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SPORT-SPECIFIC INJURY PROFILES IN BRAZILIAN SCHOOL ATHLETES: A PROPORTIONAL ANALYSIS ACROSS 15 SPORTS DURING INTERNATIONAL COMPETITIONS

PERFIS DE LESÕES ESPECÍFICAS POR ESPORTE EM ATLETAS ESCOLARES BRASILEIROS: UMA ANÁLISE PROPORCIONAL EM 15 MODALIDADES ESPORTIVAS DURANTE COMPETIÇÕES INTERNACIONAIS

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ABSTRACT

Background: Sports injuries represent a significant health concern among youth athletes and may vary according to the specific demands of each sport. However, comparative investigations across multiple sports within the same competitive environment remain limited.

Objective: To analyze the proportional distribution of injuries, emergency care, hospital referrals, head trauma, musculoskeletal injury types, and autonomic nervous system dysfunction among Brazilian school athletes participating in international competitions. Methods: This observational longitudinal study analyzed injuries sustained by Brazilian school athletes during eight international competitions organized by the International School Sport Federation (ISF) between 2018 and 2023, encompassing 15 sports modalities. Injury surveillance was conducted prospectively by trained sports physiotherapists using a standardized electronic medical record system. Outcomes included proportions of head injuries, emergency care, hospital referrals, muscle, joint, bone and tendon injuries, and autonomic nervous system dysfunction. Comparisons among sports were performed using chi-square or Fisher's exact tests ($p < 0.05$). Results: A total of 1,451 injuries were recorded. Significant differences were observed in the proportions of emergency care, muscle injuries, joint injuries, and autonomic nervous system dysfunction across sports. Combat sports, particularly judo, karate, wrestling, and taekwondo, demonstrated the highest proportions of emergency care. Athletics and soccer presented the highest proportions of muscle injuries, whereas basketball and handball exhibited the greatest proportions of joint injuries. Karate showed a significantly higher proportion of autonomic nervous system dysfunction compared with athletics. No significant differences were identified in the distribution of head

injuries, hospital referrals, bone injuries, or tendon injuries among sports. Conclusion: Distinct sport-specific injury profiles were identified among Brazilian school athletes participating in international competitions. Combat sports were associated with greater emergency care requirements, while athletics and soccer were characterized by a predominance of muscle injuries and basketball and handball by joint injuries. These findings support the implementation of sport-specific surveillance strategies and targeted injury prevention programs to improve athlete safety during international school sporting events.
Keywords: Sports injuries; School athletes; Sports epidemiology; Injury surveillance; Emergency care; Youth sports.

RESUMO

Introdução: As lesões esportivas representam uma importante preocupação de saúde entre atletas jovens e podem variar de acordo com as características específicas de cada modalidade. Entretanto, estudos comparando diferentes esportes dentro do mesmo ambiente competitivo ainda são limitados. Objetivo: Analisar a distribuição proporcional de lesões, atendimentos de emergência, encaminhamentos hospitalares, traumatismos cranianos, tipos de lesões musculoesqueléticas e disfunções do sistema nervoso autônomo em atletas escolares brasileiros participantes de competições internacionais. Métodos: Estudo observacional longitudinal que analisou lesões ocorridas em atletas escolares brasileiros durante oito competições internacionais organizadas pela International School Sport Federation (ISF) entre 2018 e 2023, abrangendo 15 modalidades esportivas. A vigilância das lesões foi realizada prospectivamente por fisioterapeutas esportivos treinados, utilizando um sistema eletrônico padronizado de prontuário. Os desfechos avaliados incluíram as proporções de traumatismos

