Injury Patterns, Risk Factors, and Return to Sport in Brazilian Jiu Jitsu

A Cross-sectional Survey of 1140 Athletes

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Background: Brazilian jiu jitsu (BJJ) is a growing martial art that focuses on grappling techniques.

Purpose: To quantify the 3-year incidence of BJJ-related injuries and detect common injury patterns as well as risk factors among those practicing BJJ. It was hypothesized that there would be a high incidence of injuries, they would be caused by submissions in sparring situations, and they would occur predominantly at the extremities.

Study Design: Descriptive epidemiology study.

Methods: Active BJJ athletes were invited to take an English-language online survey developed by orthopaedic surgeons together with BJJ athletes and a sports scientist. Data were recorded regarding athlete demographics, sporting activity level, injuries within the past 3 years that caused at least a 2-week time loss, injury mechanisms, and return to sport.

Results: Overall, 1140 responses were received from 62 different countries; 88.9% of all athletes were male, and 63.9% were regular competitors. Within the investigated cohort, 1052 injuries were recorded in 784 athletes, for an injury incidence of 308 per 1000 athletes per year. The lower extremity (45.7%) and upper extremity (30.2%) were predominant sites of injury, with injuries to the knee (27.1%) being the most common. The most frequent knee injuries were meniscal injuries (n = 65), anterior cruciate ligament (ACL) tears (n = 36), and medial collateral ligament injuries (n = 36). ACL tears were especially associated with long time frames for return to sport. Most injuries occurred during sparring (77.6%) and were caused by submissions (29.7%) and takedowns (26.4%). Competing regularly ($P = .003$), older age ($P < .001$), and higher belt rank ($P = .003$) were significant risk factors for injury.

Conclusion: Injury incidence was high among BJJ athletes surveyed, with 2 out of 3 athletes reporting at least 1 injury within a 3-year period that caused a 2-week absence from training. Most injuries occurred during sparring, and we believe that a high potential for injury reduction lies in drawing awareness to common injury patterns and sites in athletes.

Keywords: BJJ; martial arts; sports injuries; injury prevention; grappling; return to sport; knee injury; shoulder injury

Brazilian jiu jitsu (BJJ) is a unique martial art that emphasizes grappling techniques, in contrast to sports such as boxing that focus on striking. In a BJJ match, athletes aim to secure superior positioning and immobilize the opponent by applying chokeholds and joint locks. Rooted in Kodokan judo, BJJ was developed in the early 20th century and is associated with the Gracie family from Rio de Janeiro, Brazil. In 1993, Royce Gracie won the first Ultimate Fighting Championship, an event in which athletes with different martial art backgrounds compete in hand-to-hand combat. Royce Gracie's success brought mainstream popularity to BJJ.[23,27]

Studies that have been conducted on the epidemiological characteristics of injuries in other martial arts, such as judo, boxing, taekwondo, Shotokan karate, and wrestling,[1,4,11,14,15,19,26] indicate that injury rates and sites of injury may differ between martial arts.[9,30] Data on the epidemiology, mechanisms, and the prevention of injuries in BJJ are still relatively limited.

Moriarty et al[17] and Petrisor et al[21] investigated BJJ-related injuries in both training and competition and found that injuries occur commonly in BJJ: The studies reported a high injury prevalence (9/10 athletes sustaining at least 1 injury)[21] and a 6-month injury incidence rate of 59.2%.[17] Both studies also examined the most common site of injury, with Moriarty et al reporting the knee and Petrisor et al reporting the upper extremity and neck to be the most common. Other studies focused on injuries sustained

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during competition or training exclusively. Scoggin et al[23] collected data on injuries occurring during competitions, including injury mechanisms and specific diagnoses. Their reported injury incidence was 9.2 per 1000 match participations, with the elbow being the most injury-prone joint. McDonald et al[16] similarly compiled data on injuries, with the exception of injury mechanisms, and focused on those injuries occurring in training. The investigators found that the hand, fingers, foot, toes, arm, and elbow were the most commonly affected body regions.

Although some studies provide more knowledge on BJJ injury occurrence and site of injury, they lack information on injury diagnoses and mechanisms. Those that have reported on diagnoses and mechanisms did so within a limited scope of BJJ activity (training vs competition). It has yet to be determined which movements lead to specific pathologies and in which phase of training or competition they occur for a large cohort. Additionally, beyond the injury itself, the current literature also lacks information on postinjury data, such as BJJ injury-specific return-to-sport rates.

