find out from the calf muscle, the normal H-reflex is in a group of healthy adults. This study is conducted for the period of one year in 2020-2021, in the department of Physiology AIIMS Bhopal, 119 adult male healthy volunteers who were asymptomatic from peripheral neuropathy and had a mean age of 30.40±6.78 were evaluated, to compare the normative tibial H reflex to their stature, body mass index, core body temperature, and limb length. The parameters considered were M- Latency, H-Latency, M-Amplitude, H- Amplitude and H/M Ratio in their left and right legs, respectively. A total of 111 participants (93.3%) were in the age group of 40 years or younger, with the mean age (in years) being 30.40±6.78. Only eight (8) participants (6.7%) belonged to the over-40 age group. The average weight (Kg), height (cm), and limb length (cm) were 173.11 cm, 10.48 cm, and 94.28 cm respectively. The mean ±SD latencies of the H reflex were 30.93±4.42 and 31.01±5.21 milliseconds in the right and left legs, respectively. Leg length and H reflex latency had a significant correlation (r = 0.55, p=0.05). There was no discernible correlation between age and the H reflex latency. The right and left H reflex latencies should vary by no more than 1.8 ms to be deemed normal. This research examined tibia H-reflex side-to-side latency variability and amplitude. Neurologic function may be assessed using the H-reflex. Due of its sensitivity to external circumstances, the H-reflex must be elicited carefully. The H-reflex may reveal neuronal function following damage if assessed appropriately.

[Mymensingh Med J 2024 Oct; 33 (4): 1258-1266]

Key words: H reflex, S1 radiculopathy, Electromyography

Introduction

Paul Hoffmann looked at the H reflex for the first time in 1910. He noticed that when the tibial nerve was stimulated less than fully, the calf muscles responded slowly[1]. The F waves, A waves, H reflex and blink reflex are late reactions that tend to help improve regular nerve conduction tests. The H-reflex, which is a monosynaptic segmental spinal reflex, involves tests of nerve conduction over the whole length of the nerve, suggesting neuro- and radiculopathy defects[2]. It is one of the easiest reflexes that can be recorded in human subjects, which has become a common approach in the analysis of motor control studies. Perhaps the main usage for H-reflex studies is to help clinicians review proximal conduction (i.e., plexuses and peripheral nerve roots). In order to obtain a reflex response, as impulses enter the motor neuron reservoir (alpha-motor neurons)[3], the afferent firing (Group Ia afferents) must be coordinated, and it must create a suitable compound excitatory postsynaptic potential (EPSP) to discharge the lowest threshold motor neurons. A reflex response would be delayed and decrease in size by the pathological dispersion of the afferent firing. When severe, even though all afferent axons are capable of firing, distribution might abolish the reflex reaction entirely.

1. **Dr Akriti Gupta, Assistant Professor, Department of Physiology, Atal Bihari Vajpayee Govt. Medical College Vidisha M.P, India; E-mail:*
2. **Dr Sunil Chouhan Additional Professor, Department of Physiology, AIIMS Bhopal, India; E-mail: sunil.physiology@aiims bhopal.edu.in*
3. *Dr Veerendra Arya, Associate Professor Department of Pulmonary Medicine (Super Specialty) NSCB Medical College Jabalpur, India*
4. *Professor Dr Ruchi Singh, Additional Professor, Department of Physiology, AIIMS Bhopal, India*
5. *Professor Dr Ragini Shrivastava, Additional Professor, Department of Physiology, AIIMS Bhopal, India*
6. *Dr Naveen Ravi, Senior Resident, AIIMS, Bibinagar, India*

**for correspondence*

Loss of axons without slowing conductivity can often contribute to a brief delay since the threshold for motor neuron discharge on the EPSP compound is reached later. As a consequence, the reflex reaction is susceptible to minimal changes and can be absent if there is no clinically observable deficit[4]. This reflex may be used to determine the excitability of the spinal reflex[5,6] and can also include details on conduction in peripheral nerve fibre proximal parts, such as in the plexus of the limb and in the dorsal and ventral roots[7]. In adults, this reflex has been widely studied in the soleus, quadriceps, and radial flexor muscles; it can also be elicited from the biceps femoris[8], tibialis anterior[9], extensor digitorum longus[10] and extensor digitorum brevis[11]. While there are many normative studies in the literature[12,13,14,15], the normative values and normograms of Schimsheimer[16] are convenient.

