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Study on Overload Injuries during Periods of Intense Physical Activity Complemented by Isokinetic Dynamometry Evaluation*

Estudo das lesões de sobrecarga durante período intenso de atividade física complementado com avaliação por dinamometria isocinética

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Abstract

Objective The present study aims to measure the incidence of overload injuries in training soldiers, who are subjected to intense physical exercise, and to compare it with a control group. Next, it intends to verify whether there is any relationship between overload injuries and some neuromuscular function parameters.

Methods Analytical, prospective observational study. Both the observational and the control group consisted of soldiers from the Portuguese Army. Clinical evaluation was performed by medical interview in the week prior to the beginning of a military parachuting course and in the week immediately after its completion. The neuromuscular performance was assessed by isokinetic dynamometry during the medical interview.

Results With 44 of the 57 military personnel in training complaining of pain, the observational group had significantly more injuries than the control group ($p < 0.001$). Five complaints had traumatic origin and 39 were overload injuries. Of the 39 military personnel with overload injuries, 21 reported limited sports performance. However, isokinetic dynamometry showed no statistically significant differences in neuromuscular performance ($p = 0.223$ and $p = 0.229$).

Conclusion Military personnel in training are prone to overload injuries, with an incidence rate >Q5 70%. The implementation of strategies for injury monitoring and prevention is critical to promote health and physical capacity.

Keywords
- overload injuries
- isokinetic dynamometry
- physical activity
- military personnel

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Resumo

Objetivo Osautorespretendemmediraincidência de lesões de sobrecargaemmilitaresemformação, quesãosubmetidos a exercíciofísicointenso, e compará-la com um grupocontrole. Posteriormente, pretende-se verificar se existealgumarelação entre aocorrência de lesões de sobrecarga e algunsparâmetros da função neuromuscular.
Métodos Estudoobservacionalprospectivoanalítico. Grupo de observação e grupocontroleconstituídospormilitares do ExércitoPortuguês. Aavaliaçãoclínicafoifeitaporentrevistamédicanasemanaque antecede o início do curso de paraquedismomilitar e nasemanaimediatamenteapós o final do curso. Emsimultâneo com aentrevistamédica, foirealizada a avaliação da performance neuromuscular através da dinamometriaisocinética.
Resultados Com 44 dos 57 militaresemformação a referirqueixasálgicas, o grupo de observaçãoapresentousignificativamentemaislesõesque o grupocontrole ($p < 0.001$). Cinco queixas foram de origem traumática e 39 foramlesões de sobrecarga. Dos 39 militares com lesões de sobrecarga, 21 referiramlimitação do rendimentoesportivo. No entanto, naavaliaçãopordinamometriaisocinética, não se verificaramdiferençasestatisticamentesignificativasnaevolução da performance neuromuscular ($p = 0.223$ e $p = 0.229$).
Conclusão Os militares em formação são indivíduos propensos a sofrerem lesões de sobrecarga, tendo-se obtidouma taxa de incidência de lesões de sobrecarganaordem dos 70%. A implementação de estratégias de monitoração e prevenção das lesõessãofundamentaisnapromoção da saúde e da capacidadefísica.

Palavras-chave
- lesões de sobrecarga
- dinamometria isocinética
- esforço físico
- militares

Introduction

Overload injuries are lesions with no identifiable acute trauma; they are reportedly the most frequent type of injury in sports.[1,2] These injuries are caused by repetitive microtraumas resulting from excessive loads exceeding the adaptive tissue capacity and/or with insufficient recovery between applications, leading to progressive damage to affected structures.[1–5] To date, the pathophysiology involved in this type of injury is not fully understood and current models are based on theoretical concepts.[4,6] The theoretical model on tendon injuries (►**Fig. 1**) focuses on the balance between applied load and tissue rest as a predictor of injury.[4] Previous injuries and inadequate physical preparation are additional associated factors.[7] According to other works,[8,9] 66% of athletes training 20 to 35 hours per week for a year develop performance-limiting overload injuries[8]; this is a common cause of premature interruption of sports activity[9] and chronic pain.[9–11] Neuromuscular function assessment with isokinetic dynamometry is common and used to diagnose injuries and musculoskeletal disorders.[12] Military personnel is usually exposed to various stressors, such as prolonged and strenuous physical exercise, hydration deficits, adverse weather conditions and sleep deprivation.[13–15] The identification and understanding of factors favoring this type of injury[13–15] is the first step toward its prevention.[16]

