



Sports Injury and Physiotherapy Services in the 2018 PyeongChang Winter Paralympic Games: Considerations and Potential Recommendations for Future Paralympics

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Key Words

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Background: The PyeongChang 2018 Winter Paralympic Games (WPG) being one of the most successful Paralympic Games (PG) in modern athletic world history, hosted the largest number of elite athletes representing 49 National Paralympic Committees (NPCs).

Objects: The present investigation highlighted the demographic and clinical characteristics of injured athletes and non-athletes and the physiotherapy services provided during the PyeongChang 2018 WPG.

Methods: Prospective descriptive epidemiology study, in which the study group comprised of 201 participants (51 athletes and 150 non-athletes) who were admitted to and utilized the polyclinic physiotherapy service of 2018 PyeongChang WPG in Physiotherapy Department of Paralympic Village from March 1, 2018 to March 20, 2018.

Results: Qualitative frequency analysis of injury type demonstrated highest number of chronic injuries (51%, n = 100) in athletes and non-athletes. Anatomical injury site analysis revealed that the spine and shoulder areas were affected with equal frequency for athletes (54.9%, n = 14), whereas for non-athletes, the frequencies of spine and shoulder area injuries were 36.7% (n = 55) and 26% (n = 39), respectively. The PyeongChang WPG showed a high rate of athletes visiting the physiotherapy service during the pre-competition period (33.3%, n = 50), which may have led to smaller incidence rate of traumatic injury. The physiotherapy treatment service analysis demonstrated that manual therapy (35.4%, n = 230) was most commonly utilized, followed by transcutaneous electrical nerve stimulation/interference current therapy (TENS/ICT), therapeutic massage and therapeutic exercise.

Conclusion: We established the importance of prophylactic and preventive physiotherapy services to reduce the risk of sports injuries during WPG.

INTRODUCTION

The PyeongChang 2018 Winter Paralympic Games (WPG) was one of the most successful legacy Paralympic Games (PG) in modern athletic world history, hosting the largest number of elite athletes (569 athletes) and representing 49 National Paralympic Committees (NPCs) [1]. The Medical Commission of the International Paralympic Committee (IPC) has initiated a prospective injury surveillance and an associated provision of sports medicine and physiotherapy services project to better identify injury risk factors and develop effective management

strategies. Recent prospective injury surveillance of the PG suggests a growing number of the athletes with disabilities reporting a variety of musculoskeletal injuries, particularly during the WPG [2,3].

1. Risk Factors Associated With Winter Paralympic Games and Physiotherapy Service

IPC and surveillance studies reported that as many as 502 elite athletes (44 NPCs) and 541 elite athletes (45 NPCs) who participated in the 2010 Vancouver and 2014 Sochi PG events, respectively, demonstrated a higher risk of injuries when com-



pared to the Olympic Games events [4]. The sports medicine and physiotherapy service has been by far the most utilized at the Paralympic Village polyclinic (PVP) by both athletes and non-athletes, including residents of the village, family members, supporting staff, and volunteers. Hence, the highest standards and quality of sports medicine and physiotherapy services are paramount and frontline onsite prevention coupled with comprehensive PVP care over several Olympic games have been emphasized [5].

Despite the importance of high standard and quality of physiotherapy care, there is a dearth of information on the epidemiology of sports injury and related physiotherapy services at the WPG in current literature. However, some sports injury and physiotherapy services can be predicted for certain sports-specific disciplines and equipment modifications (e.g. wheelchair curling, sledges) and prosthetics (e.g., stump socket) which predispose elite athletes to unique injuries [6-9]. Epidemiological injury surveillance has been done for every PG, but there is a limited number of WPG physiotherapy service-related studies reporting the epidemiology (onset time) of the sports injuries [1-3], especially with details about the anatomical region, number of injuries, high-incidence sports disciplines, nature of injury (acute or overuse), and treatment (number of treatments and modalities). Thus, the importance of physiotherapy services and preventive care have not been adequately addressed in the literature. In line with the mission and research objectives of the IPC, we have developed a neuro-musculoskeletal injury and physiotherapy service database, followed by a preliminary phase of data collection and analysis implemented at the PyeongChang 2018 WPG. The specific aim of the present project was to evaluate the demographic and clinical characteristics of injured athletes and non-athletes and the physiotherapy services provided during the PyeongChang 2018 WPG. Furthermore, we aimed to ascertain the importance of prophylactic preventive physiotherapy services to the risk of sports injury during WPG. The information obtained from this project would serve as a clinical guideline and shed light on the future of physiotherapy services required for athletes in upcoming WPG.