In the present study, we aimed to quantify the 3-year incidence of BJJ-related injuries and detect common injury patterns and risk factors among those practicing BJJ. We also set out to review the effectiveness of any measures that athletes take to prevent injuries and identify postinjury behavioral adaptations. It was hypothesized that there would be a high incidence of injuries with a minimum absence from training of 2 weeks, the injuries would be caused by submissions in sparring situations, and they would occur predominantly at the extremities.

METHODS

Development of the Survey and Data Collection

A survey of injuries incurred during BJJ was developed by orthopaedic surgeons together with BJJ athletes and a sports scientist. After an initial pilot survey, the final 67-item questionnaire (see Supplementary Material) was presented using a commercial website for online surveys (SurveyMonkey; Momentive Europe Unlimited). It was shared by members of the public, specifically BJJ athletes, through social media platforms (Reddit, Facebook, Instagram, Beltchecker), where BJJ practitioners were asked to participate. The online survey was open for 61 days between June and August 2020. Study approval was obtained by the ethics committee of our institution, and all data were collected anonymously.

The survey comprised 3 sections. Participant data (sex, country of residence, age, height, weight) were collected in the first section. The second section focused on training experience and exposure: years of training, belt rank, training hours per week, and competition frequency and level. Additionally, data were collected on preventive measures that were taken by athletes to reduce the risk of injury. The third section contained questions related to injuries. Athletes were asked to report injuries in the last 3 years of participating in BJJ. Injury was defined as any musculoskeletal problem that occurred during training or competition. To limit this to significant cases, we specified injuries causing an absence in training for at least 2 weeks. All injuries were self-reported and required no verification by a specialist. With each reported injury, athletes were asked to specify the injury location (head, neck, shoulder, upper arm, elbow, forearm, wrist, hand, fingers, thorax and trunk, spine, upper back, lower back, hip, thigh, knee, calf, ankle, foot, toes) and mechanism; time frames for return to activity, sport, and competition; and behavioral changes that were adopted after the injury occurred to prevent future injuries. To keep the survey short and participation rates high, we limited the number of reportable injuries to 3.

For each injury, we recorded the time frame needed to achieve the following milestones:

- Return to activity (eg, running, biking, swimming, lifting weights)
- Return to technique training (no sparring, just drills)
- Return to full-contact training or sport (sparring included)
- Return to competition

The results were categorized into the following time intervals: (1) <1 month, (2) 1 to 3 months, (3) 3 to 6 months, (4) 6 to 9 months, (5) 9 to 12 months, (6) >1 year, and (7) return to activity not yet achieved. A total of 8 athletes with recurrent injuries were excluded from the return-to-sport analysis to create a homogeneous and comparable subgroup.

Statistical Analysis

Quantitative data were represented by mean ± standard deviation (SD) for normally distributed data and by median (interquartile range) for data that were not normally distributed. Normal distribution was tested using the Shapiro-Wilk test and graphically confirmed. Categorical variables were described by absolute and relative frequencies.

A hierarchical linear regression model performed in 3 stages was used to determine risk factors for the number

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Ethical approval for this study was obtained from the Technical University of Munich (reference: 180/20 S).

of accumulated BJJ-related injuries over the 3-year period before completion of the survey. Stage 1 consisted of participant factors (sex, age, height, and weight), stage 2 encompassed factors related to training and competition (belt rank, training hours per week, and competition frequency per year), and stage 3 was comprised of measures undertaken to prevent injury (sleeping, eating, and training habits and other measures). The number of injuries accumulated over the 3-year time period was defined as the dependent variable. Statistical analysis was performed using SPPS 26.0 software (IBM). Independent variables with $P < .05$ were defined as significant.

RESULTS

Study Population

A total of 1517 athletes participated in this survey. After the exclusion of incomplete questionnaires, data from 1140 athletes (88.9% male) from 62 countries were eligible for final analysis. The mean age of the athletes was 31.7 ± 7.9 years. The data indicated that 728 (63.9%) athletes competed at least once per year; further, 424 (37.2%) competed at a regional level championship, 138 (12.1%) at a national championship, and 166 (14.5%) at an international championship.

