Injuries and Overuse Syndromes in Competitive and Elite Bodybuilding

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Key words
- bodybuilding
- weightlifting
- overuse syndrome
- exercise pain
- injury rate

Abstract

Competitive bodybuilding is a weightlifting sport similar to powerlifting, strongman competition and Olympic weightlifting, which aims to increase muscle mass, symmetry, and body definition. Although data regarding rates of injury, overuse syndromes and pain during routine training is available for these other disciplines, it is rare for competitive bodybuilding. The aim of this study was to investigate rates of injury, pain during workouts and/or overuse syndromes, as well as the influence of particular intrinsic and external factors. Data was collected using questionnaires from 71 competitive and elite bodybuilders. The information included training routines and prior injuries. Participants were recruited from bodybuilding clubs in Germany. 45.1 % of athletes reported symptoms while training. The overall injury rate was computed to be 0.12 injuries per bodybuilder per year (0.24 injuries per 1000 h of bodybuilding). Athletes over 40 exhibited higher rates of injury ($p = 0.029$). Other investigated parameters showed no effects. Most injuries occurred in the shoulder, elbow, lumbar spine and knee regions. A large proportion of bodybuilders complained of pain not resulting in interruptions of training/competition. The injury rate is low compared to other weightlifting disciplines such as powerlifting, Olympic weightlifting or strongman competition. In comparison to team or contact sports the injury rate is minimal.

accepted after revision
December 29, 2013

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DOI http://dx.doi.org/10.1055/s-0034-1367049
Published online: June 2, 2014
Int J Sports Med 2014; 35: 943–948 © Georg Thieme Verlag KG Stuttgart · New York
ISSN 0172-4622

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Introduction

Competitive bodybuilding is a weightlifting sport with the aim of increasing muscle mass, symmetry, and body definition. A perfect body proportion exhibits as little body fat as possible [26]. This is achieved through an exercise regimen with weights as well as a specially designed nutrition program, often varying for “off-season” and “on-season” cycles. The “off-season” generally includes massive nutrient and supplement intake combined with weightlifting exercise to gain weight and increase muscle mass. In the "on-season” or period leading to a competition, athletes attempt to maintain muscle mass while increasing definition and body symmetry. During competition, the body is displayed to judges in particular poses [5,25]. Thus, competitive bodybuilders are attempting to reach a muscular ideal, which is quantified. For some athletes, this sport might elicit a continuous struggle for perfection. Associated compulsions include spending hours in the gym, abnormal eating patterns, or even substance abuse [25]. It has remained unclear whether the excessive weight training and diet cycles lead to increases in overuse syndromes or injuries compared to other sports or weightlifting disciplines. Data for competitive and elite bodybuilding is rare, although several studies have examined this issue for the disciplines of powerlifting and Olympic weightlifting. In the existing studies investigating bodybuilders, the competitive level of the athletes is unclear [8,14]. The other disciplines have completely different goals than bodybuilding, involving lifting the maximum weight in a certain number of attempts. Estimated injury rates in powerlifting, weightlifting and strongman competition are low compared to other sports [28,32,38].

Acute injuries commonly occurring during weight training include sprains, strains, tendon avulsions, and compartment syndromes [29,30]. Common chronic injuries include rotator cuff and patellar tendinopathies as well as stress injuries and fractures to the vertebrae, clavicles, and upper extremities. Muscle hypertrophy, poor technique, or overuse can contribute to nerve injuries such as thoracic outlet syndrome or

suprascapular neuropathy. Chronic medical conditions observed in weight-training athletes include vascular stenosis and weightlifter's cephalgia [24,30].

In general, the major concerns of this field are the small number of epidemiologic studies for weight training sports, and the predominance of case studies of acute and traumatic injuries [19]. The current study was designed as a retrospective, epidemiological survey of competitive and elite bodybuilders. Along with the retrospective component, current training data was collected and assessed. To the authors' knowledge, only 3 studies examining adult bodybuilders have been published [8,14,22]. The questionnaire in this study focused on data implicating individual external and intrinsic parameters to offer a better understanding of the epidemiology of this sport. Thus, the goals of this survey were to identify problem zones during workouts, rates of injury and other interacting factors.