cranianos, atendimentos de emergência, encaminhamentos hospitalares, lesões musculares, articulares, ósseas e tendíneas, além de manifestações de disfunção do sistema nervoso autônomo. As comparações entre modalidades foram realizadas por meio dos testes qui-quadrado ou exato de Fisher, adotando-se nível de significância de 5%. Resultados: Foram registradas 1.451 lesões. Diferenças significativas foram observadas nas proporções de atendimentos de emergência, lesões musculares, lesões articulares e disfunções do sistema nervoso autônomo entre as modalidades esportivas. Os esportes de combate, especialmente judô, karatê, wrestling e taekwondo, apresentaram as maiores proporções de atendimentos de emergência. O atletismo e o futebol de campo apresentaram as maiores proporções de lesões musculares, enquanto o basquetebol e o handebol apresentaram as maiores proporções de lesões articulares. O karatê demonstrou proporção significativamente maior de disfunção do sistema nervoso autônomo em comparação ao atletismo. Não foram observadas diferenças significativas na distribuição de traumatismos cranianos, encaminhamentos hospitalares, lesões ósseas ou lesões tendíneas entre as modalidades. Conclusão: Foram identificados perfis de lesão específicos de cada modalidade entre atletas escolares brasileiros participantes de competições internacionais. Os esportes de combate apresentaram maior necessidade de atendimento emergencial, enquanto o atletismo e o futebol foram caracterizados pelo predomínio de lesões musculares, e o basquetebol e o handebol pelo predomínio de lesões articulares. Esses achados reforçam a importância de estratégias específicas de vigilância epidemiológica, planejamento médico e programas direcionados de prevenção de lesões para aumentar a segurança dos atletas em eventos esportivos escolares internacionais.

Palavras-chave: Lesões esportivas; Atletas escolares; Epidemiologia

esportiva; Vigilância de lesões; Atendimento de emergência; Esporte juvenil.

INTRODUCTION

School sports play an important role in the physical, psychological, and social development of children and adolescents. However, participation in organized sports also exposes young athletes to a considerable risk of injury, particularly during training and competitive events. Previous studies have shown that injury patterns differ substantially according to sport characteristics, with contact and combat sports generally presenting higher injury frequencies than non-contact sports. Sprains, muscle strains, fractures, and contusions are among the most common diagnoses, predominantly affecting the lower limbs (PRIETO-GONZÁLEZ et al., 2021; CASWELL et al., 2017).

The epidemiology of sports injuries among youth athletes has been investigated in several individual sports, including soccer, basketball, athletics, swimming, and combat sports. Evidence suggests that contact sports are associated with higher frequencies of traumatic injuries, whereas individual sports often present different injury profiles related to repetitive loading and overuse mechanisms (AL-QAHTANI et al., 2023; SO-YOUNG et al., 2020; SHARADZE et al., 2023). Nevertheless, comparisons across multiple sports within the same population and competitive environment remain limited.

Furthermore, most available studies focus primarily on injury occurrence and anatomical location, while less attention has been given to injury severity, emergency care requirements, hospital referrals, head trauma, and autonomic or functional neurological

manifestations during school sport competitions. Understanding these sport-specific injury profiles may provide valuable information for medical planning, injury prevention programs, and athlete safety during international events.

Therefore, the aim of this study was to analyze the proportional distribution of injuries, emergency care, hospital referrals, head trauma, musculoskeletal injury types, and autonomic nervous system manifestations among Brazilian school athletes participating in international competitions organized by the International School Sport Federation (ISF) between 2018 and 2023.

MATERIALS AND METHODS

This epidemiological, observational, and longitudinal study investigated injuries sustained by Brazilian school athletes during eight international competitions organized by the International School Sport Federation (ISF) between 2018 and 2023, including three editions of the Gymnasiade, one edition of the Combat Games, one ISF World Cup, and three editions of the South American School Games, encompassing 15 sports modalities. The study followed the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and its extension for sports injury and illness surveillance (STROBE-SIIS). All athletes officially registered by the Brazilian School Sport Confederation (CBDE) and participating in the international events during the study period were considered eligible. Injuries were defined according to the International Olympic Committee consensus statement as any acute sport-related complaint requiring assessment or treatment by the physiotherapy team, regardless of time loss, while pre-existing conditions, chronic complaints

unrelated to sports participation, and systemic diseases not involving the musculoskeletal or autonomic nervous systems were excluded.