TABLE 1
Overview of Injury-Causing Mechanisms

Injury Mechanism and Description	n (%)
Submission	
My opponent was attempting a submission	246 (23.4)
Armbar	55
Kimura	31
Heel hook	27
I was attempting a submission on my opponent	66 (6.3)
Triangle choke	19
Rear naked choke	8
Armbar	7
Takedown	
I was taken down	178 (16.9)
I was taking my opponent down	100 (9.5)
Guard pass	
I was passing guard	107 (10.2)
My opponent was passing my guard	145 (13.8)
Sweep	
I was sweeping my opponent	45 (4.3)
I got swept by my opponent	40 (3.8)
Other	115 (11.8)

Injury Incidence

Within the 3-year period that this survey covered, 356 (31.2%) athletes stayed injury free, 556 (48.7%) reported 1 injury, 188 (16.6%) reported 2 injuries, and 40 (3.5%) reported 3 injuries with an absence from training of >2 weeks according to this study's definition of injury. With 1052 injuries reported, an incidence rate of 308 injuries per 1000 athletes per year was determined. The most commonly injured body regions were the lower (45.7%) and the upper extremity (30.2%), specifically the knee (27.1%) and shoulder (14.6%).

Mechanism of Injury

Injury mechanisms are shown in Table 1. Most injuries occurred during submissions (29.7%), takedowns (26.4%), and guard passes (24.0%). In guard, both athletes are on the ground with 1 athlete attempting to use his legs to control his opponent while the other athlete is attempting to overcome this defense in order to reach a more dominant position, a technique known as a guard pass. Within injuries occurring during submissions, the majority were sustained by the submitted individual (78.9%), whereas a minority occurred in the athlete applying the submission (21.1%). Submission techniques that caused the most injuries to the individual they were applied to were the armbar (22.4%), the kimura (12.6%), and the heel hook (11%) (Figure 1).

Injury Timing

The majority of injuries occurred during sparring (n = 816; 77.6%). Competition and technique training/drilling led to injury in 101 (9.6%) and 120 (11.4%) cases, respectively.

Figure 1. Overview of the 3 submission techniques that most often caused injury to the athlete against whom they were performed. (A) Armbar: the attacker (white) applies pressure on the defender's elbow (black), causing hyperextension. (B) Kimura: the attacker forces the defender's shoulder into forceful internal rotation. (C) Heel hook: the attacker causes rotation of the foot, ankle, and lower leg.

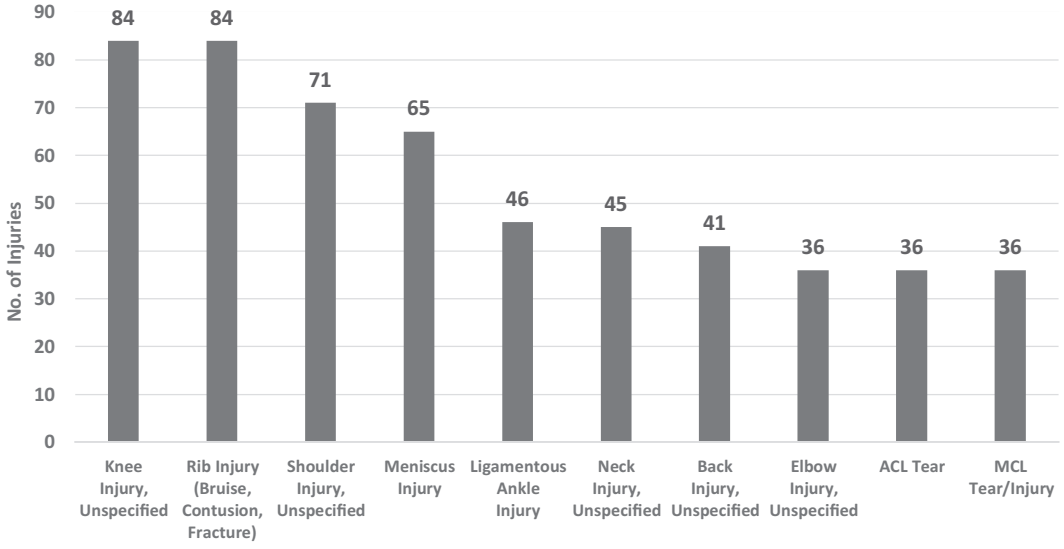

Figure 2. Most common injuries in all participants. ACL, anterior cruciate ligament; MCL, medial collateral ligament.