Materials and Methods

Study design

This survey was conducted as an epidemiological study. Data was collected by questionnaire. Participation in the study was voluntary and anonymous. This study was performed in accordance with the ethical standards of the IJSM [15].

Subjects

In 2010, 71 competitive bodybuilders (54 male, 17 female) completed a questionnaire and were interviewed. They were recruited from incorporated bodybuilding clubs in Germany. Study subjects were selected by the coaches in these associations, who were instructed to choose active, competitive members.

The average age of the cohort was 33.9 ± 9.2 (range 18–55) years. Male athletes had an average age of 34.7 ± 9.5 years and females 34.7 ± 8.3 years. The average weight of participants during the competition season was 80.6 ± 16.0 kg (male: 87.9 ± 10.9 kg, range 63–118 kg; female: 57.5 ± 8.1 kg, range 50–78 kg). During the off-season, the average weight of the group was 90.6 ± 18.5 kg (male: 98.3 ± 13.2 kg, range 72–130 kg; female: 66.1 ± 9.1 kg, range 51–96 kg). Of the 71 subjects, 55 (77.5 %) regularly participated in bodybuilding competitions. 35 (49.3 %) of the participants had won competitions on the national or international level. The average maximum loads lifted by the participating bodybuilders (self-reported) were: squat 156 ± 65.8 kg, bench press 135.2 ± 44.8 kg, and dead lift 145.3 ± 70.9 kg.

Questionnaire

There were 5 parts to the questionnaire. The first part assessed general information such as gender, age, weight, competitive wins, competitive level of success (regional, national, international), as well as each subject's maximum load for squat, bench press, and dead lift. The second section collected workout-related data, e. g. regarding warm-up, use of supporting devices, routine endurance training, maximum weights during workouts, and workout duration. In addition, participants were instructed to localize pain symptoms during workouts and relate them to particular exercises. These questions referred to the current ongoing training. The instructions defined pain as unpleasant sensations exceeding those normally experienced during exercise, particularly when negatively affecting performance. Data regarding medical support during workouts and competitions was also collected. Medical support was defined as attention from a physician or physical therapist. The third part of the questionnaire assessed frequency and localization of previous injuries and/or disorders of the musculoskeletal system. Answers were based on the entire bodybuilding career. The subjects were offered space to specify diagnoses. Injury was defined as an incident provoking an interruption in either training or competition. The fourth part of the questionnaire focused on general health disorders. The fifth and final part assessed parameters regarding lifestyle, nutrition, and medical therapy. The questions were validated by 3 orthopedic surgeons and a statistician.

Statistical analysis

Significance was set at $p < 0.05$. The chi-square test was used to analyze differences in the study cohort regarding the entire bodybuilding career. The following parameters formed the basis of this analysis: gender, age (>40 vs. <40 years), medical support (attention from a physician or physical therapist), duration of workouts (<120/>120 min per day), competition on international level (yes or no), routine warm-up (yes or no), and use of supporting devices (yes or no). Overall injury rates were estimated as the number of injuries per athlete per year and the number of injuries per 1 000 h of exercise.

Results

Training information of the participants

The participating athletes had been bodybuilding for an average 12.4 ± 7.8 years (male 14.9 ± 7.2 years, female 4.1 ± 3.53 years). During the competitive season, participants trained 4.6 ± 1.3 days per week (range 2–7 days per week). During the off-season, they trained 3.5 ± 1.45 days per week (range 1–7 days per week). Average workout time during competition season was 90.0 ± 34.8 min per unit (range 60–210 min per unit). During the off-season, the bodybuilders trained 87.5 ± 30.5 min per unit (range 60–180 min per unit). On average, the athletes trained with 77.7 ± 15.2 % (range 20–100 %) of the possible maximum load during the off-season, and with 70.2 ± 17.3 % (range 20–100 %) during the on-season.