Methods

All participants signed an informed consent form prior to examination, and the Institute research board and ethical committee (IMO 320) approved this research. The research included 119 male participants aged 30.40 years (mean SD: 6.78 years), height 173.11±4.98 cm, with no background or clinical proof of peripheral or central nervous system illness. Method: To rule out possible confounding factors like diabetes, vitamin B-12 or folate deficiency, or uncontrolled thyroid disease, the participants were directly asked if they had any health problems or took any medications. A physical exam was done to rule out people who might have neuromuscular or neuropathic disorders that haven't been found yet. Every participant provided written, informed permission before any testing was performed. At rest, the healthy participants “H” reflex were recorded. To reduce spinal strain, subjects were positioned in a semi-prone posture. The subjects were instructed to lie face down with one leg bent to one side (the Sims posture), with the angles of the knee and ankle being approximately 154°–164° and 95°–105°, respectively. The recording was conducted using surface electrodes (Nihon kohen). The limb position was slightly modified (semi-prone) in order to place the electrode according to Braddom and Johnson's approach. In the soleus muscle, the recording surface electrode was placed 2 cm distally to the medial gastrocnemius, and the reference electrode was placed at the location of the Achilles tendon insertion in the posterior midline. A ground electrode was mounted between the active electrode and the reference electrode. The stimulation was a 1-m long square-wave pulse of 0.1 Hz at an intensity of 6-27 mA. The signals were filtered from 5 Hz to 5 kHz. The temperature of the skin over the route of the nerve was within the range of 32°-35°C. The H-reflex test was carried out in accordance with the steps specified by Palmieri et al., with stimulation administered to the posterior tibial nerve in the popliteal fossa (mid-popliteal crease) while maintaining the anode distally. Bilateral recordings of the overall amplitude and latency of the H-reflex (Hmax); the ratio of Hmax/Mmax amplitude; and Hmax latency were made.

Statistical analyses: Calculations were made using the statistical program SPSS for Windows, version 17.0 and data were reported as means SD (range) unless otherwise noted (SPSS Inc., Chicago, IL, USA). We found the normative reference limits for the Hmax latency, amplitude and the ratio of the Hmax amplitude to the Mmax amplitude.

Results

Table I displays all data, including means, standard deviations, and measurement standard errors. This sample group consisted entirely of adult males. The average male weight was 70.42±10.48 and the age range for the men was 15 to 44 years. The variable age (years) was not normally distributed (Shapiro-Wilk Test: p=0.001). The body mass index (Kg/m^2), temperature (left and right) and limb length were 23.51±3.43 (Kg/m^2), 31.52±1.27°C, 31.61± 1.27°C, 94.28±6.81 cm, respectively (Table I). Figure 1 shows how the electrodes are placed when the patient is semi-prone or prone. Figure 2 shows the H reflex in the right and left legs, respectively. The scatter plot shows the relationship between age (years) and H-latency (ms), as seen in figure 3 (Left). Each point represents a distinct case. The overall pattern of correlation between the two variables is shown by the blue trendline. The shaded gray area displays the 95.0% confidence interval of this trendline. Since at least one of the variables was not normally distributed, non- parametric tests (Spearman's correlation) were utilized to examine the correlation between the two variables. There was a positive connection between age and H-

Latency (ms) (left), however, it was not statistically significant (rho=0.16, p=0.082). The association between limb length (cm) and H-latency (ms) is seen in the scatter plot above (left). Each point represents a distinct case. The blue trendline in figure 4 illustrates the overall trend of correlation between the two variables. The shaded gray area displays the 95.0% confidence interval of this trendline. Since at least one of the variables was not normally distributed, non-parametric tests (Spearman's correlation) were utilized to examine the correlation between the two variables. Limb length (cm) and H-latency (ms) had a somewhat positive connection (rho=0.16, p=0.082), but it was not statistically significant. The mean, standard deviations and percentile values for the observed latencies are shown in Table II. Higher latencies were associated with older age, a higher BMI, and a higher height; as a result, the results are divided into subgroups as shown in Table III. Table IV provides a summary of H-reflex data.

