

## ORIGINAL ARTICLE

# A Study on Incidence of Injuries Among Malaysian Karate Athletes and Correlation With Body Composition and Physical Fitness: A Cross-sectional Study

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## ABSTRACT

**Introduction:** There are limited studies that investigate the correlation of body composition and physical fitness components such as muscle strength, core endurance, and cardiorespiratory fitness in relation to injuries in karate athletes. Our objectives in this study were to investigate the incidence of injuries among Malaysian karate athletes, and explore the correlation between body composition, muscle strength, core endurance, and cardiorespiratory fitness with the incidence of injuries. **Materials and methods:** This was a cross-sectional study of 153 karate athletes from January 1, 2023 to December 31, 2023. Demographic data, baseline anthropometric assessments using body impedance analysis, dominant hand grip strength, Young Men's Christian Association (YMCA) step test, and 1-minute sit-up test were obtained. Injury data collection was done retrospectively using the recall technique. Data were analyzed using SPSS V.26. **Results:** Our demographics showed 18.3% (n=28) are young adults more than 21 years old, whereas 81.7% (n=125) are in the adolescent age group (13-21 years). 87 athletes sustained at least one injury with a total of 158 injuries. The incidence of injury was 1032.6 injuries per 1000 athletes exposure, with repeated injuries in the same athlete at 52.8%. Most of the injuries occurred during training (n=104, 65.8%). The most injured region was the head/face/neck (n=36, 22.8%). Higher levels of predicted peak oxygen consumption (VO<sub>2</sub> peak) were associated with a decreased likelihood of sustaining multiple injuries. **Conclusion:** The significant injury rate among Malaysian karate athletes during training, emphasizes the need for targeted prevention efforts with cardiovascular fitness being key to reducing multiple injuries.

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**Keywords:** Karate, Injury, VO<sub>2</sub> peak, Muscle strength, Core endurance

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## INTRODUCTION

Karate is a combat sport that was born in Okinawa, Japan, and has gained popularity worldwide. It made its long-awaited debut at the 2020 Tokyo Olympics. Fundamentally, there are three pillars of karate which are Kihon, Kata, and Kumite. Kihon is the foundational training in karate, emphasizing the essential basics (1). Kata involves precise and rehearsed movements that mimic real-life combat scenarios, whereas Kumite is karate combat, which is a sparring discipline that pits two competitors against one another in a fighting arena by showcasing their skills (2).

In combat sports, athletes expose themselves to potential injuries due to the nature of the sport, which is full contact and focuses on high performance. The International

Olympic Committee (IOC) consensus statement has defined injury as tissue damage or other derangements of normal physical function due to participation in sports, resulting from the rapid or repetitive transfer of kinetic energy (3). The likelihood of injury is most pronounced in hybrid styles such as mixed martial arts, moderate in striking styles such as boxing, kickboxing, karate, and taekwondo, and least in grappling styles like judo (4). In Malaysia, there is still a gap in understanding the extent and profile of injuries among karate athletes, including injury incidence, injury pattern, common injury regions, injury severity, and time loss. There is also inadequate data on injury association with gender, belt rank, years of training, and baseline physical attributes of the athletes as well as physical fitness. While karate is often reported to have a lower injury probability when compared with sports such as football and rugby, the specific factors contributing to injury risks in karate remain less clearly defined (5). Internal factors such as age, gender, fitness level, belt rank, years of training, and overall health contribute to an athlete's vulnerability to injuries in karate, while external factors including the nature of the

sport, playing surface, equipment, usage of protective gear, and adherence to rules also play significant roles in shaping injury risks. (6). There are limited studies that have investigated the correlation between body composition and physical fitness components such as muscle strength, core endurance, and cardiorespiratory fitness in relation to injuries in karate athletes. Karate demands high levels of physiological, motor, and functional skills such as muscle strength, flexibility, speed, agility, balance, reaction time, coordination, cardiorespiratory endurance, and anaerobic capacity (7). Our objectives in this study were to investigate the incidence of injuries among Malaysian karate athletes and explore the correlation between body composition, muscle strength, core endurance, and cardiorespiratory fitness with the incidence of injuries.

