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EFFECTS OF 10 WEEKS OF MILITARY TRAINING ON NEUROMUSCULAR FUNCTION IN NON-OVERREACHED AND OVERREACHED CONSCRIPTS

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Abstract

The purpose of the study was to examine how military training influences neuromuscular function in non-overreached and overreached conscripts. A total of 24 male conscripts participated in the study (8 weeks basic training+2 weeks specialized training). All measurements were conducted during weeks 1, 5, 8 and 10. After the training period, non-overreached (NOR, n= 16) and overreached (OR, n= 8) groups were compared. Isometric maximal forces (bench press, elbow flexion and knee extension), single twitch (plantar flexors), H-reflex, M-wave (Hmax/Mmax) and V-wave (V/Mmax) (soleus) were measured. In knee extension, force production increased in NOR by 22.5±20.5% ($p<0.01$) between weeks 1 and 8, which was not observed in OR (-1.1±18.2%, $p>0.05$). In OR, plantarflexion twitch contraction time increased between weeks 5 and 10 82.2±34.4% ($p<0.01$), which was not observed in NOR. No changes were observed in the H-reflex and V-wave responses in either of the groups. In conclusion, short term overreaching can also reduce the performance of the neuromuscular system, however, it seems to be more muscle than neural based. To avoid overreaching, more individualized periodization should be used during basic training. To enhance neuromuscular performance, maximal and explosive strength training should also be added into the basic training program.

Keywords: Muscle, Neuromuscular, overreaching, military training

Introduction

It is well known that the physical fitness of young people has decreased in western countries during the past decades (Leyk et al., 2006, Santtila et al., 2006). For example, the average 12- minute running distance among Finnish conscripts has decreased by 12% from the year of 1979 to 2004 (Santtila et al., 2006). Poor physical fitness, together with higher body mass (Santtila et al., 2006) and fat mass (Kautiainen et al., 2002) have been observed in the young adolescents, which may cause higher loading and insufficient recovery leading to weak training adaptations and even injuries during a basic training (BT) period. Simultaneously with reduced physical fitness, the physical demands of the military service have increased (e.g. increased loads) leading to a significantly more challenging military service environment (Friedl et al., 2015).

Despite injuries and high physical demands, military training has generally been shown to improve physical fitness. BT studies have shown that aerobic performance (Santtila et al., 2009, Tanskanen et al., 2011a) and muscle strength properties (Hofstetter et al., 2012, Piirainen et al., 2008, Santtila et al., 2009) of the lower and upper limb muscles have improved after the training. Similarly, Williams (2005) has shown improved aerobic performance, increased fat free mass and decreased body fat percentage (fat%) in British army recruits during BT. In some cases, however, overreaching (short term overtraining) or even overtraining syndrome (long term overtraining) (Tanskanen et al., 2011b) may occur.

