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The H- and T-Reflex Response Parameters of Long- and Short-Distance Athletes

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Summary

It is well known that the training level of a muscle belongs to the parameters that affect the H-reflex response amplitude. The aim of this study was to investigate the effects of training type on H- and T-reflex response parameters. For this purpose, 20 long-distance athletes (group I, test group), 18 short-distance athletes (group II, test group) and 20 non-trained subjects (group III, control group) were involved in this study in which the H- and T-reflex amplitude and latency values were measured. The H-reflex amplitude and latency values found in groups I, II and III were 3.64±0.28 mV and 26.88±1.45 ms, 3.17±0.26 mV and 26.19±1.89 ms, and 6.07±0.34 mV and 26.77±1.32 ms, respectively. The T-reflex amplitude and latency values of the groups I, II and III were 3.30±0.18 mV and 32.01±1.02 ms, 3.11±0.20 mV and 31.47±1.16 ms, 4.24±0.21 mV and 31.47±1.16 ms, respectively. There was no statistically significant difference between the groups with respect to latencies of H- and T-reflexes (p>0.05). In both test groups, the amplitudes of the H-reflex and T-reflex were significantly smaller than the control group (p<0.05). The results of this study suggest that training of muscles affect the H- and T-reflex response parameters.

Key words
H-reflex • T-reflex • Athlete • Electromyography • Training

Introduction

The Hoffman reflex (H-reflex) and T-reflex are among the most commonly studied reflexes in clinical electrophysiology laboratories for evaluating nerve and muscle functions. It is known that several factors affect the normal values of H- and T-reflex amplitudes and latencies (Tesch and Karlsson 1985, Schimsheimer *et al.* 1987, Kameyama *et al.* 1989, Oh 1993, Kuruoglu and Oh 1993, Frijns *et al.* 1997, Simonsen and Dyhre-Poulsen 1999). While body height, extremity length and age exhibit direct correlation with the latency values of these reflexes, their amplitude is related with contraction of muscle, intensity of stimulus, vestibular stimulation, movements of head and neck, and temperature (Verhagen *et al.* 1988, Kameyama *et al.* 1989, Oh 1993). The type and training level of skeletal muscle also affects H-reflex amplitude (Casabona *et al.* 1990). The aim of this study was to determine the effects of the type of training on H- and T-reflex response parameters.

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Methods

The subjects gave their written informed consent to participate in this study and the Firat University Local Ethics Committee for research on human subjects approved the protocol of this study. All subjects involved in this study were closely method with respect to their age and height. A total of 58 subjects were included in this study. They comprised twenty long distance athletes (group I), 18 short distance athletes (group II) in the test groups, and 20 non-trained subjects (group III, control).

Questionnaires were used for quantifying each subject's level of training and based on their daily training schedules, the subjects self-reported their weekly volume of effective training in the questionnaire. Reproducibility was assessed by readministering the same questionnaire to the subjects a month later. Weighed κ coefficient of the training program ranged from 0.86-1.0, depending on the sporting activity, indicating that the repeatability was almost perfect.

Table 1. Training characteristics of long-distance athletes

	Precompetition	**Competition**	**Rest**
Training volume			
km/week	84.6±44.7	76.6±48.1	28.3±14.5
hour/week	9±6	9±5	2±2
Training intensity %			
Low intensity	35.2±19.6	28.3±19.9	72.3±42.8
Moderate intensity	48.3±17.8	53.2±35.4	28.7± 22.5
High intensity	16.5±9.2	18.5±8.8	0.0± 0.0

The test groups were chosen from Firat University Sports Academy students in the racing season, the third group was chosen from Medical School students. Long- and short-distance athletes were selected from Firat University Athletics team. The training characteristics of short- and long-distance athletes are given in Tables 1 and 2, respectively. The precompetition period included the months of November, December, January and February. During this period, none of the subjects had participated in any race. The competition period included the months of March to August. The rest period included the months of August and September. During this period the subjects did not interrupt their training but the training volume and intensity were significantly reduced ($p<0.01$). Long- and short-distance runners competed at the club or Turkish National level. The study group included 20 long-distance runners who were engaged in specific endurance-training (Table 1) and 18 short-distance runners who were subjected to specific power-training (Table 2). The untrained control group consisted of 20 healthy subjects who did not perform any kind of sports, were not engaged in any regular training program professionally, or for fun throughout their life and devoted less than 2 hours/week to recreational and occupational physical activity.