**MATERIALS AND METHODS**

**Study Design**

This was a cross-sectional study conducted in eight karate training centres in the Klang Valley. Participants aged 13 years and above were enrolled regardless of their gender, belt rank, and level of experience. The sample size for this study was calculated to be 153 athletes, considering a 10% participant dropout rate. All participants were personally informed at the training centres regarding the study, and consent was obtained. Informed consent was obtained from the participants before the study was conducted, and for those aged below 18 years, consent was obtained from their parent/guardian with the participants' assent. These were performed at the training centres by the primary investigator for all participants. Ethical approval for the study was obtained from the University of Malaya Research Ethics Committee (UM.TNC2/UMREC\_2256.)

**Data Collection**

Data were collected from January 1, 2023 to December 31, 2023. Athletes were required to complete a questionnaire via Google form regarding demographics and injury profile with the assistance of the primary investigator. The questionnaire was adapted from the Australian Sports Injury Data Dictionary (ASIDD) (8). The data included age, date of birth, sex, race, belt ranking, years of experience, past medical history, history of previous injury, type of injury, mechanism of injury, site of injury, time of occurrence during warm-up, training or competition, hours of training per week, usage of protective gear, and time loss due to injury. During data collection, the investigator requested the athletes to provide a retrospective account of any injuries sustained within the previous one year. All findings were recorded in a standard clinical research form.

**Anthropometric assessments**

Baseline body composition measurements via portable bioelectrical impedance analysis (BIA) were performed to measure weight, skeletal muscle mass, body fat mass,

body fat percentage, and body mass index. The portable BIA used was the InBody H20N model manufactured in South Korea. Height was assessed using a stadiometer. They also underwent a short battery of physical tests to assess other fitness parameters namely, the 3-minute YMCA step test (Figure 1), Jamar hand grip dynamometer test (Figure 2) and, 1-minute sit-up test (Figure 3).

**3-minutes YMCA Step Test**

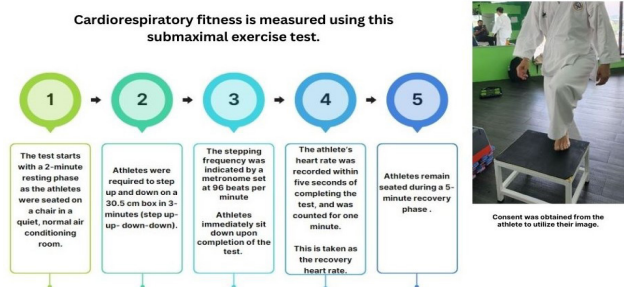


Figure 1: Illustrates the step of YMCA steps test.

**Hand Grip Strength Test**

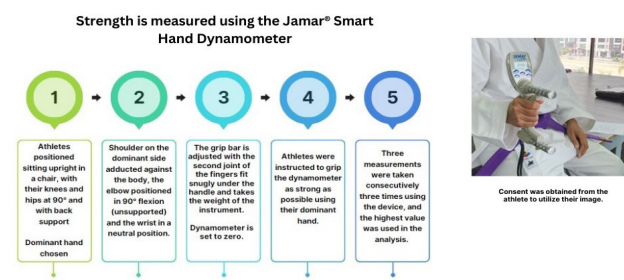


Figure 2: Illustrates the step of hand grip strength test.

**1-minute Sit-Up Test**

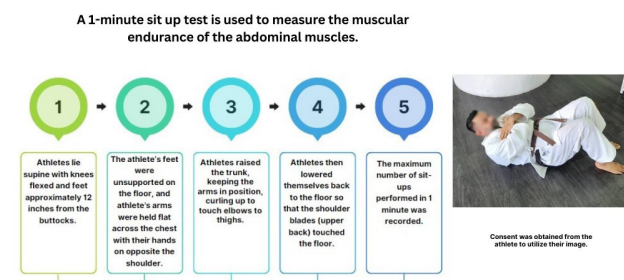


Figure 3: Illustrates the step of 1-minute sit-up test.

**YMCA step test**

The test began with a 2-minute resting phase while the athletes were seated on a chair in a quiet, normal air conditioning room. Athletes were required to step up and down on a 30.5 cm box in 3 minutes (step up-up-down-down). The stepping frequency was indicated by a metronome set at 96 beats per minute. Athletes immediately sat down upon completion of the test. The athletes' heart rate was recorded within five seconds of completing the test and was counted for

one minute using a pulse oximeter. This was taken as the recovery heart rate. Finally, subjects remain seated during a 5-minute recovery phase (9). Subsequently, VO<sub>2</sub> peak was calculated whereby it is peak oxygen consumption. VO<sub>2</sub> peak reflects the highest level of oxygen consumption attained during the specific exercise test. Although it may not necessarily represent an individual's true maximum oxygen consumption, as it is determined by the intensity and duration of the exercise protocol however, VO<sub>2</sub> peak provides valuable information about an individual's aerobic fitness level and capacity to perform strenuous physical activity.