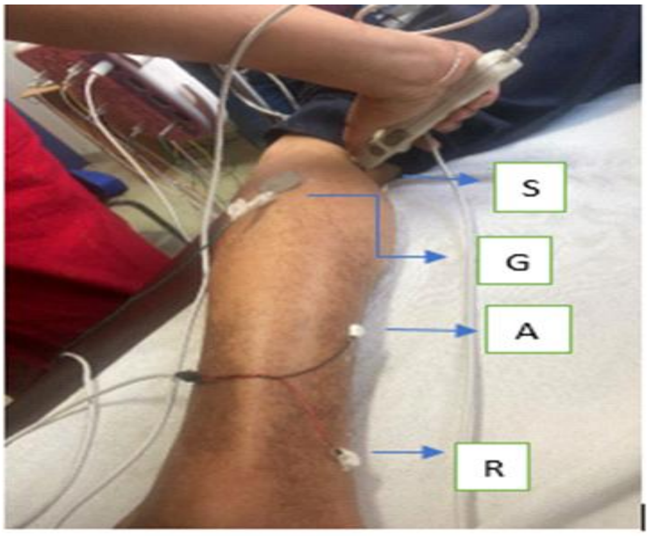


Figure 1: Showing electrode placement in semi prone and prone position Active electrode in soleus muscle and stimulating tibial nerve

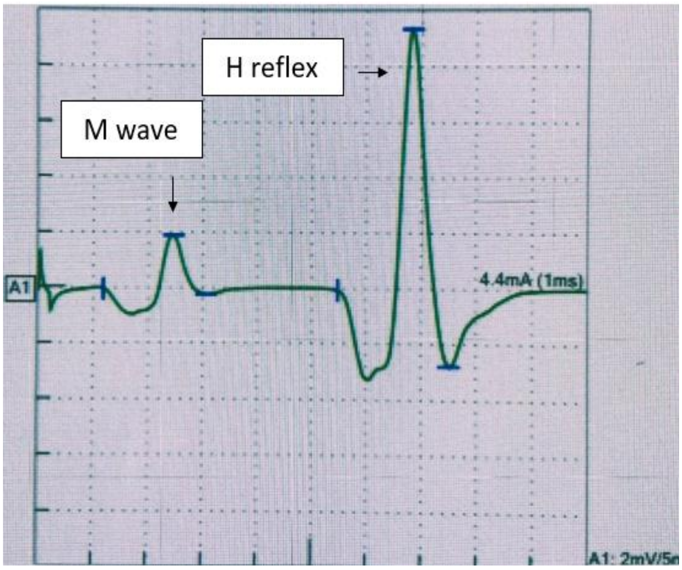
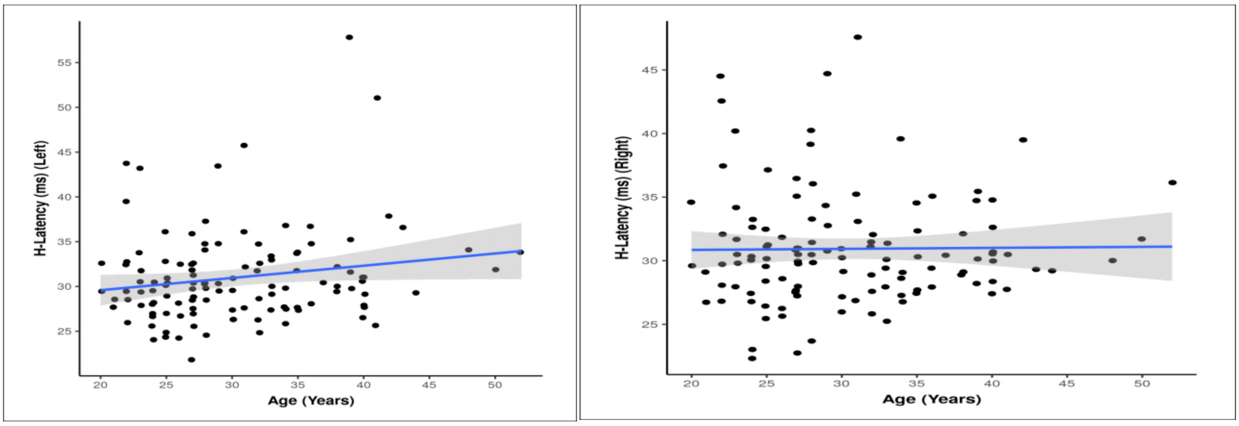


Figure 2: Showing H reflex in leg obtained from stimulating tibial nerve with active electrode placement in soleus muscle