Table 2. Training characteristics of short-distance athletes

	Precompetition	**Competition**	**Rest**
Training volume			
km/week	42.3±24.7	40.4±28.1	16.5±13.8
hour/week	6±4	6±4	2±2
Training intensity %			
Low intensity	15.6± 9.6	18.3±14.9	75.2±36.3
Moderate intensity	34.3±17.8	36.1±26.4	24.8± 36.3
High intensity	50.1±34.1	45.6±45.8	0.0± 0.0

The mean regular sportive activity and training period of subjects in test groups I and II were 8.9±4.1 years (6-17 years) and 8.1±3.4 years (5-15 years), respectively. All subjects were non-smokers with normal dietary habits, none had any medical problem, they were not under any prescription drugs and their lower extremity nerve conduction velocity values in all the groups were within normal limits.

The subject lay comfortably in the prone position on a physical examination table. Their skin was degreased, conducting paste was applied before recording and stimulating electrodes were placed. The skin temperature was kept above 31 °C over the recording area. The recording electrode was placed above the medial gastrocnemius muscle halfway between the midpoint of the popliteal fossa and upper border of the medial malleolus. The reference electrode was also placed in the same line 5 cm distal to the active electrode, and the ground electrode was placed between the tendon and reference electrode. A 15 cm thick support was placed under the ankle to ensure 90 degrees of flexion and 0.5 ms pulses of constant voltage were applied to the tibial nerve in the popliteal fossa. The time base was adjusted to 10 ms, sensitivity to 0.5-5 mV and filters to 10-500 Hz. The signals were amplified and filtered before being stored in a personal computer for later off-line analysis. The intensity of the stimulus was increased by 0.5 mA until maximum H-reflex amplitude and minimum motor response was obtained and then 5 maximum

H-reflex responses were recorded. The maximum peak-to-peak amplitude and latency values were used for statistical evaluation.

For T-reflex recordings, subjects lay comfortably in the prone position on a physical examination table with their feet hanging freely over the edge of the table. The position of electrodes remained the same. A non-aversive tap to the heel tendon by a hand-controlled electronic hammer was used to elicit the T-reflex. Care was taken for tapping to not make it too unpleasant for the patient and this was repeated 5 times at 5 ms intervals to avoid fatigue of the muscle. The time base was adjusted to 5 ms, sensitivity to 5 mV/division. Signals were differentially amplified; band-pass filtered (10 Hz-10 kHz), digitized at a sampling rate of 2000 Hz, and recorded on a personal computer for off-line peak-to-peak amplitude and distal latency measurements. The time from stimulation to the first observed deflection was taken as the distal latency. The reflex responses with smallest distal latency were used for statistical analysis. Interpeak interval (peak-to-peak) was regarded as the amplitude.

Data are expressed as means ± S.E.M. Statistical evaluation was performed using SPSS for windows and student's *t* test was used for descriptive statistics. $P<0.05$ was considered to be statistically significant.

Results

The mean age and body height of group I, II, III were 23.62±3.17 (range: 18–29 years) and 172.00±7.12 cm (range: 160-186 cm); 22.91±3.79 (range: 18-28 years) and 173.08±7.50 cm (range: 160-187 cm); and 22.14±2.31 (range: 17-28 years) and 172.90±6.05 cm (range: 162-188 cm). Since there were no significant differences between the age and height of the studied and control groups ($p>0.05$), comparisons were made between the groups (Kuruoglu and Oh 1994).

