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Sport Injuries in Elite Paralympic Swimmers With Visual Impairment

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Context: Visually impaired athletes sustain overuse injuries in the lower limbs, but the pattern of injuries may vary according to the sport. The characteristics of sports injuries in visually impaired swimmers are unknown.

Objective: To determine the characteristics and epidemiologic measures (prevalence, clinical incidence, and incidence rate) of sports injuries in visually impaired elite national swimmers and to assess differences among visual classes and between sexes.

Design: Descriptive epidemiology study.

Setting: International Paralympic competitions held between 2004 and 2008.

Patients or Other Participants: Twenty-eight elite, visually impaired swimmers (19 males, 9 females) from the Brazilian Paralympic Team participated in this study. Twelve were visual class S11 (blind swimmers), 12 were S12 (low-vision swimmers), and 4 were S13 (low-vision swimmers).

Intervention(s): A standardized report form was used to collect data during 5 competitions. This was endorsed by 2 Brazilian sports governing bodies.

Main Outcome Measures: The characteristics, prevalence, clinical incidence, and incidence rate of injuries were calculated.

Results: Eighteen athletes reported 41 sports injuries, with a prevalence of 64%, clinical incidence of 1.5 injuries per athlete, and an incidence rate of 0.3 injuries per athlete per competition. Overuse injuries (80%) were more frequent than traumatic injuries (20%). The clinical incidence and prevalence varied according to sex and visual class, but no statistical differences were observed ($P > .05$). The highest proportion of injuries was in the trunk (46.34%), followed by the upper limbs (34.15%). The shoulders (29.27%) were most affected, followed by the thoracic (21.95%) and lumbar spine (17.07%). Spasm (36.59%) was the most frequent diagnosis, followed by tendinopathy (26.83%).

Conclusions: Visually impaired swimmers had a relatively high proportion of overuse injuries, predominantly associated with muscle spasm in the spine and tendinopathy in the shoulders. No differences were apparent in injury prevalence and clinical incidence among visual classes or between sexes.

Key Words: epidemiology, disability sport, musculoskeletal injuries

Key Points

- Visually impaired swimmers experienced a relatively high proportion of overuse injuries during competition.
- Injuries were predominantly associated with muscle spasm in the spine and tendinopathy in the shoulders.
- No differences were observed in injury prevalence or clinical incidence among visual classes or between sexes.

Swimming was first introduced to the Paralympic Games in Rome, Italy, in 1960. It is a multidisability sport in which athletes with physical, motor, visual, and intellectual impairments compete across a range of impairment classifications.[1] Visually impaired athletes must be formally evaluated by an ophthalmologist to determine their visual classification (ie, the degree of impairment). Athletes are categorized in 1 of 3 levels: S11 (from no light perception in either eye up to light perception, unable to recognize the shape of a hand at any distance or direction); S12 (from ability to recognize the shape of a hand up to a visual acuity of 20/600 or a visual field of less than 5° in the best eye with the best practical eye correction); S13 (from visual acuity above 20/600 to 20/200 or a visual field of less than 20° and more than 5° in the best eye with the best correction).[2] Athletes in the S11 visual class must wear opaque goggles to standardize light perception in competition, negating any potential advantage over athletes who do not have residual vision.[1]

In Paralympic sports, the large variety of disabilities, sports modalities, and sports classification systems creates a significant challenge for those studying the epidemiology of sports injuries.[3,4] The characteristics of sports injuries appear to depend on the nature of disability and the sport, but most of the published studies adopt a cross-disability research design, leading to problems in data interpretation, particularly because different disabilities and sports may manifest in different injury patterns.[4] Sports injuries are also associated with numerous risk factors that are usually classified as extrinsic (eg, sport, rules, climate, surface, equipment) or intrinsic (eg, body composition, age, sex, flexibility, strength, balance, proprioception), with many intrinsic risk factors considered modifiable.[5] With regard to Paralympic sports, the disability must be considered an intrinsic risk factor that cannot be modified.[6]

Table 1. Number of Participating Athletes, Injured Athletes, and Injuries by Visual Class and Sex in Each Swimming Competition