Defining overreaching is extremely challenging, and it may require several physiological and psychological markers before a diagnosis of overreaching can be established. Tanskanen et al., (2011b) have defined overreaching by using five different markers, which included reduced VO_2max, increased RPE during submaximal exercise, increased somatic symptoms, the added feeling of being physically or mentally overloaded, and over 10% sick leave from daily service. If three of these five markers were observed, the subject was suggested to be overreached. From a neuromuscular point of view, Lehmann et al., (1997) and have shown reduced muscle contractility of the knee extensors muscles after 6 weeks of overreaching. They speculated that this was caused, at least partly, by reduced energy-dependent processes in peripheral structures. In neural adaptations, Raglin et al., (1996) have shown reduced H-reflex response along with unchanged M-wave during an intensive training period. In general H-reflex method has been suggested to represent excitability of the motoneurons in spinal level. However, several other mechanism such as post activation depression, pre-synaptic inhibition of Ia-terminals, recurrent inhibition of motoneurones, muscle spindle unloading and activation of the Golgi tendon organs may have influence on the response making it more like oligo-synaptic response (Misiaszek, 2003, Pierrot-Deseilligny and Burke, 2005). V-wave, which is an electrophysiological variation of the H-reflex, is measured during ongoing maximal muscle contraction. V-wave indicates neural drive efficiency from central sources, but changes in spinal level may also have effects on it (Aagaard et al., 2002, Hight et al., 2018, Upton et al., 1971). The V-wave response has been shown to decrease during acute fatigue (Racinais et al., 2007), suggesting reduced activation of the supraspinal sources. However, it should be pointed out, that same mechanisms may affect both H-reflex and V-wave responses, so it is not possible to separate the adaptation in spinal or supraspinal level, respectively. It is not clear at present, how these responses may change during overreaching. Like in acute state, long-term overreaching may cause impaired activity of the supraspinal or spinal sources and thus lower activation of the target muscles. As mentioned earlier overreaching may play an important role in military environment but it is not known what kind of influences several weeks (8 weeks BT + 2 weeks specialized training (ST)) of physically and mentally demanding training has on the neuromuscular system in overreached conscripts. In our previous study (Piirainen et al., 2008), it was assumed that those ones who are not physically fit and have higher fat%, will have major problems to develop their performance from neuromuscular point of view. However, this was not the case, and it underlines the importance of loading-recovery-nutrition balance regardless of the body composition. In the present study, overreaching was defined according to accepted criteria, which gives an opportunity to analyse BT and its effects on neuromuscular system in overreaching state. The results of the present study may give new information of the effects of overreaching on the neuromuscular system and may help to design physical training of the BT period more optimally. This could also have effects in the prevention of injuries and even dropouts during BT.

It was hypothesized that conscripts who overreached according to the criteria of Tanskanen et al., (2011b), would also show lower force production of the lower limb muscles, reduced single twitch responses, lower H-reflex responses and lower V-wave responses, caused by reduced spinal and/or supraspinal excitability. Marching and combat exercises may cause higher loading in lower limb than upper body muscles and, therefore, overreaching could be muscle group specific.

Methods

Subjects

A total of 24, healthy male participants (18-21 years) volunteered for the present study. After the BT, the participants were divided into groups: non-overreached (NOR n = 16, height 1.78 ± 0.08 m, body mass 83.0 ± 21.4 kg, fat% 20.2 ± 9.9) and overreached (OR n = 8, height 1.76 ± 0.12 m, body mass 79.2 ± 19.0 kg, fat% 20.5 ± 6.7) according to criteria of Tanskanen et al., (2011a, 2011b). Criteria´s are presented more detailed in Table 1. Possible overreaching was defined after the training period and if three out of five criteria were observed, a conscript was confirmed to be overreached. All participants provided written informed consent and were aware of the protocol and possible risks of the study. They were also advised of their rights to withdraw from the study at any time. The study was conducted according to the Declaration of Helsinki, and approved by the Local Central Hospital Ethics Committee.

Military training

In the beginning of military service, conscripts completed a compulsory 8 weeks BT period, which was same for all conscripts. Training intensity was quite low during the first three weeks of training but increased during the latter half of BT. Training consisted of heavy physical exercises, like marches, combat training, and other low-intensity physical exercises. During marches and combat exercises, conscripts carried heavy training equipment, which weighed between 15-25 kg depending on the exercise. Standard BT program consist of 12 hours of physical training per week, which mainly consist of aerobic-based exercises. The total amount of military related physical exercises during BT was approximately 100 hours (Tanskanen et al., 2011, Santtila et al., 2009). The detailed training performed during this BT program has previously been described (Tanskanen et al., 2011a, Tanskanen et al., 2011b).

Immediately after BT, conscripts continued in specialized military training (ST) .Training was more military-based, however, the total amount of physical training load was similar compared to BT (Santtila et al., 2012).

