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EFFECT OF STEP TEST ON FATIGUE AND MUSCLE CONDITIONING IN AN ELITE GROUP OF THE BRAZILIAN MARINE CORPS

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SUMMARY
This study aims at determining the effects of short-term high intensity step test on fatigue process and muscle conditioning in a military elite group of the Marine Corps. Surface electromyography (EMG) of the right vastus lateralis muscle were obtained from twenty military of the Amphibious Commands, with age 30.5 ± 1.4 years (mean ± SD), body mass 80.4 ± 8.0 kg, and height 1.74 ± 0.05 m. The step test was applied with subjects rising up and down as fast as possible for 120 s on a 40 cm height step. The post-exercise heart rate and lactatemia were significantly greater than pre-exercise. The slope between root mean square value of EMG and time was significant for seven subjects, which showed an increase of muscle activity along time. However, to a set of 13 subjects this parameter was not significant. This absence of a homogeneous response should be object of future evaluation.

INTRODUCTION
The cadence of dynamic contractions can allow an arterial inflow to the working muscles and a consequent venous return to the right heart chambers [1]. This contraction type does not affect the metabolic state as the isometric ones, thus the muscle fiber conduction velocity does not decrease [2]. Therefore, during exercises with relatively longer rest between contractions, spectral analysis of the surface electromyography may not be useful to monitor muscle fatigue. The time domain analysis is an alternative method in which the root mean square (RMS) may be used as an estimator of signal amplitude [3]. Moreover, this index may reflect alterations in either central neural drive or peripheral factors during exercises [4]. Thus, an increase in RMS is expected to occur during exercise due to fatigue [5].

The Amphibious Commands are an elite group composed by marines of the Brazilian Navy. The approval of these military at different stages of training depends on their physical performance, which is evaluated by standardized physical tests. Additionally, the step test is currently performed to assess physical performance, but relatively longer rest intervals are interspersed between dynamic contractions. Therefore, the fatigue process during step test and its relation to muscle activity need to be clarified.

The aim of this study was to determine the effects of short-term high intensity step test on fatigue process and muscle conditioning in military elite of the Marine Corps.

METHODS
Twenty military of the Amphibious Commands volunteered to participate in this study, with age 30.5 ± 1.4 years (mean ± SD), body mass 80.4 ± 8.0 kg, and height 1.74 ± 0.05 m. The study was approved by the local ethics committee and the subjects signed a free informed consent.

Previously, the subjects were prepared for placement of the Ag/AgCl surface electrodes on right vastus lateralis muscle by shaving and abrasion. The electrodes were placed in accordance to SENIAM [6], with 35 mm interelectrode distance, and the reference electrode on malleolus lateralis.

The step test was applied with subjects rising up and down as fast as possible for 120 s on a 40 cm height step. The feet were changed every rise and all subjects carried a 17.5 kg backpack. This is a standard adopted by the Brazilian Navy to assess the physical fitness and this mass is a half of the loaded backpack in military operations.

Electromyograms (EMG) were collected at 2 kHz by a conditioner EMGSystem (Brazil). Signals were filtered for delimitating the frequency band to 10-400 Hz and rejecting the 60 Hz main noise and harmonics [7]. The RMS EMG values were calculated at each 1 s time window and linear regression was performed to calculate slope along time (RMS_{slope}). Additionally, the RMS values of the initial and final 10 s were calculated ($RMS_{initial}$ and RMS_{final}).

Heart rate (HR_{pre} and HR_{post}) was recorded, and blood samples were drawn before and immediately after step test from the antecubital vein. The samples were centrifuged at 1000 rpm to separate the plasma, which was stored at 4 °C. Then, 10 μL of plasma were used to quantify lactatemia ($[Lactate]_{pre}$ and $[Lactate]_{post}$) by calorimetry using a Bioclin kit (Brazil).

Two-tailed and one-tailed Student's t tests were performed to evaluate the significance of the slopes and increases in

RMS, HR, and [Lactate], respectively. A correlation matrix was calculated and significance was also tested by one-tailed Student's t test. The significance level was 0.05.

RESULTS AND DISCUSSION

RMS_{slope} was only significant for seven subjects, even with r^2 lower than 0.18 ($p < 0.05$) (Table 1), which showed an increase of muscle activity along time. Furthermore, for these subjects RMS, HR, and [Lactate] at the final of the exercise were significantly greater than those at the beginning ($p < 0.05$) (Table 1). Three samples of plasma were discarded due to problems in calorimetric analysis. The Pearson correlation coefficient between RMS_{slope} and increases of the [Lactate] was significant ($p = 0.03$) and equal to 0.80, showing that there is a concomitant increase, as observed in other studies [5].

This increase in both RMS value and [Lactate] strongly suggest the occurrence of fatigue [8,9]. However, further studies are required to determine whether this did not occur homogeneously in all subjects.

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Table 1: Electromyographic and physiological variables representing changes during (RMS_{slope}), at the beginning and at the end ($RMS_{initial}$ and RMS_{final}), and at the pre- and post-exercise ($[Lactate]_{pre}$, HR_{pre}, $[Lactate]_{post}$, and HR_{post})

Subjects	RMS_{slope} (Hz/s)	p Value	$RMS_{initial}$ (µV)	RMS_{final} (µV)	HR_{pre} (bpm)	HR_{post} (bpm)	$[Lactate]_{pre}$ (mmol/L)	$[Lactate]_{post}$ (mmol/L)
1	-0.002	0.98	92.90	89.86	120	198	1.38	9.65
2	0.008	0.93	97.03	98.92	85	173	0.96	7.53
3	0.205	0.02*	116.49	135.33	72	174	‡	‡
4	-0.159	0.13	131.83	91.27	83	180	0.83	6.83
5	0.116	0.12	68.26	80.54	105	175	1.07	5.21
6	0.374	0.04*	181.62	208.05	84	176	0.90	7.07
7	0.115	0.25	99.17	105.95	67	166	2.06	7.58
8	-0.116	0.09	94.29	84.69	68	164	2.71	9.73
9	0.094	0.57	149.29	165.74	87	172	1.21	6.61
10	0.210	$< 10^{-3}$*	87.80	112.52	74	164	1.58	5.24
11	0.232	0.02*	110.30	140.16	74	166	1.54	6.59
12	0.056	0.49	115.79	139.80	67	176	‡	‡
13	0.069	0.62	170.90	156.69	68	175	‡	‡
14	0.376	$< 10^{-3}$*	60.69	103.60	71	166	0.92	6.14
15	0.224	$< 10^{-3}$*	62.37	78.91	72	180	1.11	4.18
16	-0.137	0.37	153.53	139.54	84	172	0.85	6.46
17	-0.005	0.96	95.01	90.31	80	162	1.12	6.95
18	0.117	0.23	138.89	162.49	71	145	0.64	5.61
19	-0.141	0.46	178.06	157.16	73	164	1.54	8.01
20	0.323	$< 10^{-3}$*	100.82	131.40	85	190	0.93	5.87
Mean	-	-	115.25	123.65†	80	172†	1.26	6.78†
SD	-	-	35.93	34.45	13	11	0.52	1.46

* Significant RMS_{slope} ($p < 0.05$).
† Significantly greater than initial ($p < 0.05$) and pre- values ($p < 0.0001$).
‡ Discarded due to problems in calorimetric analysis.