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Epidemiology of injuries in resistance training practitioners - a prospective study

Epidemiologia de lesões em praticantes de treinamento resistido – um estudo prospectivo

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Abstract - Resistance training (RT) has become increasingly popular in recent decades, playing an important role in reducing the risk of musculoskeletal injuries related to muscle imbalance, which is expressed as a relationship between agonist and antagonist muscles, such as knee flexors and extensors. However, if not performed correctly, resistance training can increase the risk of injury. The aim of this study was to estimate the prevalence, incidence, and injury incidence rate in resistance training practitioners. A 6-month prospective cohort study, developed from February 2018 to August 2018 via a questionnaire. A prevalence of 59.6% of injuries among participants was observed, with an incidence of 25% during the 6-month follow-up, resulting in an incidence rate of 0.24 every six months or 1.07 every 500 training hours. The present study made it possible to identify the values of prevalence, incidence and the incidence rate, which are high, as they are similar compared to Olympic weightlifting athletes.

Key words: Cohort studies; Exercise; Resistance training; Wounds and injuries.

Resumo - *O Treinamento Resistido (TR) tem se tornado cada vez mais popular nas últimas décadas, desempenhando um papel importante na redução do risco de lesões musculoesqueléticas relacionadas ao desequilíbrio muscular, que se expressa como uma relação entre músculos agonistas e antagonistas, como flexores e extensores do joelho. No entanto, se não realizado corretamente, o treinamento resistido pode aumentar o risco de lesões. O objetivo deste estudo foi estimar a prevalência, a incidência e a taxa de incidência de lesões em praticantes de treinamento resistido. Um estudo de coorte prospectivo de seis meses foi desenvolvido de fevereiro de 2018 a agosto de 2018, por meio de um questionário. Foi observada uma prevalência de 59,6% de lesões entre os participantes, com uma incidência de 25% durante o acompanhamento de seis meses, resultando em uma taxa de incidência de 0,24 a cada seis meses ou 1,07 a cada 500 horas de treinamento. O presente estudo permitiu identificar os valores de prevalência, incidência e a taxa de incidência, e considerá-los elevados, pois são, comparativamente, semelhantes aos valores apresentados por atletas de levantamento de peso olímpico.*

Palavras-chave: *Estudos de coorte; Exercício; Treinamento de força; Ferimentos e lesões.*

INTRODUCTION

Resistance training (RT) has become increasingly popular in recent decades. While previously, RT was utilized by a select few athletes to enhance their strength and size, it has now evolved into an essential component of training for most sports and the general population, serving as a crucial element in injury prevention[1]. This training method refers to a specialized form of physical conditioning involving the progressive use of a wide range of resistive loads, varying movement speeds, and diverse training modalities. These include weight machines, free weights (barbells and dumbbells), elastic bands, medicine balls, and plyometrics[2,3].

Several components constitute the structure of an RT program, encompassing all movements that integrate isometric, lengthening, and shortening movement[3]. Previous studies suggest that different muscle actions influence the acute responses to exercise. For instance, when using the same load, it is possible to perform more repetitions when only eccentric actions are executed compared to combined concentric and eccentric actions. This, in turn, allows for greater repetitions than concentric-only muscle actions[4]. Several researchers have proposed the theory that low-intensity exercise (≤50% of one repetition maximum [1RM]) can promote increases in muscle size equal, or perhaps even superior, to that at higher intensities, provided training is carried out to volitional muscular failure[5].

Another related benefit of RT is the reduction of the risk of injury. While RT is not without risks, the literature does not suggest that it increases the risk for injury if done in a safe manner[2]. Current research findings indicate a relatively low risk of injury in children, adolescents, and young adults who follow age-appropriate resistance training guidelines, including qualified supervision and instruction[6,7].

In this context, the sports medicine literature shows little association between exercise intensity and injuries. Additionally, RT plays an important role in reducing the risk of musculoskeletal injuries related to muscle imbalance, expressed as a relationship between agonist and antagonist muscles—such as knee flexors and extensors. The training program is crucial for reducing the individual risk of muscle injury by correcting existing imbalances using resistance[8]. Therefore, this study aimed to estimate the prevalence, incidence, and injury incidence rate in practitioners of resistance training, particularly in bodybuilding practitioners. We hypothesized that the highest prevalence of injuries would occur among older participants, while the highest incidence would occur among less experienced participants in RT.

