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Sports-related injuries and illnesses in Paralympic athletes

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Sports-related injuries and illnesses in Paralympic athletes

Kristina Fagher



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DOCTORAL DISSERTATION

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December 6th, 2019 at 1.00 p.m.

Faculty opponent

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Physiology, Sahlgrenska Academy at Gothenburg University

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<p>Abstract: Elite sport poses the athlete at a risk for sustaining a sports-related injury or illness. As Paralympic athletes' performances and professionalism are steadily improving, there is an increasing need to understand the epidemiology of sports-related injuries and illnesses in Paralympic athletes. Therefore, the overall aim of this thesis was to describe and gain an in-depth understanding of the epidemiology of sports-related injuries and illnesses in Swedish Paralympic athletes, in order to assist the future development of evidence-based preventive measures adapted for Paralympic athletes.</p> <p>A methodological pluralism was used to assess sports-related injuries and illnesses in Paralympic athletes. First, 18 Swedish Paralympic athletes were interviewed to explore Paralympic athletes' perceptions of experiences of sports-related injuries. Based on this a study protocol for epidemiological research was structured. An eHealth application for self-reported data collection of injuries and illnesses adapted to Paralympic athletes was developed and evaluated in a pilot feasibility and usability study. Finally, data on retrospective period and point prevalence and weekly annual incidence of injuries, illnesses and athlete health were collected from 107 Swedish Paralympic athletes.</p> <p>The results revealed that Paralympic athletes' perceptions of their experiences of sports-related injuries are complex, and in several ways differ from able-bodied athletes. It was common with injuries related to the impairment, overuse symptoms, and a risk behaviour. Accordingly, all these features need to be considered in epidemiological research of Paralympic athletes, which was described in the study protocol. The method to collect self-reported eHealth based data was feasible and usable, but the content and technique of data collection needed to be adapted to Paralympic athletes' pre-existing impairments and prerequisites. Retrospective data revealed that the 1-year period prevalence of severe injuries was 31%, and the point prevalence of all injuries was 32%. More severe injuries were reported by young athletes, and athletes reporting pain and using analgesics. The behaviours 'continuing training injured' and 'feeling guilt when missing exercise' were associated with a severe injury. A history of a previous severe injury, having pain, using analgesics and being upset when unable to exercise were associated with a current injury. The period prevalence of severe illnesses was 14%, and 13% of the athletes reported a current illness. A previous severe illness, being female and a history of feeling anxious/depressed were associated with an ongoing illness.</p> <p>Prospective data collected weekly during 52 weeks showed that the annual incidence proportion for injury was 68% and for illness 77%. The injury incidence rate was 6.9/1000 hours of sport exposure and the illness incidence rate 9.3/1000 hours of sport exposure. Most injuries occurred during training and 34% were classified as severe. For 59% of the injuries the impairment was involved in the injury mechanism. An increased injury risk was observed among athletes in team sports, athletes with a previous severe injury and male athletes. The most common illness type was infection (84%). For 28% of the illnesses the impairment was involved in the cause of illness. Athletes in team sports and males with a previous severe illness had a higher illness risk.</p> <p>In conclusion, this thesis reveals that it is feasible and usable to collect self-reported eHealth-based data on sports-related injuries and illnesses in Paralympic athletes. Qualitative and quantitative data demonstrate that sports-related injuries and illnesses among Swedish Paralympic athletes are a concern affecting both the individual athlete as well as athlete availability. The results from this thesis can be used in the development of preventive measures targeting Paralympic athletes.</p>		
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Kristina Fagher



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“Sport has the power to change the world” (Nelson Mandela)

Table of Contents

Abstract	9
List of papers	11
Abbreviations	13
Preface	15
Context of this thesis	16
Introduction	17
The development of Para sport and Paralympic sport	17
The Para athlete and Paralympic athlete.....	18
Classification in Para sport	19
Paralympic sport and the Paralympic Games	20
Sports-related injuries and illnesses	22
Epidemiology of sports-related injuries	22
Epidemiology of sports-related illnesses	22
Surveillance of sports-related injuries and illnesses	23
Sports-related injuries and illnesses in Para sport and Paralympic sport	24
Epidemiology of sports-related injuries	24
Epidemiology of sports-related illnesses	26
Athlete health surveillance in Paralympic sport.....	27
Self-reported data on athlete health	28
eHealth technology	28
Rationale	31
Aims	33
Study design and overview	35
Paralympic athletes' perceptions of sports-related injuries (Study I)	37
Study design	37
Setting and recruitment.....	37
Data collection and analysis	38
Paralympic athletes' perceptions of experiences of injuries	38
Causes of sports-related injuries.....	39
Consequences of sports-related injuries	40

The possibilities of preventing sports-related injuries.....	41
The development of a study protocol (Study II)	43
Requirements.....	44
Definitions of injuries and illnesses	45
Survey design	45
Pilot feasibility and usability study (Study III).....	47
Study design	47
Setting and recruitment.....	48
Data collection and analysis	49
Feasibility and usability of athlete health monitoring	49
Quantitative feasibility and usability evaluation	49
Qualitative feasibility and usability evaluation	50
The Sports-Related Injury and Illness in Paralympic Sport Study (SRIIPSS)	
(Studies IV and V)	53
Study design	53
Setting and recruitment.....	53
Prevalence study (Study IV).....	54
Incidence study (Study V)	55
Categorisation (Studies IV and V).....	55
Statistical methods (Studies IV and V).....	56
Sports-related injuries, illnesses and health among Paralympic athletes	57
Athlete demographics (Studies IV and V).....	57
Prospective athlete health data (Study V).....	60
Injuries - prevalence and incidence	62
Associations and risk factors of injuries.....	64
Illnesses - prevalence and incidence.....	67
Associations and risk factors of illnesses	69
Ethical considerations	71
Discussion	73
General discussion.....	73
Sports-related injuries: type, severity and risk factors.....	73
Sports-related illnesses: type, severity and risk factors	78
Athlete health and well-being.....	81
Prevention and future research	82
What do these epidemiological data reveal?	82
Time for action, towards the development and implementation of preventive measures	83
Methodological considerations	87

Definitions and data collection	87
Trustworthiness and validity	87
Epidemiological data	88
Conclusions	89
Practical implications	91
Future perspectives	93
Populärvetenskaplig sammanfattning	95
Acknowledgements	97
References	100
Appendix	112

Abstract

Elite sport poses the athlete at a risk for sustaining a sports-related injury or illness. As Paralympic athletes' performances and professionalism are steadily improving, there is an increasing need to understand the epidemiology of sports-related injuries and illnesses in Paralympic athletes. Therefore, the overall aim of this thesis was to describe and gain an in-depth understanding of the epidemiology of sports-related injuries and illnesses in Swedish Paralympic athletes, in order to assist the future development of evidence-based preventive measures adapted for Paralympic athletes.

A methodological pluralism was used to assess sports-related injuries and illnesses in Paralympic athletes. First, 18 Swedish Paralympic athletes were interviewed to explore Paralympic athletes' perceptions of experiences of sports-related injuries. Based on this a study protocol for epidemiological research was structured. An eHealth application for self-reported data collection of injuries and illnesses adapted to Paralympic athletes was developed and evaluated in a pilot feasibility and usability study. Finally, data on retrospective period and point prevalence and weekly annual incidence of injuries, illnesses and athlete health were collected from 107 Swedish Paralympic athletes.

The results revealed that Paralympic athletes' perceptions of their experiences of sports-related injuries are complex, and in several ways differ from able-bodied athletes. It was common with injuries related to the impairment, overuse symptoms, and a risk behaviour. Accordingly, all these features need to be considered in epidemiological research of Paralympic athletes, which was described in the study protocol.

The method to collect self-reported eHealth based data was feasible and usable, but the content and technique of data collection needed to be adapted to Paralympic athletes' pre-existing impairments and prerequisites. Retrospective data revealed that the 1-year period prevalence of severe injuries was 31%, and the point prevalence of all injuries was 32%. More severe injuries were reported by young athletes, and athletes reporting pain and using analgesics. The behaviours 'continuing training injured' and 'feeling guilt when missing exercise' were associated with a severe injury. A history of a previous severe injury, having pain, using analgesics and being upset when unable to exercise were associated with a current injury. The period prevalence of severe illnesses was 14%, and 13% of the

athletes reported a current illness. A previous severe illness, being female and a history of feeling anxious/depressed were associated with an ongoing illness.

