Injury Patterns and Rates Amongst Students at the National Institute of Circus Arts

An Observational Study

David Munro, PhD

Despite the ever-growing global participation in circus arts, very little research has been conducted into injuries associated with this physical discipline. To date, no studies have examined the incidence of injuries in circus training institutions and schools. In this study, data were collected over an academic year from all student injury presentations to the physiotherapy staff at one Australian circus school. A total of 351 injuries resulting in 1,948 treatments occurred in 33 female and 30 male circus students. The most common mechanisms of injury were acrobatics/tumbling (23%), handstands (12%), adagio (11%), and Chinese pole (10%). The most commonly injured body parts were the ankle (25%), lumbar spine (14%), and shoulder (12%). Interestingly, combined spinal injuries (cervical, thoracic, and lumbar) contributed to 35% of all initial injuries. Females sustained 71% of all hip injuries, but only 33% of all forearm injuries. Males accounted for 59% of all ankle injuries. There were no significant gender-based differences in other body areas. Results indicated that there is no gender-based difference in the overall rate of injury. However, females sustained significantly higher rates of hip injuries and males presented with more forearm and ankle injuries, perhaps reflecting the specific form and style of circus training and contortion undertaken. Spinal injuries had the highest overall rate of initial and follow-up presentations, indicating that both preventative and rehabilitative strategies could be addressed. It is suggested that the most common mechanisms of injury reflect both the amount of time spent training specific disciplines and the extreme physical difficulties and demands placed on the body. *Med Probl Perform Art* 2014; 29(4):235–240.

Spearheaded by the hugely successful *Cirque du Soleil*, modern contemporary circus is a shining star on the world's entertainment stage. In 2008, a world-wide survey led to the identification of 680 circus arts training facilities in 52 different countries.[13] In addition to this considerable collection of circus artists are an unknown (but presumably quite large) number of street, independent, and freelance performers working and training around the world. The Australian circus industry also has a rich, varied, and highly entertaining history. From humble beginnings in 1847, Robert Radford pioneered the first successful documented circus in Australia.[21] Today, contemporary Australian circus is a world leader of a relatively recent global phenomenon.

At the heart of Australia's circus incubator beats the National Institute of Circus Arts (NICA), located in Prahran, Victoria. In 2001, NICA opened to offer Australia's only full-time 3-year training program, culminating in a Bachelor of Circus Arts. It is an innovative and industry-endorsed program that has already produced a wide range of internationally recognised and award-winning artists. Students enroll from all over the world, bringing to NICA a broad and varied skill set that changes and diversifies each year. Many students have previous training as elite-level gymnasts, often looking to expand their skills and artistic expression via the wider creative outlet of circus arts. Others are dancers, stunt performers, free runners, BMX riders, street jugglers and artists, community circus participants, or one of many other type of physical performer.

Despite the ever-growing global participation in circus arts, very little research has been conducted into injuries associated with this physical discipline. By analysing the *Cirque du Soleil* electronic database over a 5-year period, Shrier et al.[20] described injuries sustained by professional artists working across 17 different shows. The data were limited to professional performers and show-related injuries only. Training injury rates and student injury rates could not be calculated. Amongst other findings, their results did suggest that the shoulder was the most commonly injured upper-extremity joint and that females sustained more hip/groin injuries than males. Wanke et al.[26] examined acute injuries in student circus artists with regard to gender-specific differences via a retrospective descriptive epidemiological study. Data were collected via the Berlin State Accident Insurance and a State Training School over a 17-year period. All work accidents were registered in standarised work accident reports, as well as in exposure data, but it was unclear precisely how this was reflected over the 17-year period. A total of 169 work accidents were reported over this time, averaging less than 10 per year. Although providing some novel data, it was unclear as to the direct relevance of this study to the students at NICA or a similar circus training facility.