Competition	Participating Athletes						Injured Athletes						No. of Injuries					
	S11	S12	S13	F	M	T	S11	S12	S13	F	M	T	S11	S12	S13	F	M	T
Paralympic Games 2004	3	—	—	1	2	3	3	—	—	1	2	3	4	—	—	1	3	4
Pan-American Games 2005	9	11	3	7	16	23	3	4	1	3	5	8	3	3	1	2	5	7
World Championship International Blind Sports Federation 2007	7	4	3	5	9	14	6	2	3	4	7	11	12	3	7	4	18	22
Para Pan-American Games 2007	9	2	2	5	8	13	4	0	1	3	2	5	6	0	0	3	3	6
Paralympic Games 2008	2	—	1	1	2	3	1	—	0	1	0	1	2	—	0	0	2	2
Total	12	12	4	9	19	28	9	5	4	6	12	18	26	6	8	10	31	41

Abbreviations: F, female; M, male; T, total.

The practice of competitive sports predisposes all individuals to sports injuries, irrespective of disability. Epidemiologic studies related to sports injuries are therefore important: to allow prospective participants to make informed choices about involvement based on the risk of injury; to provide information for medical and health care professionals to ensure care in disability sport; and to direct researchers, practitioners, and administrators to develop preventive strategies and create a safe environment for participation.[3]

It is well documented that visually impaired athletes sustain more injuries in the lower limbs and that the most common injuries are tendinopathy, strain, and contusion.[7–9] In general, Paralympic swimming is considered a low-risk sport.[10] Unfortunately, to date, few authors have investigated and reported injuries by sport and disability type, and published studies do not therefore reveal the true pattern and nature of injuries in elite, visually impaired swimmers. The aim of this study is to determine the characteristics and epidemiologic measures (prevalence and clinical incidence) of sports injuries in elite, visually impaired national swimmers and to assess differences among visual classes and between sexes.

METHODS

This was a descriptive, observational epidemiologic study of sports-related injuries in elite, visually impaired Brazilian swimmers. Ethical approval was obtained from the University of Campinas Research Ethics Committee. The Brazilian Paralympic Committee (CPB) and the Brazilian Confederation of Sport for Blind Athletes (CBDC) gave permission for access to athletes and medical records for the purposes of this study.

Participants

Twenty-eight athletes (19 males, 9 females) with visual disability gave informed consent to participate in this study. Twelve athletes were classified as S11 (blind swimmers), 12 as S12 (low-vision swimmers), and 4 as S13 (low-vision swimmers). All athletes represented the Brazilian Swimming Team in international competitions between 2004 and 2008. Their participation varied depending on squad selection for each event. The form was administrated during the following competitions: Paralympic Games 2004 (Greece), International Blind Sports Federation Pan-American Games 2005 (Brazil), International Blind Sports Federation World Championship 2007 (Brazil), Para Pan-American Games 2007 (Brazil), and Paralympic Games 2008 (China).

Definition of Terms

A *reportable injury* was defined as any injury that caused an athlete to stop, limit, or modify participation for 1 or more days.[8] To standardize the location of injury, the body was divided into the following segments and regions: head (head, face); upper limb (shoulder, arm, elbow, forearm, wrist, hand, fingers); lower limb (hip, thigh, knee, lower leg, ankle, feet), and trunk (spine, abdomen, rib cage). The mechanism of injury was determined as traumatic (resulting from a specific, identifiable event) or overuse (caused by repeated microtrauma without a single identifiable event responsible for the injury).[10]

Epidemiologic measures (prevalence, clinical incidence, and incidence rate) were evaluated. *Prevalence* is defined as the proportion of athletes who have an existing injury at any given point in time; it is calculated by dividing the number of injured athletes by the number of athletes exposed at the specified time.[11,12] *Clinical incidence* is defined by using the number of injuries as the numerator and the number of athletes at risk as the denominator.[11] *Incidence rate* is the number of injuries divided by the total person-time at risk (athlete-exposures).[11] In this study, the athlete-exposure is represented by competition and year.

Injury Report Form

A standardized injury report form, used routinely by the CPB and CBDC, required documentation of the following information: athlete name, age, sex, visual classification, sport, event, injured body part, and mechanism and diagnosis of injury. During the competitions, the multidisciplinary Brazilian medical team consisted of orthopaedists, physiotherapists, and nurses. The orthopaedists determined the precise diagnosis of each sports-related injury, after which athletes were referred to a physiotherapist. Sports injuries that occurred outside the period of competition were not recorded. When an athletes suffered a recurrent injury, the injury was counted only once.