The authors intend to measure the incidence of overload injuries in training soldiers, who are subjected to intense

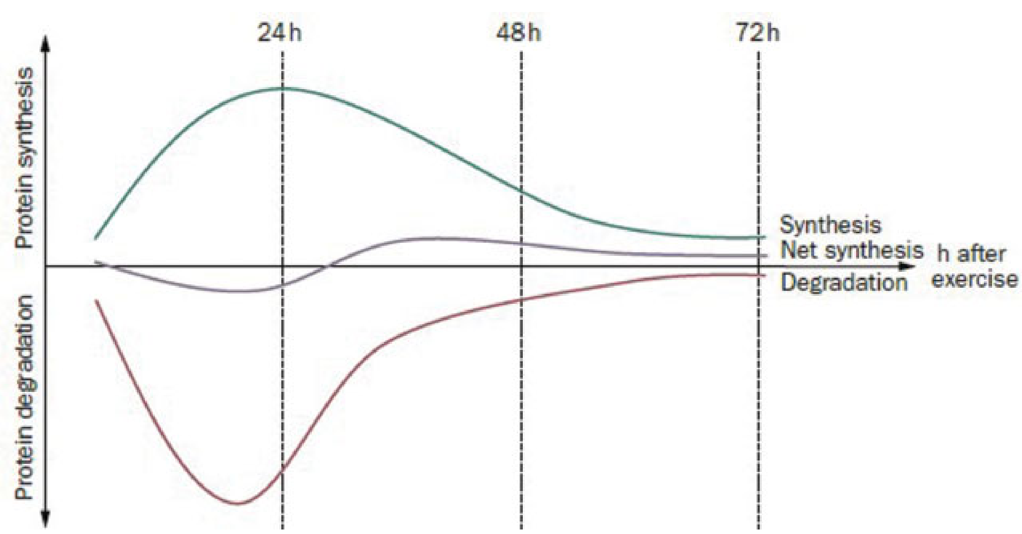

Fig. 1 Schematic representation of collagen synthesis and degradation after a physical exercise session.[4]

physical exercise, and to compare it with a control group, consisting of soldiers under usual physical training. Next, we aim to verify whether there is any relationship between overload injuries and some neuromuscular function parameters.

As secondary objectives, the authors intend to assess neuromuscular performance evolution and to determine if it is influenced by pain.

Method

Study Type, Population and Sample

This is a prospective, analytical observational study. The target population consists of soldiers from the Portuguese Army. The sample was divided in two groups: 1) observational group, including 57 male soldiers (aged 19 to 25 years old; $M = 21$ years) who attended the Military Parachuting course of the Portuguese Army; 2) control group, composed of 30 male soldiers (aged 21 to 28 years old; $M = 25$ years old) who did not attend any Army course.

A random sample of 38 soldiers from the observational group was selected for isokinetic dynamometry tests. The inclusion criteria for the observational group were military personnel who successfully completed the Military Parachuting course of the Portuguese Army and who were submitted to planned medical evaluations. The control group included military personnel submitted to planned medical evaluations and who did not participate in any Army course. The exclusion criteria for the observational group were soldiers who abandoned the Portuguese Army's Military Parachuting course and those who were not submitted to planned medical evaluations. In the control group, military personnel who were not submitted to planned medical evaluations were excluded from the study.

Materials and Procedures

The present study was performed in the Exercise Physiology Laboratory of a Military Health Center. Clinical evaluation through a medical interview was performed in two moments: in the week before the beginning of a military parachuting course and in the week immediately after the completion of the course. In the first phase, the clinical interview consisted of a directed anamnesis and an objective examination. The main focus of the medical interview at the second phase was the investigation of musculoskeletal complaints during the parachuting course, the medical treatment performed and how such complaints affected physical performance.