This study aimed to determine the most common injuries, injury patterns, and injury rates, whether there are any differences in injury profiles with respect to gender, and to identify the apparatus, equipment, or activity that provides the most common mechanism of injury

Dr. Munro is Head Physiotherapist at the National Institute of Circus Arts (NICA), Prahan, and private practitioner at Absolute Physiotherapy, Prahan, Victoria, Australia.

Address correspondence to: Dr. Munro, Absolute Physiotherapy, 131 High Street, Prahran, 3181 VIC, Australia. Tel +61395103555, fax +61395106948. drdavidmunro@yahoo.com.

amongst students at NICA. Importantly, this study hopes to provide immediate clinical implications for those therapists working within the global circus arts environment, and more broadly within the greater physical theatre industry in general.

METHODS

Design

Injury definition is very important in calculating the injury rate. It has been suggested that the definition of an injury can affect the results of risk factor analysis.[5] As such, some authors have proposed that a uniform injury definition should be utilised within and across sport to facilitate comparison.[11,17,22,24] However, due to the likely limitations associated with each definition,[6,15] no consensus has been reached.

For the purposes of this study, an injury has been defined as a *medical attention injury*—i.e., any injury assessed by a qualified health care professional,[4] in this particular case being one of the physiotherapy staff at NICA. Although time-loss injury may provide a more accurate and consistent definition,[1,12,16] medical attention injury has been suggested to more accurately reflect the burden of the problem.[8,24]

Data Collection

Data were collected over a full academic year at NICA from all student injury presentations to the physiotherapy staff. Only those injuries sustained at NICA, either during training or a show, were included. Although the students are entitled to seek care elsewhere if they wish, it is NICA policy that they must attend the physiotherapy team with any new injury for assessment. This way, the physiotherapist can liaise with the training staff in regards to safety restrictions, return to practice, training loads, etc. In this regard, it can be assumed that almost all of the injuries that occurred during this period have been captured. Any injury sustained outside NICA (e.g., spraining an ankle whilst jogging or participating in another sport) was excluded.

Information collected included mechanism of injury, apparatus or activity involved, anatomical location, treatment sessions required, and gender. An initial injury was defined as one that the student had not previously reported to the physiotherapy staff at NICA. Follow-up visits were defined as treatment sessions following the first visit. If a student attended for an initial injury and received no further treatment for that particular injury, it was recorded as one initial visit and no follow-up visits. Multiple injuries involving different body parts of the same student within a single presentation (e.g., a student presenting with knee, neck, and ankle pain following a fall) were regarded as individual initial injuries and recorded as such. In terms of ongoing care, the physiotherapy team attends NICA on a daily basis and this service is provided without cost to the student. Although some students may choose to seek care outside NICA, cost to attend the health care team is not a barrier, and it is most likely that the great majority of students seek ongoing care at NICA.

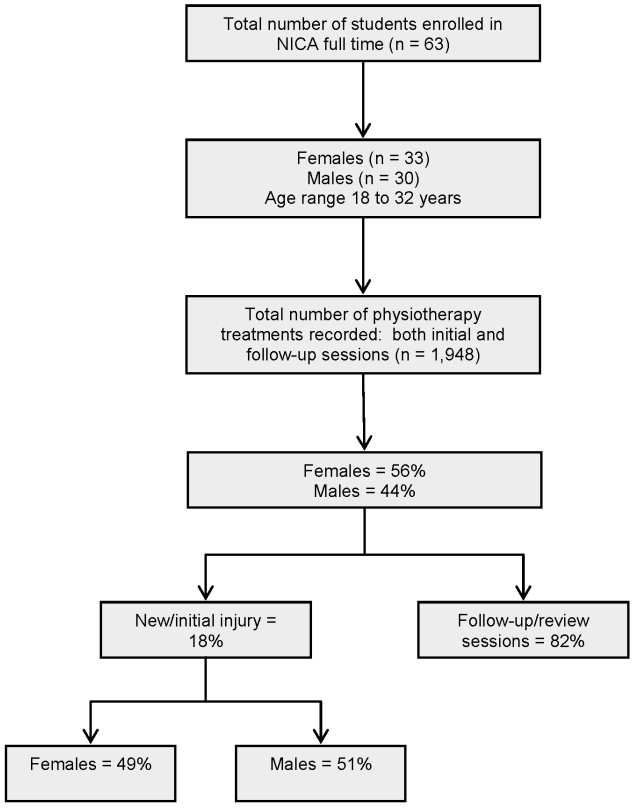

FIGURE 1. General student data and physiotherapy attendance.