Injury surveillance was conducted prospectively throughout all competitions by a team of 20 sports physiotherapists previously trained in standardized assessment and recording procedures. All evaluations were documented using the electronic medical record system “Prontuário CBDE,” a digital platform developed specifically for healthcare monitoring during school sport events. Medical assistance was provided through both on-field emergency care during competitions and outpatient physiotherapy services located at temporary healthcare centers established at competition venues. To improve data quality and minimize information bias, daily audits were performed by senior clinicians, and duplicate records were identified through athlete accreditation numbers and competition registration databases. During clinical evaluations, demographic information, sport modality, injury mechanism, anatomical location, and suspected tissue involvement were recorded. Vital signs, including heart rate, blood pressure, peripheral oxygen saturation, and level of consciousness when clinically indicated, were assessed during emergency evaluations and whenever neurological, cardiovascular, or autonomic symptoms were reported.

Injuries were classified according to anatomical location and tissue involvement, including muscle, joint, tendon, bone, head and face, and spinal complaints. Athletes presenting symptoms such as dizziness, presyncope, syncope, palpitations, unexplained tachycardia, blood pressure instability, hyperventilation, excessive sweating, nausea, visual disturbances, or other transient neurovegetative manifestations without evidence of acute structural

injury were classified as presenting Autonomic Nervous System Dysfunction (ANSD). This category was adopted exclusively for epidemiological surveillance purposes and did not constitute a formal neurological diagnosis. Injury severity was determined according to the need for emergency care and hospital referral. Athletes with suspected concussion, fractures, significant head trauma, cardiorespiratory instability, or clinical conditions requiring further medical investigation were immediately removed from competition and referred to local hospital services according to event medical protocols. The primary outcomes were the proportional distributions of head injuries, emergency care episodes, hospital referrals, muscle injuries, joint injuries, bone injuries, tendon injuries, and autonomic nervous system dysfunction across sports modalities, with proportions calculated using the total number of recorded injuries within each sport as the denominator.

The study was approved by the Research Ethics Committee under approval number 6.554.588 and conducted in accordance with the Declaration of Helsinki and Resolution 466/2012 of the Brazilian National Health Council. Because the participants were minors, written informed consent was obtained from parents or legal guardians, and assent was obtained from the athletes whenever applicable. Statistical analyses were performed using R software (version 4.2.3; R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were expressed as absolute frequencies, proportions, and corresponding 95% confidence intervals, while comparisons between sports were performed using chi-square tests or Fisher's exact tests when appropriate. Statistical significance was established at $p < 0.05$.

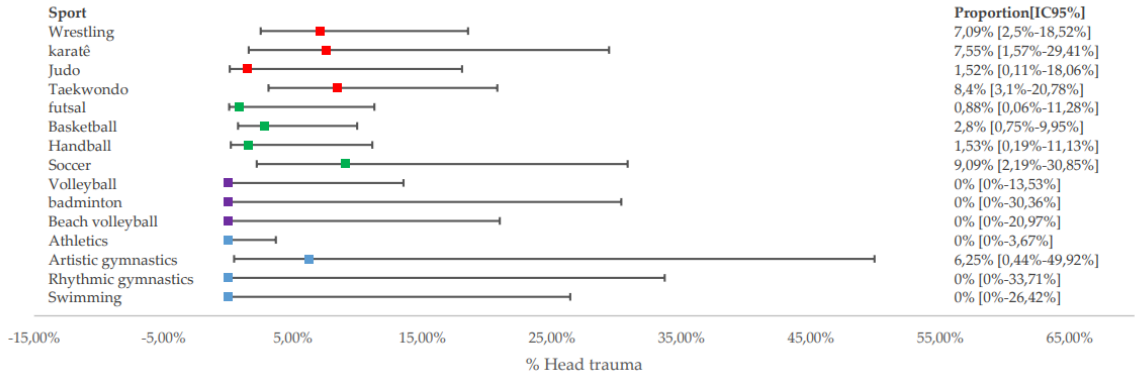
RESULTS

A total of 1451 injuries were recorded across the 15 sports analyzed. Significant differences between sports were identified in the proportions of emergency care, muscle injuries, joint injuries, and autonomic nervous system dysfunction. In contrast, head injuries, hospital referrals with subsequent removal from competition, bone injuries, and tendon injuries demonstrated similar proportional distributions across sports modalities.