A comparably lower number of injuries occurred during warm-ups (n = 15; 1.4%).

Frequently Specified Injuries

The most commonly reported injuries are shown in Figure 2. Table 2 shows return-to-sport data for the 5 most frequently specified injuries: anterior cruciate ligament (ACL) tear, ligamentous ankle injury, medial collateral ligament (MCL) injury, meniscal injury, and rib injury (bruise, contusion, fracture).

Including recurrent injuries, a total of 36 ACL tears were reported by 35 athletes; in 36.1% of instances, the ACL tear was the result of takedowns, affecting the taken-down athlete. Ligamentous ankle injuries (ie, ankle sprains) were reported in 46 cases by 45 athletes. The majority (60.9%) of ligamentous ankle injuries occurred during submissions, predominantly during toeholds (14 athletes) (Figure 3), straight ankle locks (8 athletes), and heel hooks (6 athletes). A total of 36 MCL injuries or tears were reported by 36 athletes. More variation in injury mechanism was observed for MCL injuries and tears compared with other injuries: 10 injuries (27.8%) were attributed to submissions, equally divided between the submitting and submitted opponents, and 6 injuries (16.7%) occurred each in taken-down opponents and passing opponents. Of all 65 meniscal injuries reported by 61 athletes, 18 (27.7%) resulted from takedowns, equally divided between the participants performing the takedown and the participants who were taken down. Furthermore, 16 (24.6%) occurred during guard passes, with 11 of those occurring in the athletes whose guard had been passed and 5 in the athlete performing the guard pass. Finally, a total of 82 athletes reported 84 rib injuries. The majority of these injuries occurred in athletes whose guards were passed (29.8%) or who were taken down (23.8%).

Risk Factors

Participant Factors. From the hierarchical linear regression model, older age was determined to be a significant risk factor ($P < .001$) for injury over a 3-year time period. Other participant factors showed no significant association with injury incidence (Table 3). Participant variables accounted for 2% of the variability in injury incidence ($R^2 = 0.020$).

Factors Related to Belt Rank, Training, and Competition Behavior. Training experience and weekly training hours showed no association with the number of injuries accumulated. However, taking part in competitions was a significant risk factor ($P = .003$). In contrast to athletes who did not participate in competitions (36.1%), who had on average 0.76 ± 0.72 injuries, competitive athletes (63.9%) had 1.01 ± 0.80 injuries. Belt rank also had a significant correlation with injury incidence ($P = .003$). Athletes with a white belt (the lowest rank; 36.3% of all athletes) had the lowest incidence of injury (0.73 ± 0.69), whereas brown-belt athletes (the second highest rank; 6% of all athletes) had the highest number of injuries (1.22 ± 0.84) (Table 4). Variables related to belt rank as well as training and competition behavior accounted for 5% of the variability in injury incidence ($R^2 = 0.050$).

Factors Related to Injury Prevention. Measures taken for injury prevention, specifically dietary, sleep, and mobility- and strength training-related activities, showed no significant impact on injury incidence over the 3-year period (Table 5). However, factors related to injury prevention accounted for 6.3% of the variability in injury incidence ($R^2 = 0.063$).

Behavioral Adaptations After Injuries

Athletes were asked about single behavioral changes that had been implemented after each injury to prevent further

TABLE 2
Return-to-Sport Data for the 5 Most Common Injuries[a]