Anatomic distribution of ongoing workout pain

Findings regarding pain during workouts are based on the ongoing training of the athletes. 32 bodybuilders (45.1 %) complained of pain during workouts (**Fig. 1**). Of these, 7 (9.9 %) reported head/cervical spine issues, 1 (1.4 %) had chest problems, 9 (12.7 %) experienced arm and shoulder pain, and 9 (12.7 %) indicated hand/wrist pain. Thus, 25.4 % of the athletes reported upper extremity problems. In addition, 9 (12.7 %) subjects specified back pain and 11 (15.5 %) reported lower extremity pain.

Pain distribution during specific exercises

Table 1 shows the localization of pain during specific exercises (powerlifting disciplines). The squat exercise most frequently generates pain during workouts. The lower extremities are particularly affected by squats. Back pain was induced by squats, dead lifts, and other exercises. Arm/shoulder and hand/wrist pains were noted while performing the bench press and other exercises. Problems in the cervical spine and the chest were also often aggravated by the bench press. Exercises besides squat, dead lift, and bench press induced predominantly upper extremity pain.

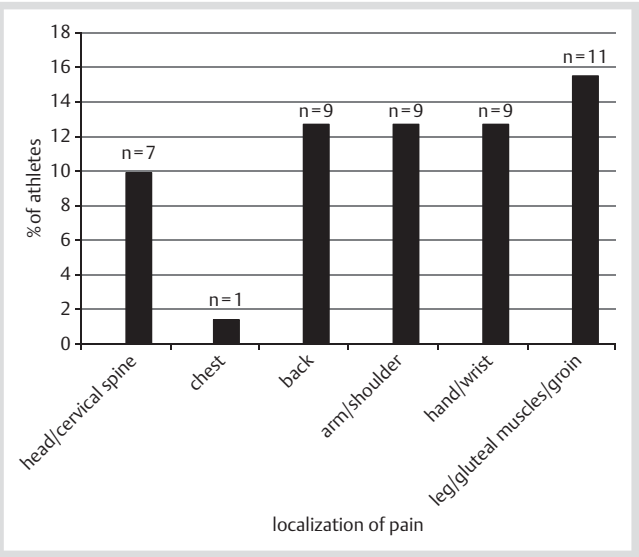

Fig. 1 Anatomical distribution of workout pain.

Table 1 Pain distribution during specific exercises.

Exercise	total	LE	UE	Back	Head/CS
squat	17 (23.9)	11 (15.5)	0	4 (5.6)	2 (2.8)
dead lift	4 (5.6)	0	0	4 (5.6)	0
bench press	9 (12.7)	0	7 (9.9)	0	2 (2.8)
others	30 (42.3)	3 (4.2)	19 (26.8)	4 (5.6)	4 (5.6)

numbers are absolute numbers of athletes (% in parentheses), LE = lower extremities, UE = upper extremities, CS = Cervical Spine

Frequency of injury (career)

These findings are according to retrospective appraisal of each participant's entire bodybuilding career. Overall, 39.4% (n = 28) of athletes had never suffered a bodybuilding-induced injury (**Fig. 2**). The overall injury rate was calculated as 0.12 injuries per bodybuilder per year. In this group of subjects, there were approximately 0.24 injuries per 1 000 h of bodybuilding.

Frequency of injury did not differ significantly based on gender. Older athletes showed higher injury rates (< 40 vs. > 40 years, p = 0.029). There was no significant difference between athletes receiving medical support during competitions and/or training and those who did not. In addition, the following variables did not statistically affect the rate of injury: use of supporting devices, exercise weight (more or less than 70% of the maximum weight), duration of workout (more or less than 120 min), warm-up training, or performing the sport on regional vs. national/international level.