Head Injuries

No significant differences were observed in the proportional distribution of head injuries across sports modalities (Figure 1). Although proportions were statistically equivalent, field soccer (9.09%), taekwondo (8.40%), karate (7.55%), wrestling (7.09%), and artistic gymnastics (6.25%) presented the highest numerical proportions of head injuries.

Figure 1. Proportion of head injuries according to sport modality.

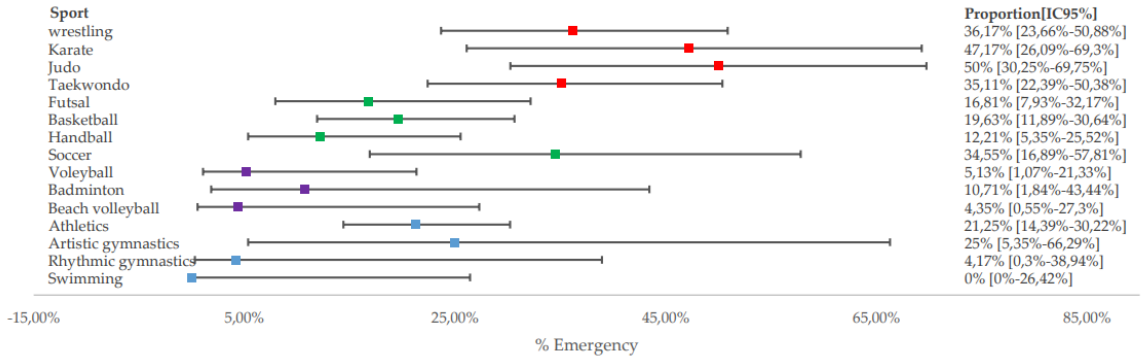


Emergency Care

Significant differences were identified in the proportions of emergency care across sports modalities (Figure 2). Combat sports demonstrated the highest proportions of emergency assistance, particularly judo (50.00%), karate (47.17%), wrestling (36.17%), and

taekwondo (35.11%). Post-hoc comparisons revealed that judo presented significantly higher proportions than handball (12.21%), volleyball (5.13%), beach volleyball (4.35%), and swimming (0%). Karate showed higher proportions than handball and volleyball, whereas wrestling and taekwondo exhibited higher proportions than volleyball. No significant differences were observed among the remaining sports.

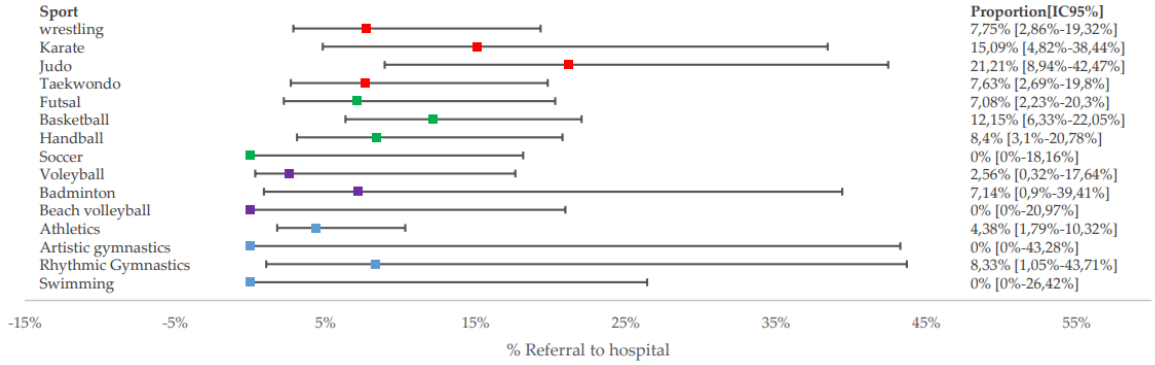
Figure 2. Proportion of emergency care according to sport modality.