METHOD

Participants

The present study involved a total of 104 volunteers (54 men and 50 women). Participants were recruited from nine gyms located in Teixeira de Freitas, Bahia (Brazil) and were enrolled in the study based on the following criteria: (i) being at least 16 years of age; (ii) practicing strength training exclusively; (iii) not having any osteomioarticular lesions at the time of the first approach to data collection. All subjects were informed of the intent, experimental procedures, benefits and risks of the study and signed an informed consent form before data collection.

Study design

A 6-month prospective cohort study was conducted to estimate the injury incidence rate associated with strength training and determine the influence of risk factors on the risk of injury. At the baseline, following the explanation of the research objectives and procedures, a registration was made for subsequent contact. After the follow-up period, injury information and variables related to strength training were obtained through a questionnaire sent by email.

Data collection

The survey was developed from February 2018 to August 2018 via a questionnaire. It was based on surveys developed to assess injuries in track and field[9,10] and CrossFit[11]. The questionnaire was modified to reflect specific factors that should be measured in resistance training participants. Previously, the survey was tested with resistance training practitioners, not included in the final study, and was adjusted based on feedback. From this process, we established a 3-fold injury criterion that encompassed a wide variety of injuries that can occur with resistance training[11]. "Injury" encompassed any new musculoskeletal pain, feeling, or injury resulting from resistance training that leads to one or more of the following options[11]:

1. Total removal from resistance training and other outside routine physical activities for >1 week;
2. Modification of normal training activities in duration, intensity, or mode for >2 weeks;
3. Any physical complaint severe enough to warrant a visit to a health professional.

First, we aimed to determine the prevalence of injuries in the 104 participants. Subsequently, we calculated the incidence of lesions during the 6-month follow-up. Additionally, we calculated the incidence rate of injuries during the follow-up period in relation to the hours of training.

In addition, we specifically looked to determine if there was any association between injury (no or yes) and time of injury (1 to <3, 3 to <6 and ≥6 months) with age, resistance training experience, frequency, time training, follow a training program, receive counseling from the instructor, have interrupted their activities at the gym and the reason for the disruption. Additionally, only for the injury time the association with the amount of injuries during the follow-up, credit the injuries to the resistance training, the attitude after the injury and diagnostic methods. Finally, we analyze the frequency of lesions in the body parts by sex, the types of treatment methods and the drugs consumed. All information, including diagnoses, obtained for the study, was derived from self-reports, and was not independently verified by a physician.

Statistical analyses

To construct the database, we used the software Epidata, version 3.1b (Epidata Association, Denmark), and data analyses were carried out using SPSS software version 20.0 (IBM Corporation, USA). The Chi-square test or Fisher's exact test was employed to determine the association between the variables investigated through the analysis of equal proportions. A significance level of 5% was adopted.

Ethical procedures

All subjects were informed of the intent, experimental procedures, benefits and risks of the study and signed an informed consent form before data collection. All procedures involved in this study were approved by the Ethics Committee of Ethics Committee of State University of Bahia (protocol number: 2.019.040/2017) and followed the principles outlined in the Declaration of Helsinki.

RESULTS

A total of 104 individuals participated in the study, comprising 54 women and 50 men. The majority of participants had four years or more of experience with strength training, engaging in training at least five times a week with a minimum duration of 60 minutes. The weekly average of training was 4.38 hours (±1.86), with a monthly average of 116.82 hours (±49.79). Among the participants, 62 (59.6%) had previously experienced an injury related to strength training, with 80.6% reporting only one injury. Additional information about strength training according to sex is presented in Supplementary File 1.

A prevalence of 59.6% of injuries among participants was observed, with an incidence of 25% during the 6-month follow-up, resulting in an incidence rate of 0.24 every 6 months or 1.07 every 500 training hours.

Table 1 presents the distribution of injury aspects and injury time in strength practitioners. It was observed that among the practitioners who suffered injuries, 83.9% (n=52) interrupted strength training, with 38.5% (n=20) attributing the interruption to injuries.

Table 1. Age distribution, training variables and aspects of injuries by occurrence and time of injury in strength training practitioners. Teixeira de Freitas, BA, Brazil, 2018.