Participants were 63 students enrolled full-time at NICA. All students had equal access to the physiotherapy staff for injury reporting and treatment. Data for this study were collected from existing records and without identifying information, and so it was deemed exempt from formal ethical review by the Swinburne Human Research Ethics Committee.

Data Analysis

Statistical data analysis was undertaken utilising an independent two-samples *t*-test. Confidence intervals were assessed at 95% as presented in this study.

RESULTS

General Student Data and Physiotherapy Presentations

Of the 63 students enrolled full-time at NICA, 33 were female and 30 male. The age group ranged from 18 to 32 years, with a mean age of 22 years (Fig. 1).

A total of 1,948 physiotherapy attendances were recorded during this time. This total represents both initial

TABLE 1. Mechanism of Initial Injury

Activity/Apparatus	Percentage of Occurrence
Acrobatics/tumbling	23%
Handstands	12%
Adagio	11%
Chinese pole	10%
Warm up	8%
Teta-board	5%
Skipping, hoop diving, trampoline, trapeze, cube, straps, rope, and all others	All ≤5%

and follow-up sessions. Of this number, 857 (44%) were male students and 1,090 (56%) females. Given the slightly higher number of female students enrolled in the course, there was no clinically relevant differences in total physiotherapy attendances with respect to gender.

When examined more closely, of the 1,948 total attendances, 351 (18%) were for initial injuries and 1,597 (82%) were follow-up sessions for existing injuries. Of the initial injuries, 179 (51%) of these were in males and 172 (49%) females.

Mechanism of Initial Injury

Examination of the mechanism of initial injury data revealed that acrobatics/tumbling was the most common activity leading to injury (23%) (Table 1). Acrobatics/tumbling was defined as being a ground-based activity only, not involving any partner work or direct contact interaction, aerial rigs, or other apparatus/props such as hoops, juggling balls/clubs, or *cyr* (German) wheel for example. Handstands accounted for 12% of all initial injuries. Both double- and single-arm handstands were recorded in the same grouping. For the purposes of this study, adagio injuries were separated from general acrobatic injuries and accounted for 11% of all initial injuries. Adagio, defined as partner-to-partner balancing with one person acting as a flier and the other as a base, accounted for 11% of all initial injuries. No differentiation was made between the base and flier in this instance.

Anatomical Areas Injured

The ankle joint was the most commonly injured anatomical area, representing 26% of all initial injuries (Fig. 2). Lumbar spine accounted for 13% of all initial injuries and shoulder 12%. Combined data for cervical, thoracic, and lumbar spine accounted for 35% of all initial injuries.

When examined in terms of total treatments, the ankle joint represented only 20% of all attendances. Treatments for lumbar spine injuries also constituted 20% of total treatments, despite that area representing only 13% of initial injuries. Shoulder (13%) and thoracic spine (12%) total presentations were the only other body areas above 10%. When the combined spinal data were examined (cervical, thoracic and lumbar), 39% of all total treatments were attributed to this grouping.

Differences in Initial In jury Based on Anatomical Location and Gender

There was no difference in the rate of initial injury between male and female students. However, when examined in relation to specific anatomical locations, several distinctions emerged (Table 2). Females accounted for 71% of all initial injuries attributable to the hip joint and males 29% (p=0.022). By contrast, female students only represented 33% of all initial injuries associated with the forearm/wrist area, whilst males accounted for 67% (p=0.039). The difference with regards to the ankle joint was less, but still significant, with females reporting 41% of all initial injuries and males 59% (p= 0.043). All other anatomical areas were not statistically significantly different with respect to gender.