VO<sub>2</sub> peak was calculated using an equation as follows: (10, 11)

For men:

$$VO_2 \text{ peak (mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 111.33 - (0.42 \times \text{HR})$$

For women:

$$VO_2 \text{ peak (mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) = 65.81 - (0.1847 \times \text{HR})$$

### Hand Grip Strength

Athletes were positioned sitting upright in a chair with their knees and hips at 90° and with back support. The dominant hand was chosen. The shoulder on the dominant side was adducted against the body, the elbow was positioned in 90° flexion (unsupported), and the wrist was in a neutral position. Using the Jamar hand held dynamometer, athletes were then instructed to grip the dynamometer as strongly as possible. Three measurements were taken consecutively three times using the device, and the highest value was used in the analysis (12).

### 1-minute sit-up test

A 1-minute sit-up test was used to measure the muscular endurance of the abdominal muscles. Athletes lie supine with knees flexed and feet approximately 12 inches from the buttocks. The athlete's feet were unsupported on the floor, and the athlete's arms were held flat across the chest with their hands on opposite the shoulder. Athletes raised the trunk, keeping the arms in position, curling up to touch elbows to thighs, and then lowered back to the floor so that the shoulder blades (upper back) touched the floor. The maximum number of sit-ups performed in one minute was recorded (13).

### Statistical analysis

Age, baseline anthropometric (weight, height, body mass index, skeletal muscle mass, and percentage body fat), and baseline fitness assessments (hand grip strength, 1-minute sit up test, and VO<sub>2</sub> peak) were presented in mean and standard deviation, and demographic data (gender, hand dominant, belt rank, and years of training), region of injuries, type of injuries, severity of injuries, and mechanism of injuries were presented in frequency and percentage. Injury incidence rates per 1000 athletes exposure.(14)

Univariate and multivariate binary logistic regression

analyses were used to determine the factors associated with injury among athletes. Demographic factors, body composition, and physical performance were categorized where required and used as predictors for the model. All analyses were performed using SPSS version 26.0 and a p-value < 0.05 was considered statistically significant.

## RESULTS

In this study, we examined 153 karate athletes comprising 101 (66%) males and 52 (34%) females. Our demographics showed that 18.3% (n=28) were young adults more than 21 years old, whereas 81.7 % (n=125) were in the adolescent age group (13-21 years). 45.8% (n=70) had 6-10 years of training, 24.8% (n=38) had 1-5 years in training, 18.3% (n=28) had 11-15 years in training and 11.1% (n=17) had more than 15 years of training. The highest belt rank was from the brown belt 42.5% (n=65). This is outlined in Table I.

**Table I: Baseline demographic data of 153 karate athletes.**

Demographics	N(%)
Age	18.16 (6.8)*
	13
	14-15
	16-17
	18-20
	21 and above
Gender	101 (66) †
	Female
	52 (34) †
Hand Dominance	135 (88.2) †
	Right
	Left
Belt Rank	29 (19) †
	Yellow/Green/ Blue/ Purple
	Brown
	65 (42.5) †
	Black
	59 (38.6) †
Years of Training	38 (24.8) †
	1-5 years
	6-10 years
	70 (45.8) †
	11-15 years
	28 (18.3) †
	> 15 years
	17 (11.1) †

\* expressed as mean (Standard deviation)

† expressed as frequency (percentage)

N: frequency

The mean BMI in our study was 22.1 ± 4.92 kg/m<sup>2</sup> with a mean skeletal muscle mass of 24.9 ± 6.3 kg. For the baseline physical fitness component, the VO<sub>2</sub> peak was 58.6 ± 12.2 (ml.kg.min) and the dominant hand grip strength was 32.1 ± 9.83 kg. The baseline anthropometric and physical fitness components are outlined in Table II.