Variables	Injury		p	Injury time (months)			p
	No	Yes		1 to <3	3 to <6	≥6	
	n (%)	n (%)		n (%)	n (%)	n (%)	
Age (years)			0.839				0.193
16-26	22 (52.4)	36 (58.1)		6 (50.0)	12 (85.7)	18 (50.0)	
27-37	15 (35.7)	19 (30.6)		4 (33.3)	2 (14.3)	13 (36.1)	
≥38	5 (11.9)	7 (11.3)		2 (16.7)	0 (0.0)	5 (13.9)	
How long have you been doing gym for?			0.540				0.362
0 to 6 months	5 (11.9)	9 (14.5)		3 (25.0)	0 (0.0)	6 (16.7)	
6 to 1 years	5 (11.9)	3 (4.8)		1 (8.3)	1 (7.1)	1 (2.8)	
1 to 2 years	5 (11.9)	13 (21.0)		2 (16.7)	5 (35.7)	6 (16.7)	
2 to 3 years	10 (23.8)	15 (24.2)		3 (25.0)	5 (35.7)	7 (19.4)	
≥4 years	17 (40.5)	22 (35.5)		3 (25.0)	3 (21.4)	16 (44.4)	
On average, how many days a week do you do strength training?			0.683				0.779
1 to 2	4 (9.5)	11 (17.7)		3 (25.0)	2 (14.2)	6 (16.7)	
3 to 4	13 (31)	13 (21.0)		2 (16.7)	5 (35.7)	6 (16.7)	
≥5	25 (59.5)	38 (61.3)		7 (58.3)	7 (50.0)	24 (66.7)	

Note. NA: not applicable.

Table 1. Continued...

Variables	Injury		p	Injury time (months)			p
	No	Yes		1 to <3	3 to <6	≥6	
	n (%)	n (%)		n (%)	n (%)	n (%)	
On average, how long is each of your training sessions?			0.620				0.223
30 minutes	1 (2.4)	3 (4.8)		1 (8.3)	0 (0.0)	2 (5.6)	
60 minutes	21 (50)	37 (59.7)		5 (41.7)	7 (50.0)	25 (69.4)	
90 minutes	16 (38.1)	17 (27.4)		6 (50.0)	5 (35.7)	6 (16.7)	
120 minutes	4 (9.5)	5 (8.1)		0 (0.0)	2 (14.3)	3 (8.3)	
Do you follow a training program prescript (sets, workload, equipment and repetitions)?			0.610				0.668
Yes, always	19 (45.2)	26 (41.9)		5 (41.7)	3 (21.4)	18 (50.0)	
Yes, sometimes	12 (28.6)	18 (29.0)		4 (33.3)	6 (42.9)	8 (22.2)	
No	5 (11.9)	4 (6.5)		1 (8.3)	1 (7.1)	2 (5.6)	
No, I know how to train only	6 (14.3)	14 (22.6)		2 (16.7)	4 (28.6)	8 (22.2)	
Do you seek help from the gym trainer frequently?			0.637				0.312
Yes, always	18 (42.9)	21 (33.9)		7 (58.3)	5 (35.7)	9 (25.0)	
Yes, sometimes	17 (40.5)	30 (48.4)		4 (33.3)	6 (42.9)	20 (55.6)	
No. I know how to train only	7 (16.7)	11 (17.7)		1 (8.3)	3 (21.4)	7 (19.4)	
Have you ever had any personal injury?							
No	NA	NA		NA	NA	NA	
Yes	NA	NA		12 (100)	14 (100)	36 (100)	
In the past six months, in the event of an injury, how many times have you been injured?							0.217
1	NA	48 (77.4)		8 (66.7)	10 (71.4)	32 (88.9)	
2	NA	11 (17.7)		3 (25.0)	3 (21.4)	3 (8.3)	
3	NA	2 (3.2)		0 (0.0)	1 (7.1)	1 (2.8)	
4	NA	1 (1.6)		1 (8.3)	0 (0.0)	0 (0.0)	
How long ago did these injuries occur?							
1 to 3 months	NA	12 (19.4)		NA	NA	NA	
3 to 6 months	NA	14 (22.6)		NA	NA	NA	
≥6 months	NA	36 (58.1)		NA	NA	NA	

Note. NA: not applicable.

Table 1. Continued...