DISCUSSION

The results of this study reflect that circus arts, like other physically demanding sports and performing arts, are associated with a particular and unique injury rate and pattern. With respect to students studying at NICA, there are

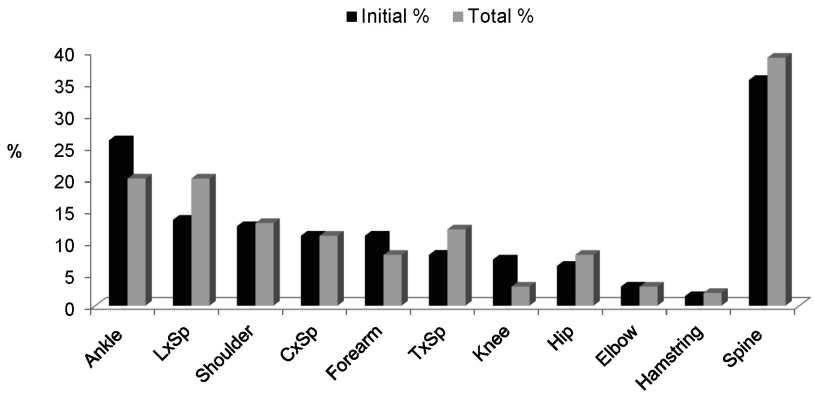

FIGURE 2. Initial and total injury data by anatomical area.

no significant gender differences in initial injury rates or total treatment rates. Although females represented 56% of all total treatments, they also had higher representation within the student numbers, making up 33 of the 63 students enrolled at NICA (52%). The results of the current study reflect those reported by Shier et al.,[20] who reported that although the overall injury rate for female artists was slightly higher than that of male artists, it was not significantly different. Wanke et al.[26] similarly did not report any significant gender-specific differences overall.

One of the novel findings from this study was the identification of acrobatics/tumbling as the most common mechanism of initial injury. The author knows of no other study that these results can be directly compared to. Shier et al.[20] only examined show-related injuries in a professional company and was unable to comment on training-related injuries, and particularly not within a student training facility. Wanke et al.[26] did report on student circus artists, with 87% of injuries having occurred in "the gym" and 13% occurring at places not associated with the physical training (e.g., corridors, showers, classrooms, and on the way home or to work). The data did seem to suggest, however, that 50% of all work accidents during the technical-physical training could be assigned to "floor acrobatics." No definition of floor acrobatics was made, so it is unclear if this included activities such as adagio, handstands, hoop diving, or other apparatus-based activity, all of which may be associated with particular injuries. Wanke et al.[26] also reported that 10.3% of injuries during the technical-physical training could be attributable to tightrope, skipping, rope, or slack-line. These four disciplines appeared to have been grouped together, as they involve some form of rope, despite the fact that they are quite different activities requiring very diverse physical demands. For example, tight rope and slack rope involve balancing on a rope (or more often in practice, a wire), skipping is a land-based activity reliant on repetitive jumping, and rope generally refers to a single vertical hanging piece of rope on which an artist climbs and performs various acts of contortion and strength.

When examining the most common mechanism of injury at NICA, the number of students and time spent undertaking each task within a typical training week must be considered. Acrobatics/tumbling forms a large part of the general training program at NICA and is undertaken by all students at NICA. During the first-year program, most students would undertake some form of acrobatics/tumbling on a daily basis. During the second and third years, the proportion of students undertaking acrobatics/tumbling would decrease, with numbers reflecting those students choosing this discipline as one of their specialties. It is reasonable to propose, therefore, that acrobatics/tumbling represents the highest mechanism of injury at NICA, not because it is the most difficult, high risk, or dangerous *per se*, but because it is one of the highest frequency activities undertaken by nearly all students and the rate of injury reflects this exposure.

TABLE 2. Initial Injury by Anatomical Area and Gender

Anatomical Area	Male	Female
Hip	29%	71%*
Forearm	67%*	33%
Ankle	59%*	41%
All others	NAD	NAD

* $p \leq 0.05$. NAD, no apparent difference.