Time to Return	ACL Tear (n = 34)	Ligamentous Ankle Injury (n = 44)	MCL Injury (n = 36)	Meniscal Injury (n = 57)	Rib Injury (Bruise, Contusion, Fracture) (n = 80)
Return to activity (eg, running, biking, swimming, lifting weights)					
<1 mo	9 (26)	23 (52)	13 (36)	23 (40)	34 (43)
1-3 mo	12 (35)	17 (39)	19 (52)	17 (30)	37 (46)
3-6 mo	9 (26)	2 (5)	3 (8)	11 (19)	5 (6)
6-9 mo	3 (8)	1 (2)	1 (3)	3 (5)	3 (4)
9-12 mo	1 (3)	0	0	1 (2)	1 (1)
>1 y	0	0	0	1 (2)	0
Not yet achieved	0	1 (2)	0	1 (2)	0
Return to technique training (no sparring)					
<1 mo	4 (12)	25 (57)	8 (22)	11 (19)	20 (25)
1-3 mo	5 (15)	13 (30)	19 (53)	20 (35)	52 (65)
3-6 mo	8 (24)	3 (7)	6 (17)	18 (32)	6 (8)
6-9 mo	10 (29)	1 (2)	1 (3)	1 (2)	1 (1)
9-12 mo	4 (12)	0	0	4 (7)	1 (1)
>1 y	2 (6)	1 (2)	1 (3)	3 (5)	0
Not yet achieved	1 (3)	1 (2)	1 (3)	0	0
Return to full-contact training (sparring included)					
<1 mo	2 (6)	14 (32)	4 (11)	5 (9)	9 (11)
1-3 mo	3 (9)	16 (36)	12 (33)	13 (23)	48 (60)
3-6 mo	6 (18)	9 (20)	13 (36)	19 (33)	19 (24)
6-9 mo	4 (12)	2 (5)	4 (11)	9 (16)	4 (5)
9-12 mo	9 (26)	0	1 (3)	4 (7)	0
>1 y	8 (24)	0	1 (3)	5 (9)	0
Not yet achieved	2 (6)	3 (7)	1 (3)	2 (4)	0
Return to competition					
<1 mo	1 (3)	4 (9)	2 (6)	3 (5)	7 (9)
1-3 mo	0	6 (14)	2 (6)	2 (4)	9 (11)
3-6 mo	2 (6)	11 (25)	6 (17)	6 (11)	14 (18)
6-9 mo	5 (15)	3 (7)	5 (14	9 (16)	4 (5)
9-12 mo	1 (3)	0	2 (6)	6 (11)	2 (3)
>1 y	11 (32)	0	2 (6)	2 (4)	1 (1)
Not yet achieved	14 (41)	20 (45)	17 (47)	29 (51)	43 (54)

[a]Data are reported as number (%) of participants. Recurrent injuries were excluded from the return-to-sport analysis. ACL, anterior cruciate ligament; MCL, medial collateral ligament.

injuries (Table 6). For the athletes who reported making behavioral adaptations, the 3 most common measures reported were stretching more (20.3%), fighting with less intensity (12.4%), and tapping—accepting the opponent's victory via a "tapping" hand motion—earlier (10%). However, in 18.6% of cases, no adaptations were made.

DISCUSSION

Key Findings

Injury incidence was high among the studied BJJ athletes, with 2 out of 3 athletes sustaining at least 1 injury, defined as an absence from training of at least 2 weeks, over the last 3 years. Among BJJ injuries, the lower and upper extremity, specifically the knee and shoulder, were the most common sites of injuries. The majority of all injuries occurred during sparring. Fewer than 1 of 10 injuries occurred during competition. Belt rank influenced injury incidence significantly. Additionally, athletes who competed regularly and were older had significantly more injuries.

Incidence and Common Sites of Injury

The 3-year injury incidence rate of 68.8% in our study population can be compared only to the 6- and 12-month injury incidence rates reported by 2 previous studies[16,17] because, to our knowledge, there are no published 3-year incidence rates on BJJ injuries. McDonald et al[16] reported a 12-month injury incidence of 85.7%, with the hand/fingers, foot/toes, arm/elbow, and knee being the most common injury sites among their cohort (86.4% male; 59.3% competitors). These numbers may differ from our study's findings due to the fact that McDonald et al combined foot/toe and hand/finger as 1 injury site each. Those investigators also looked exclusively at injuries occurring during BJJ training only, which may not display the whole spectrum and quantity of BJJ-related injuries. Moriarty et al[17] reported

Figure 3. Illustration of the toehold. Attacker (white) puts the defender's (black) ankle into hypersupination.

TABLE 3
Hierarchical Linear Regression Model of Risk Factors for Injury in Brazilian Jiu Jitsu: Participant Factors

Independent Variable	Injury Incidence	*P* Value
Sex		.898
Men (n = 1104)	0.92 ± 0.78	
Women (n = 126)	0.93 ± 0.81	
Age		**<.001**
Injured group (n = 784)	32.46 ± 7.78	
Noninjured group (n = 356)	30.12 ± 8.01	
Height		.938
Injured group (n = 784)	174.04 ± 20.21	
Noninjured group (n = 356)	174.63 ± 20.28	
Body weight		.645
Injured group (n = 784)	82.10 ± 17.87	
Noninjured group (n = 356)	81.16 ± 17.96	