Statistical Analysis

All data were collated using Excel 2007 (Microsoft Corporation, Redmond, WA) and analyzed using SPSS 14.0 (SPSS, IBM Brazil Ltd, Sao Paulo, Brazil). Descriptive statistics were calculated and used to determine the total and relative frequency of injuries. The Shapiro-Wilk test was conducted to determine the normality of data distribution. Where the normality of data distribution could be assumed, a 1-way analysis of variance test was performed. Alternatively, the Kruskal-Wallis test was used

Table 2. Prevalence and Clinical Incidence by Visual Class and Sex in Each Swimming Competition

Competition	Prevalence/Risk, % (Injured Athletes/Participating Athletes * 100)						Clinical Incidence, Injuries/Participating Athletes					
	S11	S12	S13	F	M	T	S11	S12	S13	F	M	T
Paralympic Games 2004	100	—	—	100	100	100	1.3	—	—	1.0	1.5	1.3
Pan-American Games 2005	33	36	33	43	31	35	0.3	0.3	0.3	0.3	0.3	0.3
World Championship International Blind Sports Federation 2007	85	50	100	80	78	79	1.7	0.8	2.3	0.8	2.0	1.6
Para Pan-American Games 2007	44	0	50	60	25	38	0.7	0	0.0	0.6	0.4	0.5
Paralympic Games 2008	50	—	0	100	0	33	1.0	—	0.0	0.0	1.0	0.7
Total	75	42	100	67	63	64	2.3	0.5	2.0	1.1	1.6	1.5

Abbreviations: F, female; M, male; T, total.

to assess differences among visual classes and between sexes. The level of significance was set a priori at $P < .05$.

RESULTS

Of the 28 athletes, 18 sustained a total of 41 sports injuries (Table 1), giving a prevalence of 64%. Descriptive data on the prevalence and clinical incidence in each competition, also presented by visual class and sex, are provided in Table 2. The overall clinical incidence was 1.5 injuries per athlete. The incidence rate was 0.3 injuries per athlete per competition.

With regard to sex, the injury prevalence was slightly higher in female compared with male swimmers (Table 2), but this was not statistically significant ($P = .12$). Similarly, the clinical incidence was higher in male compared with female swimmers (Table 2), but again, not significantly ($P = .16$). With regard to visual class, S13 athletes presented a higher prevalence of injury, followed by S11 and S12 athletes ($P = .18$). The clinical incidence in S11 athletes was higher, followed by S13 and S12 athletes ($P = .1$; Table 2). No statistical differences were found between subgroups ($P > .05$).

With regard to the mechanism of injury (Figure 1), of 41 injuries, 33 were overuse injuries (80%). The frequency and distribution of injuries by body segment (Figure 2) reveal that the trunk sustained 46.34% of injuries, mostly in the spine (43.9%), followed by the upper limbs, lower limbs, and head.

The frequency of injuries in each anatomical region (Figure 3) showed that the proportion of shoulder injuries was greater than the proportion of injuries to the thoracic and lumbar spine.

The frequency of sports injuries also varied by diagnosis (Figure 4), with the greatest frequencies reported as spasm (36.59%) and tendinopathy (26.83%).

DISCUSSION

Although not statistically significant, a trend for the prevalence of injury to be higher in S13 swimmers (100%), followed by S11 (75%) and S12 (42%) was noted, but the clinical incidence was higher in S11 (2.3 injuries per athlete) and S13 (2.0 injuries per athlete) swimmers, compared with S12 (0.5 injuries per athlete) swimmers (Table 2). These trends are worthy of further investigation with larger cohorts. In this group, a larger number of S13 athletes was injured, but S11 athletes presented with a greater number of injuries per athlete, resulting in a complex relationship between visual class and injury. Magno e Silva et al[6] analyzed a group of 131 visually impaired athletes in different sports and found that athletes with less visual function had a higher prevalence of injury. It is also noteworthy that swimmers in the classes with better vision delivered the best performances.[13,14]

The sport-specific demands of swimming improve performance and yet simultaneously reduce shoulder stability (increased shoulder range of motion; increased internal rotation and adduction strength; and prolonged, fatiguing, shoulder-intensive training), which can predispose individuals to injury.[15] As the current study did not evaluate other external factors such as training load, we cannot be more conclusive about the factors affecting injury outcomes.