Variables	Injury		p	Injury time (months)			p
	No	Yes		1 to <3	3 to <6	≥6	
	n (%)	n (%)		n (%)	n (%)	n (%)	
Do you believe that your injuries are related to strength training?							0.717
No	NA	30 (48.4)		6 (50.0)	8 (57.1)	16 (44.4)	
Yes	NA	32 (51.6)		6 (50.0)	6 (42.9)	20 (55.6)	
What is your attitude after the injury?							0.534
Continued training	NA	4 (6.5)		0 (0.0)	0 (0.0)	4 (11.1)	
Stopped doing some exercises	NA	42 (67.7)		9 (75.0)	10 (71.4)	23 (63.9)	
Stopped training	NA	16 (25.8)		3 (25.0)	4 (28.6)	9 (25.0)	
Did you interrupt your activities at the gym?			0.006				0.808
Yes	25 (59.5)	52 (83.9)		10 (83.3)	11 (78.6)	31 (86.1)	
No	17 (40.5)	10 (16.1)		2 (16.7)	3 (21.4)	5 (13.9)	
What is the reason?			<0.001				0.549
Injuries	0 (0.0)	20 (38.5)		6 (60.0)	4 (36.4)	10 (32.3)	
Poor service	0 (0.0)	5 (9.6)		1 (10.0)	0 (0.0)	4 (12.9)	
Financial difficulties	7 (28.0)	9 (17.3)		2 (20.0)	1 (9.1)	6 (19.4)	
Demotivation	14 (56.0)	9 (17.3)		0 (0.0)	3 (27.3)	6 (19.4)	
Others	4 (16.0)	9 (17.3)		1 (10.0)	3 (27.3)	5 (16.1)	

Note. NA: not applicable.

A total of 69 injuries were observed among practitioners. The most recurrent injuries among men were in the spine (n=7), shoulder (n=18), and knee (n=6), while among women, the main injuries were in the spine (n=6), knee (n=15), and ankle (n=4). Table 2 presents the distribution of injuries according to sex.

Table 2. Distribution of lesion site by sex. Teixeira de Freitas, BA, Brazil, 2018.

Body part	Sex		
	Male (n)	Female (n)	Total (n)
Spine	7	6	13
Hip	1	3	4
Groin	0	0	0
Shoulder	18	1	19

Body part	Sex		
	Male (n)	Female (n)	Total (n)
Knee	6	15	21
Upper leg	1	2	3
Elbow	0	0	0
Ankle	1	4	5
Calf	0	0	0
Wrist	2	0	2
Foot/toe	0	1	1
Back	0	0	0
Hand	0	1	1
Neck	0	0	0
Total	36	33	69

Table 3 presents the diagnostic methods according to the time of injury among the assessed strength training practitioners. The main diagnostic methods were clinical, X-Ray and magnetic resonance imaging.

Table 3. Distribution of injury time by diagnostic methods in strength training practitioners. Teixeira de Freitas, BA, Brazil, 2018.

Diagnosis	Injury time (months)			P
	1 a <3	3 a <6	≥6	
	n (%)	n (%)	n (%)	
Clinical				
Yes	3 (37.5)	3 (25.0)	1 (4.0)	0.043
No	5 (62.5)	9 (75.0)	24 (96.0)	
X-Ray				
Yes	6 (75.0)	5 (41.7)	6 (24.0)	0.033
No	2 (25.0)	7 (58.3)	19 (76)	
Magnetic resonance imaging				
Yes	0 (0.0)	4 (33.3)	14 (56.0)	0.016
No	8 (100)	8 (66.7)	11 (44.0)	
Ultrasound				
Yes	0 (0.0)	0 (0.0)	1 (4.0)	0.664
No	8 (100)	12 (100)	24 (96.0)	
Computed tomography				
Yes	1 (12.5)	0 (0.0)	2 (8.0)	0.505
No	7 (87.5)	12 (100)	23 (92.0)	
Scintigraphy				
Yes	0 (0.0)	0 (0.0)	1 (2.8)	0.693
No	12 (100)	14 (100)	35 (97.2)	

Figure 1 illustrates the main methods for diagnosing injuries, with the most frequent being magnetic resonance imaging (n=18), followed by X-ray (n=17), and clinical examination (n=7).

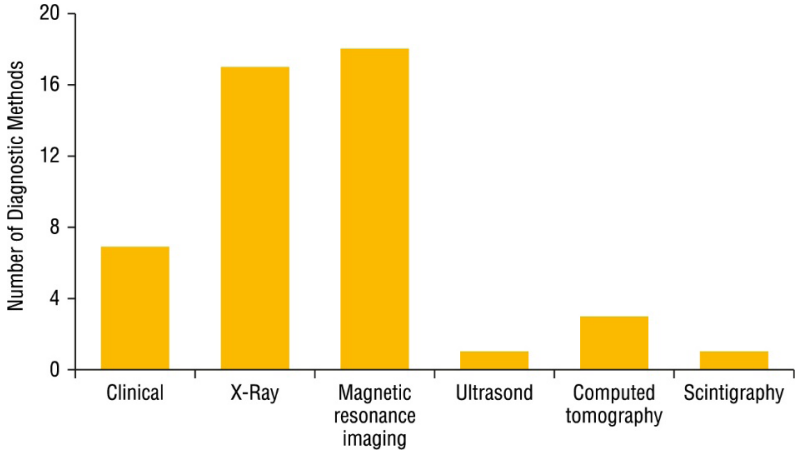

Figure 1. Diagnostic methods of injuries self-reported by resistance training participants.