Test protocol

Body composition (weight and fat%) was measured at the beginning of the service. Neuromuscular measurements were completed during the weeks 1, 5, 8 and 10, at same time of the day. Maximal force production was measured during isometric knee extension, elbow flexion and extension using specific dynamometers. After that, H-reflex and V-wave responses were measured from the soleus muscle and single twitch response from the plantarflexors. The physical activity was planned to be of a low intensity on the day before measurements to avoid effects of acute fatigue and / or muscle damage on the measurements.

Body composition

Percent body fat and body mass were measured with eight-point bioelectrical impedance (Inbody720, Biospace Co. Ltd, Seoul, Korea) at the beginning of the study. Measurements were performed between 6 a.m. and 7 a.m. after an overnight fast and after voiding, with no exercise for 12 hours before the test. The physical activities in the daily program were planned to be of a low intensity on the day preceding measurement. Body composition parameters indicate anthropometric characteristics of the groups in the beginning of BT.

Maximal voluntary knee extension, elbow flexion and extension contractions (MVC)

Knee extension MVC was measured using a custom-built force dynamometer (University of Jyväskylä, Finland). Participants sat in the dynamometer with hip and knee joint angles at 110 and 107 deg, respectively (180 deg is full extension). Isometric elbow flexion was measured in the same bench as knee extension, but with an arm dynamometer. During elbow flexion, the elbow joint was flexed to 90 deg and the brachium was placed in sagittal plane of the body. Isometric elbow flexion (University of Jyväskylä, Finland) was performed standing. The brachium was raised to shoulder level in the coronal plane, and the elbows joints were flexed to the angle of 90 deg. In all muscle groups, participants performed 3 MVCs (lasting 2-3 seconds) as fast as possible at 1 min intervals. Data were collected through ISO4-isolation units into to ME6000 device and MegaWin software (v.2.4, Mega Electronics Ltd, Kuopio, Finland) for later analyses. Maximal force was analysed from the beginning of force production and maximal force is referred to as a peak force.

Electromyography

Bipolar EMG electrodes (Ag-AgCl, 2 cm interelectrode distance) were placed over the soleus muscle according to the recommendations of SENIAM (Hermens et al., 1999). Before placement, the skin was shaved, abraded with sand paper, and cleaned with alcohol. Reference electrode was placed over the malleolus lateralis. Data were sampled (band pass filtered 15-500 Hz, sampling rate 1000 Hz, gain 1000) and analysed using ME6000 electromyography device and MegaWin software (Mega Electronics Ltd, Kuopio, Finland)

H-reflex and V-wave

Subjects stood straight and relaxed as possible during the H-reflex measurements. Low muscle activity was visually controlled from data before every stimulation. H-reflex and M-wave responses were measured from the soleus muscle by stimulating the tibial nerve in the popliteal fossa. A cathode (1.5 x 1.5 cm) was placed over the tibial nerve and an anode (5 x 8 cm) was placed superior to the patella. The most appropriate stimulation point was located based on the strength of the EMG signal (highest M-wave peak-to-peak response). After finding the appropriate point, the stimulation electrode was fixed using elastic tape. Rectangular pulses with a duration of 0.2 ms were delivered at approximately 10 second intervals (Digitimer model DS7A, Digitimer Ltd. Welwyn Garden City, England). An increasing intensity interval (mA) was then chosen to enable the H-reflex excitability curve to be measured with at least 30 data points (one stimulation at each point) up to the maximal M-wave. From the H-reflex excitability curve, maximal H-reflex and maximal M-wave peak-to-peak amplitudes were analysed, and their ratio was calculated. In the V-wave measurement, placement of the anode and cathode and the duration of the stimulation pulse were the same as in the H-reflex measurement. The subjects sat on an ankle force dynamometer (University of Jyväskylä, Finland) and performed five maximal plantar flexions at the hip angle of 110 deg, knee angle of 180 deg, and ankle angle of 90 deg with 1-minute intervals. A supramaximal (125% intensity of maximal M-wave) stimulus in the tibialis nerve was given 1 second after (during MVC) the start of the contraction, and the response was measured in the soleus muscle. It was visually controlled that force level was, at least, 95% of MVC during the stimulations. Maximal M-wave and V-wave peak-to-peak amplitudes were analysed, and V/Mmax ratio calculated evaluating neural drive activity from the central nervous system.