[a]Incidence is expressed as mean ± SD. Bolded *P* value indicates significant difference between groups ($P < .05$).

a 6-month injury rate of 59.2%. The knee was the most commonly injured site (20.8%), which is consistent with the results of the present study. Regarding injury prevalence, Petrisor et al[21] reported an injury prevalence of >90% among BJJ athletes, in whom more injuries were sustained in training than in competition, aligning with our findings. Silva et al[24] reported that novice athletes (white- and blue-belt athletes by definition) sustained injuries more frequently in training than in competition, and advanced athletes (purple, brown, and black belt) vice versa. According to Scoggin et al,[23] data on 8 statewide BJJ tournaments in Hawaii, USA, showed that of all orthopaedic injuries, the elbow joint was the most injury-prone site (38.9%) and the knee was the second-most frequent site of injury (15.2%). The findings reported by the aforementioned studies indicate that the common sites of injury may differ between training and competition.

TABLE 4
Hierarchical Linear Regression Model of Risk Factors for Injury in Brazilian Jiu Jitsu (BJJ): Belt Rank, Training, and Competition Behavior[a]

Independent Variable	Injury Incidence	*P* Value
BJJ belt rank		**.003**
White belt (n = 414)	0.73 ± 0.69	
Blue belt (n = 396)	0.96 ± 0.77	
Purple belt (n = 171)	1.10 ± 0.86	
Brown belt (n = 68)	1.22 ± 0.84	
Black belt (n = 91)	1.09 ± 0.86	
Training hours per week		.890
1-5 h (n = 630)	0.86 ± 0.75	
6-10 h (n = 418)	1.02 ± 0.81	
11-15 h (n = 67)	0.97 ± 0.93	
16-20 h (n = 13)	0.69 ± 0.63	
≥20 h (n = 12)	1.00 ± 1.04	
Competition frequency per year		**.003**
None (n = 412)	0.76 ± 0.72	
1-2 competitions (n = 515)	0.98 ± 0.78	
3-4 competitions (n = 129)	1.10 ± 0.83	
≥5 competitions (n = 84)	1.07 ± 0.90	

[a]Incidence is expressed as mean ± SD. Bolded *P* values indicate significant difference between groups ($P < .05$).

The differences in these findings may be attributed partially to the fact that the definition of injury varies greatly among epidemiological studies on BJJ injuries. For example, das Graças et al[5] defined BJJ injuries as "any symptomatic manifestation of pain, or physical dysfunction, due to training practice or . . . competitions." Moriarty et al,[17] in contrast, defined injuries more stringently as complete abstention from BJJ training or any other physical activity for >1 week and/or moderate modification of BJJ training and sporting activities for >2 weeks and/or evaluation by a medical professional. Thus, the difference in these definitions is likely to be a major reason for the difference in the injury rates reported. We exclusively collected data on injuries necessitating an absence from training for at least 2 weeks, which may lead to an underestimation of absolute injury numbers. Through our definition, however, the nature of such disruptive injuries and their most frequent mechanisms can be well explained. To our knowledge, this is the first study that collected comprehensive injury data (occurrence in training vs competition, injury mechanism, diagnosis, and return to sport) in a large cohort. Beyond BJJ-exclusive studies, Stephenson and Rossheim[25] investigated BJJ, judo, and mixed martial arts (MMA) injuries that were treated in US emergency departments. Whereas judo practitioners mainly experienced leg injuries, MMA and BJJ athletes seeking medical service in emergency departments mainly had head injuries (43% and 21%). Because of the injury severity typically observed in emergency departments, their data showcase the difference in severe injuries across each sport rather than the total spectrum of injuries (mild to severe) associated with each sport.

TABLE 5
Hierarchical Linear Regression Model of Risk Factors for Injury in Brazilian Jiu Jitsu: Preventive Measures[a]