Figure 2 presents the main methods of treating injuries, the main ones being rest (n=46), medication (n=41) and physiotherapy (n=26).

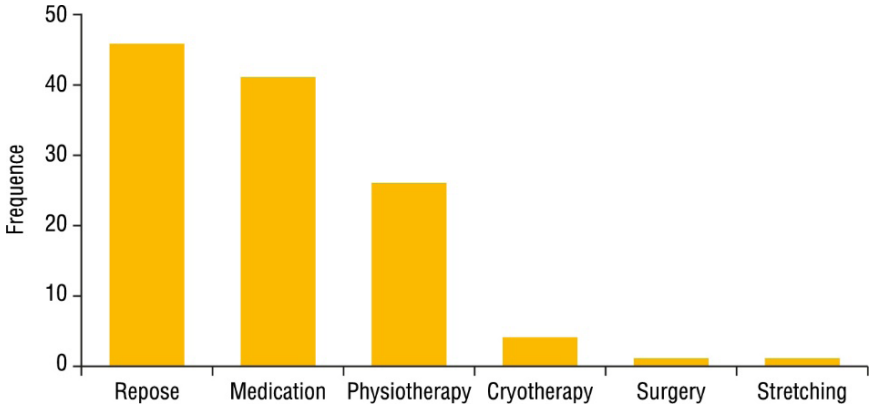

Figure 2. Treatment methods used by practitioners of resistance training after injury.

Figure 3 shows the distribution of the number of drugs consumed by bodybuilders to treat the injury, with anti-inflammatory drugs being the most used (n=40), followed by muscle relaxant (n=16) and analgesic (n=12).

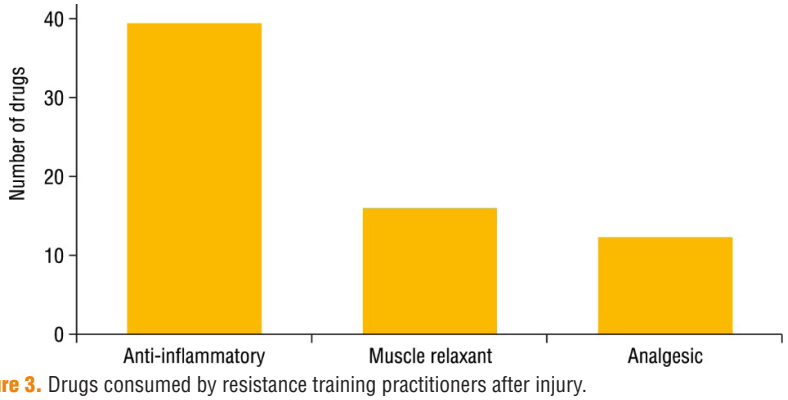

Figure 3. Drugs consumed by resistance training practitioners after injury.

DISCUSSION

The main aims of the present study were to estimate the prevalence, incidence, and injury incidence rate in practitioners of resistance training and investigate the methods of diagnosis. The key findings of this study were: i) a prevalence of 59.6% of injuries among participants, an incidence of 25% during the 6-month follow-up, and an incidence rate of 0.24 every six months or 1.07 every 500 training hours; ii) the most commonly used diagnostic methods were magnetic resonance, X-ray, and clinical examination; iii) the most commonly used treatment methods were rest, medication, and physical therapy; iv) the most consumed drugs were anti-inflammatory, muscle relaxant, and analgesic.

The most common injuries were to the knee, shoulder, and spine, aligning with findings from a systematic review published by Aasa et al.[12]. However, we observed a higher prevalence of injuries in CrossFit, at 59.6%, compared to 20%[11], 35%[13], but this can range from 43% to 73% among CrossFit practitioners[14]. In powerlifting, the prevalence ranges from 43% to 70%, in weightlifting from 48% to 76%, and in strongman, it reaches 82%[14].