MATERIALS AND METHODS

1. Participants

The study group comprised of 201 participants (51 athletes

and 150 non-athletes) who were admitted to and utilized the polyclinic physiotherapy service from March 1, 2018 to March 20, 2018. Informed consent was provided by all participants for the use of de-identified medical data gathered during the Games. Paralympic athletes participated in five major sports disciplines: Para alpine skiing, Para snowboard, Para Nordic skiing (combining Para cross country skiing and Para biathlon), Para ice hockey, and wheelchair curling [1]. Non-athletes include: coaches, Olympic families, work forces, and other staffs.

The IPC medical committee members provided a preliminary investigation plan for sports medicine and physiotherapy services prior to the Games via email to all the NPCs chefs de mission (n = 49). Further detailed information about the current study was provided at a medical briefing and during individualized training sessions, which took place during the pre-competition period with 41 team physicians and medical staff attending, at the chefs de mission hall.

The study was implemented by members of the IPC Medical Committee and approved by the Institutional Review Board of Yonsei University Wonju Severance Christian Hospital (IRB no. CR320022). The physiotherapy service procedure and data collection were approved by the PyeongChang 2018 Medical Service Committee for the PG.

2. Defining Injury and Physiotherapy Service

We defined injuries and illnesses as a “complaint of sports-related musculoskeletal that caused the athlete to seek medical attention during the study period, regardless of the athlete’s ability to continue with training or competition [3].” Injuries were categorized into three types: acute (pre-existing and partially rehabilitated conditions were not included), recurring (same type of injuries that occur repeatedly at the same location on the body [10]), or chronic (a type of “overuse syndrome” which reflects an accumulation of unrepaired, relatively minor damage [11]).

The IPC classifies sports into ten categories; however, we reorganized the data into five impairment types based on the web-based injury and illness capturing system (WEB-IISS). Characteristics of each impairment type have been defined in Table 1.

The five major comprehensive physiotherapy services included advice (counseling, consultation, referral), therapeutic exercise, manual manipulative therapy, therapeutic modalities, and assistive (prophylactic) devices. A specific description of

the sub-categories has been presented in Table 2. The selection of physiotherapy service items was based on the recommendation and guidelines of International Olympic Committee (IOC)/IPC medical commissions and clinical evidence in current literature.

3. Availability, Access and Staff Allocation

Physiotherapy services were provided in the PVP to support all the medical needs associated with preventive or prophylactic services, sports injuries and recurrent or chronic injuries for 569 athletes and non-athletes for 20 days, from March 1, 2018 to March 20, 2018, including the pre-competition period (March 1 to March 8), competition period (March 9 to March 18), and post-competition period (March 19 to March 20). The operating hours were from 7:00 AM to 11:00 PM. The physiotherapy department in the PVP was easily accessible due to its central location.

Table 1. Description of impairment types

Type	Description
Spinal cord injury	All those athletes having a spinal cord lesion, spina bifida or polio.
Cerebral palsy	A condition in which damage inflicted on the brain has led to motor function disorder.
Limb deficiency	Total or partial absence of bones or joints as a consequence of trauma, illness or congenital limb deficiency.
Vision impairment	Vision impacted either by an impairment of the eye structure, optical nerves or optical pathways, or the visual cortex.
Ambulatory	Guide runners

A total of 18 top Korean sports physiotherapists were involved in the service. The physiotherapists were divided into two separate shifts of morning and night, with each shift lasting eight hours and staffed by eight therapists. The service was administered by a chief physiotherapist (Sung H. You, PhD, PT, Yonsei University Mirae Campus), one medical IPC doctor (Dr. Young H. Lee) and 18 professional sports physiotherapists. The physiotherapists played a critical role in providing treatment and rehabilitation for clients, along with initial assessments and evaluations to maximize performance of the para-athletes and prevent further injuries.

Each treatment involved a multidisciplinary approach where clients were first assessed by the medical doctor. The physiotherapists administered the prescribed treatment consisting of different modalities including manual therapy and simple exercises. Re-visiting patients who came in for simple conditioning and/or pain control directly went to the physiotherapists in charge.

4. Medical Forms, Data Management, and Statistics

Physiotherapists utilized the 'IPC EMS Physical Therapy Service Form' to record initial examination of admitted patients. The electronic medical record (EMR) aimed to provide basic demographics, foundation of injury, physical assessment and available physical therapy treatment lists. A clear understanding of the injury profile (i.e., acute, recurring, or chronic) was needed to better understand and determine the treatment approaches and sports therapy disciplines to be used.