**Table II: Baseline anthropometric and fitness testing data of 153 karate athletes.**

Baseline Anthropometric	Mean (SD)
Height (cm)	165.9 (9.35)

CONTINUE

**Table II: Baseline anthropometric and fitness testing data of 153 karate athletes. (CONT.)**

Baseline Anthropometric	Mean (SD)
Weight (kg)	61.4 (16.44)
Body Mass Index (kg/m <sup>2</sup> )	22.1 (4.92)
Skeletal Muscle Mass (kg)	24.9 (6.43)
Percentage Body Fat (%)	25.3 (10.75)
Physical Fitness Component	
Dominant Hand Grip Strength (kg)	32.1 (9.83)
1-minute Sit-up Test	32.0 (9.88)
3-minute YMCA Step Test	111.8 (17.31)
VO2 peak	58.6 (12.20)

SD: Standard Deviation, VO2 peak: peak oxygen consumption

Of the 153 athletes in the study, 87 athletes sustained at least one injury, with a total of 158 injuries. The incidence of injury was 1032.6 injuries per 1000 athletes exposure, with a repeated injuries rate in the same athlete of 52.8%. 29.8% (n=26) athletes had two injuries, 19.5% (n=17) had three injuries, 1.14% (n=1) had four injuries, and 2.3 % (n=2) had five injuries. Most of the injuries occurred during training (n=104, 65.8%). The most injured regions were the head/face/neck (n=36, 22.8%), followed by the wrist/hand (n=20, 12.7 %) and ankle (n=18, 11.4%), as shown in Table III. The most common types of injuries were sprain and strain (n=65, 41.1%), followed by bruise and contusion (n=28, 17.7%) as shown in Table IV. For the mechanism of injury, the most common cause was struck by another player (n=72, 45.6%), as shown in Table VI. 82.9% (n=131) of athletes had mild injury time loss, whereas 5.7% (n=9) had severe injury time loss (Table V).

**Table III: Injured region.**

Region	N (%)
Abdomen	4 (2.5)
Ankle	18 (11.4)
Chest	7 (4.4)
Foot	16 (10.1)
Forearm	4 (2.5)
Head/Face/Neck	36 (22.8)
Hip/Groin	10 (6.3)
Knee	16 (10.1)
Lower Leg	8 (5.1)
Shoulder	3 (1.9)
Spine	4 (2.5)
Thigh	11 (7.0)
Upper Arm	1 (0.6)
Wrist/Hand	20 (12.7)

N: frequency

**Table IV: Type and mechanism of injury.**

Type of Injuries	N (%)	Mechanism of Injuries	N (%)
Abrasion wound	13 (8.2)	Collision with another player/referee	15 (9.5)
Bruise/Contusion	28 (17.7)	Collision with fixed object	6 (3.8)
Concussion	2 (1.3)	Fall from height/ Awkward landing	1 (0.6)
Dislocation/Subluxation	4 (2.5)	Fall/ Stumble on same level	8 (5.1)
Fracture	1 (0.6)	Jumping	6 (3.8)
Inflammation/Swelling	13 (8.2)	Others	18 (11.4)
Loss of consciousness	6 (3.8)	Overuse	14 (8.9)
Open wound/Laceration/Cut	4 (2.5)	Slip/Trip	6 (3.8)
Others	13 (8.2)	Struck by another player	72 (45.6)
Overuse injury to muscle or tendon	7 (4.4)	Twisting	12 (7.6)
Chest wall injury	2 (1.3)		
Sprain or strain (muscle, tendon, or ligament tear)	65 (41.1)		

N: frequency

**Table V: Severity of injury based on the time loss from training.**

Severity of Injury	N (%)
Mild (0-7 days)	131 (82.9)
Moderate (8-28)	18 (11.4)
Severe (>28 days)	9 (5.7)

N: frequency

**Table VI: Univariate analysis of predictors of injuries in 153 karate athletes.**

		Crude Odds Ratio	95% Confidence Interval		p-value
			Lower Limit	Upper Limit	
<b>Age</b>	13	0.56	0.15	2.01	0.370
	14-15	2.57	0.96	6.91	0.061
	16-17	1.73	0.65	4.60	0.275
	18-20	4.00	1.28	12.47	0.017
	21 and above	1.00	-	-	
<b>Gender</b>	Male	1.36	0.69	2.66	0.377
	Female	1.00	-	-	
<b>Belt Rank</b>	Yellow/Green/ Blue/Purple	0.25	0.10	0.64	0.004
	Brown	0.88	0.43	1.84	0.741
	Black	1.00	-	-	