Single twitch

A single twitch was measured from the plantarflexors, because neural parameters (H-reflex and V-wave) were measured from soleus muscle. Subject was seated on the ankle force dynamometer, with a same setup as in the V-wave measurements, except only one leg on the plate. Subject was fixed in the chair with safety belts, and leg was placed over the supporting plate. The subjects were told to hold their feet on the force plate as relaxed as possible. A supramaximal stimulus was subsequently applied to the tibial nerve. Two trials were performed with supramaximal stimulation intensity and with 10-second interval. Average maximum twitch force and twitch contraction time (from the onset of the force production to peak force) were analysed.

Statistical analysis

Mean values and standard deviations (±SD) were calculated. After checking normality, independent sample t-tests were done for body composition parameters. For neuromuscular results, Two-way repeated measures ANOVA (LSD post hoc) was used to assess main effects (training; within subjects effects) of measurement interval, overreached (group; between subjects effects) (NOR, OR) and interaction (training x group). Box´s and Levene´s tests were used to identify normal distribution and if normality was not observed, Log-transformed values were used. Mauchly’s test of sphericity was used to test the assumption of sphericity. Where this assumption was violated, Greenhouse-Geisser adjustments were used. Where significant main effects or interactions were observed, pairwise comparisons were used to identify the location of differences between measurement intervals and training status.

Results were considered statistically significant for p-values below 0.05. Data were analysed using PASW software version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

Body composition in the beginning of BT

There were no differences were observed in weight (NOR 82 ± 21 kg, OR 76 ± 18 kg) and fat% (NOR 20.2 ± 9.9% kg, OR 20.1 ± 7.1%) in the beginning of the BT.

MVC

In knee extension force, significant interaction was observed during the training (F=4.816, $p<0.01$). In NOR, knee extension MVC (Table 2) increased significantly between the first and fifth week (10.7 ± 21.2% $p<0.05$) and between the fifth and eight week (8.0 ± 13.1% $p<0.05$) of training. However, no significant improvements were observed during the last two weeks. In OR, no significant changes were observed in knee extension MVC during the 10-week period. In addition, no significant differences were observed in knee extension MVC between the groups before, during or after the 10-week period. Significant main effect of training was observed in elbow flexion (F=9.205, $p<0.001$) with no significant interaction. Table 2 demonstrate that both groups showed improved elbow flexion between the fifth and tenth week (NOR, 16.4 ± 12.0% $p<0.001$; OR, 16.3 ± 10.1% $p<0.01$). However, in elbow extensors, no significant main effects or interactions were observed during the training.

H-reflex and V-wave

In H-reflex and V-wave responses, no main effects of time (F=2.281, p=0.090; F=0.513, p=0.675), group (F=2.120, p=0.163; F=0.142, p=0.711) or interactions (time x group; F=0.100, p=0.960; F=0.948, p=0.424) were observed during the 10-week period, respectively. All H-reflex, V-wave and M-wave values and ratios are presented in Table 3.

Single twitch

No differences were observed between the groups or within the groups in single twitch force. However, in twitch contraction time (Figure 1) main effect of training (F=10.498, p<0.001) and training x group interaction (F=5.556, p<0.01) was observed. Contraction time increased in OR between the fifth and eighth week by 50.2 ± 64.6% (p<0.01) and between the fifth and tenth week by 82.1 ± 34.3% (p<0.001). No changes were observed in NOR and no differences in time to peak force observed between the groups during the 10 weeks of military training.

Discussion

In the present study, both lower and upper limb muscles (knee extensor, elbow flexor) maximal muscle strength improved in NOR during the 10 weeks of training, whereas knee extension force did not improve in OR. The main specific finding of the present study was that muscle contractile speed was reduced in the plantarflexor muscles in OR, which was not observed in NOR. In addition, second main finding was that no changes was observed in spinal and supraspinal activity in either group, suggesting that short term overreaching will not have major influence on neural control.