Independent Variable	Injury Incidence	*P* Value
Increased hours of sleep per night		.371
With measure (n = 453)	0.90 ± 0.79	
Without measure (n = 687)	0.94 ± 0.78	
Meditating		.656
With measure (n = 171)	0.92 ± 0.80	
Without measure (n = 969)	0.92 ± 0.68	
Taking a nap		.177
With measure (n = 241)	0.89 ± 0.78	
Without measure (n = 899)	0.93 ± 0.78	
Improving sleep quality		.573
With measure (n = 281)	0.91 ± 0.81	
Without measure (n = 859)	0.93 ± 0.77	
High protein intake		.227
With measure (n = 520)	0.94 ± 0.80	
Without measure (n = 620)	0.90 ± 0.77	
High fruit and vegetable intake		.363
With measure (n = 344)	0.97 ± 0.84	
Without measure (n = 796)	0.90 ± 0.76	
High carbohydrate intake		.102
With measure (n = 120)	0.83 ± 0.80	
Without measure (n = 1020)	0.93 ± 0.78	
Eating fewer processed foods		.616
With measure (n = 413)	0.98 ± 0.84	
Without measure (n = 727)	0.89 ± 0.75	
Vegetarian, plant-based, or vegan diet		.568
With measure (n = 105)	1.00 ± 0.85	
Without measure (n = 1035)	0.92 ± 0.77	
Mobility training (eg, yoga, stretching)		.131
With measure (n = 624)	0.97 ± 0.80	
Without measure (n = 516)	0.87 ± 0.76	
Weight or strength training		.988
With measure (n = 619)	0.94 ± 0.80	
Without measure (n = 521)	0.90 ± 0.77	
Hot and/or cold baths or therapy		.275
With measure (n = 215)	1.01 ± 0.83	
Without measure (n = 925)	0.90 ± 0.77	
Other		.692
With measure (n = 36)	0.97 ± 0.84	
Without measure (n = 1104)	0.92 ± 0.78	

[a]Incidence is expressed as mean ± SD.

TABLE 6
Behavioral Changes Implemented by Athletes After Injury[a]

Change	No. of Responses (%)
Stretching more	214 (20)
Fighting with less intensity	130 (12)
"Tapping" faster or earlier	102 (10)
More training within BJJ	97 (9)
More training outside of BJJ	87 (8)
Less training within BJJ	58 (6)
Implementation of strength training	20 (2)
Eating healthier food	15 (1)
Sleeping more	12 (1)
Training less outside of BJJ	1 (<1)
Other	116 (11)
Nothing	196 (19)

[a]BJJ, Brazilian Jiu Jitsu.

Injury Timing and Mechanism

In the present study, 77.6% of all injuries occurred during sparring, with only a small minority occurring during competition (9.6%). This rate of injuries sustained in competition is considerably lower than that in other martial arts such boxing (57%), judo and karate (~70%), and wrestling (90% of all catastrophic injuries occurring in competition).[3,13,29] Additionally, our study showed that more than half (56.1%) of all injuries were caused by takedowns and submissions. By contrast, Moriarty et al[17] reported that most injuries occurred during a scramble or transition (58.5%) whereas only a minority of injuries were caused by submissions (15.2%) and takedowns (5.9%). Scoggin et al[23] assessed injuries during BJJ competitions and found submissions (22.2%), specifically the armbar (13.9%), and takedowns (13.9%) to be injury-prone movements. This correlates with the findings of the present study, in which these 2 techniques are also frequently the cause of injury. However, due to the rules of the competitions that Scoggin et al studied, heel hooks,[2] a major cause of injuries in our findings, were not allowed. Competitions with a limited set of rules therefore give a limited spectrum of injury mechanisms in BJJ. In our study, 29.7% of all injuries occurred during submissions. This is not unexpected, as submissions aim to render the opponent unable to fight and ultimately tap out, forfeiting the match. However, as a close second in our findings, takedowns constituted 26.4% of all injuries. This is notable because these movements do not aim to injure the opponent but rather aim to gain a superior position and earn points in competition settings. In other martial arts where takedowns are the primary objective, a higher injury rate from takedowns is expected. For instance, takedowns constitute the main mechanism of injury in wrestling[20] and in judo, a sport primarily focused on throwing movements with some grappling elements. Being thrown by an opponent in judo constitutes the most common cause of injury.[7,22,28] In an effort to lower takedown-related injuries, studies have shown that a lack of falling skills may be associated with injuries,[8,10] whereas improvement of break-fall techniques may lower the risk of severe injuries.[18,22] However, despite the unnecessarily high rate of takedown injuries in BJJ as shown by our study, Moriarty et al found no correlation regarding instruction on break-falling and injury risk for BJJ athletes.