Prospective data collected weekly during 52 weeks showed that the annual incidence proportion for injury was 68% and for illness 77%. The injury incidence rate was 6.9/1000 hours of sport exposure and the illness incidence rate 9.3/1000 hours of sport exposure. Most injuries occurred during training and 34% were classified as severe. For 59% of the injuries the impairment was involved in the injury mechanism. An increased injury risk was observed among athletes in team sports, athletes with a previous severe injury and male athletes. The most common illness type was infection (84%). For 28% of the illnesses the impairment was involved in the cause of illness. Athletes in team sports and males with a previous severe illness had a higher illness risk.

In conclusion, this thesis reveals that it is feasible and usable to collect self-reported eHealth-based data on sports-related injuries and illnesses in Paralympic athletes. Qualitative and quantitative data demonstrate that sports-related injuries and illnesses among Swedish Paralympic athletes are a concern affecting both the individual athlete as well as athlete availability. The results from this thesis can be used in the development of preventive measures targeting Paralympic athletes.

List of papers

This thesis is based on the following papers, which will be referred to in the text by Roman numerals (I-V).

I. Fagher K, Forsberg A, Jacobsson J, Timpka T, Dahlström Ö, Lexell J. Paralympic athletes' perceptions of their experiences of sports-related injuries, risk factors and preventive possibilities. *Eur J Sport Sci.* 2016 Jun 22;1-10.

II. Fagher K, Jacobsson J, Timpka T, Dahlström Ö, Lexell J. The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS): A study protocol for a prospective longitudinal study. *BMC Sports Sci Med Rehabil.* 2016 Aug 30;8(1):28.

III. Fagher K, Jacobsson J, Timpka T, Dahlström Ö, Lexell J. An eHealth Application of Self-Reported Sports-Related Injuries and Illnesses in Paralympic Sport: Pilot Feasibility and Usability Study. *JMIR Hum Factors.* 2017 Nov 29;4(4):e30.

IV. Fagher K, Dahlström Ö, Jacobsson J, Timpka T, Lexell J. Prevalence of sports-related injuries and illnesses in Paralympic athletes. *PM & R.* 2019 Jul 1. doi: 10.1002/pmrj.12211 [Epub ahead of print].

V. Fagher K, Dahlström Ö, Jacobsson J, Timpka T, Lexell J. Injuries and illnesses in Swedish Paralympic athletes – a 52-week prospective study of incidence and risk factors. *Manuscript submitted for publication.*

Abbreviations

CI: Confidence interval

CP: Cerebral palsy

COREQ: Consolidated criteria for Reporting Qualitative research

CtES: Commitment to exercise scale

DG: Digestive/Gastrointestinal system

e.g.: for example

FITT: Fit between Individual, Task, and Technology framework

HR: Hazard ratio

ICD: International Statistical Classification of Disease and Related Health Problems

ICF: International Classification of Functioning, Disability and Health

II: Intellectual impairment

IB: Incidence burden

IR: Incidence rate

IP: Incidence proportion

IPC: International Paralympic Committee

IQR: Interquartile range

IT: Information Technology

MDN: Median

MS: Multiple sclerosis

NCT: National clinical trial identifier number

NSAID: Non-steroid anti-inflammatory drugs

PI: Physical impairment

PSSUQ: Post-Study System Usability Questionnaire

RPE: Rating of perceived exertion

ROM: Range of movement

SD: Standard deviation

SCI: Spinal cord injury

SIC: Subsequent injury categorisation

SP: Survival probability

SPIRIT: Standard Protocol Items: Recommendations for Interventional Trials

SRIIPS: Sports-related injuries and illnesses in Paralympic sport

SRIIPSS: The Sports-Related Injuries and Illnesses in Paralympic Sport Study

STROBE: Strengthening the reporting of observational studies in epidemiology

TLRI: Training load rank index

TRIPP: Translating Research into Injury Prevention Practice framework

UG: Urogenital/Gynaecological body system

VI: Visual impairment

WHO: World Health Organization

Preface

The human anatomy, physiology and behaviour have always fascinated me, and this was the reason why I chose to study Physiotherapy. Injuries and illnesses to the human body soon began to interest me even more. Understanding the mechanism, treatment, rehabilitation and prevention of such incidents became a crucial part in my early career.

My interest in research started when I was a bachelor exchange student at Melbourne University in 2009, which is a seat of learning that is striving for research excellence. After finishing my master degree in Sports Science and Medicine at Lund University, it was therefore a natural step for me to continue with the PhD-programme. I have also continued to work as a clinical Physiotherapist during my PhD studies.

My first encounter with Para sport was when I met my supervisor at a sports medicine seminar in 2013. Defending my thesis was then something far away in the future and looking back I have gained a lot of experience. After having interviewed 18 Paralympic athletes and then followed 107 Paralympic athletes for 52 weeks I have gained a deep and humble understanding of the health of Paralympic athletes. The clinical work with the athletes at competitions around the world has also provided me with an exceptional insight into on-field work within the Paralympic movement.

Most of all, I have gained experience of science during these years. Although both quantitative and qualitative approaches to research have unique merits, it is common that researchers are educated to uniquely align themselves to one school of thought. I am thus delighted that I had the opportunity to use them both in my PhD-project. I have also presented my research at several international conferences, attended courses, supervised students and lectured, which all have improved my research skills. I have met colleagues from all around the world, which has engaged me into ongoing and future collaborations.

I hope to continue combining research and clinical work in the future. One of my main goals is to continue understanding and developing safe and sound participation in sports. PhD-studies are an exciting and challenging journey in life, and my reflection is that the knowledge and experiences that I have gained from this thesis are in many ways unique.

Context of this thesis

This PhD-project was carried out within the Rehabilitation Medicine Research group, Faculty of Medicine, Lund University. The project has been pursued in direct dialogue with athletes and stakeholders at Parasport Sweden and the Swedish Paralympic Committee. Close collaboration has also been established with the Athletics Research Centre, Linköping University.

The knowledge about sports-related injuries and illnesses in Paralympic athletes was very limited at the start of this project in 2013. Together with my main supervisor, Professor Jan Lexell, I first conducted and published the critical review "*Sports-related injuries in athletes with disabilities*". I was then accepted as a PhD-student in 2014, and together with my supervisors Jan Lexell, Jenny Jacobsson, Örjan Dahlström and Toomas Timpka I designed the research project the Sports-Related Injury and Illness in Paralympic Sport Study (SRIIPSS). I first conducted a qualitative study where I interviewed 18 Swedish Paralympic athletes. This study was conducted in collaboration with Professor Anna Forsberg, Lund University. Based on this data a study protocol for longitudinal epidemiological data collection was developed and described. An eHealth application for data collection adapted to Paralympic athletes was then developed in collaboration with the software company Briteback. The eHealth application was later evaluated in a pilot feasibility and usability study. Finally, data on retrospective and point prevalence and weekly incidence of injuries, illnesses and athlete health were collected from 107 Swedish Paralympic athletes for 52 weeks.

Each week I followed up data, sent out closure forms and provided technical support to the athletes. I have developed the project plans, research questions, questionnaires, performed the data analyses and written the manuscripts for all the studies in this PhD-project, all in close collaboration with my supervisors. I have also written two applications to the Regional Ethical Review Board, attended ten PhD courses, presented my research at twelve scientific conferences, supervised two bachelor students, applied for external grants and lectured at the Faculty of Medicine, Lund University.

To the best of my knowledge, this is the first project with a longitudinal approach that has monitored Paralympics athletes' health over time, that has adapted the data collection methods to athletes with an impairment and has assessed the athletes' own perceptions of injuries. The results from this thesis thus serve as a starting point for a greater knowledge of sports-related injuries and illness in Paralympic athletes.