Hospital Referrals and Removal From Competition

No significant differences were observed in the proportions of hospital referrals and subsequent removal from competition across sports modalities (Figure 3). Nevertheless, higher numerical proportions were observed in judo (21.21%), karate (15.09%), basketball (12.15%), handball (8.40%), and wrestling (7.75%), suggesting a greater burden of more severe injuries in these sports.

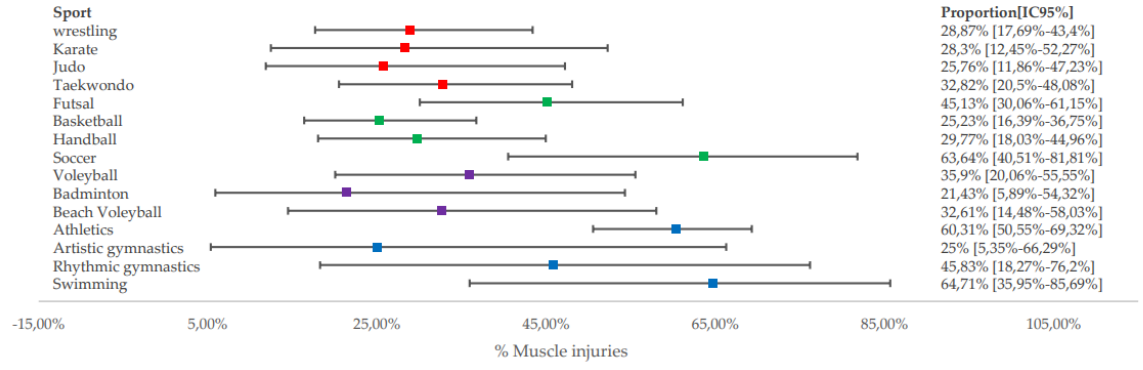
Figure 3. Proportion of hospital referrals and removal from competition according to sport modality.



Muscle Injuries

Significant differences were identified in the distribution of muscle injuries among sports modalities (Figure 4). Athletics demonstrated a higher proportion of muscle injuries (60.00%) than wrestling (28.87%), judo (25.76%), taekwondo (32.82%), basketball (25.23%), and handball (29.77%). Likewise, field soccer (63.64%) presented a higher proportion of muscle injuries than basketball (25.23%). No additional significant differences were detected.

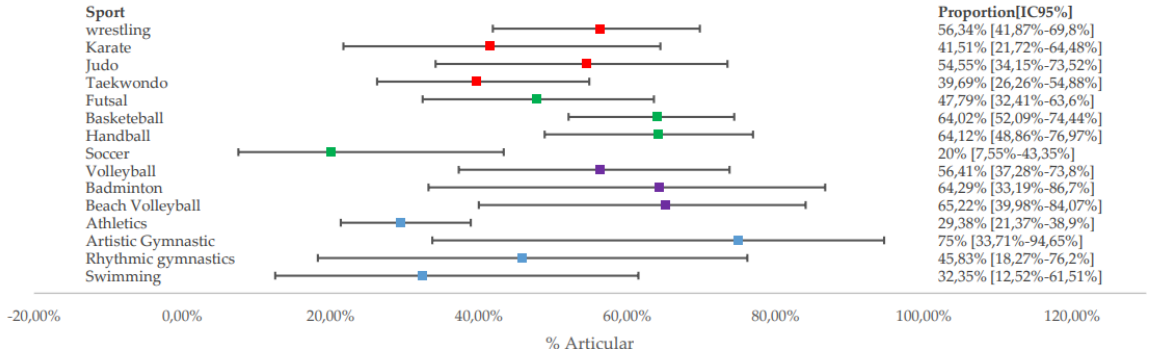
Figure 4. Proportion of muscle injuries according to sport modality.



Joint Injuries

The proportional distribution of joint injuries differed significantly across sports modalities (Figure 5). Basketball (64.02%) and handball (64.12%) presented higher proportions of joint injuries than field soccer (20.00%) and athletics (29.38%). No additional significant differences were observed among the remaining sports.