Risk Factors

Our findings indicated that belt rank, higher age, and competing regularly were significant risk factors for injuries. Moriarty et al[17] found that an increase in training years and body weight lowered the injury risk, whereas an increase in training days per week and status as an instructor increased injury risk. Das Graças et al[5] also found age to be a significant risk factor ($P < .05$), as adolescent athletes

(aged 12-17 years) had a lower injury risk than adult (aged 18-30 years) and master (aged >30 years) athletes. Their analysis of current factors for retrospective sports injuries showed age and global flexibility of the posterior static muscle chain to be the most predictive variables for injuries in BJJ ($P < .05$). Female sex and sport exposure time were the most predictive variables for the onset of injuries in adolescent athletes ($P < .05$). Within adults, belt rank was also significantly associated with injuries in BJJ ($P = .031$). Therefore, the findings of das Graças et al indicating belt rank and age as significant risk factors for injury incidence align with the present study. Kreiswirth et al[12] analyzed the incidence of joint injuries during a World Championship in No-Gi BJJ, a subdiscipline where athletes compete in athletic clothing instead of a *gi* (a kimono) and, notably, gripping opponents' clothing is not allowed. Their study showed that more experienced athletes (brown and black belt) had a higher risk of injury than less experienced athletes (blue and purple belt). Due to the different ruleset of this subdiscipline and the fact that the lowest experience level was excluded (white-belt athletes cannot compete in the No-Gi tournament examined in the study), extrapolation of these data to classic BJJ is limited. Studying martial arts beyond BJJ, Zetaruk et al[30] compared 5 different sports (Shotokan karate, aikido, taekwondo, kung fu, and tai chi) and found athlete age >18 years, training experience >3 years, training time >3 hours per week, and martial art style to be significant risk factors for injury incidence.

Limitations

One of the limitations of the retrospective data used in this study was that all injuries, diagnoses, severity level, and time frames for return to activity, sport, and competition were self-reported and may not have been confirmed by a medical professional. This limits the accuracy of the reported injuries and diagnoses. Accuracy may further be affected by respondents' recall capability. For instance, Gabbe et al[6] reported a decline in recall accuracy as the level of detail requested increased. Their findings showed that when respondents were asked to report on injuries that occurred in the past 12 months, only 61% of athletes were able to record the exact number, body region, and diagnosis of each injury sustained. Nonetheless, the time frame covered in our study was set to 3 years in order to obtain a detailed picture of the epidemiology of injuries in BJJ and analyze the return to sport after these injuries. The return-to-sport analysis was limited by recent injuries that were still in the healing process at the time of data collection, which could not be differentiated from those injuries from which athletes may never recover. Additionally, injuries were not sorted by the method of treatment, which further limits the relevance of the return-to-sport analysis performed. Furthermore, the maximum number of reportable injuries was limited to 3 injuries. Although this was a measure to minimize the time needed to complete the survey in order to keep participation rates high, a few athletes' injuries may have been underreported. However, this is only potentially applicable to those who reported 3 injuries (40/1140 athletes). Additionally, because the title of this survey was "Injuries in Brazilian Jiu Jitsu," athletes with injuries may have found participation more relevant than those who had not experienced any injuries. This possible selection bias may have inflated the reported incidence of injuries. Finally, within this study, preventive measures were not shown to influence the number of injuries occurring in a 3-year time period. Prospective long-term studies are needed to evaluate injury prevention measures for primary prevention as well as the efficacy of postinjury behavioral adaptations described in this study to prevent future injury occurrence.

CONCLUSION

Study findings indicated that injury incidence in BJJ is high, with 784 of 1140 athletes (68.8%) reporting at least 1 injury requiring a 2-week absence from BJJ training in a 3-year time frame. The most commonly injured sites were the lower (45.7%) and upper extremity (30.2%), specifically the knee (27.1%) and shoulder (14.6%). Of all knee injuries, meniscal injuries (n = 65), ACL tears (n = 36), and MCL tears or injuries (n = 36) were most common. Because most injuries occurred in sparring (77.6%), there is a high potential for lowering injury risk in BJJ by improving the safety in sparring. Education about injury frequency during submissions and their mechanisms can help athletes become more aware of high-risk movements that may lead to injury. Additionally, because most injuries occur during submissions, safe practices, such as tapping out early (and allowing time for a tap-out), should be encouraged to reduce the likelihood of injury. This may be achieved by emphasizing the learning experience that sparring provides over the focus on winning that is typically encouraged for competition.

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