Introduction

Sport is today one of the largest movements in Sweden, with more than three million people being members of a sports club.¹ Participation in sport leads to several health benefits as it improves both physical and mental health. For example, it reduces the risk for cardiometabolic disease, fractures, dementia, mental illness and some cancer types.² Sport also supports the development of social skills during different periods in people's lifetime. Sport has therefore a great impact on the quality of life for the individual person as well as for our health economics, as it can prevent and treat disease.² The interest in sport and its associated benefits for persons with an impairment (Para sport) has also increased in the last few decades.³ Para sport is, however, still a young sporting discipline and despite the fact that sport poses the athlete at a risk for suffering a sports-related injury or illness few studies have assessed the burden of such incidents in Para sport.

The development of Para sport and Paralympic sport

The history of modern Para sport stretches back to the Second World War. Morbidity and mortality rates were high with many wounded soldiers and civilians, and a lack of independence, social exclusion and physical inactivity were common among individuals with an impairment. There were few treatment and rehabilitation protocols available at this time for individuals with a chronic impairment, and injuries such as severe spinal cord injury (SCI) were often fatal due to medical and psychological complications.^{4,5}

To improve health and well-being, the neurosurgeon Sir Ludwig Guttmann, innovatively recognised sport as a tool to restore physical strength, cardiorespiratory fitness, psychological health and social inclusion. Consequently, organised sport was implemented as rehabilitation at Stoke Mandeville Hospital, England, near to the end of the Second World War, and Guttmann described sport "as a tool to enable self-worth, connection and meaning". The popularity of sport grew fast and on the same day as the London Summer Olympics 1948, the first Stoke Mandeville Games were organised.^{4,5}

The event developed quickly, and in 1960 the first official Paralympic Games were held in Rome, in parallel to the Olympic Games.³ The first Winter Paralympic Games were then held in Örnsköldsvik, Sweden in 1976. Since 1988, the

Paralympic Games have been held in the same venues as the Olympic Games, and one year later the International Paralympic Committee (IPC) was established.³ The 2012 Paralympic Games in London brought about a major change in attitudes, about Para sport, in terms of performances, participation, social inclusion and legacy.⁶

The terminology disability sport was commonly used for describing sports for individuals with an impairment when this project was initiated. However, during the past years the terminology has changed to Para sport and Paralympic sport. More specifically, Para sport refers to sports for persons with an impairment at all levels whereas Paralympic sport is elite sports that is contested at the Paralympic Games. Similarly, Para athlete is the term for all sportspersons with an impairment, and Paralympic athletes indicates that the athlete is at a level to be able to compete at the Paralympic Games.⁴

The Para athlete and Paralympic athlete

What characterises Para and Paralympic athletes is the existing impairment, whether it is physical, visual or intellectual.⁶ According to the World Health Organization (WHO) the definition of an impairment is: “a problem in body function or structure”.⁷ Depending on the nature of the impairment the athlete may also have a greater risk for suffering from secondary health complaints, early age related health conditions, health risk behaviours and higher rates of premature death.⁷

For example, individuals with SCI may be predisposed to infections, skin breakdown, osteoporosis, contractures, spasticity, pain, depression, fatigue, hyperthermia, bowel dysfunction and cardiorespiratory insufficiency.⁸⁻¹⁰ Several of these health complaints may also be present in individuals with other neurological diseases such as multiple sclerosis (MS), stroke, traumatic brain injury and cerebral palsy (CP).¹¹⁻¹³ Individuals with more rare diagnosis such as Becker muscular dystrophy, Duchenne muscular dystrophy and Friedreich’s ataxia may in addition suffer from health complaints such as heart arrhythmias and a malformed skeleton.^{14,15} Joint contractures and muscle fibrosis are present in individuals with arthrogryposis, which often leads to musculoskeletal problems.¹⁵ The biomechanics is often altered among individuals with limb deficiency, which may cause stress fractures, tendinopathies and osteoarthritis. Also stump conditions such as phantom pain, rashes and heterotopic ossification are common. Furthermore, alterations in the vascular physiology may induce cardiac disease.^{16,17}

Individuals with visual impairment have in general a greater risk for morbidity and unintentional injury and illness such as cardiometabolic disease, depression, falls and fractures.¹⁸⁻²⁰ Other health conditions that are sometimes present with diagnoses related to visual impairments are joint problems, obesity, hearing impairment, diabetes and development delay.¹⁵ Individuals with intellectual impairments have more often a poor mental and physical health compared to the rest of population.

Higher rates of health complaints, such as gastrointestinal disease, obesity, epilepsy, cardiometabolic disease and mental illness have been reported.²¹ Altogether, the Para athlete and Paralympic athlete have other conditions due to the impairment and the sometimes associated health complaints when entering sports in comparison with an able-bodied athlete, which possibly could affect training behaviour as well as the epidemiology and consequences of sports-related injuries and illnesses.

Classification in Para sport

To be eligible to compete in Para sport, the athlete must fit into one of the ten impairment categories in the IPC classification system, adopted as described in the WHO's International Classification of Functioning, Disability and Health (ICF) (Table 1).²² In this system the athletes are classified by an independent classifier, by the degree of activity limitation resulting from their impairment and its impact on performing the activities of a specific sport. The main goal is to group athletes into classes, the aim of which is to ensure that the impact of the athletes' impairment is minimised and sporting excellence decides which athlete wins.^{4 23}

Table 1. The ten eligible impairments for participation in Para sport.

<i>Impaired muscle power</i>	Reduced force generated by muscles, e.g. (for example) spinal cord injury, spina bifida, polio
<i>Impaired passive range of movement</i>	Reduced range of movement in one or more joint permanently, e.g. arthrogyrosis
<i>Limb deficiency</i>	Total or partial absence of bones or joints, e.g. accident, bone cancer, dysmelia
<i>Leg length difference</i>	Bone shortening in one leg, e.g. congenital deficiency, trauma.
<i>Short stature</i>	Reduced standing height due to abnormal dimensions of bones, e.g. achondroplasia, growth hormone dysfunction
<i>Hypertonia</i>	Abnormal increase in muscle tension and a reduced ability of a muscle to stretch due to a neurological condition, e.g. cerebral palsy, brain injury, multiple sclerosis
<i>Ataxia</i>	Lack of co-ordination of muscle movements due to a neurological condition, e.g. cerebral palsy, brain injury, multiple sclerosis
<i>Athetosis</i>	Unbalanced, involuntary movements and a difficulty in maintaining a symmetrical posture due to a neurological condition, e.g. cerebral palsy, brain injury, multiple sclerosis
<i>Visual impairment</i>	Defect of the eye structure, optical nerves, optical pathways or visual cortex, e.g. cataract, glaucoma, retinitis pigmentosa
<i>Intellectual impairment</i>	Limitations in intellectual functioning and adaptive behaviour as expressed in conceptual, social and practical adaptive skills that originates before the age of 18

In order to structure the data, research studies from the Paralympic Games have categorised athletes into groups with similar impairments²⁴, which has also been conducted in this project. Subsequently, the athletes were categorised into: athletes with visual impairment (VI), athletes with intellectual impairment (II), and athletes with the following physical impairments (PI); SCI, limb deficiency (amputation, dysmelia and congenital deformity), central neurological impairment (CP, MS, traumatic brain injury, stroke and other neurological impairments) and les autres

(e.g. Friedreich's ataxia, Duchenne muscular dystrophy, polio).²⁵ In this project, the athletes were also grouped into being ambulatory (walking) or a wheelchair user.

Paralympic sport and the Paralympic Games

The interest of Paralympic sport has continued to grow during the last years, and the Paralympic Games are nowadays one of the largest sport events in the world. The number of participating athletes and the number of international competitions are increasing each year, and Paralympic athletes' performances and professionalism are also steadily being improved.^{26,27} For example, new world records were set in 14 of 20 of the 100 meter athletic sprint races during the Paralympic Games in Rio 2016. It is also noteworthy that the visually impaired 1500 meter Paralympic Champion ran faster than the 1500 meter Olympic Champion in 2016.²⁸ With improved technology and more focus on performance enhancement strategies it has been hypothesised that Paralympic athletes' performances will continue to increase even more during the coming decade.^{29,30}

Twenty two summer sports and six winter sports were included in the Paralympic Programme at the time of the data collection for this thesis (Figure 1). Sailing and football-7-a-side have been removed from the coming Paralympic cycle while badminton and taekwondo have been added.²⁶



Figure 1. The Paralympic summer and winter sports at the start of this project.