We also observed a 25% incidence of injuries during the 6-month follow-up, with an incidence rate of 0.24 every 6 months or 1.07 every 500 hours of strength training. This profile is also similar to CrossFit, whose incidence rate varies between 0.2 and 18.9 per 1,000 hours of training[13]. Despite similar rates, traditional resistance training appears to be safer compared to other training methods. As observed, bodybuilding presents an incidence of 1.0 injury every 1,000 hours of training, while other modalities, such as powerlifting, have an incidence of 4.0 injuries per 1,000 hours of training[14]. Strongman shows an incidence of 4.50 to 6.1 injuries per 1,000 hours of training, including indications for team sports[14,15], representing a higher injury incidence rate.

Among the main diagnostic methods were magnetic resonance imaging, radiography, and clinical diagnosis (Figure 1), with radiography being used by several practitioners with injuries regardless of the time of injury. Clinical diagnosis was more commonly used by practitioners with a short injury time, between one month and less than six months, while magnetic resonance imaging was more frequently utilized by practitioners with injuries lasting ≥ 3 months. Magnetic resonance imaging is considered the gold standard in evaluating muscle morphology in athletes due to its ability to visualize soft tissues with excellent contrast and provide high resolution and assessment of muscles[16]. However, due to its higher cost compared to the other methods, it was sought after mainly by practitioners with injuries lasting ≥3 months. In simpler cases, radiography and clinical diagnosis were chosen.

When comparing magnetic resonance imaging with clinical diagnosis and radiography, the latter tends to be the least effective in injuries caused by the practice of resistance training, as its evaluation is focused on rigid structures such as bones and does not show direct signs of injuries[17]. These structures are rarely affected by injuries in the practice of resistance training, except for serious accidents and injuries. Therefore, it is recommended that screening be carried out using clinical diagnosis and magnetic resonance imaging to confirm the injury, its degree, and extent[18].

Although the initial clinical evaluation with immediate conservative treatment (rest, ice, compression, and elevation) is widespread and essential for improving

prognosis and reducing recovery time[16], resistance training practitioners primarily used rest, medication, and physiotherapy as their main treatment methods (Figure 2). The main medications used were anti-inflammatories, muscle relaxants, and analgesics (Figure 3).

Rest was the most commonly used treatment method, and it is a fundamental procedure, especially immediately after trauma, as it prevents late muscle retraction or the formation of a larger muscle gap by reducing the size of the hematoma[17]. Another widely used method was the use of physiotherapy, which contributes to the restoration of function, creating a favorable environment for the repair of injured tissues[19]. This approach seeks to reduce signs and symptoms of the inflammatory condition, such as pain and edema, improving or accelerating regeneration[17,20].

The second most used treatment method was the use of medicines (Figure 2), with anti-inflammatory drugs being the primary choice, followed by muscle relaxants and analgesics (Figure 3). These medications are employed to control pain, inflammation, and tissue spasm, providing quick and effective relief effectively[21,22].

The use of medications cannot replace other modalities such as physiotherapy but rather serves as an adjunct in the recovery process. Chronic use of anti-inflammatories has been associated with adverse effects, including an increased incidence of gastric ulcers, kidney failure, and liver damage[23]. Researchers must recognize the potential consequences arising from the use of anti-inflammatories in the general public, considering contraindications related to these drugs. Furthermore, they must acknowledge their responsibility as educators against drug abuse.

Our study is limited by the lack of confirmation of injuries by a doctor, as injury measurements are self-reported. As strengths, we can highlight the monitoring of bodybuilders over a 6-month period, the evaluation of injury time, and the assessment of treatment methods and medications used, which contribute to a comprehensive understanding of the injury cycle until the return of normal activities without limitations.

CONCLUSION

In conclusion, the prevalence in this study was high, and the incidence rate, when compared to powerlifting and bodybuilding, indicates that the recreational practice of weightlifting is relatively safe compared to other forms of competitive weightlifting. However, there may be potential errors in the training variables, such as volume, intensity, and/or exercise execution techniques, as well as in the supervision and monitoring of training, rest and recovery time between series and training sessions, and in training periodization. These aspects should be investigated in further studies. Regarding diagnostic methods, treatments, and the use of drugs, our findings align with similar studies, suggesting that these practices are appropriate.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee – State University of Bahia and the protocol (no. 64359917.4.0000.0057) was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: GSB, DATS; Performed the experiments: GSB; Analyzed the data: LLG, RBV, DATS; Contributed reagents/materials/analysis tools: GSB; Wrote the paper: LLG, WFS, NSM, RGS, CABL, DATS.

Data Availability Statement

Research data is only available upon request

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SUPPLEMENTARY MATERIAL

Supplementary material accompanies this paper.

Supplementary File 1: Free access in https://osf.io/8pnmz/

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