Pain was assessed with a 0 to 10 scale, where 0 corresponded to "no pain" and 10 to "maximum pain." Pain-related changes in physical performance were self-assessed using a 0 to 2 scale, where 0 was "no change," 1 was "slight decrease in performance" and 2 was "moderate to severe performance limitation." For the purpose of recording sports injuries, the present study used the definition "any physical complaint" from the F-MARC consensus.[17]

Isokinetic evaluation was performed in two moments, in the week preceding the beginning of the parachuting course and in the week after its completion. Prior to this assessment, soldiers warmed-up in a rowing machine, Concept 2 (Concept 2, Inc. 105 Industrial Park Drive Morrisville, Vermont USA), for 5 minutes. Next, the HUMAC/NORM Testing and Rehabilitation System dynamometer was used along with the Humac computer software (Computer Sports Medicine Inc. 101 Tosca Drive Stoughton, Massachusetts USA). Five repetitions of knee extension/flexion were performed in concentric-concentric mode at 60°/second speed within a range of motion from 100° of flexion to 0°, with 2 minutes rest intervals between tests. These procedures were performed in both lower limbs.

Activities Performed by the Observational Group

At the Military Parachuting Course, the training of parachuting garrisons lasts 17 weeks: Combat Course preparation (2 weeks), Combat Course (9 weeks), Parachuting Course preparation (2 weeks) and Parachuting Course (4 weeks). The combat course consists of an intense instructional period in individual combat technique and sectional combat technique. Typically, classes start at 8:00 AM and end at midnight, with a daily total of 16 hours. Physical activities are usually performed in military camouflage uniform, rubber-soled boots, helmet and weapon (Galil automatic rifle). In selected activities, trainees use a backpack with ~ 20 kg in material. The Parachuting Course is a technical training on the use of all equipment required for parachuting. Classes usually start at 8:00 AM and end at 5:00 PM; in addition, there are two evening classes per week. Physical activities are always performed in work uniform (camouflage uniform and boots).

Activities Performed by the Control Group

Military from the control group performed an hour of physical training 3 times a week on alternate days; physical exercises and respective loads were defined by the soldier himself. The training equipment consisted of shorts, t-shirt and sneakers.

Data Analysis

Data analysis and statistical treatment were performed on IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA).

The Shapiro-Wilk (SW) normality tests legitimized the use of parametric statistics, since they indicated that analyzed variables presented a normal distribution: peak torque (PT) differentials in extensor and flexor muscles of both thighs and in groups organized according to pain pattern ($SW < 0.99$, $p > 0.13$), right PT differential ($SW = 0.96$, $p = 0.24$), left PT differential ($SW = 0.98$, $p = 0.67$), pain scale ($SW < 0.96$, $p > 0.80$) and PT differentials in right and left thigh extensor muscles ($SW < 0.98$, $p > 0.59$). Thus, X^2 tests, Student *t*-test, analysis of variance (ANOVA) and Fisher LSD multiple comparisons were used. A type I error of $p < 0.05$ was considered in all analyzes.

Results

A total of 44 soldiers from the observational group reported pain complaints during the parachuting course, whereas 13 soldiers denied feeling any pain. Only three soldiers from the control group reported low back pain. Participants from the observational group had significantly more injuries during the period when compared with the control group, X^2

(1) = 47.86, $p < 0.001$. Of the 44 soldiers from the observational group with pain complaints, 5 reported pain after a trauma, while 39 soldiers presented no identified trauma. The analysis of overload injuries in both groups revealed that soldiers from the observational group had significantly more overload injuries during the evaluated period compared with the control group, $X^2(1) = 37.20$, $p < 0.001$. In soldiers with overload injuries, the knee was the main affected region (►**Table 1**); in addition, running, walking and military training were the main activities responsible for complaints (►**Table 2**). Regarding the physical performance of these soldiers, 21 reported performance limitations due to pain and 18 denied the existence of any limitation.

As for treatment modalities, all soldiers reported pain improvement with rest and medication with non-steroidal anti-inflammatory drugs (►**Table 3**). At the end of the course, pain persisted in ~ 39% of the complaining soldiers. Several presumptive diagnoses were established, especially patellofemoral syndrome, which affected ~ 60% of the complaining soldiers (►**Table 4**).