Most sports are similar to those in the Olympic programme. However, other equipment such as wheelchairs, sledges and running blades are, for example, used in several of the sports. Another difference compared to able-bodied sports are that

some athletes, for example with VI or severe PI, are dependent on a guide in activities such as running, jumping or moving around the court.²⁶ Most sports allow athletes from different impairment categories to compete, and the athletes are divided into classes within the sport depending on their activity limitation (Figure 2).



Figure 2. Athletes with different impairments competing in some of the Paralympic sports. Photo: THE SWEDISH PARALYMPIC COMMITTEE

In some sports, such as wheelchair basketball, all athletes compete together but athletes with different impairments are classified into point classes on the court based on their functional ability. Sports such as goalball, football 5-a-side and judo are solely for athletes with visual impairment and boccia is only for athletes with impaired motor skills.^{23,26} The sports are either individual or team sports as for able-bodied sports, which may influence training behaviour and the type of and risks for certain injuries and illnesses.³¹ The following Paralympic sports are team sports: football 5-a-side, football 7-a-side, goalball, sitting volleyball, wheelchair basketball, wheelchair rugby, para ice hockey and wheelchair curling.

Sports-related injuries and illnesses

Epidemiology of sports-related injuries

In addition to the already existing impairment, the Paralympic athlete is, like all elite athletes, exposed to the risk of suffering a sports-related injury.⁸ Despite all the positive health effects of sports, sports-related injuries are a concern in most elite sports settings, as they may lead to morbidity, an ending of the sport career, long-term disability and mortality.³²⁻³⁴ Sports-related injuries are also a cost and burden for society. It has been estimated that 112 000 persons are injured during sports participation and seek health care in Sweden each year.³⁵ Furthermore, 10-19% of all injuries in the Scandinavian emergency rooms are related to sports.^{36,37} However, there are no data on the overall sports injury burden in Sweden. In the USA as many as 8.6 million sports injuries are reported each year³⁸, and recent data has shown that there are global tendencies of an increasing annual rate of hospital-treated sport injuries in western countries.^{39,40}

Traumatic sports injuries, such as concussion, ligament sprains, joint distortions or fractures may, for example, lead to brain damage, osteoarthritis and chronic pain for the individual athlete.^{39,41} Catastrophic injuries leading to spinal injuries and death are less common, but still a concern in several sports.⁴² Overuse-related injuries may also cause several health complaints such as inflammation, degeneration and chronic pain.⁴³ Recent research has suggested that the risks associated with sports-related injuries and its consequences are unacceptable when evaluated against acceptable criteria from occupational health.⁴⁴

In addition, an injury generally leads to time loss from sport. A training interruption due to an injury decreases physical output and resilience in training and competition, which affects sports performance both for the individual athlete as well for a team.⁴⁵ Remaining free from injury has thus become an important component of successful sports performance.⁴⁶

Epidemiology of sports-related illnesses

Sports-related illnesses have also received more focus during the last decade. However, studies concerning the epidemiology of sports-related illnesses are still underrepresented in comparison to sports injury epidemiology. There are only a few studies that have specifically assessed prospectively the burden of illnesses over time. This is a concern as several sports-related illnesses are serious conditions.³² Potentially serious illnesses that can be related to participation in sports are; heart arrhythmias, exercise-induced bronchospasm, gastrointestinal bleeding, viral myocarditis, splenomegaly, heatstroke, exercise-associated collapse and hyponatremia.^{32,47} Some events, such as sudden cardiac arrest, seem to be more

common among athletes compared to non-athletes, because of an increased risk associated with strenuous exercise.⁴⁸ Other illnesses that commonly are reported among athletes are upper respiratory tract infections and mental illness.^{49,50}

Surveillance of sports-related injuries and illnesses

To establish the extent, aetiology and risk factors for sports-related injuries, injury surveillance has been described and implemented in several able-bodied sports, such as athletics, football, tennis, cricket, rugby, aquatic sport and horse racing.⁵¹⁻⁵⁸ Based on such epidemiological data, specific prevention programmes with the aim of reducing injuries have been implemented.⁵⁹⁻⁶¹ Successful injury prevention programmes have, for example been implemented and evaluated in football and handball⁶²⁻⁶⁴, with a recent meta-analysis showing that a majority of anterior cruciate ligament injuries can be prevented by injury prevention programmes.⁶⁵

To structure data and improve the quality and evidence of sports injury prevention research, 'the sequence of prevention' was described by van Mechelen et al. 1992. In this four step model (i) the extent and severity of the problem is first outlined through injury surveillance, (ii) the aetiology, mechanisms and risk factors are then identified, (iii) preventive measures are introduced, and (iv) the effectiveness of prevention is measured by repeating the first step (Figure 3).⁶¹

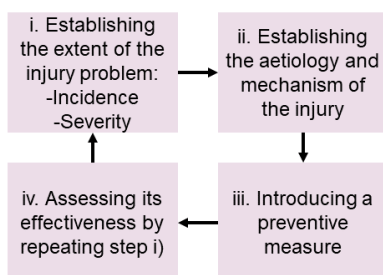


Figure 3. 'The sequence of sports injury prevention' by van Mechelen et al. 1992.

To obtain valid results a surveillance system should be sufficiently sensitive to answer the questions; i) how many; ii) how often, iii) how long; and iv) how serious? It has also been suggested that the sensitivity of a surveillance system largely depends on the definitions applied.⁶⁶ Another crucial aspect in the design of sports injury surveillance systems and prevention programmes is to understand and include items related to sport specific causes and risk factors.^{61,67} Moreover, it has been emphasised that high quality surveillance systems should be designed to target the specified population and expose athletes, coaches and staff to minimal workload.⁶⁸ However, understanding the causes and mechanisms of injuries may be challenging, as sports injuries often are complex with a multifactorial nature, and external and

internal risk factors that may interact with each other (Figure 4).^{31,59} Dynamic factors, for example, time of injury, sport situation and forces may also influence the risk.³¹

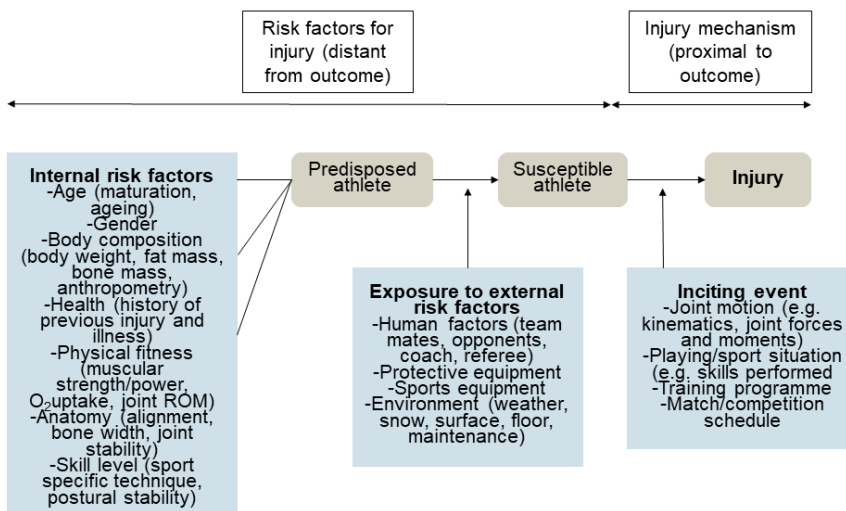


Figure 4. A dynamic, multifactorial model of sports injury aetiology, adapted from Meeuwisse (1994) and Bahr & Holme (2003). Internal risk factors such as age, gender and physical fitness may interact with external risk factors such as human factors, the environment and equipment at the same time that uncontrollable factors in the inciting event can affect the injury mechanism.

Recent research has also shown that psychological traits and athlete behaviour may increase the risk for sports-related injuries.^{60,69,70} Subsequently, a surveillance system should be adapted to multifactorial risk factors, the specific sport context and the athletes of interest.