Table 3. Comparison of H- and T-reflex values on the right and left side in long-distance athletes.

n = 20 subjects	**H-reflex**		**T-reflex**	
	Latency (ms)	**Amplitude (mV)**	**Latency (ms)**	**Amplitude (mV)**
Right leg	25.88 ± 2.03	3.94 ± 0.35	31.35 ± 2.11	3.36 ± 0.28
Left leg	27.88 ± 2.10	3.35 ± 0.32	32.67 ± 1.90	3.25 ± 0.26
P	0.600	0.574	0.139	0.871

Table 4. Comparison of H- and T-reflex values on the right and left side in short-distance athletes.

n = 18 subjects	**H-reflex**		**T-reflex**	
	Latency (ms)	**Amplitude (mV)**	**Latency (ms)**	**Amplitude (mV)**
Right leg	26.20 ± 2.79	3.19 ± 0.35	31.90 ± 2.24	3.29 ± 0.34
Left leg	26.18 ± 2.65	3.15 ± 0.35	32.04 ± 1.84	2.93 ± 0.30
P	0.560	0.414	0.151	0.768

Table 5. The comparison of H- and T-reflex values recorded from left and right legs of control subjects.

n = 20 subjects	**H-reflex**		**T-reflex**	
	Latency (ms)	**Amplitude (mV)**	**Latency (ms)**	**Amplitude (mV)**
Right leg	26.14 ±1.93	6.01 ± 0.46	31.17 ± 2.21	4.14 ± 0.28
Left leg	27.40 ± 1.85	6.13 ± 0.50	31.77 ± 2.31	4.34 ± 0.30
P	0.496	0.955	0.900	0.737

H- and T-reflex responses were recorded on the right and left extremity of 58 subjects involved in this study. Since there were no significant differences between the latency and amplitude values on the left and right side (Tables 3, 4 and 5) in either group, both values were pooled for statistical evaluation.

The mean peak amplitude and latency values of the H-reflex were 3.64±0.28 mV and 26.88±1.45 ms (n=40) and 3.17±0.26 mV and 26.19±1.89 ms for group I and II, respectively (n=36, p>0.05). The mean peak amplitude and latency values of group III (control group) were 6.07±0.34 mV and 26.77±1.32 ms (n=40). There was no significant difference between group I and II with respect to the H-reflex peak amplitude and latency of H-reflex (p>0.05), but both test groups had significantly smaller H-reflex peak amplitude values compared to the control group (*p*<0.001). There was no significant difference between the groups with respect to H-reflex latency (p>0.05, Tables 6 and 7).

The mean peak amplitude of the T-reflex in groups I, II and III was 3.30±0.18 mV (n=40), 3.11±0.20 mV (n=36) and 4.24±0.21 mV (n=40), respectively. When comparisons were made between the groups for T-reflex peak amplitude; there was no significant difference between groups I and II, but the peak amplitude of both test groups was significantly smaller than in the control group (*p*<0.05). The latency of the T-reflex was 32.01±1.02 ms (n=40), 31.97±1.11 ms (n=36) and 31.47±1.16 ms (n=40) in groups I, II and III, respectively. There was no significant difference between the groups with respect to the mean T-reflex latency values (*p*>0.05, Tables 6 and 7).

Table 6. The comparison of H- and T-reflex means values of long-distance athletes and the control group.

n = 80 extremities	**H-reflex** **Latency (ms)**	 **Amplitude (mV)**	**T-reflex** **Latency (ms)**	 **Amplitude (mV)**
Group I, n=40	26.88 ± 1.45	3.64 ± 0.28	32.01 ± 1.02	3.30 ± 0.18
Group III, n=40	26.77 ± 1.32	6.07 ± 0.34	31.47 ± 1.16	4.24 ± 0.21
P	0.540	0.001*	0.256	0.018*

Table 7. The comparison of H- and T-reflex mean values of short-distance athletes and the control group.

n = 76 extremities	**H-reflex** **Latency (ms)**	 **Amplitude (mV)**	**T-reflex** **Latency (ms)**	 **Amplitude (mV)**
Group II, n=36	26.19 ± 1.89	3.17 ± 0.26	31.97 ± 1.11	3.11 ± 0.20
Group III, n=40	26.77 ± 1.32	6.07 ± 0.34	31.47 ± 1.16	4.24 ± 0.21
P	0.201	0.001*	0.925	0.027*

Discussion

It is known that exercise can cause structural changes in skeletal muscles as well as an increase in excitability of motor units (Hoppeler 1988). But the effects of the type and intensity of exercise on these changes have not been studied in detail. The reflex tests can be used for evaluating of motor unit activities in both sedentary subjects and subjects engaged in active sports (Perot *et al.* 1991, Stam and Van Crevel 1989).

