Physiological Response of a Paratrooper Unit in Urban Combat

Joaquín Sánchez-Molina[1], José J. Robles-Pérez[2,4], Vicente J. Clemente-Suárez[3,4]

[1]Departamento de Ciencias del Deporte. Facultad de Ciencias de la Actividad Física y el Deporte. Universidad Europea de Madrid. [2]Cuartel General de Fuerzas Ligeras. Ejército de Tierra. Madrid. [3]Departamento de Ciencias del Deporte. Facultad de Ciencias de la Actividad Física y el Deporte. Universidad Europea de Madrid. [4]Centro de Estudios de Combate Aplicado (CESCA). Toledo.

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Summary

Background and objectives: Specific research in military field has traditionally been focused on the effect of combat stress and the development of diseases such as post-traumatic stress disorder. Paratroopers units are considered as elite corps as one of the most operative and due to their special way of deployment, making the foray into the area of operations by mean of a parachute jump. Current war theatres are characterized by their asymmetry and for taking place in urban areas. The organic military response in urban combats has been little studied in specific literature despite its importance for training and specific instruction, for this reason, the objective of the present study was to analyze the physiological response of a paratrooper unit during a simulation urban combat.
Material and Methods: Heart Rate, Blood Lactate and rated of perceived exertion, were analyzed before and after a simulated urban combat in 12 paratroopers of the Spanish Army. The simulated action was preceded by an automatic parachute jump from a training platform.
Results: After the simulation, subjects showed a significant increase ($p < 0.05$) in the values of lactate (1.26 ± 0.20 mmol/l vs. 2.56±0.45 mmol/l) and heart rate (38.79±3.13% vs. 75.80±7.08 FC max.).
Conclusions: The paratrooper unit conducted a simulation of combat and an aerobic threshold at 75% of maximum heart rate and blood lactate concentration of 2.6mmol/l were reached. The increase in the lactate and heart rate values after the simulation may be due to the activation of the body defense mechanisms´ (sympathetic nervous system).

Key words:
Lactate. Combat. Military. Rated of perceived exertion. Heart rate.

Respuesta fisiológica de una unidad paracaidista en combate urbano

Resumen

Antecedentes y objetivos: La investigación específica en el ámbito militar se ha centrado tradicionalmente en el efecto del estrés de combate y el desarrollo de patologías como el desorden de estrés postraumático. Las unidades paracaidistas son considerados cuerpos de élite por ser una de las más operativas y por su forma especial de despliegue, realizando la incursión en la zona de operaciones mediante un salto paracaidista. Los actuales escenarios bélicos, se caracterizan por su asimetría y por producirse en entornos urbanos. La respuesta orgánica en situaciones de combate urbano ha sido poco estudiada en la literatura específica a pesar de su importancia para el entrenamiento e instrucción específica, por lo que se planteó como objetivo de la presente investigación analizar la respuesta fisiológica de una unidad paracaidista durante una simulación de combate en población.
Material y métodos: Se analizó la frecuencia cardiaca, lactato sanguíneo y percepción subjetiva de esfuerzo en 12 hombres (29,9±5,5 años) paracaidistas del Ejército de Tierra Español antes y después de realizar una simulación de combate urbano. La simulación venía precedida de un salto automático en paracaídas desde una torre de entrenamiento.
Resultados: Después de la simulación, los sujetos mostraron un aumento significativo ($p<0,05$) en los valores de lactato (1,26±0,20 mmol/l vs. 2,56±0,45mmol/l) y de frecuencia cardiaca (38,79±3,13 % vs 75,8±7,08% FC max.).
Conclusiones: El análisis de los datos muestra como una simulación de combate provoca un incremento de los valores de lactato sanguíneo con respecto al valor basal, situándolo en valores de umbral aeróbico. La unidad paracaidista realizó esta simulación a una intensidad del 75% de la frecuencia cardiaca máxima y con una concentración de lactato sanguíneo de 2.6 mmol/l. El aumento de los valores de lactato y frecuencia cardiaca durante la simulación puede ser debido a la activación de mecanismos de defensa del cuerpo humano (sistema nervioso simpático).