Sports illness surveillance is less common, although data collection methods and definitions have been described in for example athletics and swimming.^{52,55}

Sports-related injuries and illnesses in Para sport and Paralympic sport

Epidemiology of sports-related injuries

Few studies concerning sports injury epidemiology in Para sport and Paralympic sport had been carried out when this project started, and there are still no evidence-based prevention programmes.⁷¹ Existing research shows that the overall rates of injuries are considerably high, with a trend towards more injuries among Paralympic

athletes compared to able-bodied athletes.^{33,72-77} It has been suggested that the insertion of new sports, poor environment and increases in training loads have contributed to this.^{72,74,76}

Table 2. Studies of sports-related injuries among Paralympic athletes or Para elite athletes.

Author, year	Setting, population	Method, injury definition (yes/no), outcome measures	Main results
Derman et al. 2019	Paralympics 2018, 567 athletes	Prospective, y IR, IP	IR: 20.9/1000 athlete days, IP: 19.8%
Fagher et al. 2019	Great Britain Judo Grand Prix, 45 athletes	Retrospective, y, 1-year prevalence	Prevalence 84 %
Derman et al. 2018	Paralympics 2016, 3657 athletes	Prospective, y IR, IP	IR: 10/athlete days, IP: 12.1%
Wieczorek et al. 2017	21 Polish amputee soccer players	Prospective, y, number of injuries, IP	16 injuries, IP: 38%
Derman et al. 2016	Paralympics 2014, 547 athletes	Prospective, y IR, IP	IR: 26.5/1000 athlete days, IP: 24.5%
Blauwet et al. 2016	Paralympics 2012, 977 athletic athletes	Prospective, y IR, IP	IR: 22.1/1000 athlete days, IP: 18.4%
Webborn et al. 2016	Paralympics 2012, 977 football players	Prospective, y IR, IP	IR: 22.4/1000 athlete days, IP: 31.4%
Willick et al. 2016	Paralympics 2012, 977 weight lifting athletes	Prospective, y IR, IP	IR: 12.7/1000 athlete days, IP: 12%
Bauerfind et al. 2015	9 months, 14 Polish wheelchair rugby athletes	Prospective, n, IR	IR: 0.3/training day
Willick et al. 2013	Paralympics 2012, 3565 athletes	Prospective, y IR, IP	IR: 33.3/1000 athlete days, IP: 23.3%
Gawronski et al. 2013	Paralympics 2008, 2012, 91 Polish athletes	Prospective, y IR, IP	IR: 15-30/1000 athlete days, IP: 31-54.9%
Magno e Silva et al. 2013 a	5 competitions 2004-2008, 28 Brazilian swimmers	Prospective, y IR, IP	IR: 0.3/competition, IP: 64%
Magno e Silva et al. 2013 b	5 competitions 2004-2008, 13 Brazilian football players	Prospective, y, IR, IP	IR: 0.12/competition, IP; 86%
Magno e Silva et al. 2013 c	5 competitions 2004-2008, 40 Brazilian athletic athletes	Prospective, y, IR, IP	IR: 0.39/competition, IP: 78%
Chung et al. 2012	3 years, 14 Hong Kong wheelchair fencers	Prospective, y, IR	IR: 3.9/1000 hours
Webborn et al. 2012	Paralympics 2010, 505 athletes	Prospective, y, IP	IP: 23.8%
Patatoukas et al. 2011	National competition, 139 Greek athletes	Retrospective, y, number of injuries	178 injuries
Athanasopoulos et al. 2009	Paralympics 2004, 3806 athletes	Retrospective, n, prevalence	Prevalence: 3%
Webborn et al. 2006	Paralympics 2002, 416 athletes	Prospective, n, IP	IP: 9%
Sobiecka et al. 2005	Paralympics 2000, 114 Polish athletes	Cross-sectional, n, number of injuries	125 injuries
Ferrara et al. 2000	World Games 1990, 220 athletes	Cross-sectional, y, number of injures	1037 injuries
Nyland et al. 2000	Paralympics 1996, 304 American athletes	Cross-sectional, y, number of injuries	254 injuries
Taylor & Williams 1995	1 year, 53 British wheelchair racers	Retrospective, y, prevalence	Prevalence: 72%
Ferrara et al. 1992	National competition 1989, 426 American athletes	Retrospective, y, prevalence	Prevalence: 32%
Ferrara et al. 1992	National competition 1989, 68 American skiers	Cross-sectional, y, number of injuries	100 injuries
Burnham et al. 1991	Paralympics 1988, 151 Canadian athletes	Retrospective, n, number of injuries	84 injuries
Ferrara & Davis 1990	1 year, 19 American wheelchair athletes	Retrospective, y, number of injuries	50 injuries

Existing retrospective studies have reported a prevalence ranging from 3-84% (Table 2). Prospective studies have reported incidence proportions (IP) ranging from 9% to 78%, and inconsistent incidence rates (IR) varying from 0.12 injuries/competition to 33.3 injuries/athlete days. Only one previous study have assessed IR based on actual exposure to sport (Table 2). It is also notable that three deaths among Paralympic athletes have been reported during major championships, 2016, 2017 and 2019.⁷⁸

Most studies have been conducted during competitions, and at the start of this project there had not been any studies with a prospective design where the burden of injuries during athletes' training and competition periods was assessed weekly (Table 2). Moreover, many of the existing studies had not described injury definitions in detail, with several studies only reporting injuries related to trauma and medical attention^{71,79}, and several studies lacked information about severity, mechanisms and risk factors for injuries.^{71,80}

Furthermore, few studies have assessed impairment-related mechanisms and risk factors for sports-related injuries. It could be hypothesised that sports-related injuries among Paralympic athletes may differ from able-bodied athletes due to the pre-existing impairment and sometimes associated health complaints, and it has been suggested the impairment itself should be considered as an intrinsic risk factor for injury.⁸¹ The use of other external equipment, such as wheelchairs and prosthesis, may also expose the athletes to other risks. For example, it is well known that shoulder complaints are common among wheelchair users in general.⁸² Research concerning risk factors such as training load and athlete behaviour is also very limited.^{71,83} Altogether, there is still a major lack of evidence-based data concerning the epidemiology of sports-related injuries in Paralympic athletes. Moreover, few studies have assessed the consequences of sports-related injuries in Paralympic athletes. For example, it could be hypothesised that a wheelchair athlete that suffer from a shoulder injury will be affected differently in comparison to an able-bodied athlete that suffer from a shoulder injury.

Epidemiology of sports-related illnesses

Few studies have described the epidemiology of sports-related illness in Para sport and Paralympic sport, while there is no study that has assessed the burden of illnesses outside competition (Table 3). The existing studies from the Paralympic Games 2012, 2014, 2016 and 2018 have shown a considerably greater proportion of illness compared to the Olympic Games.^{33,77,83-87} The overall IR has varied from 10.0-18.7 illnesses/athlete days (Table 3). The most common reported illnesses are in the respiratory system.⁸⁴⁻⁸⁷

Existing studies have emphasised the importance of further research that examines reasons for the high illness incidence in Paralympic athletes compared to Olympic

athletes.⁸⁵ Moreover, repeated longitudinal illness surveillance outside the Paralympic Games has been recommended to indicate which areas of health require attention and intervention.⁸⁷

Table 3. Studies of sports-related illnesses among Paralympic athletes or Para elite athletes.

Author, year	Setting, population	Methods, illness definition (y/n), outcome measures	Main results
Derman et al. 2019	Paralympic Games 2018, 567 athletes	Prospective, y, IR, IB, IP	IR: 12.8/1000 days, IB: 6.8 days lost/1000 days, IP: 13.6%
Groebler et al. 2019	Para athletics WC 2015, 1225 athletes	Retrospective, y, IR, IP	IR: 2.9/1000 days, IP: 3.8%
Derman et al. 2018	Paralympic Games 2016, 3657 athletes	Prospective, y, IR, IP	IR: 10.0/1000 days, IP: 12.4%
Derman et al. 2016	Paralympic Games 2014, 547 athletes	Prospective, y, IR, IP	IR: 18.7/1000 days, IP: 17.4%
Schwellnus et al. 2013	Paralympic Games 2012, 3565 athletes	Prospective, y, IR, IP	IR: 13.2/1000 days, IP: 14.2%
Gawronski et al. 2013	Paralympics 2008-2012, 91 Polish athletes	Prospective, y, IR, IP	IR: 31-46/1000 athlete days, IP: 31-55%
Burnham et al. 1991	Paralympics 1988, 151 athletes	Retrospective, n, number of injuries	83 illnesses

Athlete health surveillance in Paralympic sport

The IPC has successfully and systematically conducted injury and illness surveillance during the Paralympic Games since 2012.²⁴ However, there is still a lack of longitudinal prospective data following Paralympic athletes over time, both during training and competition periods.^{71,79,80} To allow specific analyses of injuries and illnesses regular collection of data over time are necessary in order to find complex patterns and risk factors behind the mechanisms of both injuries and illnesses.⁵¹ A need to improve the understanding of the major medical issues in each impairment group has also been emphasised.⁸ Prospective long-term data following athletes during both training and competition periods, as well as data on sport- and impairment specific risk factors are thus needed.