Military BT consists of both endurance and strength exercises. In previous studies, it has been shown that military training improves aerobic performance (Friedl et al., 2015, Hofstetter et al., 2012, Kautiainen et al., 2002, Santtila et al., 2008) and muscle strength properties (Hofstetter et al., 2012, Piirainen et al., 2008). However, the development of the strength properties may be muscle group dependent. Santtila et al., (2009) showed significant improvement in upper limb force production during the 8 weeks of BT, which was not observed in the leg muscles. The authors suggested that this was caused by an insufficient training stimulus, because in the same study, added strength training improved both upper and lower extremity force production.

In the present study, the conscripts were divided into NOR and OR groups, according to the criteria presented by Tanskanen et al., (2011b), to investigate effects on overreaching in the neuromuscular system. It was observed that in OR, upper body force properties were developed in a similar manner as in the previous study (Santtila et al., 2009). However, in the lower extremities, only NOR was able to improve their force properties during the first 8 weeks of military training. As suggested by Santtila et al., (2009), poor strength development in OR may be caused by insufficient training load. However, poor development may also be caused by overreaching of the lower extremities.

The suggestion that knee extension results in OR may be caused by insufficient recovery is also supported by the increased contraction time of the plantarflexor muscles in OR, which was not observed in NOR. On the other hand, no changes were observed in M-wave amplitudes in either of the groups, suggesting that there were no changes in muscle fibre excitability (Lepers et al., 2002) and that the reasons for increased contraction time are likely in the excitation contraction coupling process. However, typical mechanisms related to weaker excitation coupling processes, like reduced Ca^{2+} activity and/or capacity of the contractile elements to produce force (Allen et al., 2008, Duchateau and Hainaut, 1985) may also cause decrement in maximal force production capacity (Strojnik and Komi, 2000), which was not observed in the present study. One possible explanation might be the loss of energy and especially phosphocreatine, which is needed for the phosphorylation of ADP to ATP (Allen et al., 2008, Westerblad et al., 1998). Increased ADP seems to be connected to late depolarization, which slows force development (Allen et al., 2008, MacIntosh et al., 2006). Reduced contraction properties might lead to reduced mechanical efficiency, which could also increase the sensation of the loading and thus increase mental stress.

Interestingly, in the present study, no changes were observed in H-reflex and V-wave responses in either of the groups. It has been suggested that endurance type training will enhance H-reflex activity (Maffiuletti et al., 2001, Vila-Cha et al., 2012) while different forms of strength and power training increases the V-wave activity (Aagaard et al., 2002, Kinnunen et al., 2019, Vila-Cha et al., 2012). On the other hand, Racinais et al., (2007) have shown reduced V-wave responses after fatiguing exercise. There are no studies that have shown long term fatiguing, overreaching or overtraining effects in V-wave responses, but it can be suggested that when a fatigued state is prolonged with insufficient recovery, V-wave responses are also lower indicating reduced spinal or supraspinal activity. For technical reasons, both H-reflex and V-wave are most often measured from the plantarflexor muscles as was the case also in the present study. Thus a direct comparison to force production of the bigger muscle groups is difficult to make. Nevertheless, the results of the present study suggest that no severe neural fatigue state was observed. A longer study period might have shown more clearly the effects of strenuous training on the supraspinal and spinal motor control. Based on a previous study by Vila-Cha et al., (2012), an increase H-reflex response might have been expected because of a high amount of endurance based training in military service. This was not, however, observed in either of the groups in the present study. H-reflex measures mostly slow twitch muscle fibers that are mainly used during endurance type of exercise. Adaptations have been suggested to cause not only changes in presynaptic inhibition, but also in reciprocal inhibition process at the spinal level in addition to a reduced recruitment threshold of slow muscle fibers (Maffiuletti et al., 2001, Vila-Cha et al., 2012). In this case, even though no significant improvements were observed, no decrements were observed either, which supports our conclusion of a non-severe fatigued state. It is, however, difficult to compare the present findings with the respective ones in endurance training studies, because in military service other sport-related training stimulations, such as strength training and ball games may also be present (Santtila et al. 2015). Thus, the present study can be considered as a unique study showing how concurrent endurance and strength training might effect on H-reflex and V-wave responses.