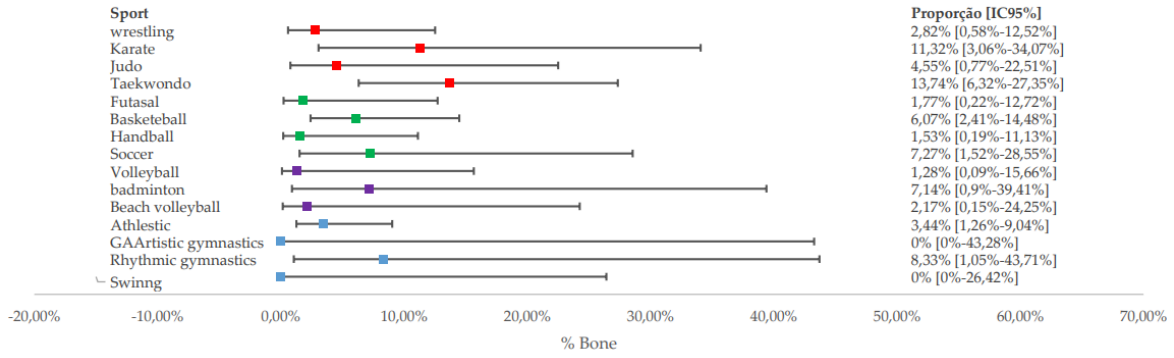
Figure 5. Proportion of joint injuries according to sport modality.



Bone Injuries

No significant differences were identified in the proportional distribution of bone injuries among sports modalities (Figure 6). Numerically, the highest proportions were observed in taekwondo (13.74%), karate (11.32%), rhythmic gymnastics (8.33%), field soccer (7.27%), and badminton (7.14%).

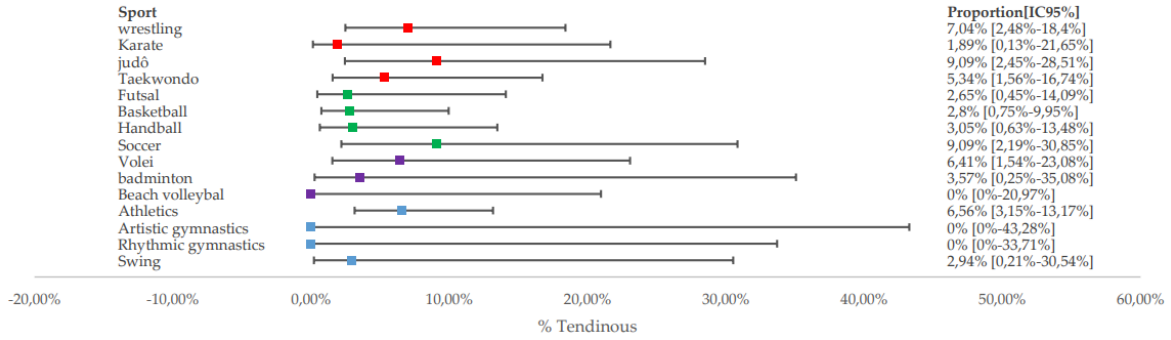
Figure 6. Proportion of bone injuries according to sport modality.



Tendon Injuries

The proportional distribution of tendon injuries was similar across sports modalities (Figure 7). The highest numerical proportions were observed in judo (9.09%), field soccer (9.09%), wrestling (7.04%), athletics (6.56%), and volleyball (6.41%).