Data were sorted and organized using SPSS version 25 (IBM

Table 2. A specific description of the comprehensive physiotherapy service sub-categories

Service	Description
Advice	Counseling, consultation, referral, and reassurance
Therapeutic exercise	Strengthening, eccentric, flexibility, balance, rehabilitation, general exercise, gait re-education, and muscle strengthening
Assistive [prophylactic] device	Taping Strapping/compression, strapping (fixation/supportive), preventive taping, treatment taping, pre-competition taping, post-competition taping, preventive kinesiotaping, and treatment kinesiotaping
Manual manipulative therapy	Manual Joint manipulation, joint mobilization, soft tissue mobilization, myofascial release techniques, trigger point therapy, muscle energy techniques, and pressure biofeedback
Therapeutic modalities	Traction Manual traction
	Massage Treatment massage, general, pre-event, inter-event, and recovery/regeneration
	Cryotherapy Ice pack and cryotherapy/cryocuff
	Heat Thermal collar and moist heat pack
	TENS/ICT Interferential current therapy and neuromuscular stimulation
	Laser Laser therapy
Shockwave	Shockwave therapy
Ultrasound	Ultrasound therapy

Co., Armonk, NY, USA). Descriptive statistical analyses of athletes and non-athletes were stated with date, number of reported injuries and number and percentage of physiotherapy modalities used for treatment. Additional data of athletes had number of athletes participating in five categories of paralympic sport.

RESULTS

Of 213 clients who visited the PVP for physiotherapy services, the details of 201 clients (94.8%) were recorded correctly in all categories. Of the 201 admitted clients, 51 were athletes (25.2%) and 150 were non-athletes (74.3%). The non-athlete category comprises coaches, Paralympic family, work force or staff.

1. Injury Incidence and Characteristics in Athletes and Non-athletes Who Utilized Physiotherapy Services

At the PyeongChang WPG, a total of 112 (54.4%) out of 567 athletes reported 142 injuries, amounting to an injury incidence rate (IR) of 20.9 per 1,000 athletes [1]. Among them, 51 athletes utilized the physiotherapy service. In the athletic population, chronic injuries were the most common (n = 29, 50.8%), followed by acute (n = 17, 34.4%) and recurrent injuries (n = 5, 19.8%) (Figure 1). This was also true for the non-athletic population, with chronic injuries (n = 71, 47.1%) being the most prevalent, followed by acute (n = 63, 40.6%) and recurrent injuries (n = 16, 11%).

The injured anatomical area was identified during consultation at the first visit. Ten athletes complained of injuries in multiple anatomical sites (19.6%). The most common ana-

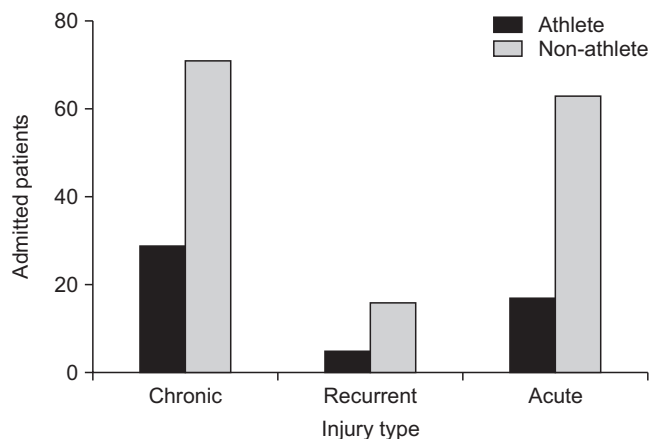


Figure 1. Injury categorization of admitted patients.

tomical areas with injuries in athletes were the shoulder and spine (n = 14), followed by the head/neck (n = 7) (Figure 2). A similar trend was seen in the injury surveillance study of the PyeongChang WPG, which documented the shoulder/arm/elbow area as the most frequently injured site [1]. In non-athlete clients, the spine was the most prevalent site of injury (n = 55), followed by the shoulder (n = 39) and head/neck (n = 21) (Figure 2). Thirty clients presented multiple anatomical sites of injury. The most frequently occurring type of injury for both athletes and non-athletes was muscle strain/tear (n = 95, 47.3%) (Figure 3).