It should be noted that some limitations may exist in the present study. In H-reflex measurements, number of stimulations on each intensity would have reduce the variation between the stimulations. In addition, no background EMG was analyzed. This as well as body position were, however, visually controlled to be as relaxed and steady as possible. Plantar flexor force values might have given additional value to the results. Nevertheless, both single twitch and V-wave values supports the conclusion of poor development of the plantar flexors.

The poor development of the OR conscripts in the present study highlights the importance of appropriate periodization (more precise individualized training load) and planning of the basic military training. These results also confirm the findings of several previous studies, which have suggested the importance of strength training, especially, in the beginning of military service (Piirainen et al., 2008, Santtila et al., 2008, Santtila et al., 2009). To find out more specific information about the changes in contractile properties of low extremity muscles, future studies should be focused to both the plantarflexor and knee extensor muscles.

In conclusion, short term overreaching will also reduce the performance of the neuromuscular system. This is supported by 1) weak force development of the knee extensors, and 2) increased twitch contraction time of the plantarflexors among OR subject. To avoid overreaching, more individualized periodization should be used during basic training, with possible lower amount of endurance training. To enhance neuromuscular performance, maximal and explosive strength training should be added in basic training program.

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TABLE LEGENDS

TABLE 1. Incidence of OR criteria among the participants. Criteria 1; A reduced maximal aerobic fitness (VO_2max) of greater than 5% (Halson et al., 2002, Snyder et al., 1995) or did not perform the test because of illness. Criteria 2; An increase in mean RPE during the submaximal exercise greater than 1.0. Criteria 3; An increase in somatic symptoms of overtraining greater than 15% from wk4 to wk7, and remaining the same or increasing from wk7 to wk8. Subjects were divided into tertiles based on an increase in somatic symptoms of overtraining from wk4 to wk7; 15% was the cut-off for the upper third. Criteria 4; Admitted feeling physically or mentally overloaded at week 7 or 8. Criteria 5; Sick leave more that 10% of daily service. Subjects were divided into tertiles based on sick leave during BT; 10% was the cut-off for the upper third.

TABLE 2. Mean (±SD) knee extension, elbow flexion and elbow extension isometric MVC during the first 10 weeks of military training. (* $p<0.05$, ** $p<0.01$ compared to week 1, # $p<0.05$, ## $p<0.01$, ### $p<0.001$ compared to week 5)

TABLE 3. Mean (±SD) H-reflex, V-wave, and M-wave responses and their ratios during the first 10 weeks of military training.

FIGURE LEGENDS

FIG 1. Mean (±SD) single twitch contraction time of the plantar flexor muscles during the 10 weeks of military training. (* $p<0.05$, ** $p<0.01$ compared to week 1, ## $p<0.01$, ### $p<0.001$ compared to week 5)

TABLE 1. Incidence of OR criteria among the participants.

ID	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	
1	x		x	x		OR
2	x	x	x	x		OR
3	x	x	x	x		OR
4	x	x			x	OR
5	x	x			x	OR
6	x	x		x		OR
7	x	x		x		OR
8	x			x	x	OR
9						NOR
10	x			x		NOR
11		x		x		NOR
12		x				NOR
13				x		NOR
14	x			x		NOR
15	x					NOR
16				x	x	NOR
17		x		x		NOR
18	x					NOR
19				x		NOR
20					x	NOR
21				x		NOR
22			x	x		NOR
23				x	x	NOR
24			x		x	NOR