Moreover, there is still a lack of data collection methods, injury and illness definitions and surveillance systems that are adapted for Paralympic athletes, which have resulted in limited accessibility and validity.⁸⁸ Given the fact that Paralympic athletes already have an impairment, it could be hypothesised that injury and illness definitions, questionnaires and data collection methods in Para sports medicine epidemiology need to be adapted to the athletes' impairment and possible impairment-related health conditions. One of the key factors that should be considered when designing a surveillance system is that it is feasible for the athlete population.⁸⁹ To improve the quality of athlete health surveillance, recent research has shown that it is beneficial to include athletes' perspectives of athlete health when designing and implementing a surveillance measure.⁶⁸ There were no studies that had described Paralympic athletes' own perceptions of sports-related injuries when this project started.

Self-reported data on athlete health

Several recently conducted studies have shown that self-report measures are sensitive and reliable tools for monitoring athletes' health, which has led to a trend of using self-reports in sports medicine research.^{51,90-93} Self-reports are cost effective and can be used in different contexts, for example, in sports with a wide geographical distribution and in sports with a lack of medical staff during training.⁹² Recent research has also shown that medical staff frequently underestimated and missed reporting injuries compared to athletes themselves due to a busy schedule, different staff, misclassification of events and barriers in communication and logistics.^{94,95} Moreover, there is a growing evidence showing that gradually developing overuse injuries are common in several sports^{51,96}, and it has been demonstrated that athletes' self-reports better capture overuse-related conditions compared to data that are collected by medical staff.^{91,94} Recent research has also shown that self-reports measure training load with a greater level of sensitivity and consistency compared to objective measures.⁹⁰

Subsequently, evidence-based longitudinal athlete health surveillance based on self-reports have been implemented and used in several sports for able-bodied athletes.^{51,92,93,95} However, there is a concern that the existing surveillance systems have not been adapted for athletes with an impairment. For example, questionnaires and response alternatives do not include impairment-related conditions such as spasticity and stump conditions. Nor has the technology been adapted, for example, for athletes with visual impairment.⁸⁸ There is thus a need to develop and evaluate a surveillance system based on self-reports that are specifically adapted to athletes with an impairment. This would allow us to obtain a comprehensive epidemiological data collection of Para and Paralympic athletes' health.

eHealth technology

eHealth is the use of information and communication technologies for health.^{97,98} eHealth is a growing field in medical informatics and public health, and it has been estimated that eHealth has the potential to play a major role in the development of an improved global health.⁹⁸

In Sweden, eHealth has already been implemented within the healthcare sector with the aim of using digital tools to achieve and maintain a good level of physical, mental and social well-being (Figure 5).⁹⁹ Moreover, there is a growing scientific and commercial interest in health apps, and medical monitoring and alarms.⁹⁹

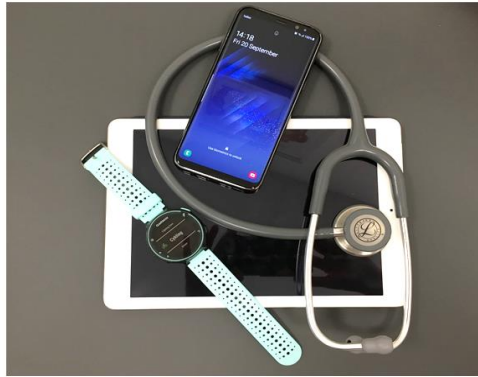


Figure 5. There is a growing interest of using eHealth within the Swedish healthcare sector to achieve and maintain a good level of physical, mental and social well-being. Photo: Kristina Fagher

eHealth has also been used in studies in sports medicine epidemiology to communicate data on able-bodied athletes' health.^{51,95} Through its digital technique, relatively low cost and easy access, eHealth empowers most individuals to communicate health outcomes and the need for healthcare, and thereby improving the knowledge, reach and equity of medicine.^{97,100,101} Another advantage is that eHealth allows individuals to provide real time data immediately and securely.¹⁰¹ The Swedish Agency for eHealth has also suggested in a recent report that eHealth has the beneficial potential of empowering health efficiency and autonomy for persons with a disability due to more accessible opportunities for communicating one's health.⁹⁹ No study had developed, adapted, evaluated and implemented an eHealth-based intervention to assess Paralympic athletes' self-reported health when this project started.

Rationale

There was limited knowledge of the epidemiology of sports-related injuries and illnesses in Paralympic athletes at the start of this project. The few existing epidemiological studies were of a variable quality, lacking definitions of injuries and illnesses, and risk factors based on sports exposure and related to the impairment had not been explored. Most studies had only been conducted during short competition periods, and data collection methods had not been adapted for Para athletes and Paralympic athletes.

Longitudinal prospective data are needed to increase our knowledge of the epidemiology of sports-related injuries and illnesses among Paralympic athletes. In order to collect such data there is, however, a need to develop methods that target the specific population and outcomes of interest. One suitable method is eHealth-based athlete monitoring using self-reports, but this has never been applied and evaluated in the Paralympic population. Recent research has also highlighted the importance of including athletes' perceptions to improve the feasibility and usability of such methods and future preventive measures. Furthermore, there is growing evidence that other health parameters such as athlete behaviour, pain, sleep and well-being may contribute to the development of injury and illness. No studies had assessed the association of these health parameters among Paralympic athletes with sports-related injuries and illnesses at the start of this project.

An improved understanding of the epidemiology of sports-related injuries and illnesses in Paralympic athletes will have direct implications for the development and implementation of preventive measures of injuries and illnesses, and thus in the long-term allow safe sport participation and maximise Paralympic athletes' performance.

Aims

Overall aim

The overall aim of this thesis was to describe and gain an in-depth understanding of the epidemiology of sports-related injuries and illnesses in Paralympic athletes, in order to assist the future development of evidence-based preventive measures adapted for Paralympic athletes.

Specific aims

The specific aims of this thesis were:

- I. To explore Paralympic athletes' perceptions of their experiences of sports-related injuries, risk factors and preventive possibilities.
- II. To present a protocol for a prospective longitudinal study: The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS).
- III. To develop an adapted eHealth based application that allows self-report data to be collected from Paralympic athletes.
- IV. To perform a 4-week pilot study and evaluate the monitoring feasibility and system usability of a novel eHealth application for self-reported sports-related injuries and illnesses, and report preliminary data on sports-related injuries and illnesses.
- V. To describe among Swedish Paralympic athletes the 1-year retrospective period prevalence of severe sports-related injuries and illnesses, the point prevalence of all sports-related injuries and illnesses, and to examine differences in prevalence proportions between athletes with different impairments, behaviours and sport characteristics.
- VI. To describe the annual incidence, type and severity of injuries and illnesses among Swedish Paralympic athletes and to assess risk factors based on sports exposure.

Study design and overview

This project started with a review article in 2013, in which it was shown that there was a paucity of literature concerning sports-related injuries and illnesses in Paralympic sport (SRIIPS). Five studies were thus conducted in a step-wise progression in order to gain greater knowledge and identify possible preventive measures for SRIIPS. First, to obtain an understanding of sports-related injuries in Paralympic sport a qualitative study concerning Paralympic athletes’ own perception of experiences was conducted. Based on these results, a study protocol was formulated to establish and improve the epidemiological data collection of SRIIPS. Thereafter, an eHealth application for data collection of epidemiological data was developed based on the two previous studies, and qualitatively evaluated in a feasibility and usability study. Finally, the Sports-Related Injury and Illness in Paralympic Sport Study (SRIIPSS) was implemented. A cross-sectional study was first conducted to assess athlete demographics, athlete behaviour and to estimate the prevalence of SRIIPS. Thereafter, a 52-week prospective study was conducted to examine the incidence, severity and risk factors of SRIIPS. The studies included in this thesis are all summarised in Figure 6 and Table 4. In the following chapters, the methods and results are then presented for each study.