Specification of injuries

The following data are based on reported diagnoses and descriptions of past injuries/disorders. Multiple answers were possible. Absolute numbers of participants are noted, and percentages regarding the entire collective are included in brackets.

Spine

Cervical spine: Overall, 26 athletes (36.6%) reported previous injuries to the cervical spine. Description/diagnoses included: pain not otherwise specified (NOS), myogelosis, arthrosis, herniated vertebral discs/protrusion, spinal stenosis, and sliding vertebrae (**Table 2**). Multiple answers were possible.

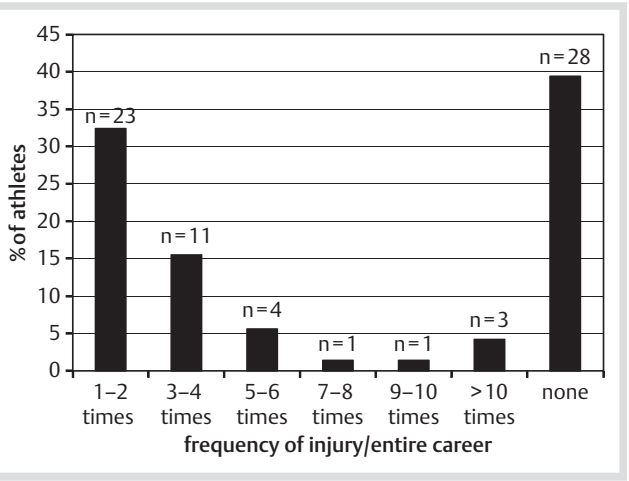

Fig. 2 Frequency of injury (bodybuilding career).

Table 2 Disorders of the cervical spine.

Diagnosis/symptom	n = 26	%
NOS (pain not otherwise specified)	10	14.1
myogelosis	14	19.7
arthrosis	2	2.8
herniated vertebral disc/protrusion	3	4.2
sliding vertebra	5	7
spinal stenosis	1	1.4
others	2	2.8

Cervical spine
(n = absolute number of athletes/% of 71 athletes)

The following parameters did not influence the rate of incidence: gender, age, medical support, routine endurance training, use of supporting devices, exercise weight (< 70%/> 70% max. weight), duration of workout (< 120/> 120 min), use of warm-up training, and performing the sport on the regional vs. national/international level.

Thoracic spine and thorax: 15 (21.1%) athletes reported previous disorders of the thoracic spine. 6 (8.4%) reported myogelosis and 4 (5.6%) athletes indicated a sliding vertebra. Other diagnoses included arthrosis (n = 1, 1.4%), herniated disc/protrusion (n = 3, 4.2%), NOS (n = 4, 5.6%), and hyperkyphosis (n = 1, 1.4%). Like the results presented above, none of the investigated parameters significantly affected the injury rate.

Lumbar spine: Injuries of the lumbar spine were mentioned by 28 (39.4%) athletes. The most frequent diagnoses listed were disc herniation, sciatica, hyperlordosis, and myogelosis (**Table 3**). The following parameters yielded no significant difference in injury rate: gender, age, medical support, exercise weight, duration of workout (< 120/> 120 min), competition level, routine endurance training, and warm-up.

Upper extremity

Shoulder: 26 (36.6%) of the bodybuilders reported previous disorders of the shoulder. Pain NOS was reported by 13 (18.3%) athletes, and inflammation by 8 (11.3%) (**Fig. 3**).

The investigated parameters mentioned above did not yield any statistical difference.

Table 3 Disorders of the lumbar spine.