We observed an overall injury prevalence of 64%, and the group sustained a clinical incidence of 1.5 injuries per athlete, indicating that some athletes sustained multiple injuries.[11] These results are similar to results reported by Reynolds et al,[16] who found that on the British Paralympic swimming team during the Paralympic Games of Barcelona (1992), of 43 athletes (multidisability), 69% were injured. In Olympic[17] and Paralympic[4] sports, swimming is generally considered a low-risk sport when compared with other activities. Magno e Silva et al[18] observed that blind elite footballers presented a clinical incidence of 2.7 injuries per athlete during a 4-year period of observation, including 5 competitions and 23 matches.

Our results demonstrated a similar value when we compared injury by sex. Female athletes (67%) had a slightly higher prevalence than male athletes (63%), but this was not significantly different ($P = .12$). Male

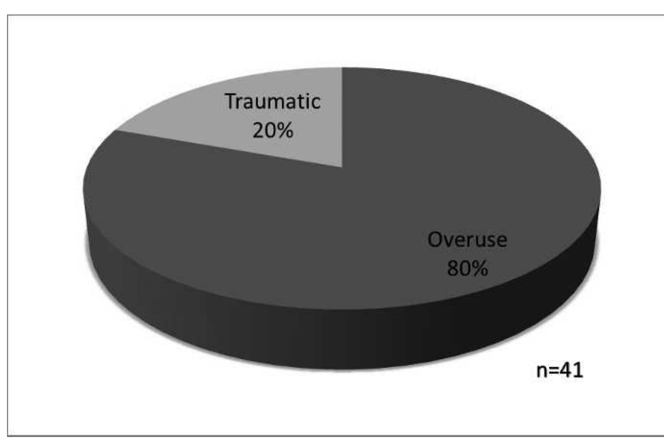

Figure 1. Mechanism of sports injuries in elite, visually impaired swimmers during competitions.

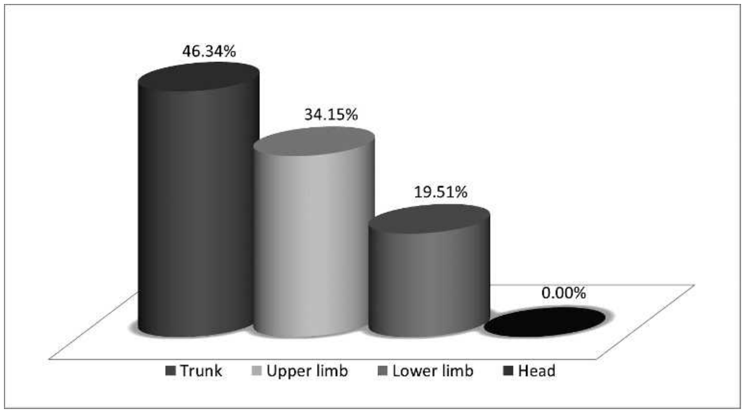

Figure 2. Sport injury by body segment in elite, visually impaired swimmers during competitions.

swimmers (1.6 injuries per athlete) had a slightly greater clinical incidence when compared with female swimmers (1.1 injuries per athlete), but again, no statistical difference was found ($P = .16$). Thus, in this group, a large proportion of female athletes were injured, but male athletes incurred more injuries per athlete. In collegiate swimmers without disability, Wolf et al[19] found an injury prevalence of 72.7% in male and 70% in female athletes. Indeed, the pattern of injuries between men and women seems to shows few differences compared with the same sport among able-bodied athletes.[20] Knowles[21] suggested that female athletes have a lower overall rate of injury when compared with male athletes without disability. Further authors should be encouraged to evaluate the risk of injury by sex in larger Paralympic sport cohorts.