Criteria 1; A reduced maximal aerobic fitness (VO_2max) of greater than 5% (Halson et al., 2002, Snyder et al., 1995) or did not perform the test because of illness. **Criteria 2**; An increase in mean RPE during the submaximal exercise greater than 1.0. **Criteria 3**; An increase in somatic symptoms of overtraining greater than 15% from wk4 to wk7, and remaining the same or increasing from wk7 to wk8. Subjects were divided into tertiles based on an increase in somatic symptoms of overtraining from wk4 to wk7; 15% was the cut-off for the upper third. **Criteria 4**; Admitted feeling physically or mentally overloaded at week 7 or 8. **Criteria 5**; Sick leave more that 10% of daily service. Subjects were divided into tertiles based on sick leave during BT; 10% was the cut-off for the upper third.

TABLE 2. Mean (±SD) knee extension, elbow flexion and elbow extension (bench press) isometric MVC during the first 10 weeks of military training.

Group	**NOR**	**OR**
WEEK 1		
Knee extension (N)	683±183	707±46
Elbow flexion (N)	318±60	334±88
Elbow extension (N)	898±356	714±182
WEEK 5		
Knee extension (N)	757±256 *	654±132
Elbow flexion (N)	325±76	322±85
Elbow extension (N)	931±259	692±175
WEEK 8		
Knee extension (N)	833±213 ** #	702±156
Elbow flexion (N)	383±97 ** ###	365±79 #
Elbow extension (N)	1021±422	829±216
WEEK 10		
Knee extension (N)	814±231 *	641±98
Elbow flexion (N)	375±95 ** ###	376±87 ##
Elbow extension (N)	1017±316	789±159

(* $p<0.05$, ** $p<0.01$ compared to week 1, # $p<0.05$, ## $p<0.01$, ### $p<0.001$ compared to week 5)

TABLE 3. Mean (±SD) H-reflex, V-wave, and M-wave responses and their ratios during the first 10 weeks of military training.

Group	**NOR**	**OR**
WEEK 1		
H_{MAX} (mV)	3.79±2.01	3.33±2.22
$M_{MAX(H)}$ (mV)	7.65±2.18	7.39±2.94
H_{MAX}/M_{MAX}	0.50±0.21	0.45±0.18
V-wave (mV)	3.55±1.68	3.75±2.71
$M_{MAX(V)}$ (mV)	8.90±1.91	8.87±2.68
V/M_{MAX}	0.41±0.17	0.41±0.24
WEEK 5		
H_{MAX} (mV)	4.53±2.37	4.52±3.02
$M_{MAX(H)}$ (mV)	8.08±2.04	8.40±2.96
H_{MAX}/M_{MAX}	0.54±0.21	0.53±0.23
V-wave (mV)	3.59±2.14	5.18±3.55
$M_{MAX(V)}$ (mV)	9.45±1.72	9.42±2.35
V/M_{MAX}	0.37±0.20	0.52±0.29
WEEK 8		
H_{MAX} (mV)	4.67±1.95	4.71±3.31
$M_{MAX(H)}$ (mV)	8.28±1.66	8.15±2.52
H_{MAX}/M_{MAX}	0.56±0.17	0.53±0.23
V-wave (mV)	3.21±1.79	3.68±2.74
$M_{MAX(V)}$ (mV)	9.20±1.53	8.66±2.92
V/M_{MAX}	0.35±0.18	0.40±0.24
WEEK 10		
H_{MAX} (mV)	5.14±1.96	4.33±1.76
$M_{MAX(H)}$ (mV)	8.05±1.90	7.10±2.33
H_{MAX}/M_{MAX}	0.63±0.16	0.56±0.08
V-wave (mV)	3.39±2.42	3.74±3.21
$M_{MAX(V)}$ (mV)	9.22±1.79	8.49±2.49
V/M_{MAX}	0.37±0.25	0.39±0.27

FIG 1. Mean (±SD) single twitch contraction time of the plantarflexor muscles during the 10 weeks of military training. (* $p<0.05$ compared to week 1, # $p<0.05$, ## $p<0.01$ compared to week 5)