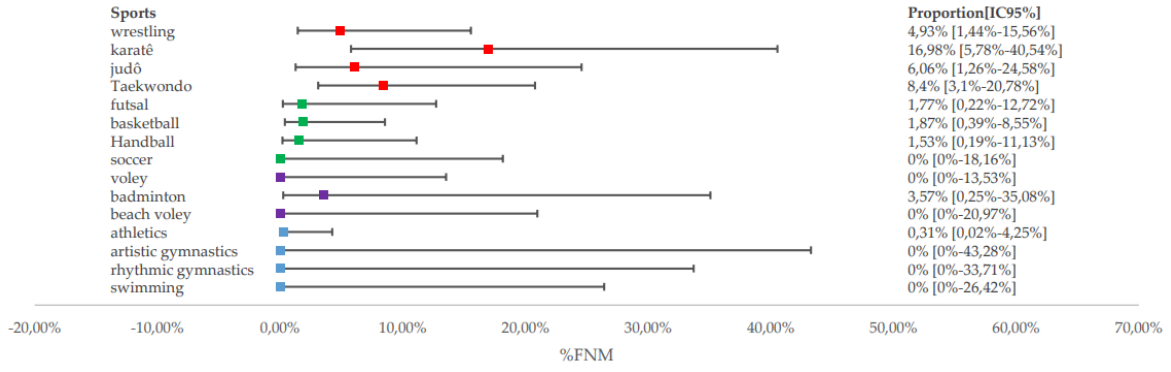
Figure 7. Proportion of tendon injuries according to sport modality.



Autonomic Nervous System Dysfunction

Significant differences were identified in the distribution of autonomic nervous system dysfunction across sports modalities (Figure 8). Karate presented a significantly higher proportion of autonomic manifestations (16.98%) than athletics (0.31%). No additional significant differences were observed among the remaining sports.

Figure 8. Proportion of autonomic nervous system dysfunction according to sport modality.



DISCUSSION

The present study identified sport-specific injury profiles among Brazilian school athletes participating in international competitions. Significant differences were observed in the proportions of emergency care, muscle injuries, joint injuries, and autonomic nervous system dysfunction, whereas head injuries, hospital referrals with subsequent removal from competition, bone injuries, and

tendon injuries demonstrated similar proportional distributions across sports. Combat sports, particularly judo, karate, wrestling, and taekwondo, exhibited the highest proportions of emergency care, while athletics and field soccer showed the greatest proportions of muscle injuries. Basketball and handball were characterized by higher proportions of joint injuries, and karate presented a greater occurrence of autonomic nervous system dysfunction.

The highest numerical proportions of head trauma were observed in field soccer, taekwondo, and karate, whereas hospital referrals with subsequent removal from competition were more frequent in judo. Bone and tendon injuries were proportionally more common in taekwondo and judo, while autonomic manifestations were more frequently observed in karate. These findings reinforce the need for increased medical surveillance during official competitions, particularly in combat sports. Although injuries are generally more frequent during training due to greater exposure time, competitions present a substantially higher injury risk per unit of exposure, especially among youth athletes (SO-YOUNG et al., 2020). Previous investigations have demonstrated that athletes aged 13 to 16 years experience higher injury rates during competition than adult athletes, suggesting increased vulnerability during adolescence (PIETER et al., 2020; LAMBERT et al., 2022; ROSSO et al., 2023). This phenomenon may be related to the intensity of competition, psychological stress, biological maturation, and limited experience in high-pressure environments (CIERNA et al., 2017; HAN et al., 2023). Consequently, preventive strategies should be prioritized during competitive events, particularly in sports involving direct physical contact.

Although most injuries did not require hospital referral or removal from competition, combat sports, together with basketball and handball, demonstrated numerically higher proportions of more severe cases. Recent evidence indicates that health problems following sports participation may be substantially underreported. DOHERTY et al. (2025) observed that 39% of athletes reported injury-related health complaints in the week following competition, whereas only 10% were formally documented in medical records. Similarly, more than 30% of adolescent athletes participating in team sports report injuries during a typical week of the season, and over 20% of these injuries may result in prolonged absence from sports participation (VON ROSEN et al., 2018; MILIĆ et al., 2025). Although head injuries were relatively uncommon in the present study, particularly regarding severe presentations requiring hospital referral, continuous surveillance remains essential given the potential long-term neurological consequences associated with repetitive head impacts (PATEL et al., 2017; WEINER et al., 2022; MCKEE et al., 2023).