Of the other specialty disciplines, handstands (12%), adagio (11%), and Chinese pole (10%) were the most commonly attributable activities to injury. One of the limitations of the current study was the inability to clearly identify the number of students undertaking each discipline and how much time they spend training each week, and to correlate this to the mechanism of injury data to more clearly establish the risk of injury for each discipline in relationship to student exposure. It is hoped that future studies may address this.

Interestingly, the warm-up part of the program contributed to 8% of all injuries. A previous internal injury audit conducted at NICA suggested that this figure was around 12%. Subsequently, the physiotherapy team initiated a series of meetings, educational sessions, and discussions with the core trainers, resulting in a transition from a generalized group activity to more individual programs. Not all students completed all warm-up routines, and some were given specific exercises or restrictions as determined by their presenting physical capacity and injury status. It would appear that this intervention has been successful in lowering the warm-up injury rate, although ongoing review and adjustment is required.

The ankle joint is the most commonly injured body area at NICA. This largely corresponds to previously published circus data,[20,26] the broader physical theatre community, and comparable sport disciplines. A survey of injuries among Broadway performers engaged in 23 permanent or touring shows demonstrated that 25% of all reported injuries were ankle related.[2] A subsequent retrospective study of 269 performers appearing in 20 West End productions revealed 18.5% of all injuries to be ankle related.[3] Several studies examining injury patterns and rates amongst gymnasts also report ankle injury rates ranging from 16 to 46%.[9,10,19,23]

When the exact mechanism of each ankle injury at NICA was examined in more detail, some revealing anecdotal trends appeared. For example, in one case an ankle injury reported to have occurred during acrobatics/tumbling in fact occurred when the student slipped into a slight gap between two mats. In another incident, a student sustained a grade III lateral ankle sprain walking off a high crash mat when they misjudged the edge and fell. The mechanism was recorded as Chinese pole, as that was what the student was engaged in at the time, although the actual apparatus did not directly contribute to the incident. Shier et al.[20] also made reference to this type of inci-

dent and presumed that the high proportion of ankle injuries in musicians (non-acrobats) was from running on stage as part of an act or backstage during the show. It would seem that although the ankle joint is often injured during high-impact acrobatic-type activities, it may also be easily injured during less high impact activities, hence reflecting its overall high level of occurrences. Future studies in this area may be improved by trying to more clearly dissociate between ankle injuries as a result of training and those that may be more accurately described as accidents.

Lumbar spine injuries represented the most commonly injured spinal area, but injury involving the total spine (combined cervical, thoracic, and lumbar) accounted for 35% of all initial injuries (Fig. 2). Both Shier et al.[20] and Wanke et al.[26] reported similar but slightly lower data (26% and 16%, respectively). It is proposed that the high proportion of spinal injuries reported at NICA reflects the extreme physical demands placed on the spinal structures during both training and performance. In particular during training, the students are pushing their bodies to their limits to see how far they can contort, bend, and stretch themselves. During the constant refining of an act, these limits are often repeated and further extended daily to achieve maximum physical and artistic results. In general, spinal injuries were more likely to be overuse-type presentations, rather than acute onset injuries. Further studies could add to this level of knowledge by identifying and describing overuse and acute-onset spinal injuries more clearly.

Although the ankle joint and total spine area represented the highest incidence of initial injury in relation to body parts, significantly more time was spent treating spinal injuries (39% total treatments spinal compared to 20% ankle). This suggests that once injured, spinal injuries take more time and more treatments to resolve within this particular group. This may reflect the extremely high demands placed on the spine during training and performance and the longer rehabilitation programs that are often required. In terms of prevention, strategies to reduce ankle injuries may be most effective, particularly those aimed at reducing "incidental" ankle injuries. Given the significant amount of time spent treating spinal injuries, physiotherapists are well placed to implement best practice techniques for spinal treatment and rehabilitation programs, particularly with a view to repetitive loading of the spine experienced in this previously overlooked population.