CONTINUE

**Table VI: Univariate analysis of predictors of injuries in 153 karate athletes. (CONT.)**

		Crude Odds Ratio	95% Confidence Interval		p-value
			Lower Limit	Upper Limit	
<b>Years of Training</b>	1 – 5 years	0.59	0.18	1.88	0.367
	6 – 10 years	2.03	0.69	5.91	0.196
	11 – 15 years	3.38	0.94	12.14	0.063
	More than 15 years	1.00	-	-	
<b>BMI</b>		1.02	0.96	1.09	0.487
<b>Skeletal Muscle Mass</b>		1.06	1.01	1.12	0.039
<b>Body Fat Percentage</b>		0.99	0.97	1.02	0.697
<b>Hand Grip Strength (Dominant)</b>		1.04	1.01	1.08	0.018
<b>1-Minute Sit Up Test</b>		1.01	0.98	1.05	0.399
<b>Recovery Heart Rate – 3-min YMCA</b>		0.98	0.96	0.99	0.037
<b>VO2 Max</b>		1.02	0.99	1.05	0.103

BMI: Body Mass Index, VO2 peak: peak oxygen consumption  
 Factors with p < 0.20 such as age, belt rank, years of training, skeletal muscle mass, hand grip strength (dominant), recovery heart rate of 3-min YMCA step test, and VO2 peak were chosen to be further used in the multivariate analysis.

During our univariate analysis (Table VI), we discovered that age, belt rank, years of training, skeletal muscle mass, dominant hand grip strength, recovery heart rate, 3-minute YMCA step test, and VO2 peak had a p-value less than 0.20 thus, these variables were included in the subsequent multivariate analysis. When performing multivariate analysis and looking into risk factors for injuries, ages 14-15 years had increased risk of injuries (OR=8.97, CI:1.91-42.12, p=0.005), while ages 16-17 years and 18-20 years had non-statistically significant increased risk (OR=2.61, CI 0.75-9.07, p=0.131), and (OR=3.55, CI: 0.92-13.6, p=0.065), respectively. Experience of less than 5 years in training had reduced risk (OR=0.46, CI: 0.09-2.46, p=0.36), whereas experience of 11-15 years had increased risk (OR=2.13, CI:0.5-9.0, p=0.30). For every unit of increase in VO2 peak, there are 0.94 odds of 3-5 injury (OR 0.94, 95% CI 0.89 – 0.99, p= 0.017), or in other words, 6% less likely of 3-5 injury compared to 1-2 injury, when adjusted for other confounders. This result is outlined in Table VII. The study findings were more focused on the intrinsic factors of injury rather than extrinsic factors, which is one of the limitations of this study.

**Table VII: Multivariate analysis of predictors of injuries in 153 karate athletes.**

		Adjusted Odds Ratio	95% Confidence Interval		p-value
			Lower Limit	Upper Limit	
<b>Age</b>	13	1.37	0.25	7.63	0.721
	14-15	8.97	1.91	42.12	0.005
	16-17	2.61	0.75	9.07	0.131
	18-20	3.55	0.92	13.60	0.065
	21 and above	1.00	-	-	

CONTINUE

**Table VII: Multivariate analysis of predictors of injuries in 153 karate athletes. (CONT.)**

		Adjusted Odds Ratio	95% Confidence Interval		p-value
			Lower Limit	Upper Limit	
<b>Belt Rank</b>	Yellow/Green/Blue/Purple	0.68	0.17	2.70	0.580
	Brown	1.01	0.39	2.59	0.985
	Black	1.00	-	-	
	1 – 5 years	0.46	0.09	2.46	0.364
<b>Years of Training</b>	6 – 10 years	1.33	0.34	5.16	0.682
	11 – 15 years	2.13	0.50	9.00	0.306
	More than 15 years	1.00	-	-	
<b>Skeletal Muscle Mass</b>		1.05	0.94	1.17	0.407
<b>Hand Grip Strength (Dominant)</b>		1.06	0.98	1.15	0.124
<b>Recovery Heart Rate – 3-min YMCA</b>		0.96	0.92	0.99	0.021
<b>VO2 peak</b>		0.93	0.88	0.99	0.023

VO2 peak: peak oxygen consumption  
 Recovery heart rate of 3-min YMCA step test and VO2 peak is found to have a significant value of p < 0.05.