2. Physiotherapy Service Admissions

Most of the athletes and non-athletes utilized the physiotherapy service during the competition period ($\mu = 35$, visits per day) (Figure 4). Thirty-two athletes (62.7%) and 55 non-athletes (36.6%) visited the physiotherapy service than once, with the

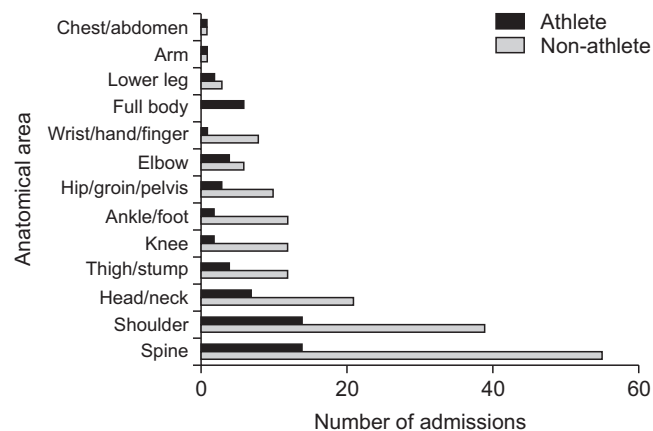


Figure 2. Number of admissions classified based on injured anatomical area.

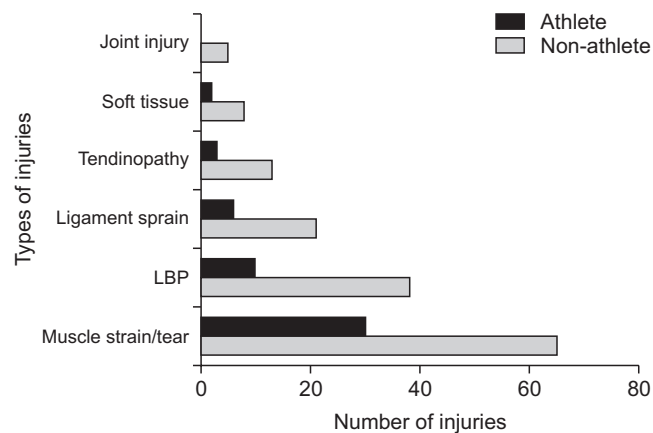


Figure 3. Physiotherapy modalities used. TENS/ICT, transcutaneous electrical nerve stimulation/interference current therapy.

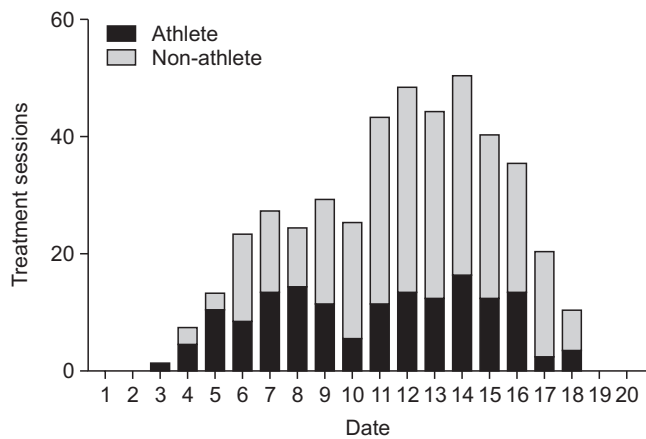


Figure 4. Treatment sessions sorted by date.

Table 3. Number of all participating athletes and admitted patients based on sport category

Category	Admitted	Total
Alpine skiing	15 (10.6)	141
Nordic skiing	14 (8.8)	159
Ice hockey	8 (5.9)	135
Wheelchair curling	8 (13.3)	60
Snowboard	6 (8.3)	72

Values are presented as number (%) or number only.

percentages indicating that athletes had higher follow-up visit rates than non-athletes. The highest rate of admission was seen among athletes of wheelchair curling (13.3%), followed by alpine skiing (10.6%), nordic skiing (8.8%), snowboard (8.3%), and ice hockey (5.9%) (Table 3).

Figure 4 shows that more athletes than non-athletes sought out physiotherapy services during the pre-competition period. During the pre-competition period, 49 of 147 treatment sessions occurred in athletes (33.3%), whereas 45 of 291 treatment sessions took place for in non-athletes (15.5%), showing a higher percentage of treatment sessions in athletes during this period.