One of the significant findings from Shrier et al.[20] was a high proportion of shoulder injuries, a similar finding to that of Wanke et al.[26] This study found that the shoulder was only the third most commonly injured joint. An earlier internal audit of injuries conducted by the physiotherapy team at NICA identified the shoulder as at high risk of injury. When examined in detail, it was revealed that the most commonly affected students with shoulder injuries were generally female, with a dance or calisthenics background and poor upper limb strength. Measures were then undertaken during our screening process to identify the most at risk students and place them on preventative strengthening programs. Their progression through the training program, in particular in relation to handstand, aerial, and contortion training, was also closely monitored. As such, the lower incidence of shoulder injuries reported in the current study may reflect this earlier intervention.

Although there was no difference in overall injury rates with respect to gender, when examined in relation to body areas there were some striking results. Females accounted for significantly more initial hip injuries than males, as has been demonstrated in previous studies.[20,26] It is proposed that the results of the current study reflect the differences in the typical training programs and performances by female students, with many more females undertaking extreme contortion and flexibility training during their time at NICA compared to males. Female students are much more likely to train regularly (almost daily) to increase split range (both middle and side), hip range (in all directions), and contortion positions, often under the guidance of a trainer providing over-pressure. This is further highlighted at "Showcase," held at the end of the 3-year course where students perform the major act they have developed. At Showcase, many more female students perform a contortion skill-based major act, be it ground, aerial, or with a partner, compared to male students. Interestingly, anatomical studies have shown sex-based differences in relation to hip joint anatomy, with females having a shorter femoral neck, a thinner femoral shaft, a lower cervicodiaphyseal (CCD) angle, a lower femoral offset, and greater anteversion of the femoral neck, which may predispose the development of certain injuries.[7,14,18,25] It is unclear how these anatomical differences may be related to gender differences in circus hip injuries.

Males accounted for significantly more forearm/wrist and ankle injuries than females. The results from Wanke et al.[26] indicated that there may be a similar gender difference but were not statistically examined. It is proposed that the gender difference seen in forearm/wrist and ankle injuries of the current study is directly related to the typical training and performance activities undertaken by male students at NICA. Although not exclusively, male students often undertake specialty training that places high loads on the lower arm (e.g., handstands, straps, Chinese pole, and base work in adagio). A difference in training load also most likely accounts for the smaller, but still significant, difference in ankle injuries. Male students will typically engage in more training activities and specialties that place high loads on the ankle, such as teta-board, tumbling, and high-impact landings. Given the high prevalence of hip injuries in female circus artists, and the high prevalence of forearm and ankle injuries in males, clinicians working in this area may be recommended to closely screen for these types of injuries in each gender group. Appropriate screening, pre-habilitation, and best practice treatment techniques would be expected to provide substantial benefit in reducing injury occurrence and improving return to training and performance times.

In conclusion, the current study provides novel data for injury patterns and rates at a full-time circus training school and immediate clinical implications for physiotherapists working with circus and other physical performers. Although there was no gender-based difference in overall injury incidence, females did sustain a higher rate of hip injuries and males forearm/wrist and ankle injuries. Screening and preventative programs targeting female hips and male forearms/wrists may be of significant benefit. Preventative programs targeting ankle injuries would be useful in reducing injury incidence across the whole cohort. A substantial proportion of the treatment time is spent with spinal-related injuries. Further investigation into best practice screening and treatment programs targeting spine injuries would be expected to aid in reducing this representation. Results presented in the current study will be incorporated into future screening, diagnostic, and preventative programs at NICA, and it is hoped that this will be reflected in an over decrease in injury incidence.