Palabras clave:
Lactato. Combate. Soldado. Percepción subjetiva de esfuerzo. Frecuencia cardiaca.

Correspondence: Vicente Javier Clemente Suárez
E-mail: vicentejavier.clemente@universidadeuropea.es

Introduction

Specific research in the military field has traditionally focused on the effect of stress in combat in the development of pathologies such as Post-Traumatic Stress Disorder (PTSD)[1], with a large proportion of war veterans exposed to combat or war zones having developed PTSD. The rate of PTSD is one of the highest among the psychological disorders, estimated to be 30% among veterans from the Vietnam war and 10% among those from the Persian Gulf[2,3]. More recent studies on active troops establish a prevalence estimated at 16.7%, and even 24.5% among military reservists[4]. A direct link is therefore revealed between the exposure to combat situations and the risk of developing PTSD[1]. Combat operations are also some of the most stressful situations for the human body, comprising a risk for the physical integrity and the very life of the combatant. The study of the organic response of this demographic has been very limited and practically exclusively centred on the analysis of different organic parameters before and after carrying out different missions[5-7]. In this respect, Lester *et al*[8] demonstrated how after 13 months on a mission to Iraq, an increase in the upper and lower body strength occurred (7% and 8% respectively), an increase in muscle power (9%) and of fat mass (9%) as well as of aerobic performance by 13%. On the other hand, Rintamäki *et al*.[9] observed how after 12 days of military manoeuvres in winter, accumulated fatigue did not occur, nor negative effects on the maximum strength and the maximum oxygen consumption, but it did cause a reduction of the heart rate of combatants, due to the exertion carried out in these manoeuvres. Currently, various studies have highlighted the psycho-physiological response of combatants due to the stress involved in the combat situations they face[1,10,11]. Along the same lines, Clemente *et al*.[12] discovered that in combat situations, combatants achieve a high activation of the sympathetic nervous system, which triggers an increase in muscle strength, heart rate and blood lactate concentration, despite the rating of perceived exertion of the combatants being lower than that obtained physiologically. The acute effects of administrating caffeine in combat were also analysed, as caffeine is an anxiogenic substance that can even be damaging given the stress and anxiety to which soldiers in combat situations are subjected[10].

Within the combat units of contemporary armies, paratrooper units are considered to be elite, as they are one of the most operative units and as a result of their special deployment technique, as not only do they have to face the same combat situations as the rest of the infantry, but they also have to enter the operation zone via a parachute jump. Specific research in these units has been reduced to case studies of the HALO (High Altitude Low Opening) and HAHO (High Altitude High Opening) jumping tactics[10,13]. In both studies, in which the paratrooper must be equipped with an oxygen mask and heavy equipment to endure the environmental conditions of the jump, an increase in the sympathetic modulation was obtained, as well as a reduction of cortical activation, of muscle strength, an increase of the creatine-phosphokinase blood concentration, and a rating of perceived exertion below that of the established organic response. Within these paratrooper units, just as other units deployed in current operation settings, there is a precedence of urban combat situations, close combat and hand-to-hand combat, in which personal defence and cuffing skills are fundamental[14]. Despite these previous studies, the organic response in urban combat situations among paratrooper units has not been studied, despite its importance for training and specific instruction, for which this research study has been proposed with the aim of studying the physiological response through the analysis of the heart rate, blood lactate concentration and the rating of perceived exertion of the combatants of a paratrooper unit during an urban combat simulation.

Material and method

Subjects

Twelve male soldiers were analysed from the Spanish Territorial Army Paratrooper Brigade (29.8 ± 5.4 years; 174.84 ± 4.1 cm; 74.63 ± 9.05 Kg; 15.8 ± 17.8 years of experience in their unit), many of them with experience on current international missions to areas of armed conflict. The soldiers were equipped with a simulated parachute for the jump and with the standard combat uniform and boots, as well as tactical and technical apparatus, simulated handgun, simulated rifle, simulated knife, cuffs and a 14 kg backpack, simulating the real equivalent weight for this kind of manoeuvre. All the procedures carried out in this research complied with the principles of the Helsinki Declaration, were approved by the General Army Headquarters of the Unit and also all participants signed a consent form.