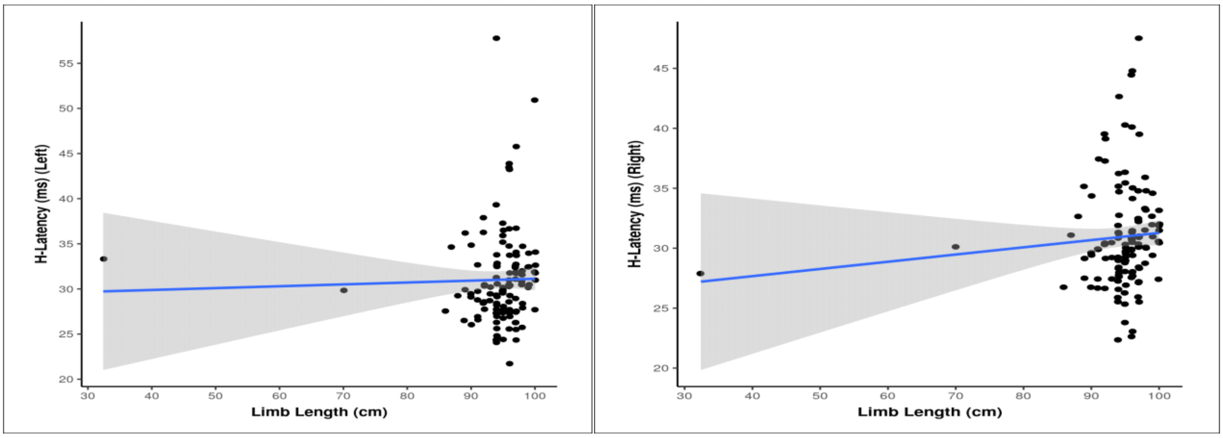
Table I: Summary of Basic details of subject in term of mean, median, standard deviations and frequency

Basic Details	Mean±SD	Median (IQR)	Min-Max	Frequency (%)
Age (Years)	30.40±6.78	29.00 (25.00-35.00)	20.00 - 52.00	
Age group				
≤40 years	-	-	-	111 (93.3)
>40 years	-	-	-	08 (06.7)
Height (cm)	173.11±4.98	173.00 (170.0-177.0)	158.00 - 184.00	
Weight (Kg)	70.42±10.48	69.00 (63.50-76.50)	43.00 - 102.00	
BMI (Kg/m^2)	23.51±3.43	23.18 (21.38-25.23)	14.37 - 34.60	
Temperature (Left) °C	31.52±1.27	31.60 (31.00-32.35)	26.10 - 34.00	
Temperature (Right) °C	31.61±1.23	31.60 (31.00-32.40)	27.70 - 34.20	
Limb Length (cm)	94.28 ± 6.81	95.00 (94.00-97.00)	32.40 - 100.00	



Correlation	Spearman correlation coefficient	p value
Age (years) vs. H-Latency (ms) (Left)	0.2	0.082
Age (years) vs. H-Latency (ms) (Right)	0.1	0.749

Figure 3: Correlation between Age (Years) and H-Latency (ms) (n=119)



Correlation	Spearman Correlation Coefficient	p value
Limb Length (cm) vs. H-Latency (ms) (left)	0.2	0.082
Limb Length (cm) vs. H-Latency (ms) (Right)	0.2	0.051

Figure 4: Correlation between Limb Length (cm) and H-Latency (ms) (Left) (n=119)

Table II: Showing correlation with amplitude

Parameters	H-Amplitude (mV)	p value
Age (Years)	Correlation Coefficient (rho) = -0.22	0.014[1]
Age group (Years)		0.326[2]
≤40 (Mean±SD)	5.16±3.31	
>40 (Mean±SD)	3.75±3.49	
Height (cm)	Correlation Coefficient (rho) = -0.15	0.100[1]
Weight (Kg)	Correlation Coefficient (rho) = -0.24	0.009[1]
BMI (Kg/m^2)	Correlation Coefficient (rho) = -0.17	0.066[1]
Temperature (Left)	Correlation Coefficient (rho) = 0.07	0.442[1]
Temperature (Right)	Correlation Coefficient (rho) = -0.14	0.125[1]
Limb Length (cm)	Correlation Coefficient (rho) = -0.12	0.176[1]
M-Latency (ms) (Left)	Correlation Coefficient (rho) = 0.01	0.917[1]
H-Latency (ms) (Left)	Correlation Coefficient (rho) = -0.22	0.016[1]
M-Amplitude (mV) (Left)	Correlation Coefficient (rho) = 0.43	<0.001[1]
H-M Ratio (Left)	Correlation Coefficient (rho) = 0.48	<0.001[1]
M-Latency (ms) (Right)	Correlation Coefficient (rho) = 0.03	0.784[1]
H-Latency (ms) (Right)	Correlation Coefficient (rho) = -0.14	0.132[1]
M-Amplitude (mV) (Right)	Correlation Coefficient (rho) = 0.42	<0.001[1]
H-Amplitude (mV) (Right)	Correlation Coefficient (rho) = 0.87	<0.001[1]
H-M Ratio (Right)	Correlation Coefficient (rho) = 0.41	<0.001[1]