The H-reflex involves the same afferent reflex pathway as the T-reflex. The stimulation area is the main difference between these two reflexes. In the H-reflex, muscle fibers are not involved and the receptor function lies outside the reflex arc. Therefore, the H-reflex is considered to reflect directly the excitability level of alpha motor neurons in the spinal cord. In H-reflex studies, stimulation is directly applied to the Ia fibers, whereas evoking the T-reflex, an electronic reflex hammer activates stretch receptors in the muscles (Oh 1993).

The main result of our study concerned the fact that the H-reflex and T-reflex amplitude of trained subjects was significantly smaller than those of the non-trained subjects. In a study on short distance athletes Casabona *et al.* (1990) found that maximum H and M responses of trained subjects was lower than in non-trained subjects and they suggested that this was due to the decreased H-reflex amplitude, and this in turn was explained by dominance of synapses between Ia motor neurons and small motor neurons in the ventral horns of the spinal cord (Casabona *et al.* 1990). Furthermore, besides H-reflex amplitudes T-reflex amplitude values of trained subjects were also found to be significantly smaller than in non-trained subjects.

In attempts to characterize muscle fiber differences in trained and non-trained subjects, marked changes in motor unit morphology and functional aspects were reported (Tesch and Karlsson 1985). Aerobic exercise with long-lasting contractions and anaerobic exercise with brief but high intensity contractions causes biochemical changes in motor units (Hakkinen *et al.* 1985). It has been shown that slowly contracting motor units and some of the fast contracting motor units that are resistant to fatigue are involved in the H-reflex (Nardone and Schieppati 1988).

The number of small motoneurons and interneurons that receive input from Ia afferents is lower in trained subjects than in sedentary subjects. This finding supports the idea that there is a close relation between morphological and functional characteristics of the neuromuscular system and that these can be affected by chronic training. However, it is also possible that the presynaptic inhibition is enhanced so that the output from the motoneuron pool in response to Ia afferent input will be decreased and the influence of Ia afferents will be limited. The different muscle fiber types of these subjects could also explain the difference obtained between the T-reflex peak amplitudes of group III and II in this study.

In both trained groups, the amplitude of the T-reflex, which was triggered by a tendon tap, did not change in parallel with the amplitude of the H-reflex, which was triggered by electrical stimulation of Ia fibers. Both reflexes are conducted *via* the same monosynaptic neuronal pathway but some existing differences between H- and T-reflexes may explain why their amplitudes did not change in parallel. Since the threshold for activation of motoneurons is higher for mechanical than electrical stimulation, the T-reflex is less synchronized than the H-reflex. Besides this, electrical stimulation also activates the inhibitory Ib afferents (Burke *et al.* 1984)which may contribute to the difference observed between H- and T-reflex amplitudes of trained subjects.

It is believed that motor neuron excitability is not the only factor in the exercise-induced changes of H- and T-reflex parameters, since other parameters may also be involved (Van Boxtel 1986). Perot *et al.* (1991) compared the pre- and postexercise H- and T-reflex parameters and found that changes occurred in muscle stretch receptor responses. In our study, the T-reflex amplitude difference observed in subjects adapted to endurance and speed training may be explained by the effects of training on muscle stretch receptors.

There is an inverse relation between the stimulus intensity and amplitude of H-reflex, as stimulus intensity increases H-reflex amplitude decreases (Schimsheimer *et al.* 1987, Kameyama *et al.* 1989). Since there were no significant difference between the stimulus intensity (4.98±0.41 mA, 5.96±0.54 mA and 5.01±0.48 mA for group I, II and III, respectively, p>0.05) in any group for obtaining maximum H-amplitude; the amplitudes we obtained were independent of stimulus intensity.

We found lower H-reflex and T-reflex amplitudes but similar H-reflex and T-reflex latencies in trained subjects.

In conclusion, the results of this study indicate that chronic training alters H- and T-reflex amplitude and that the type of training is also important in these reflex changes. These changes may enhance the adaptation ability of athletes to excessive physical activity but the mechanism mediating these changes and the exact role of this modulation remains to be determined.

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