Combat simulation

The combat simulation entailed a combat intervention in a village, preceded by a simulated automatic parachute jump from a jumping training tower. Once on the ground, they removed their jumping gear and moved on foot to the simulated urban area. The mission objective consisted in rescuing a prisoner, in this case an isolated allied combatant that they had to evacuate to a safe zone. During the simulation, the combatants, organised into intervention groups of four combatants, had to respond in accordance with international combat legislation and regulations in diverse situations: unarmed and armed civilians, enemy combatants with hidden weapons, enemy combatants with firearms, Improvised Explosion Devices (IED). After identifying the prisoner, he/she had to be taken to a safe zone, thus completing the mission.

Procedure

Before and immediately after the combat simulation, the following measurements were taken:

- Rating of perceived exertion (RPE) with the scale 6-20 (Borg, 1970).
- Blood lactate taking a 5µl of capillary blood sample from the finger of the subjects and analysing it with a lactate system, Lactate Pro (Akagui, Tokyo, Japan)

Table 1. Results of the physiological parameters measured pre and post manoeuvres (Average ± TD).

	Unit	PRE	POST (p)	% Change	d Cohen
RPE	-	6.00 ± 0.00	10.20±1.88 (0.003)	70.00	-
Lactate	mmol/l	1.26 ± 0.20	2.56 ± 0.45 (0.002)	103.17	6.50
HR	bpm	73.58 ± 5.16	143.83 ± 13.48 (0.002)	95.47	13.61
% HR	%	38.79 ± 3.13	75.80 ± 7.08	95.41	11.82

RPE: Rating of perceived exertion; HR: Heart rate.

– Heart rate via a Polar S610 heart rate monitor (POLAR, Finland). Once the results were collected, the percentage of the maximum heart rate (MHR) was calculated using the 220-age formula.

Statistical analysis

The statistical analysis was carried out using the SPSS 21.0 programme. The descriptive statistics used to display the results were the Average ± Typical Deviation (TD). Next, the normality of the sample was established with the Shapiro-Wilk test. After this, a comparative analysis was carried out of t Student averages of related measurements, as the study variables complied with the parametric assumptions. For all the comparisons, the significance index of $p < 0.05$ was accepted. The size of effect was calculated using the d Cohen [SE = Average Post-test - Average Pre-test)/ TD Pre-test].

Results

Upon studying the data obtained (Table 1), we can see how the rated perceived exertion values were 10.20 ± 1.88 ($t(11) = 7.60$; $p < 0.001$). The blood lactate concentration increased significantly from 1.26 ± 0.20 mmol/l up to 2.56 ± 0.45 mmol/l ($t(11) = 10.73$; $p < 0.001$) upon finishing the combat simulation.

The average heart rate during the manoeuvre was 143.83 ± 13.48 ppm ($t(11)=18.14$; $p < 0.001$) (75.80 ± 7.08% of the max. HR).

Discussion

The physical status and the reaction of the combatants is highly relevant both for their physical integrity as well as for the success of their actions[15]. The data analysis reveals how this combat simulation provokes an increase in the blood lactate values compared to base values, placing it within the aerobic value threshold[16]. The blood lactate concentration following an activity provides an excellent means of controlling the physiological changes that take place in organic exertion. Opposed to that found in similar studies with other military units[12, 17], where values of blood lactate were reached that exceeded those of the anaerobic threshold, paratroopers presented lower values, leading us consider that the higher the level of training, occurring particularly with the paratrooper brigade, the lower the blood lactate concentration for the same kind of exertion[18].