In relation to the injury mechanism (Figure 1), we observed that overuse injuries (80%) were more frequent than traumatic injuries (20%). The prevalence of overuse injuries in athletes with disability has been described in previous studies[6,8,9] but not in relation to specific sports. Mountjoy et al[22] also described a frequency of 35% overuse injuries when evaluating sports injuries in 5 aquatic sports. It is estimated that an able-bodied collegiate swimmer performs an average of more than 1 million strokes per arm per year[23]; however, training loads among Paralympic swimmers are unknown. In visually impaired swimmers, the prevalence of overuse injuries may be inherently related to the sport, particularly the repetitive movements of arm strokes, rather than the disability. Some traumatic injuries did occur in this sample, and it is possible that these injuries were related to the swimmer's specific visual incapacity, particularly the inability to see the line lanes and the edges of the pool. This resulted in traumatic injuries such as contusion, lacerations, and abrasions (Figure 4). The risk of colliding with obstacles, among visually impaired athletes, may increase feelings of apprehension and anxiety and may be a factor that influences performance.[13]

A study of Brazilian Paralympic swimmers (multidisability) revealed that the upper limbs accounted for 44.4% of injuries, followed by the spine (38.9%) and lower limbs (16.7%). The body parts most affected were shoulders (29.2%) and cervical (16.7%) and thoracic (12.5%) spines, and the most frequent injury diagnoses were tendinopathy (36%) and spinal pain (36%).[24] In our research, the thoracic spine was the most affected region (22.95%), mainly by muscular spasms caused by overuse in the paravertebral and scapular stabilizer muscles that are generally overloaded in swimming biomechanics.[15,23,25] Nyland et al[9] observed a higher prevalence of injury in the cervicothoracic spine (19%) of visually impaired athletes, without specification of sport, and related the number of injuries to the need to suddenly respond to auditory or tactile cues for movement correction. Swimming athletes without disability also presented with a high number of musculoskeletal

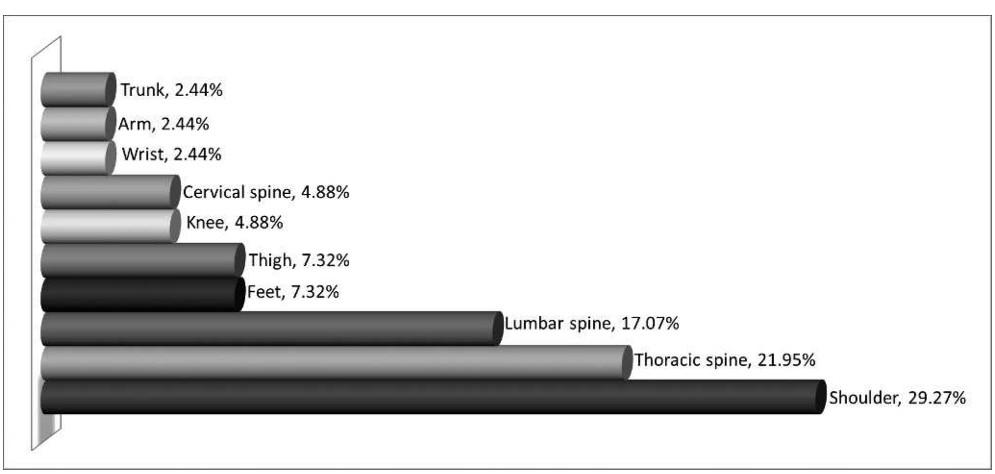

Figure 3. Sport injury by body region in elite, visually impaired swimmers during competitions.

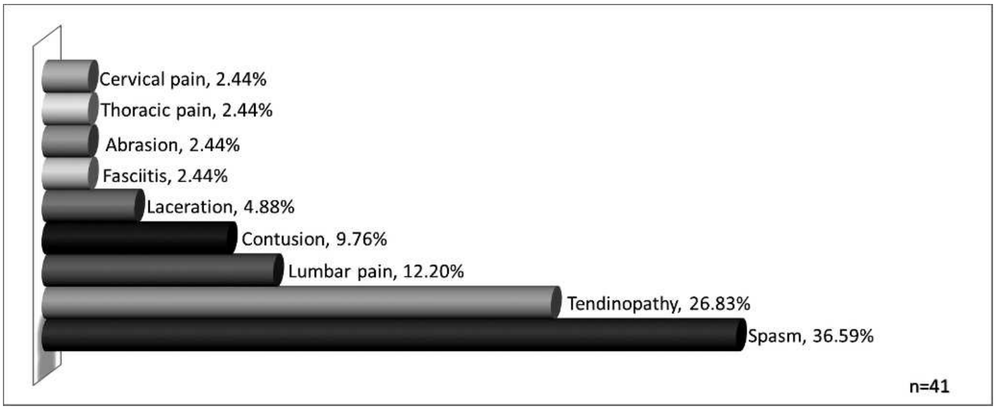

Figure 4. Sport injury diagnosis in elite, visually impaired swimmers during competitions.