1: Spearman Correlation, 2: Wilcoxon-Mann-Whitney U Test

Table III: Association between H-Latency (ms) and Parameters

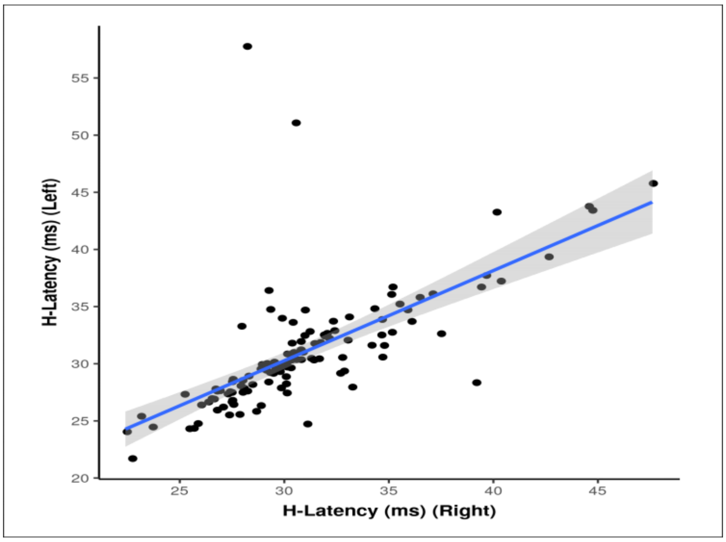
Parameters	H-Latency (ms)	p value
Age (Years)	Correlation Coefficient (rho) = 0.16	0.082[1]
Age group (Years)		0.045[2]
≤40 (Mean±SD)	30.72±4.92	
>40 (Mean±SD)	34.98±7.56	
Height (cm)	Correlation Coefficient (rho) = 0.12	0.194[1]
Weight (Kg)	Correlation Coefficient (rho) = 0.2	0.029[1]
BMI (Kg/m2)	Correlation Coefficient (rho) = 0.15	0.093[1]
Temperature (Left)	Correlation Coefficient (rho) = 0.05	0.603[1]
Temperature (Right)	Correlation Coefficient (rho) = 0.05	0.626[1]
Limb Length (cm)	Correlation Coefficient (rho) = 0.16	0.082[1]
M-Latency (ms) (Left)	Correlation Coefficient (rho) = -0.02	0.805[1]
M-Amplitude (mV) (Left)	Correlation Coefficient (rho) = -0.08	0.406[1]
H-Amplitude (mV) (Left)	Correlation Coefficient (rho) = -0.22	0.016[1]
H-M Ratio (Left)	Correlation Coefficient (rho) = -0.09	0.350[1]
M-Latency (ms) (Right)	Correlation Coefficient (rho) = 0.02	0.866[1]
H-Latency (ms) (Right)	Correlation Coefficient (rho) = 0.8	<0.001[1]
M-Amplitude (mV) (Right)	Correlation Coefficient (rho) = -0.03	0.762[1]
H-Amplitude (mV) (Right)	Correlation Coefficient (rho) = -0.2	0.033[1]
H-M Ratio (Right)	Correlation Coefficient (rho) = -0.07	0.438[1]

1: Spearman Correlation, 2: Wilcoxon-Mann-Whitney U Test

Table IV: Summary of H-Reflex

Parameter	Side	Mean±SD	Median (IQR)	Min - Max
H-Latency (ms)	R	30.93±4.42	30.10 (28.00-32.60)	22.4 - 47.6
	L	31.01±5.21	30.10 (27.75-32.70)	21.8 - 57.8
M-Latency(ms)	R	5.83±1.56	5.50 (4.80-6.30)	3.3 - 12.2
	L	5.80±1.51	5.50 (4.80-6.45)	3.5 - 10.0
M-Amplitude (mV)	R	5.42±3.48	4.90 (2.25-8.05)	0.1 - 12.7
	L	5.06±3.33	4.90 (1.90-7.80)	0.1 - 13.7
H-Amplitude (mV)	R	2.59±2.12	2.30 (1.05-3.65)	0.1 - 15.2
	L	2.37±2.05	2.00 (0.90-3.30)	0.2 - 16.2
H-M Ratio	R	0.47±0.16		
	L	0.46±0.15		