3. Physiotherapy Services

The modalities used for physiotherapy service have been described in Figure 5. The three most utilized physiotherapeutic modalities for treatment sessions were manual (n = 230, 35.4%), transcutaneous electrical nerve stimulation/interference current therapy (TENS/ICT) (n = 82, 12.6%) and massage (n = 77, 11.8%). Heat therapy, cryotherapy, taping, therapeutic exercises, ultrasound and advice were also used for some cases. Laser, shockwave and traction were used in very few cases.

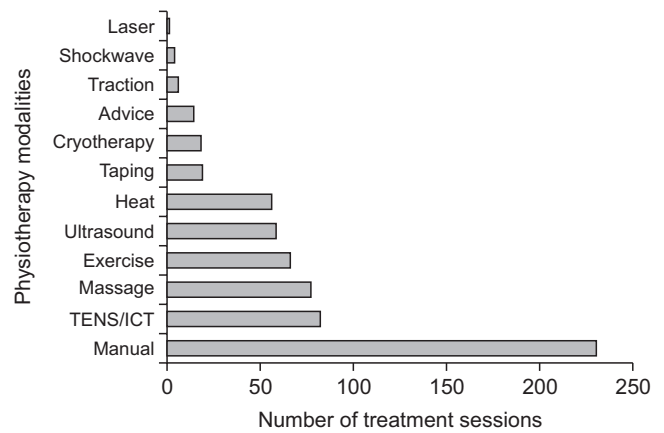


Figure 5. Types of injuries in non-athletes and athletes. LBP, low back pain.

DISCUSSION

The present investigation was proposed to highlight the injury incidence and characteristics, physiotherapy admissions and physiotherapy services provided during the PyeongChang 2018 WPG. The strategic challenges in planning physiotherapy services for a major event such as the Athens 2004 Summer PG are well documented [12], but specific guidelines and physiotherapy service operations designed to meet emerging challenges at the WPG have not been clearly delineated in current literature. Therefore, we have emphasized the need to provide physiotherapy service-related information, which will be crucial in developing systematic injury prevention and physiotherapy service programs and guidelines for the safety and optimal performance of athletes in upcoming WPG.

1. Injury Incidence and Characteristics in Athletes and Non-athletes Who Utilized Physiotherapy Services

Qualitative frequency analysis of injury type demonstrated that chronic injuries were 51% and 47% more prevalent than acute or recurrent injuries in athletes and non-athletes, respectively. This finding was consistent with a previous study showing a prevalence of 60% for chronic injuries in athletes at the 2010 Vancouver WPG [3], suggesting that increased levels of training over the years have caused more chronic injuries due to overuse [3]. Further studies to investigate effective prevention for injuries that occur during training and competition are needed.

During the PyeongChang WPG, the injury type for which both athletes and non-athletes were most frequently admitted

was muscle strain/tear (58.8% and 43.3%, respectively). This result differs from previously reported data, which indicated that soft tissue injuries were the most commonly occurring injury type among athletes with disabilities [13,14]. Our findings highlight the importance of warm-up and conditioning before training.

Anatomical injury site analysis revealed that the spine and shoulder areas were affected with equal frequency for athletes (54.9%), whereas for non-athletes, the frequencies of spine and shoulder area injuries were 36.7% and 26%, respectively. This result was similar with previous reports from the 2014 Sochi WPG (24.1%) and 2004 Athens WPG (22.2% for spine injury, 18.5% for shoulder injury), which showed that athletes experienced highest injury occurrence in the shoulder and spine [2,12]. As per existing literature, shoulder injuries occur more frequently in wheelchair athletes and spine injuries are seen more frequently in amputee athletes [7]. Shoulders are the primary weight-bearing joints in wheelchair athletes, possibly contributing to the high incidence of overuse injuries [8,15]. Moreover, upper and lower extremity amputees generally complain of spinal injuries due to compensation and muscular imbalance, which cause asymmetric movements in the limbs during training and competition [8,15]. Physiotherapy sessions should focus on strengthening of imbalanced muscles and stretching for flexibility, as well as manual therapy for relaxation of taut structures [7]. Thus, this study has identified areas at risk of injury in Paralympic athletes, and can inform injury prevention programs and policy change regarding athlete safety in future WPG.