Diagnosis/symptom	n = 28	%
NOS	6	8.5
myogelosis	7	9.9
arthrosis	2	2.8
herniated vertebral disc/protrusion	10	14.1
spondylolisthesis (sliding vertebra)	2	2.8
spinal stenosis	2	2.8
hyperlordosis	5	7
sciatica	5	7
sacroiliac joint disorders	3	4.3
others	2	2.8

Lumbar spine
(n = absolute number of athletes/ % of 71 athletes)

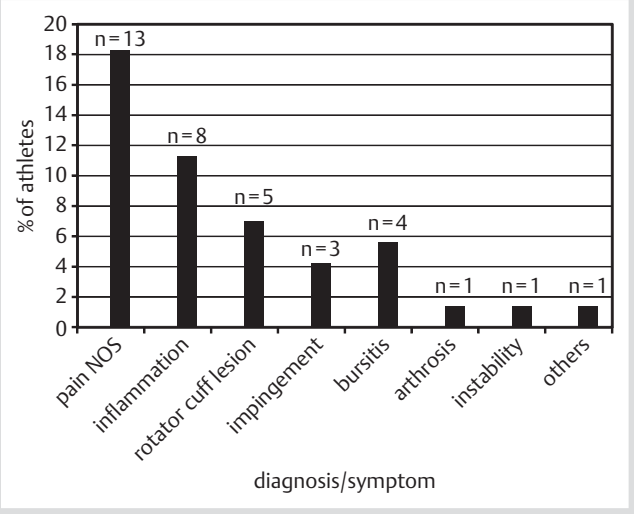

Fig. 3 Disorders of the shoulder.

Elbow: 24 (33.8%) bodybuilders reported previous injuries of the elbow region. Pain NOS was listed by 9 athletes (12.6%). Inflammation was specified by 15 athletes (21.1%). Other diagnoses included arthrosis, dislocation and instability (n = 3, 4.2%), and bursitis (n = 6, 8.4%). Muscle, tendon, or nerve disorders (n = 3, 4.2%) were also mentioned.
The analysis of the mentioned variables did not show any significant differences.

Hand/wrist: 10 (14.1%) athletes reported problems in the hand/wrist region. Pain NOS (n = 3/4.2%), tenosynovitis (n = 2/2.8%), arthrosis (n = 2/2.8), ganglion cysts (n = 2/2.8%) and other diagnoses (n = 2/2.8%) were mentioned. Other mentioned diagnoses were fracture, rheumatic disease, and ligament instability (1 athlete each case or 1.4%).
Analysis of the mentioned variables did not reveal significant differences.

Lower extremity

Hip: 4 (5.6%) athletes suffered from disorders in this region. Aside from pain, subjects specified diagnoses of arthrosis, inflammation, impingement, and strain.

Knee: Disturbances of the knee were reported by 22 subjects (31%). Pain NOS (n = 10/14.1%), patellar disorders (n = 8/11.3%), and meniscus injury (n = 2/2.8%) were mentioned. Also mentioned were arthrosis, inflammation, cruciate ligament rupture, and ligament instability (1 athlete each/1.4%).
Analysis of the mentioned variables did not reveal significant differences.

Ankle and foot: 8 athletes (11.3%) reported pathology/injury of the foot/ankle region. The most common diagnoses were flatfoot and splayfoot (n = 4 athletes, 5.6%). Ligament instability was reported by 4 athletes (5.6%). One athlete mentioned a toe dislocation (1.4%).

Medical support

28 athletes (39.4%) received medical support. Thus, 43 bodybuilders (60.6%) had no contact with physiotherapists or physicians. 19.7% of participants enlisted medical support during training and competitions, 4.2% only during competitions, and 15.5% only during training sessions.