Table V: Correlation between H-Latency (ms) (Right) and H-Latency (ms) (Left) (n = 119)



Correlation	Spearman Correlation Coefficient	p value
H-Latency (ms) (Right) vs H-Latency (ms) (Left)	0.8	<0.001

Table VI: Comparison with different authors

Work by others	H reflex -latency (ms)	side-to-side latency differences	Amplitude	HM ratio
Fisher MA. AAEM Minimonograph# 13: H reflexes and F waves: physiology and clinical indications. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine. 1992 Nov;15(11):1223-33.	35 upper limit	1.5 ms Upper limits	NA (not available)	NA
Ali AA, Sabbahi MA. H-reflex changes under spinal loading and unloading conditions in normal subjects. Clinical neurophysiology. 2000 Apr 1;111(4):664-70.	25.95 to 34.35 both lower extremities	0.02 to 1.36 ms	NA	NA
Jankus WR, Robinson LR, Little JW. Normal limits of side-to-side H-reflex amplitude variability. Archives of physical medicine and rehabilitation. 1994 Jan 1;75(1):3-7.	29.6±2 2.5	0.45±0.40	8.6±2 4.0 mV	0.74±0.17
Schimsheimer RJ, De Visser BO, Kemp B, Bour LJ. The flexor carpi radialis H-reflex in polyneuropathy: relations to conduction velocities of the median nerve and the soleus H-reflex latency. Journal of Neurology, Neurosurgery &	30.0±2.1 ms	0.09±0.70 ms	NA	NA

Psychiatry. 1987 Apr 1;50(4):447-52.				
Falco FJ, Hennessey WJ, Goldberg G, Braddom RL. H reflex latency in the healthy elderly. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine. 1994 Feb;17(2):161-7.	RT-25.2-39.2 (30.8, 2.6) LT- 24.8-36.8 (30.7, 2.6) Mean±SD	NA	NA	NA
Buschbacher RM. Normal Range for H-Reflex Recording From the Calf Muscles1. American journal of physical medicine & rehabilitation. 1999 Nov 1;78(6):S75-9.	30.3±2.4	0.2±1.0	NA	NA
Strakowski, Jeffrey A. MD; Redd, Deidre D. MD; Johnson, Ernest W. MD; Pease, William S. MD. H Reflex and F Wave Latencies to Soleus Normal Values and Side-to-Side Differences. American Journal of Physical Medicine & Rehabilitation 80(7):p 491-493, July 2001.	2.44±1.37 Both limb	0.37±0.28	NA	NA
Kimura, Jun. "Electrodiagnosis in diseases of nerve and muscle: principles and practice." (2013).	29.5±2.4	0.6±0.4	2.4±1.4	
This study findings	R 30.93 ± 4.42		5.42±3.48	0.47±0.16
	L 31.01± 5.21		5.06±3.33	0.46±0.15

Discussion

The results of this study mostly agree with those of several other studies. For example, a positive relationship was found between H-latency and patient height, which is in line with many other studies[17,18,19,20,21,22,23]. In this study, the average H reflex latency for the right and left legs, respectively was 30.93±4.42 ms and 31.01±5.21 ms. This supports earlier studies (Table V), even though the age ranges of Falco et al.[17] was between 60 and 88 years, whereas the age range of the current study is between 30 and 40±6.78 years. The variables age group, weight, H-amplitude (left and right) and H-latency (right) were all significantly associated (p=0.05) with the variable “H-latency” (mV) (Table III). The association between H-Latency (ms) (right) and H-Latency (ms) is shown by the scatter plot in figure 5 above (left). Each point corresponds to a distinct case. The blue trendline demonstrates the overall pattern of correlation between the two variables. The shaded gray area displays the 95% confidence interval of this trendline. Since at least one of the variables was not normally distributed, non-parametric tests (Spearman’s correlation) were utilized to examine the correlation between the two variables. H-Latency (ms) (right) and H-Latency (ms) (left) had a high-quality positive connection that was statistically significant (rho=0.8, p=0.001). H-Latency (ms) (left) rises by 0.79 units for every unit increase in H-Latency (ms) (Right). On the other hand, the H-Latency (ms) (right) rises by 0.57 units for every unit increase in the H-Latency (ms) (Left). Table V presents an analysis of the differences and similarities between the works of the different authors.