REFERENCES

1. Dallalana R, Brooks JH, Kemp SP, Williams AM. The epidemiology of knee injuries in English professional rugby union. *Am J Sports Med.* 2007; 35:818–830.
2. Evans RW, Evans RI, Carajal S, Perry S. A survey of Injuries among Broadway performers. *Am J Public Health.* 1996; 86(1):77–80.
3. Evans RW, Evans RI, Carajal S. Survey of injuries among West End performers. *Occup Environ Med.* 1998; 55:585–593.
4. Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Clin J Sports Med.* 2006; 16:97–106.
5. Hamilton GM, Meeuwisse WH, Emery CA, Shrier I. Examining the effect of the injury definition on risk factor analysis in circus artists. *Scand J Med Sci Sports.* 2012; 22:330–334.
6. Hodgson L, Gissane C, Gabbett TJ, King DA. For debate: consensus injury definitions in team sports should focus on encompassing all injuries. *Clin J Sports Med.* 2007; 17:188–191
7. Kaptoge S, Dalzell N, Loveridge N, et al. Effects of gender, anthroprometric variables and aging on the evolution of hip strength in men and women aged over 65. *Bone.* 2003; 32:561–570.
8. Kerr HA, Curtis C, Micheli LJ, et al. Collegiate rugby union injury patterns in New England: a prospective cohort study. *Br J Sports Med.* 2008; 42:595–603.
9. Kirialanis P, Malliou P, Beneka A, Giannakopoulos K. Occurrence of acute lower limb injuries in artistic gymnasts in relation to event and exercise phase. *Br J Sports Med.* 2003; 37:137–139.
10. Meeusen RB, Borms TF. Preventing gymnastic injuries. *Can J Sports Sci.* 1992; 15(4):227–231.
11. Meeuwisse WH, Love EJ. Athletic injury reporting: development of universal systems. *Sports Med.* 1997; 24:184–204.
12. Meeuwise WH, Sellmer R, Hagel BE. Rates and risks of injury during intercollegiate basketball. *Am J Sports Med.* 2003; 31:379–385.
13. Miroir Project. European Federation of Professional Circus Schools, 2008. Available at: http://www.fedec.eu/schools/directory. Accessed Sep 2013.
14. Noble PC, Alexander JW, Lindahl LJ, et al. The anatomical basis of femoral component design. *Clin Orthop.* 1988; 2 235:148–165.
15. Orchard J, Hoskins W. For debate: consensus injury definitions in team sports should focus on missed playing time. *Clin J Sports Med.* 2007; 17:192–196.
16. Orchard J, Seward H. Epidemiology of injuries in the Australian Football League, seasons 1997-2000. *Br J Sports Med.* 2002; 36:39–44.
17. Phillips LH. Sports injury incidence. *Br J Sports Med.* 2000; 34:133–136.
18. Sanali E, Mouttet A, Pascular G, Durante E. Three-dimensional hip anatomy in osteoarthritis analysis of the femoral offset. *J Arthroplasty.* 2009; 24:990–997.
19. Sands WA, Shultz BB, Newman AP. Women's gymnastics injuries: a 5-year study. *Am J Sports Med.* 1993; 21(2):271–276.
20. Shrier I, Meeuwisse WH, Matheson GO, et al. Injury patterns and injury rates in the circus arts. *Am J Sports Med.* 2009; 37:1143–1149.
21. St Leon M. *Circus: The Australian Story*. Melbourne: Melbourne Books; 2001.
22. van Mechelen W. Sports injury surveillance systems: "one size fits all?" *Sports Med.* 1997; 24:164–168.
23. Wadley GH, Albright JP. Women's intercollegiate gymnastics: Injury patterns and "permanent" medical disability. *Am J Sports Med.* 1993; 21(2):314–320.
24. Walden M, Hagglund M, Ekstrand J. Injuries in Swedish elite football: a prospective study on injury definitions, risk for injury and injury patterns during 2001. *Scand J Med Sci Sports.* 2001; 15:118–125.
25. Wang SC, Brede C, Lange D, et al. Gender differences in hip anatomy: possible implications for injury tolerance in frontal collisions. *Ann Proc Assoc Adv Auto Med.* 2004; 48:287–301.
26. Wanke EM, McCormack M, Koch F, et al. Acute injuries in student circus artists with regard to gender specific differences. *Asian J Sports Med.* 2012; 3(3):153–160.