**DISCUSSION**

The injury incidence was 1032.6 injuries per 1000 athletes. In our study, the incidence was higher during training than during competition. There is a lack of studies that examine the incidence of injuries during training and competition. Most incidence reported were during competition. Čierna et al. (2018) reported 41.4/1,000 athletes exposure in Karate championships (13). Arriaza et al. (2016) reported 29.9/1,000 athletes exposure during competition (15). Ziaee et al. (2015) is one of the few studies looking into injury surveillance prospectively during training only, with an incidence of 202/1,000 athletes exposure (16). Destombe et al. (2006) found that the incidence of injuries was notably higher during training sessions, accounting for (339/1000 athletes exposure), compared to competitions where only (107/1000 athletes exposure) (17). The variations in reported injury incidence are likely due to methodological differences whereby, this study's cross-sectional approach may introduce recall bias in comparison to a prospective design. Disparities in study populations and settings also contribute to differences, with our focus on only Malaysian karate athletes contrasting with other studies enrolling athletes from various countries. Variations in training intensity, frequency, and safety protocols, along with cultural norms, coaching practices, and equipment quality affect injury risk. Better safety measures and equipment availability may lead to fewer injuries overall.

The high incidence of injuries during training suggests that the intensity and nature of training activities may contribute significantly to injury risk. Factors such as repetitive movements, inadequate warm-up,

and insufficient recovery periods may exacerbate the likelihood of injuries during training. This study emphasizes the importance of injury prevention during training to reduce the incidence of injuries. In our investigation, most of the injuries resulted in mild time loss only.

In our study, the high incidence of injuries to the head, face, and neck, comprising 22.8% of all reported injuries, highlights the importance of safeguarding these critical areas during karate training and competition. Čierna et al. (2017) reported the predominant sites of injury encompass the head/neck (57%) and trunk (22%), with contusions representing the most prevalent type (85%) (14). A meta-analysis revealed that the head and neck region is the predominant site of injury in karate, with an average incidence rate of approximately 57.9%, with the most frequent injury type being contusions and lacerations (18). Although the rate of concussion and loss of consciousness was low in our study, (1.3% and 3.8% of injuries, respectively), it is important to emphasize strict concussion protocols and the usage of protective gear during competition and training. Concussions can be detrimental because of their potential long-term neurological effects (19).

Our study uncovered several key associations between demographic and physical fitness factors and the risk of injury among karate athletes. Notably, adolescents aged 14-15 years had a significantly heightened risk of injuries, emphasizing the vulnerability of this age group to karate-related injuries. These findings correspond to another study whereby, the age group between 16-20 years old had the highest injury rate and the injury rate decreased with increasing age of athletes (20). In contrast, it was found that higher-skilled athletes, such as those in the under 21 age category, tend to experience more injuries, possibly due to their use of riskier techniques or executing basic moves with greater force and speed compared to athletes in the under 18 age category (21). This finding highlights the importance of age-specific injury prevention strategies and targeted training interventions to address the unique needs and vulnerabilities of adolescent athletes. In addition, our analysis revealed interesting trends regarding the association between training experience and injury risk. Athletes with less than 5 years of training experience demonstrated a reduced risk of injuries, suggesting a potential learning curve effect or protective effect of beginner status. Conversely, athletes with 11-15 years of training experience showed an increased risk of injuries, indicating the possibility of being more prone to overuse injuries or strain associated with prolonged training duration. Experienced athletes with higher ranks and years of practice are more likely to get injured due to their increased speed, strength, self-confidence, and potentially more aggressive style over time.

The main highlight of our study identified that peak

oxygen consumption was a significant predictor of injury risk among karate athletes. Higher levels of VO<sub>2</sub> peak were associated with a decreased likelihood of sustaining 3-5 injuries compared with 1-2 injuries, suggesting a potential protective effect of cardiovascular fitness against multiple injury occurrences. This underscores the importance of incorporating aerobic conditioning and cardiovascular fitness training into karate athletes' training programs to enhance injury resilience and overall performance. A local study found that Malaysian karate senior athletes had VO<sub>2</sub>max comparable to elite Taekwondo athletes due to intense aerobic training meaning that longer training duration of the seniors caused significantly higher performance than junior athletes (22). Another study suggests that repetitive movements like forward, backward, and sidesteps, along with hopping, and short bursts of intense techniques during fights primarily rely on aerobic metabolism for energy, supplemented by high-energy phosphates for quick bursts of power (23). This could indicate that lower VO<sub>2</sub> peak levels may increase the risk of injury during karate due to decreased endurance and fatigue during repetitive movements and intense techniques.