Discussion

In contrast to the goal of Olympic weightlifting and powerlifting, i. e., the lifting of maximal weight, the goal of bodybuilding is the development of a muscular and defined body. This goal is associated with extensive training, specialized nutrition, as well as the abuse of anabolic substances [33]. Epidemiologic studies are already available showing the frequency of types of injury encountered in weightlifting and powerlifting [18]. However, this type of data is rare for the bodybuilding discipline [8, 14].
Which problems do these athletes need to overcome during daily training and when performing particular exercises? Which parts of the body are most frequently affected by injuries and pain? An earlier study by our group showed that more than 40% of elite powerlifters complain of pain during training [32]. The current study found that 45.1% of bodybuilders have similar complaints. In particular, there were complaints regarding the upper extremities. Participants in other sport disciplines also complain of relevant pain during exercise. For example, rowers often complain of back pain [35]. Swimmers often experience shoulder pain [34]. In contrast to the current study, however, the studies quoted above relied on retrospective observations. Our data reflects the experience of the participants at the time of collection. It seems that pain is accepted as part and parcel of high performance bodybuilding. High levels of motivation, discipline and willpower may explain this [5]. This may also be the reason for the low rate of (time-loss) injury experienced by these athletes, with 0.12 injuries per athlete per year and 0.24 injuries per 1 000 h of training. Injury was defined as an event causing interruption in training or competition. Using this definition, 40% of the athletes had not yet been injured during their entire career. This was true despite minimal support from medical professionals. Symptoms during training may decrease performance without inducing interruptions in training or competition. Thus, it seems that serious injuries were not generally present. Our findings are confirmed by previous data about recreational bodybuilders with comparably low injury rates. The previous study estimated a per year injury rate per bodybuilder of 0.42. The injury rate per 1 000 h of training was estimated to be 1.0 [8]. This previous study did not define injury rate as a time-loss injury. Clearly this could explain the variation in the 2

rates. In addition the subjects in the previous study were recreational bodybuilders. The motivation to continue training despite pain and injury might be higher in a competitive group. The injuries in the previous study were treated mostly at home (58%); thus, serious injuries were unlikely. Another previous study of bodybuilders does not provide a defined injury rate [14].

The rate of injury in the current investigation is lower than rates cited for weightlifting, powerlifting or strongman competition [16,28,32,36,38]. In these disciplines, the relatively low injury rates are assumed to be between 1–2/year and 1–5.5/1000 workout hours [6,14,16,18,27,28]. These studies suggest with powerlifting, for example, that moderately short-term injuries can be expected, with average symptom duration from 11.5 to 18.4 days [6,16,27].

The major limitations of the current data are the retrospective design of the study and the associations with the entire career as bodybuilder [12]. Despite this, it can still be assumed that bodybuilding does not approach the injury rates of contact sport disciplines. In sports such as ice hockey, professional rugby, handball, or soccer, injury rates range from 13.5–83 injuries/1000 training hours [3,4,13,20,31]. Even dancing shows a significantly higher rate of injury (1.5–4 injuries/1000 training hours) [9,37,40].

The minimal injury rate in bodybuilding could be due to multiple factors. Despite the excessive amount of training, in comparison to contact sports, bodybuilding deals with relatively slow, defined, and controlled movements. Contact with opponents inevitably leads to higher rates of injury. Another explanation for the low injury rate compared to powerlifting and weightlifting could be the smaller loads that bodybuilders must lift to achieve their training goals. In this discipline it is certainly easier, when symptoms are present, to modify or change exercises to rest particular body regions.

Despite this, however, we found that a large proportion of the athletes experience relevant symptoms during daily training. At the same time, the rate of time-loss injuries, i.e., those inducing interruptions of training, remains low. Such a discrepancy has also been reported for other sports, e.g. professional beach volleyball. There, the relatively low injury rate (0.8/1000 training hours) contrasts with the large proportion of athletes complaining of relevant overuse syndromes. The group investigating these athletes concluded that "traditional" cohort studies implementing a time-loss definition of injury might underestimate overuse syndromes [1,2]. Our data also show that the true problem in bodybuilding is not acute injury. Instead, it is the everyday pain occurring during training, which under appropriate conditions then leads to chronic complaints. Our finding that older athletes have increased risk for time-loss injuries ($p = 0.029$) might underscore this assumption. With older athletes, there may be a decrease in the compensatory mechanisms. In contrast to this data, previous studies of powerlifting did not yield age-dependent injury rates [6,18,32]. There is evidence that compared to other gym users, competitive bodybuilders are less satisfied with muscle size and are significantly more predisposed to practices aimed at gaining unhealthy levels of muscle bulk [17]. Perhaps such cases, with increased age and decreased muscle building capacity, would account for the increased injury rate with age.