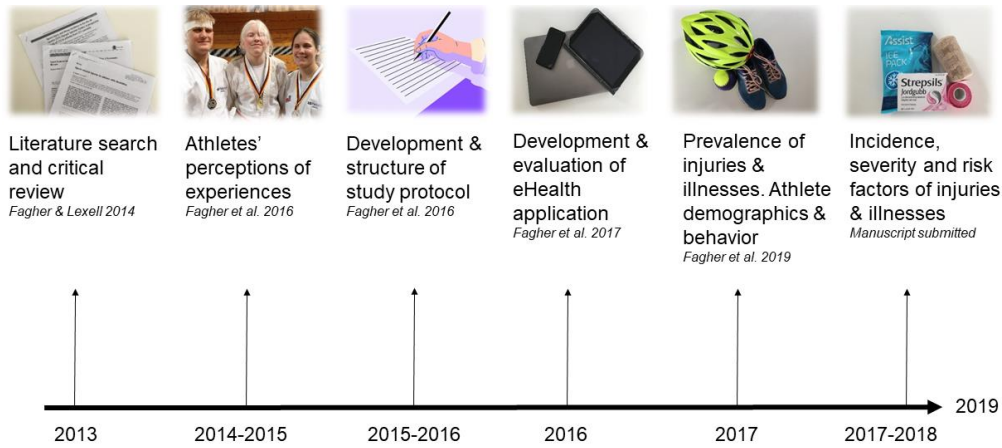


Figure 6. Timeline of the development and progression of the studies in this thesis. Photo: Kristina Fagher

Table 4. Overview of the five studies in this thesis.

Study I.	
Aim	To explore Paralympic athletes' perceptions of their experiences of sports-related injuries, risk factors and preventive possibilities
Study design	Qualitative study
Setting	18 Swedish Paralympic athletes with PI, VI and II
Data collection	Semi-structured interviews
Analysis	Phenomenography
Study II.	
Aim	To present a study protocol for a prospective longitudinal study: The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS)
Study design	An argument-based method for investigation of design problems was used to structure a study protocol
Setting	Not applicable
Data collection	Synthesis of previous research, athletes' own perceptions and the structure of Paralympic sport
Analysis	Design argumentation
Study III.	
Aim	To perform a 4-week pilot study and (1) evaluate the monitoring feasibility and system usability of a novel eHealth application for self-reported SRIIPS and (2) report preliminary data on SRIIPS
Study design	Prospective pilot feasibility and usability study
Setting	28 Swedish Paralympic athletes with PI, VI and II
Data collection	eHealth based athlete self-reports of SRIIPS during 4 weeks. System use. Qualitative post survey assessment
Analysis	Descriptive statistics. Thematic analysis
Study IV.	
Aim	To describe among Swedish Paralympic athletes the 1-year retrospective period prevalence of severe SRIIPS, the point prevalence of all SRIIPS, and to examine differences in prevalence proportions between athletes with different impairments, behaviour and sport characteristics
Study design	Retrospective cross-sectional study
Setting	104 Swedish Paralympic athletes with PI, VI and II
Data collection	Study specific eHealth-based baseline questionnaire
Analysis	Descriptive statistics, chi square statistics, Cramers V, log-linear analysis
Study V.	
Aim	To describe the annual incidence, type and severity of injuries and illnesses among Paralympic athletes and to assess risk factors based on sports exposure
Study design	Prospective longitudinal study
Setting	107 Swedish Paralympic athletes with PI, VI and II
Data collection	Study specific eHealth-based athlete self-reports of SRIIPS during 52 weeks
Analysis	Descriptive statistics, Kaplan-Meier survival analysis, log-rank test, cox proportional hazard regression, Mann-Whitney U test, Kruskal Wallis test, chi square statistics

Paralympic athletes' perceptions of sports-related injuries (Study I)

Study design

The first step in this project was to obtain an in-depth understanding of the nature and preventive possibilities of sports-related injuries in Paralympic sport. A qualitative study exploring Paralympic athletes' own perceptions of experiences of sports-related injuries was thus conducted. Qualitative research enables us to understand human thoughts and behaviour concerning a phenomena in a holistic manner.¹⁰² Recent research has also emphasised the importance of including the athletes' perspective when designing and implementing injury and illness surveillance and preventive measures, as the uptake of such interventions is suboptimal.^{68,103} For this study, the qualitative method phenomenography was used. Phenomenography originates from educational research and rests on a non-dualistic ontology. The assumption is that we perceive, conceptualise and communicate a phenomena in the world we experience.^{102,104} The focus in this study was thus to gain an understanding of the athletes' perceptions that stem from the experiences of a sports-related injury. These perceptions are most likely to be able to influence future research and interventions.

Setting and recruitment

A total of 25 athletes from the Swedish Paralympic programme were invited to participate in this study. To be eligible for the study, the participants had to be between 18 and 45 years of age, and have had at least one sports-related injury. To ensure variation in gender, impairments and sports a purposive sampling procedure was used. The first 18 athletes (11 men and 7 women, with PI ($n=9$), VI ($n=8$) and II ($n=1$)) who accepted the invitation were interviewed. The athletes represented ten different Paralympic summer and winter sports.

Data collection and analysis

Data were collected through individual interviews from September–November 2014. A semi-structured interview guide centred on a few initial questions about the athletes' perceptions of experiences of sports-related injuries, their mechanisms, risk factors and consequences, and the possibilities to prevent them was used. Two pilot interviews were conducted to ensure suitability of the method. All the interviews were performed by the PhD-student and Physiotherapist (KF). The interviews were audiotaped and transcribed verbatim.

The interviews were then analysed using phenomenography, according to the 7-step model described by Sjöström and Dahlgren 2002 (Table 5).¹⁰² Data were condensed into domains, categories and essences. To improve the scientific quality, the Consolidated criteria for Reporting Qualitative research (COREQ) was followed.¹⁰⁵

Table 5. The 7-step model described by Sjöström & Dahlgren (2002) used for the qualitative phenomenographic analysis.

Step	Action
1	Familiarisation: the interviews were read through
2	Compilation: the most important parts of the informants' responses were identified
3	Condensation: the individual responses were reduced in order to identify the most central parts of longer responses or dialogues
4	Grouping: similar responses were tentatively grouped or categorised
5	Comparison: a preliminary comparison of the categories was made to find associations between them after which they were revised
6	Naming: the categories were named for the purpose of highlighting their essence
7	Contrastive comparison: the unique character or essence of each category and the linkage between them were described

Paralympic athletes' perceptions of experiences of sports-related injuries

In summary, the athletes' perceptions of sports-related injuries focused on three parts: the causes of injuries, the consequences of injuries and the possibilities to prevent injuries. The qualitative analyses then revealed nine different categories with a corresponding essence (Figure 7).

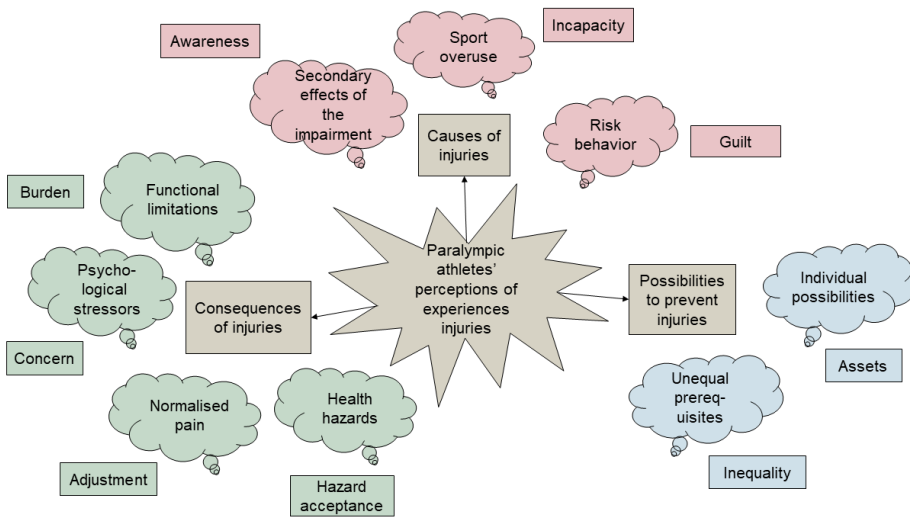


Figure 7. Paralympic athletes' perceptions of experiences of causes, consequences and possibilities to prevent sports-related injuries described as domains (boxes), categories (baloons) and essence (small boxes).