Neuromuscular performance assessments (►**Table 5**) showed an increase in mean PT values. To determine the differences between neuromuscular performance evolution and pain, soldiers from the observational group were subdivided into 3 groups, corresponding to 3 levels of the independent variable (IV): 1) with no pain during the course (18.4%); 2) with pain only during the course (39.5%); and 3) with pain during and after the end of the course (42.1%). There were no statistically significant differences between these three groups, both for the dependent variable (DV) right PT differential (final PT – initial PT), $F(2.31) = 1.01$, $p = 0.377$, and for the DV left PT differential, $F(2.31) = 1.21$, $p = 0.313$. Moreover, Fisher LSD multiple comparison tests did not identify any statistically significant difference.

Analyzing the evolution of neuromuscular performance with the self-perception of physical performance, there were no statistically significant differences, right PT differential, $t(27) = 1.25$, $p = 0.223$, and left PT differential, $t(27) = 1.23$, $p = 0.229$.

Discussion

Running is one of the most popular sporting activities and it is associated with recognized health benefits; however, it is implicated in several overload pathologies, predominantly in lower extremities.[7,18] In this anatomical region, the most frequently observed conditions include patellofemoral syndrome, Achilles tendinopathy, patellar tendinopathy, medial tibial stress syndrome, plantar fasciitis and stress fractures.[19] It must be highlighted that the overwhelming majority of complaints started during running, marching or military instruction, which are extremely demanding activities for the lower limbs. In addition, it must be noted that ~ 80% of the complaints started during combat course, a fact that can be explained by the constant use of rubber sole boots (with limited shock absorption capacity), the high demand of this phase, insufficient rest periods and the use of heavy uniform/equipment. Theoretical models of tendon injuries[4] (►**Fig. 1**) and ground reaction forces[19] (►**Fig. 2**) corroborate these facts and act as predictors of overload injuries.

All military personnel reported an improvement in complaints with rest during the weekend. However, only ~ 10% of the soldiers reported symptom remission without any other type of treatment. A high percentage of soldiers empirically used non-steroidal anti-inflammatory drugs (84.6%), while only 2 soldiers (5.0%) underwent rehabilitation with physical therapy. In effect, physical activity modification is the main aspect of the medical treatment of any overload injury. Other

Table 2 Activity resulting in pain

	Frequency	%
Military march and instruction	29	74.4
Running	8	20.5
Rope track	2	5.1
Total	39	100

Table 3 Observed therapeutic modalities

	N	%
Rest	4	10.3
Rest and anti-inflammatory agents	33	84.6
Rest, anti-inflammatory agents and physical therapy	2	5.1
Total	39	100.0

Table 1 Incidence of pain distributed over anatomical regions

	n	%
Shoulder and Arm	2	5.1
Knee	27	69.2
Leg	1	2.6
Achilles tendon	3	7.7
Foot	3	7.7
Lumbar spine	3	7.7
Total	39	100.0

Table 4 Presumptive diagnoses

	n	%
Patellofemoral stress	24	61.5
Iliotibial band syndrome	1	2.6
Achilles tendinitis	3	7.7
Plantar fasciitis	2	5.1
Unspecified tendinitis	6	15.4
Lumbar pain	3	7.7
Total	39	100.0

Table 5 Isokinetic dynamometry evaluation values

	Minimum	Maximum	Mean
60°/second right extensors PT, 1st Assessment	129	247	183.55
60°/second right extensors PT, 2nd Assessment	114	252	190.39
60°/second right extensors PT, Differential	−13	33	3.95
60°/second right flexors PT, 1st Assessment	72	172	123.32
60°/second right flexors PT, 2nd Assessment	76	186	135.24
60°/second right flexors PT, Differential	−22	52	9.92
60°/second left extensors PT, 1st Assessment	104	259	173.18
60°/second left extensors PT, 2nd Assessment	115	270	185.79
60°/second left extensors PT, Differential	−18	28	7.76
60°/second left flexors PT, 1st Assessment	69	160	118.79
60°/second left flexors PT, 2nd Assessment	81	183	132.21
60°/second left flexors PT, Differential	−33	35	11.76
Ratio right flexors/extensors, 1st Assessment	50	88	68.29
Ratio right flexors/extensors, 2nd Assessment	48	96	71.97
Ratio right flexors/extensors, 1st Assessment	53	84	68.87
Ratio right flexors/extensors, 2nd Assessment	55	86	70.76