2. Physiotherapy Admissions and Treatment Sessions

It has recently been reported that the Para snowboard athletes had the highest IR of injury in the PyeongChang WPG [1]. Interestingly, despite such high injury incidence in the Para snowboard athletes, we found that the admission status was

highest for wheelchair curling (13.3%), followed by alpine skiing (10.6%), nordic skiing (8.8%), snowboard (8.3%), and ice hockey (5.9%) (Table 3). We anticipated that Para snowboard athletes would demonstrate the most frequent physiotherapy admission and service utilization rates based on the incidence report, which found as many as 59 of 72 competing Para snowboard athletes with acute traumatic injuries (82%). Furthermore, the Para snowboard event was adopted as an individual WPG category for the first time at the PyeongChang WPG [1]. The underutilization of the physiotherapy admission service by the snowboard athletes may be due to the fact that the medical staff or physiotherapists of the respective national teams were employed for primary care, failing which participants were referred to the PyeongChang WPG polyclinic physiotherapy service. The number of admissions based on the type of impairment of athletes and sports category was also analyzed (Table 4). Athletes with more diverse impairment types participated in alpine and Nordic skiing, whereas athletes with spinal cord injury and limb deficiency primarily competed in wheelchair curling and Nordic skiing.

3. Physiotherapy Service

The physiotherapy treatment service analysis demonstrated that manual therapy (35.4%), including DR.YOUSTM instrument-assisted soft tissue mobilization, McKenzie mechanical diagnosis and treatment, joint mobilization and manipulation were most commonly utilized, followed by TENS/ICT, therapeutic massage, therapeutic exercise, ultrasound and heat therapy. For acute injuries, electrical modalities including TENS/ICT and ultrasound along with cryotherapy and icing were most frequently used to control inflammation, pain, and swelling. For the subacute and chronic conditions, manual therapy along with therapeutic massage, heat therapy and therapeutic exercise were used. Taping, traction, shockwave and laser therapy were also used occasionally for patients with

Table 4. Number of admissions based on type of impairment and sports category (N = 51)

	Wheelchair curling	Ice hockey	Nordic skiing	Alpine skiing	Snow board	Total
Spinal cord injury	8	4	1	0	0	13 (25.5)
Cerebral palsy	0	0	1	2	1	4 (7.8)
Limb deficiency	0	4	6	3	5	18 (35.3)
Vision impairment	0	0	1	5	0	6 (11.8)
Ambulatory	0	0	5	5	0	10 (19.6)
Total	8	8	14	15	6	51 (100.0)

Values are presented as number only or number (%).

localized pain or for injury prevention.

The outcome of the study confirms that our physiotherapy service was systemically delivered by the most qualified and experienced (elite) sports physiotherapy professionals with the highest educational credentials. Most professionals had final degrees of MS or PhD in the field of physical therapy profession and evidence-based approaches to maximize rapid recovery of acute and chronic injuries. The majority of the attending sports physiotherapy professionals are trained in manual sports therapy for national, international, and Olympic athletes. In the polyclinic, we closely collaborated with physiatrists, orthopedists, prosthetic and orthosis specialists, Korean medical doctors for acupuncture services, ophthalmologists, and dentists as a medical team.

4. Limitations

The EMR that was designed for the WPG was employed during the PyeongChang 2018 WPG without a prior validation process. As such, different injury surveillance and clinical characteristics of injured athletes between the WPG and Winter Olympic Games exist and may mandate for a modified EMR. Nevertheless, the present Olympic Games EMR system seems to be sufficient to address the fundamental injury surveillance and clinical characteristics of injured athletes as anticipated. However, a further study should be implemented to determine the validity and reliability of the EMR for WPG before we adapt the system as a standardized assessment.

CONCLUSIONS

The present investigation highlights the first injury surveillance and clinical characteristics of injured athletes and non-athletes and physiotherapy services provided during the PyeongChang 2018 WPG. We established the important clinical ramifications for sports injury management and preventive physiotherapy services to reduce the risk of sports injuries during WPG. The Olympic Games EMR system requires some degree of modification to incorporate the characteristics of Paralympic-participating athletes, which will provide invaluable information for future WPG projects.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

AUTHOR CONTRIBUTIONS

Conceptualization: HP, JHY. Data curation: JYC, JH, YHL, JHY. Formal analysis: HP, JYC, JHY. Investigation: JYC, JH, JHY. Methodology: HP, JYC, JHY. Project administration: HP, YHL, JHY. Resources: JYC, JH, YHL, JHY. Supervision: HP, JH, YHL, JHY. Validation: YHL, JHY. Visualization: HP, JHY. Writing - original draft: HP, JH, JHY. Writing - review & editing: HP, YHL, JHY.

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