Muscle strength is a key physical fitness component. Greater muscular strength is strongly associated with improved force-time characteristics that contribute to an athlete's overall performance. However, there was no significant association between hand grip strength and injury in our study. This is the first study to investigate the role of muscle strength in reducing injury risks in karate, marking a novel exploration in this area. Grip strength, often seen as a holistic indicator of overall body strength, has been linked to various muscle groups, including the legs, underscoring its significance as a comprehensive strength marker (24). Our findings revealed a mean dominant hand grip strength of 32.1 kg with a standard deviation of 9.83, suggesting that, on average, these athletes fall into the category of poor hand grip strength according to American College of Sports Medicine (ACSM) guidelines for fitness levels based on age and sex. The prevalence of poor grip strength among these athletes may contribute to their susceptibility to injury, particularly considering their adolescent age group. This could potentially be attributed to insufficient emphasis on strength training, highlighting an area for targeted intervention in injury prevention strategies.

Previous research on core muscles in combat sports athletes lacked evidence of correlation in reducing injury risks, while our study revealed that the average 1-minute Sit-up Test performance among these athletes was 32 with a standard deviation of 9.88, indicating excellent core endurance as they surpassed the threshold for excellence by performing more than 25 sit-ups in 1 minute. However, despite the benefits of core strength training in karate for enhancing core endurance and kicking movements, it does not significantly improve overall physical fitness compared to alternative

training methods, suggesting its integration within a comprehensive strength training regimen rather than sole reliance (7).

There was also no significant correlation between anthropometric markers and injury in our study. Vitale et al. (2018) found that age, training volume, and BMI were found as significant predictors of injury in martial arts (25). This could be attributed to the wide range of age groups in this study. Athletes with slender physiques and vertical skeletal development have an advantage in karate performance, as evidenced by lower body fat percentages in elite athletes than non-elite practitioners (26) Although anthropometric assessments and strength showed no correlation with injury, these parameters are integral for karate performance.

To the best of our knowledge, this is the first study to examine the association between anthropometric, peak oxygen consumption, muscle strength, and core endurance with injury incidence in karate athletes. Our study highlights the importance of assessing these factors to prevent further injuries. Our study also demonstrates the feasibility of on-field assessment of the above aspects, which is helpful for coaches to plan personalized training strategies. By looking into various aspects of injury prevalence, including severity, patterns, and demographic factors, it provides a thorough understanding of the problem. Moreover, the study's findings offer insights for injury prevention in karate training programs. However, several limitations should be acknowledged. Firstly, the cross-sectional design employed in this study limits our ability to establish causal relationships between variables. Additionally, the focus on karate athletes from the Klang Valley region may limit the generalizability of the results to broader populations. Moreover, reliance on self-reported data for injury occurrences and training history introduces the possibility of recall bias and inaccuracies. Unmeasured variables, like previous injuries and coaching quality, may confound results despite adjusting for confounding factors. Thus, further study is needed to address these confounding factors.

## CONCLUSION

Our study investigated injury patterns and risk factors among Malaysian karate athletes, focusing on the correlation between body composition, muscle strength, core endurance, cardiorespiratory fitness, and injury incidence. We found a high incidence of injuries 1032.6/1000 athletes exposure, particularly during training sessions, highlighting the need for targeted prevention efforts. The head, face, and neck were the most common regions of injury. Although the rate of concussions was low, adherence to strict concussion protocols and the use of protective gear is an essential aspect of injury management. The study findings show the significance of cardiovascular fitness in reducing

the risk of sustaining multiple injuries, emphasizing the importance of integrating aerobic conditioning into injury prevention strategies. However, hand grip strength, core endurance, and anthropometric markers showed no significant associations with injury risk but they can be integrated into personalized training strategies to enhance overall performance and injury resilience. Despite study limitations, our findings provide valuable insights for developing tailored injury prevention strategies in karate.

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