Abbreviation: PT, peak torque.

successful treatment modalities are topical ice application, oral non-steroidal anti-inflammatory drugs and rehabilitation exercises.[20] However, during the parachuting course, soldiers must follow instructions and answer in the best possible way to the physical load imposed under penalty of exclusion, and this is a potential aggravation factor for established injuries. Rehabilitation with physiotherapy was not available at the unit and was performed only in weekends on a private basis, which justify its low completion rate. Cryotherapy is an inexpensive and easily administered treatment that increases the pain threshold and plastic deformation capacity of tissues; in addition, it is associated with inhibition of the inflammation cascade.[21] However, topical ice application was not used, partly because of its reduced accessibility during the course.

The present study revealed an increase in mean PT, especially in the initially weaker muscles that registered a greater progression, resulting in reduced muscle asymmetries. This was an expected result, since exercises performed during the training period equally stimulate both members.

Applied load optimization is a basic prerequisite for the good development of neuromuscular performance.[22] The present study did not reveal a statistically significant difference between the performance of soldiers who never reported pain and those with injuries. In addition, there was no statistically significant difference between soldiers

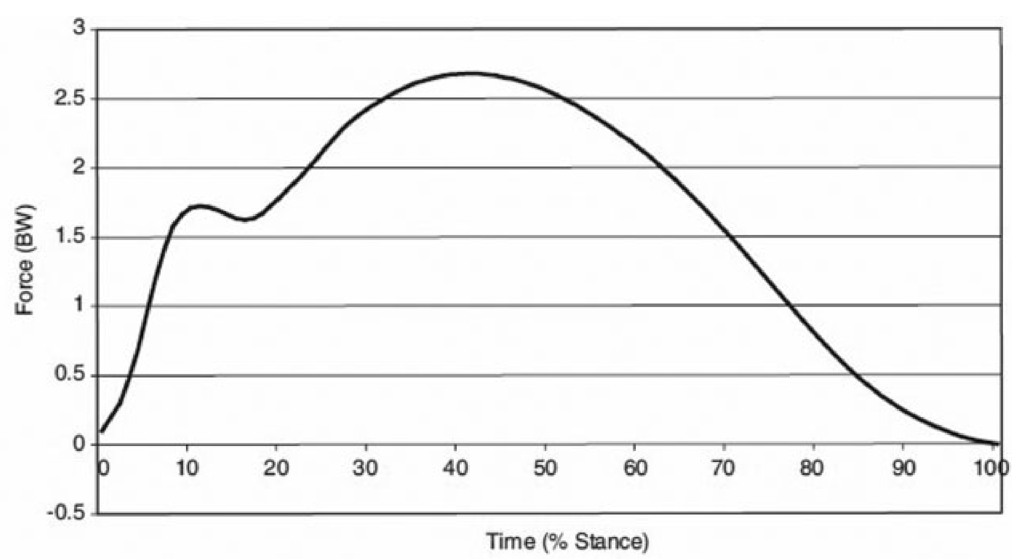

Fig. 2 Representative diagram of the vertical component of the ground reaction forces during the walking cycle. *BW*, body weight.[19]

reporting sports limitations due to pain and those with no limitations. Several factors can explain this unexpected outcome standardization: the short course duration, not allowing greater differentiation between soldiers performance; the similar physical load for all soldiers; and the eliminatory character of attendance during the course for those with no aptitude or physical performance consistent with the imposed load.

Conclusion

Overload injuries encompass a varied set of conditions that are quite distinct from each other and closely related to intense physical exercise. The risk of developing this type of injury is associated with both intrinsic, athlete-specific factors and extrinsic factors. Since there is no control over the performed physical load, used equipment or environmental conditions during exercise, soldiers in training are, par excellence, prone to overload injuries, with a 70% incidence rate.

Neuromuscular performance evolution among soldiers completing the parachuting course was similar.