The data for powerlifting shows that the deadlift primarily generates back complaints and symptoms in the lower extremities. This is also true for squats, although here symptoms occur more frequently and primarily in the lower extremities. Naturally, bench press leads to upper extremity symptoms. The results of the current study correspond with those of our previous study of powerlifters [32]. In addition, other studies concerned with joint biomechanics, the spine, and lower extremities during squats corroborate our results [10,23,39]. In practice, upper extremity complaints during squats can be minimized by training modifications (using a special bar modifying the center of mass, or performing a front squat) [11,32].

The current results show that the lumbar spine, the upper extremity including shoulder and elbow, and the knee are most frequently affected by relevant injuries. These results are comparable to those of studies of other weight lifting disciplines [6,14,16,18,27,28,38]. Goertzen et al. estimate an injury rate of 40% for the upper extremity (shoulder and elbow). The lumbar spine and the knee were also frequent areas of injury. Muscle lesions (e.g. tears, tendinitis, sprains) were the cause of 83.6% of injuries in this study. Overall, the total injury rate for powerlifters is estimated as being twice as high as that for bodybuilders [14]. In the previous study of recreational bodybuilders complaints of injury were centered on the shoulder, upper extremities and spine. The knee joint was not as important [8]. One reason for this might be the focus by recreational bodybuilders on the upper body. Even strongman competitors exhibit injury patterns similar to our own results with reported injuries in the lower back, shoulder and bicep and knees [38]. These patterns are most likely due to the large role of traditional weight training for this specialized discipline.

In the current study, the subjects were asked to report previous injuries, and if possible to indicate a diagnosis. Acute symptoms may stem from chronic degeneration. It is difficult even for medical practitioners to correlate injuries or overuse syndromes with particular activities [7,12,21]. From these results, however, it is evident that decreased access to medical care did not influence the frequency of injury. This also holds true for the other investigated parameters (gender, duration of workout, level of competition, warm-up, and use of support devices). This is in contrast to powerlifting, for which several parameters (e.g. gender, level of competition, and use of support devices) did impact injury rates [28,32]. This might be explained by the markedly higher weights used in powerlifting, which is also reflected as an average increase in the possible maximum load during bench press, squats, and deadlifts (see subjects) [32].

To prevent symptoms during training, modifications have been developed for particular exercises (e.g. squat, bench press). These modifications can help athletes return to training after injury. They involve hand spacing, grip selection, as well as start and finish positions used for the bench press to decrease microtrauma to the shoulder joints and to reduce strain on the passive and active shoulder stabilizers [11]. Proper bench press technique, bench press training program variables (e.g. warming up, training volume, and intensity), and addressing imbalances and deficits of the upper body musculature and range of motion are recommended particularly for athletes suffering from upper extremity injuries [18]. Generally, lifters should perform the most demanding, challenging exercises early in their training sessions, and should avoid tiredness, fatigue, technical errors and excessive overload [19]. For bodybuilders it should be easier to prevent particular pain-inducing exercises than for powerlifters, since there are no compulsory exercises in the discipline.

Conclusion

Bodybuilding is a weightlifting sport in which a large number of athletes complain of pain or problems during routine workouts. The health care practitioner should be aware that such problems do not necessarily require an interruption of training. The distribution of injury corresponds to that found in previous studies of powerlifters and weightlifters (lumbar spine, upper extremities, and knees). The time-loss injury rate itself is low compared to other sport disciplines, particularly contact sports. It is also significantly lower compared to powerlifting and weightlifting. Individual factors aside from age, both intrinsic and external, do not affect the rate of general injury.

Acknowledgements

JS is supported by the German Federal Ministry of Research and Education (BMBF grant 01KN1106).

Conflict of interest: The authors have no conflict of interest to declare.

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