Clinical implication

The H: M ratio[24] shows what percentage of the motoneuron pool can be turned on. The most accurate way to measure the H:M ratio in the soleus is with the person lying on their back, where it has been said to reach a reliability of 0.97[25]. H reflexes have been shown to be therapeutically beneficial in a range of diagnostic contexts[26]. Magladery and McDougal[27], who reported on its clinical importance in 1950. A sub-maximal, orthodromic stimulation of I-A sensory fibers causes the H reflex. It is most consistently detected across the flexor carpi radialis, soleus and sometimes the quadriceps muscles[28]. Nerve root damage (S1, C6, C7), plexopathy and peripheral neuropathy have been linked to it in clinical studies[29]. In this study, the normative H-reflex was recorded using the soleus muscle by stimulating the tibial nerve. In many people, the soleus H-reflex is not elicited at rest (despite excellent technique) but occurs at (near-) normal latency with a voluntary contraction. An indicator of motor neuron pool activity and therefore of excitability is the ratio of the peak-to-peak maximum H-reflex to the maximum M amplitude (H/M). For calf H-reflexes, the H/M ratio often falls below 0.7[30]. Participants in the prone position had considerably higher H/M ratios, according to Koceia’s results. Therefore, while reporting the HM ratio, the individual's position is required[31], hence we have used the subject in the prone position, and the results are similar to those of other authors as shown in Table V.

Conclusion

In conclusion, this study supports the findings of several previous studies, indicating a positive relationship between H-latency and patient height. The average H-reflex latency for the right and left legs in our study was consistent with earlier research, despite a difference in the age range of participants. Variables such as age group, weight, H-amplitude (left and right), and H-latency (right) were found to be significantly associated with the variable "H-latency" (mV).

The scatter plot analysis demonstrated a strong positive correlation between H-Latency (ms) for the right and left legs, indicating that an increase in H-Latency for one leg corresponds to an increase in H-Latency for the other leg.

The clinical implications of the study highlight the usefulness of the H:M ratio in assessing the activation of the motoneuron pool. The accurate measurement of the H:M ratio in the soleus muscle is achieved with the individual lying on their back, and H reflexes have shown therapeutic benefits in various diagnostic contexts. The H reflex, elicited by sub-maximal stimulation of I-A sensory fibers, is consistently observed in specific muscles and has been linked to nerve root damage, plexopathy and peripheral neuropathy. The ratio of peak-to-peak maximum H reflex to maximum M amplitude (H/M) serves as an indicator of motor neuron pool activity and excitability. Notably, the participant’s position, particularly the prone position, affects the H/M ratio.

Overall, the results of this study contribute to the existing body of knowledge and provide insights into the relationship between H-latency and patient characteristics. The findings have potential implications for diagnostic and therapeutic approaches involving H reflexes, particularly in assessing motor neuron pool activity and identifying neurological conditions. Further research is warranted to explore the clinical significance of these findings and validate their applicability across diverse populations.

References

1. Palmieri RM, Ingersoll CD, Hoffman MA. The Hoffmann reflex: methodologic considerations and applications for use in sports medicine and athletic training research. Journal of Athletic Training. 2004;39(3):268.
2. Jerath N, Kimura J. F wave, A wave, H reflex, and blink reflex. Handbook of Clinical Neurology. 2019;160:225-39.
3. Schieppati M. The Hoffmann reflex: a means of assessing spinal reflex excitability and its descending control in man. Progress in Neurobiology. 1987;28(4):345-76.
4. Burke D. Clinical uses of H reflexes of upper and lower limb muscles. Clinical Neuro-physiology Practice. 2016;1:9-17.
5. Misiaszek JE. The H-reflex as a tool in neurophysiology: Its limitations and uses in understanding nervous system function. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine. 2003;28(2):144-60.
6. Pierrot-Deseilligny E, Mazevet D. The monosynaptic reflex: a tool to investigate motor control in humans. Interest and limits. Neurophysiologie Clinique/Clinical Neurophysiology. 2000;30(2):67-80.
7. Kimura J, Daube J, Burke D, Hallett M, Cruccu G, de Visser BW, Yanagisawa N, Shimamura M, Rothwell J. Human reflexes and late responses. Report of an IFCN committee. Electroencephalography and Clinical Neurophysiology. 1994;90(6):393-403.
8. Pierrot-Deseilligny E, Morin C, Bergego C, Tankov N. Pattern of Group I fibre projections from ankle flexor and extensor muscles in man. Experimental Brain Research. 1981; 42(3-4):337-50.
9. Ellrich J, Steffens H, Treede RD, Schomburg ED. The Hoffmann reflex of human plantar foot muscles. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine. 1998;21(6):732-8.
10. Deschuytere J, Rosselle N. Diagnostic use of monosynaptic reflexes in L5 and S1 root compression. InHuman Reflexes, Pathophysiology of Motor Systems, Methodology of Human Reflexes. Karger Publishers. 1973. p.360-6).
11. Schieppati M, Nardone A, Siliotto R, Grasso M. Early and late stretch responses of human foot muscles induced by perturbation of stance. Experimental Brain Research. 1996; 107(3):515-6.
12. Guiheneuc P, Bathien N. Two patterns of results in poly-neuropathies investigated with the H reflex: Correlation between proximal and distal conduction velocities. Journal of the