The implementation of monitoring and prevention strategies for these injuries is critical to promote the health and physical capacity of the athlete. Among the several measures to be adopted, the following stand out: reduction of the physical load during combat course, decrease military equipment weight and footwear improvement.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Clarsen B. Overuse Injuries in Sport [dissertation]. Oslo, Norway: Norwegian School of Sport Sciences; 2015
2 Hreljac A. Impact and overuse injuries in runners. Med Sci Sports Exerc 2004;36(05):845–849
3 DiFiori JP, Benjamin HJ, Brenner J, et al. Overuse injuries and burnout in youth sports: a position statement from the American Medical Society for Sports Medicine. Clin J Sport Med 2014;24 (01):3–20
4 Magnusson SP, Langberg H, Kjaer M. The pathogenesis of tendinopathy: balancing the response to loading. Nat Rev Rheumatol 2010;6(05):262–268
5 van Wilgen CP, Verhagen EA. A qualitative study on overuse injuries: the beliefs of athletes and coaches. J Sci Med Sport 2012;15(02):116–121
6 Warden SJ, Davis IS, Fredericson M. Management and prevention of bone stress injuries in long-distance runners. J Orthop Sports PhysTher 2014;44(10):749–765
7 van Mechelen W. Running injuries. A review of the epidemiological literature. Sports Med 1992;14(05):320–335
8 Jacobsson J, Timpka T, Kowalski J, et al. Injury patterns in Swedish elite athletics: annual incidence, injury types and risk factors. Br J Sports Med 2013;47(15):941–952
9 Cook JL, Khan KM, Harcourt PR, Grant M, Young DA, Bonar SF; The Victorian Institute of Sport Tendon Study Group. A cross sectional study of 100 athletes with jumper's knee managed conservatively and surgically. Br J Sports Med 1997;31(04):332–336
10 Jonas S, Phillips EM. ACSM's Exercise is Medicine: A Clinician's Guide to Exercise Prescription. Philadelphia: Wolters Kluwer; 2009
11 Miller M, Thompson S. Delee&DrezOrthopaedic Sports Medicine. 4th ed. Philadelphia: Saunders/Elsevier; 2015
12 Dvir Z. Isokinetics: Muscle Testing, Interpretation and Clinical Applications. 2nd ed. New York: Churchill Livingstone; 2003
13 Nindl BC, Leone CD, Tharion WJ, et al. Physical performance responses during 72 h of military operational stress. Med Sci Sports Exerc 2002;34(11):1814–1822
14 Nindl BC, Barnes BR, Alemany JA, Frykman PN, Shippee RL, Friedl KE. Physiological consequences of U.S. Army Ranger training. Med Sci Sports Exerc 2007;39(08):1380–1387
15 Opstad PK, Wiik P, Haugen AH, Skrede KK. Medical consequences in young men of prolonged physical stress with sleep and energy deficiency. NDRE/Publication 95/05586. Norwegian Defence Research Establishment; 1995
16 Välimäki VV, Alfthan H, Lehmuskallio E, et al. Risk factors for clinical stress fractures in male military recruits: a prospective cohort study. Bone 2005;37(02):267–273
17 Dvorak J, Junge A, Grimm K, Eds. F-MARC Football Medicine Manual. 2nd ed. FIFA-Strasse Switzerland; 2009
18 Schwellnus MP, Jordaan G, Noakes TD. Prevention of common overuse injuries by the use of shock absorbing insoles. A prospective study. Am J Sports Med 1990;18(06):636–641
19 Hreljac A. Etiology, prevention, and early intervention of overuse injuries in runners: a biomechanical perspective. Phys Med Rehabil Clin N Am 2005;16(03):651–667, vivi
20 Hess GP, Cappiello WL, Poole RM, Hunter SC. Prevention and treatment of overuse tendon injuries. Sports Med 1989;8(06): 371–384
21 Swenson C, Swärd L, Karlsson J. Cryotherapy in sports medicine. Scand J Med Sci Sports 1996;6(04):193–200
22 Kawamori N, Haff GG. The optimal training load for the development of muscular power. J Strength Cond Res 2004;18(03): 675–684