Karate demonstrated the highest proportion of autonomic nervous system dysfunction among the analyzed sports. Although karate injuries in children and adolescents are generally characterized by mild traumatic events such as bruises and superficial lesions, often resulting in minimal training interruption (THOMAS et al., 2018), the occurrence of transient autonomic manifestations deserves attention. Previous reports have described symptoms including palpitations, dyspnea, excessive sweating, dizziness, nausea, and blood pressure instability occurring in the absence of identifiable structural injury, potentially reflecting acute autonomic responses to physical exertion, emotional stress, pain, or traumatic stimuli (GRABOWSKI et al., 2022; OLESKO et al., 2023). While these

manifestations are usually self-limiting, they may complicate sideline clinical decision-making and require careful assessment by healthcare professionals. Therefore, monitoring autonomic symptoms should be incorporated into medical surveillance protocols during youth competitions.

Muscle and joint injuries represented the most prevalent musculoskeletal complaints across sports. Athletics and field soccer demonstrated the highest proportions of muscle injuries, findings that are consistent with previous epidemiological studies. In youth soccer, muscle injury rates range from 0.9 to 7.2 injuries per 1,000 hours of exposure and may account for more than one-third of all reported injuries (PRIETO-GONZÁLEZ et al., 2021). Similarly, youth athletics presents injury rates of approximately 4 injuries per 1,000 exposures, with muscle strains representing a substantial proportion of all complaints (MARTÍNEZ-SILVÁN et al., 2020). The predominance of muscle injuries may be explained by the high demands imposed by sprinting, acceleration, deceleration, and repetitive explosive movements, particularly during periods of rapid growth and maturation (MARTÍNEZ-SILVÁN et al., 2020; ROBLES-PALAZÓN et al., 2021; ŠKOMRLJ et al., 2025). Although previous studies suggest slightly higher injury rates in soccer than athletics, both sports demonstrate similar injury mechanisms and anatomical distributions (HALL et al., 2020; EK et al., 2021).

Joint injuries were particularly common in basketball and handball, which is consistent with the biomechanical demands of these sports. Frequent jumping, landing, pivoting, and rapid changes of direction expose athletes to increased stress on the ankle and knee joints. Previous studies have reported that ankle injuries account for up to 45% of injuries among female youth basketball players,

whereas knee injuries represent approximately 51% of injuries among males (OWOEYE et al., 2020; AARTS et al., 2021). In handball, shoulder injuries are also highly prevalent due to repetitive overhead throwing movements, in addition to the substantial burden of knee and ankle complaints (MØLLER et al., 2024). In a cohort of 679 adolescent handball players, 46% reported injuries involving the shoulder, knee, or ankle during a single season (ASAI et al., 2021). Together, these findings support the implementation of sport-specific neuromuscular training and injury prevention programs targeting the most vulnerable anatomical regions.

This study has some limitations that should be acknowledged. First, exposure time was not available, preventing the calculation of injury incidence rates and restricting the analyses to proportional distributions. Second, only injuries requiring physiotherapy assessment were included, which may have resulted in underreporting of minor complaints. Third, diagnostic confirmation through imaging examinations was not systematically available for all cases. Nevertheless, the study benefits from a large multicenter sample collected during international competitions, standardized injury surveillance procedures, and a homogeneous healthcare structure across all events, providing a comprehensive overview of injury patterns among Brazilian school athletes.

CONCLUSION

Sport-specific injury profiles were observed among Brazilian school athletes participating in international competitions. Combat sports, particularly judo, karate, wrestling, and taekwondo, demonstrated the highest proportions of emergency care and numerically greater proportions of hospital referrals with subsequent removal from

competition. Athletics and field soccer exhibited the highest proportions of muscle injuries, whereas basketball and handball presented the greatest proportions of joint injuries. Additionally, karate showed a higher proportion of autonomic nervous system dysfunction compared with athletics. Although most injuries were mild and did not require hospital referral, these findings highlight the importance of sport-specific injury surveillance, medical planning, and targeted prevention strategies to improve athlete safety during international school sport events.

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