Neurological Sciences. 1976;30(1):83-94.
13. Lachman T, Shahani BT, Young RR. Late responses as aids to diagnosis in peripheral neuropathy. Journal of Neurology, Neurosurgery & Psychiatry. 1980;43(2):156-62.
14. Sabbahi MA, Khalil MO. Segmental H-reflex studies in upper and lower limbs of patients with radiculopathy. Archives of Physical Medicine and Rehabilitation.1990;71(3):223-7.
15. Buschbacher RM. Normal Range for H-Reflex Recording From the Calf Muscles1. American Journal of Physical Medicine and Rehabilitation. 1999;78(6):S75-9.
16. Schimsheimer RJ, De Visser BO, Kemp B, Bour LJ. The flexor carpi radialis H-reflex in polyneuropathy: relations to conduction velocities of the median nerve and the soleus H-reflex latency. Journal of Neurology, Neurosurgery & Psychiatry. 1987;50(4):447-52.
17. Falco FJ, Hennessey WJ, Goldberg G, Braddom RL. H reflex latency in the healthy elderly. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine. 1994;17(2):161-7.
18. Aminoff M. Electrodiagnosis of Clinical Neurology. 4th edn. Churchill. 2000.
19. Ghavanini MR, Ghadi RS, Ghavanini AA. The central loop of H-reflex in the S1 spinal nerve: normal values and constitutional influencing factors. Electromyography and Clinical Neurophysiology. 2001;41(5):259-62.
20. Mazzocchio R, Scarfò GB, Mariottini A, Muzii VF, Palma L. Recruitment curve of the soleus H-reflex in chronic back pain and lumbosacral radiculopathy. BMC Musculo-skeletal Disorders. 2001;2:1-8.
21. Metwally NA, Hashem AH. The Role of H-reflex latency in Assessment of Radiculopathy in Patients with Chronic Low Back Pain. International Journal. 2014;2(11):1073-7.
22. Sadeghi S, Ghavanini M, Ashraf A, Jafari P. Effects of age and leg length upon central loop of the gastrocnemius-soleus H-reflex latency. BMC Neurology. 2004;4(1):1-4.
23. Metwally NA, Hashem AH. The Role of H-reflex latency in Assessment of Radiculopathy in Patients with Chronic Low Back Pain. International Journal. 2014;2(11):1073-7.
24. Palmieri RM, Ingersoll CD, Hoffman MA. The Hoffmann reflex: methodologic considerations and applications for use in sports medicine and athletic training research. Journal of Athletic Training. 2004;39(3):268.
25. Palmieri RM, Hoffman MA, Ingersoll CD. Intersession reliability for H-reflex measurements arising from the soleus, peroneal, and tibialis anterior musculature. International Journal of Neuroscience. 2002; 112(7):841-50.
26. Strakowski JA, Redd DD, Johnson EW, Pease WS. H reflex and F wave latencies to soleus normal values and side-to-side differences. American Journal of Physical Medicine & Rehabilitation. 2001;80(7):491-3.
27. Urbscheit N, Bishop B. Potentials evoked from the abductor digiti minimi muscle in the normal and neurologically involved hand. Physical Therapy. 1972;52(5):500-7.
28. Fisher MA. AAEM Minimonograph# 13: H reflexes and F waves: physiology and clinical indications. Muscle & Nerve: Official Journal of the American Association of Electro-diagnostic Medicine. 1992;15(11): 1223-33.
29. Pastor P, Valls-Sole J. Recruitment curve of the soleus H reflex in patients with neurogenic claudication. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine. 1998;21(8):985-90.
30. Delwaide PJ. Contribution of human reflex studies to the understanding and management of the pyramidal syndrome. In Electro-myography in CNS Disorders. Butterworth-Heinemann. 1984. p.77-109.
31. Koceja DM, Trimble MH, Earles DR. Inhibition of the soleus H-reflex in standing man. Brain Research. 1993;629(1):155-8.