injuries in the cervical and thoracic spine.[22,26] Goldstein et al[27] noted that in a group of female swimmers, 15.8% had spine abnormalities. We hypothesize that the relatively high prevalence of injuries in this area is related more to the mechanics of swimming and to the rotational movement of the head during breathing than to the disability type. The lumbar spine was the third most injured body part in this study (Figure 3). Compared with other athletes, swimmers often present with a greater lumbar curvature; furthermore, the butterfly and breast strokes predispose athletes to pain in this anatomical region.[26] We did not evaluate sport injuries according to the stroke style. However, it would seem logical that the stroke style is one extrinsic factor that can be related to the development of a sport injury, and this needs to be considered in further epidemiologic studies of Paralympic swimming.

In the upper limbs, the body part with the greatest injury frequency was the shoulder (Figure 3), which was mainly related to rotator cuff tendinopathy. In able-bodied swimmers, the shoulder is also the body part most frequently affected by injury.[15,22,23,26] Wolf et al[19] found that the shoulder accounted for 31% of injuries in collegiate swimmers without disability. In swimming, both the upper and lower limbs are used to generate a propulsion force through the water,[23,28] but close to 90% of the propulsion is generated by the upper limbs.[25] It would appear that most shoulder pain is caused by instability stemming from demands that are specific to the sport of swimming.[15] Various anatomical regions of the lower limbs were also affected by injuries, the feet being the most prone to contusions and lacerations (Figures 3 and 4). These injuries can be related to errors of judgment, particularly during the turn, or to direct contact with the lane line. Thigh injuries were predominantly related to muscle spasms, whereas the knees were mainly affected by tendinopathy (Figures 3 and 4). Swimming is a noncontact and non–weight-bearing sport[29]: knee pain and knee injuries generally occur because of repetitive movement (ie, overuse), particularly in athletes who perform breaststroke. Rodeo[30] referred to other studies with non–visually impaired athletes, in which the prevalence of knee injury varied between 27% and 75%.

One important observation from our study was that no reported injuries affected the head region (Figure 2). This suggests that use of a tapper may be an effective method of avoiding trauma to the head and face. All visually impaired athletes (S11, S12, and S13) are permitted the assistance of a support staff person, the tapper, who indicates to the swimmer the approach to the end of the pool, touching the athlete with sensorial information.[1]

To our knowledge, we are the first to report on the prevalence, clinical incidence, incidence rate, mechanisms, and distribution of sports injuries among elite, visually impaired swimmers. Although the sample size is relatively small, it includes all available elite swimmers representing Brazil throughout a 4-year period of observation and highlights the unique risks associated with this sport. In conclusion, Brazilian Paralympic swimmers with visual impairment were predominantly affected by overuse injuries. The trunk was the most affected body segment, followed by the upper limbs and lower limbs. More specifically, the shoulders and the cervical and thoracic spine were the body areas most affected by injuries. The most frequent diagnoses were spasm and tendinopathy. Female and male athletes presented similar prevalence and clinical incidence values. With respect to visual class, S13 athletes showed a higher prevalence of injuries, but S11 athletes had a higher clinical incidence. These results suggest that injury-prevention strategies in elite, visually impaired swimmers should focus on managing training loads to prevent overuse injuries. To prevent traumatic injuries, strategies should be developed to further assist athletes in gauging their position relative to the lane end, preventing traumatic contact injuries such as contusions and lacerations.

Further research should aim to quantify training loads, overall athlete-exposures, and other extrinsic factors that can be related to sports injuries. This requires a strategic approach to optimize the capture and analysis of data related to intrinsic and extrinsic risk factors, which ultimately requires the development of an electronic database system. This will allow all practitioners to enter and manage sports injury data from different athletes, teams, and locations.

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