In the cases of previous studies, fundamentally noteworthy is the high psychological load of the tests carried out, in which soldiers face each other and they have to control a large number of uncertainties (such as windows, doors, holes, light changes or civilians mixed with potential terrorists), requiring a quick interpretation-assessment, and which are the focus of hostile situations, thus supposing a threat to them. This kind of situation can take the soldier to a state of psychological over-stimulation, generating anxiety or panic[12, 19], and symptoms of fatigue of the central nervous system[17]. This high degree of activation and muscle tension is reflected in the significant increase of blood lactate concentrations among the combatants.

The increase of lactate values and of the heart rate during the simulation may be due to the activation of the human body's innate defence mechanisms, such as the fight-flight reaction, in which the sympathetic nervous system is activated and prepares the body for any dangerous situation[12,17,20]. This leads us to propose the importance of psychological training and the ability to manage situations of tension and stress, opening up the possibility of quantifying the organic fatigue load induced by stress and contrasting it with the performance of the combatants, as indicated in recent studies[17]. The average heart rate obtained from the subjects during the test (143.83 ± 13.48 bpm) is very similar to that obtained for subjects in an ultra-resistance trial of 24 hours that was 150.5 ± 20.60 bpm[21] which was above that obtained in an ultra-resistance cycling trial of 525 km, which produced 126.00 bpm[22]; and it is also above the values obtained for a subject that covered 172 km in 24h at a HR intensity of 119 ± 80 bpm[23]. The intensity of the load that the combatants carried according to the average heart rate, would be in the aerobic-anaerobic transition zone, and within that at aerobic level 2[24,25]. The authors indicate the blood lactate concentration for this zone to be at around 3 mmol/l, a slightly higher value than that reached by the subjects; once again highlighting the preparation and training of the military subjects used in this study.

The rating of perceived exertion values were between very light and moderate, which can be explained thanks to the accumulated experience and adaptation achieved by these paratroopers following years of practice, manoeuvres and deployments in the current international operations areas. These results are similar to those reported in other kinds of extreme situations for the body, such as ultra-resistance trials[26,27], where the organism is also subject to extreme situations. In

these trials the fatigue mechanisms are established by blood markers of muscle damage, an accumulation of metabolites or a reduction in the electrolyte concentration, taking the runners to their physiological limits, which directly affects their psychological response, obtaining elevated rating of perceived exertion values (RPE) and a very elevated sensation of fatigue, despite lactate levels being low. However, in combat, psychological stress is at its maximum, with these psychological factors (stress, anxiety, panic, uncertainty) having a direct effect on the physiological response.

The response of the combatants analysed differs from specific trials and tests carried out on other bodies, such as fire-fighters[28], also subject to huge stress and extreme situations for the body during their missions and training sessions, and whose intervention equipment is also considerably heavy, between 10 and 14 Kg[29]. Various studies have revealed the high demands of oxygen consumption, heart rate and blood lactate in laboratory tests and in real and simulated situations among fire-fighters[30-32]. These high values have traditionally been attributed to the muscular metabolic activity, thermo-regulatory pressure and fatigue resulting from protective equipment and the specific exertions, highlighting the importance of a good level of cardiovascular resistance and of muscle strength[33]. As such, following a brief simulation of patient rescue in a hospital, Von Heinburg *et al*[28] observed lactate concentration values of 13 ± 3 mmol/L in operations of 5-9 minutes, compared to those lasting 15 minutes, and 2.56 ± 0.45 mmol/L of lactate following the combat situation of the paratrooper group. We reiterate the importance of training and experience when it comes to facing these situations, such as that revealed by the paratrooper brigade, being one of the most operative and prepared elite units in the Spanish Territorial Army.

Practical application

The results obtained have highlighted the organic response of the paratroopers in a simulated combat situation. With these results, specific training sessions could be proposed, applied to military operative interventions in situations of urban combat, possibly using traditional training methods such as extensive continuous methods, or long and/or methodological current intervals, such as high-intensity interval training (HIIT)[34].

Conclusion

The combatants of a paratrooper unit carried out an urban combat simulation at an aerobic intensity range of 75% of the maximum heart rate and a blood lactate concentration of 2.6 mmol/l.

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