Causes of sports-related injuries

The athletes perceived that the impairment was one of the causes of a sports injury. Athletes with different impairments spoke of the injury pattern varying depending on their impairment. For example, athletes with VI perceived that several incidents were related to collisions and falls. Athletes with II talked of the injuries that could occur because of lack of attention, whereas athletes with PI stated that factors such as weak muscles, loss of innervation, spasticity and wheelchair use could predispose them to injuries.

“When you are visually impaired and take part in sport, you have to accept that you get more injuries than other athletes”

Several athletes described that impairment-related energy demands both in their daily life and in sports, such as wheelchair use or poor vision, could increase the risk for injury. The general perception was that Paralympic athletes' bodies are more vulnerable in sport, in combination with a reduced recovery function, which could increase the risk for injury.

“I spend three times as much energy as you when I go the same distance, so I push myself much harder”

The essence was interpreted as awareness, as most athletes were aware of the effects from the impairment (Figure 7).

Another perception was that sports overuse could cause injuries. They spoke of overuse injuries being common in Paralympic sport, and that too much monotonous

training, a rapid increase in training volume, continuous training with pain, training beyond the body's capacity, absence of recovery, training sessions without quality and too much sport specific training could cause injuries

"I have overuse problems in my shoulder, it's because I expose it more than its capacity and I have no innervation to the muscles around my shoulder blades"

There was also a perception that intense training at a young age could lead to injuries. The essence was interpreted as an incapacity to train optimally when having an impairment (Figure 7).

Finally, the athletes perceived that injuries sometimes occurred due to their own behaviour. Many of them talked of choosing to train while having pain or being injured because they lacked knowledge, were negligent, had reduced well-being because of not training, had too little time prior an important competition and there were too few athletes during competitions. A common perception was that it was difficult to admit to oneself that one is injured.

"I had pain, but I continued to train. I could easily have prevented the injury if I had listened to myself and stopped in time"

Moreover, the perception was that one's carelessness could cause an injury. For example, inattention, forgetting protection gear, using analgesics to decrease symptoms and a lack of patience during injury prevention training could lead to an injury. Many athletes spoke of continuing to train due to failure and the guilt of having pain or being injured, and the essence was interpreted as guilt.

Consequences of sports-related injuries

The athletes' perception was that the consequences of a sports injury were often related to functional limitations that affected them both in their daily life and in sports.

"It's hard with an injury, when you are already disabled, you feel like you have a disability even before you start"

The perception was that a disabled body is more vulnerable during an injury, and they experienced that tasks in daily life consumed more energy when they were injured and that life in general, transportation and household work became more difficult. Another consequence of an injury was a decrease in sports performance, affecting both the individual athlete and sometimes an entire team. The essence was interpreted as a burden (Figure 7).

Another consequence of an injury was psychological stressors. The athletes perceived that an injury often lead to feelings of fear and insecurity about what could happen to one's body.

“I’m often thinking, what will happen if I get an injury to my non-disabled side, I wouldn’t be able to manage my daily life. That’s what I am afraid of”

Other perceptions of their experiences were that an injury led to sadness, stress, concentration difficulties, depression, anxiety, and decreased motivation. The essence was interpreted as concern (Figure 7).

Most athletes perceived that pain was a consequence emanating both from participation in sports and from an injury. The athletes’ experiences were that pain should be seen as a warning signal for injury. Pain following an injury often led to anxiety and fear. All the athletes had experienced pain when participating in sports, and the perception was that pain is something that is associated with Paralympic sport. The athletes perceived that sports-related pain persisted in daily life and that impairment-related factors such as changed biomechanics, weak muscles, spasticity and wheelchair use also caused pain. The essence was described as adjustment, as the athletes interpreted pain as something normal in Paralympic sport (Figure 7).

“What can reduce my pain is to stop doing sport or to stop using my wheelchair”

Another consequence of a sports injury was the exposure to health hazards. The athletes’ perceptions were that elite sport is dangerous, risky and unhealthy. The perception was that the consequences of elite sport could lead to harmful incidents to the musculoskeletal and cardiovascular system.

“Elite sport is not healthy, you are close to the limit of your body”

The athletes’ experiences were that training intensities and competitiveness had increased the last years, which intensified the health hazards. In a first order perspective, this domain was described as the risk and consequences of injuries. However, in a second order perspective, the athletes stated that it was worth being an elite athlete, and it was a choice they had made. The essence was interpreted as hazard acceptance (Figure 7).

The possibilities of preventing sports-related injuries

The athletes’ perceptions were that several sports-related injuries could be prevented. One perception was that each individual should take responsibility for listening to his/her body, to not train while being injured and to use optimal equipment. Other perceptions were that strategies such as warming-up, core stability, balance and flexibility could prevent injuries. However, in order to move towards prevention, the athletes requested better information about preventive measures to improve their own knowledge about how to train and prevent injuries. The essence was interpreted as assets (Figure 7).

Finally, the athletes’ perceptions were that the prerequisites for Paralympic sport compared to sport for able-bodied were unequal, which limited the possibilities to

prevent injuries. Unequal prerequisites were found to be linked to support from sporting organisations, the healthcare services, sports clubs and the environment. The athletes' experience was that it was difficult to find coaches who had knowledge about both training and the impairments. Another perception was that healthcare professionals sometimes did not take sports injuries in Paralympic sport seriously.

“If you go to the primary healthcare centre they just tell you to rest or continue to train.”

The experience was also that the access to medical help was sufficient during competitions, but not during training. Some athletes expressed difficulties in finding a health insurance because of the impairment. Several athletes also stated that they experienced a high level of demands from the Paralympic organisations to achieve sporting excellence, without having the optimal resources of being an elite athlete and at the same time having a disability. The essence of this category was interpreted as inequality (Figure 7).

“Don't forget that we are disabled, we are not just athletes.”

The development of a study protocol (Study II)

Impairment-related injuries, sports overuse, pain, a risk behaviour, psychological stressors and other prerequisites were identified in the results in Study I as common features in Paralympic sport. In order to enhance the quality of epidemiological data collection in Paralympic sports medicine, a study protocol for a prospective longitudinal study of electronically self-reported injuries and illnesses among Swedish Paralympic athletes was thus developed according to the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) guidelines.¹⁰⁶ A study protocol facilitates an assessment of methodological and ethical issues before a research project begins.¹⁰⁶ Another crucial aspect of sports medicine epidemiology is to define an injury/illness.⁶⁰

Since this is a young research field with a heterogeneous population, an argument-based method for investigation of design problems was used to structure the study protocol. In this operational research process, an interdisciplinary approach was used to establish logical theories, test accuracy, and thereafter establish a design rationale.^{107,108} The focus of the design rationale was to document both the development process and resulting design.¹⁰⁸ The research team, comprising sports medicine epidemiologists, physicians, physiotherapists and disability researchers thus conducted an argumentation including discussions about the types of data that should be collected, outcome measures, definitions, data storage, and ethical, methodological and logistical considerations. Examination of the requirements was followed by iterated drafting of protocol specifications based on previous research within sports medicine, the athletes' own perceptions of experiences of sports-related injuries (Study I) and the context of Swedish Paralympic sport. The following protocol specifications were drafted in the study protocol:

- Design and rationale
- Setting and participants
- Recruitment
- Inclusion criteria
- eHealth based data collection
- Pilot evaluation
- Protocol implementation
- Definitions of injury and illness
- Outcome measures
- Psychological profile
- Weekly e-diary
- Injury and illness report form
- Injury and illness closure form
- Statistical analysis plan

Requirements

The argument-based method identified three different requirements for epidemiological studies of sports-related injuries and illness in Paralympic sport (Figure 8).

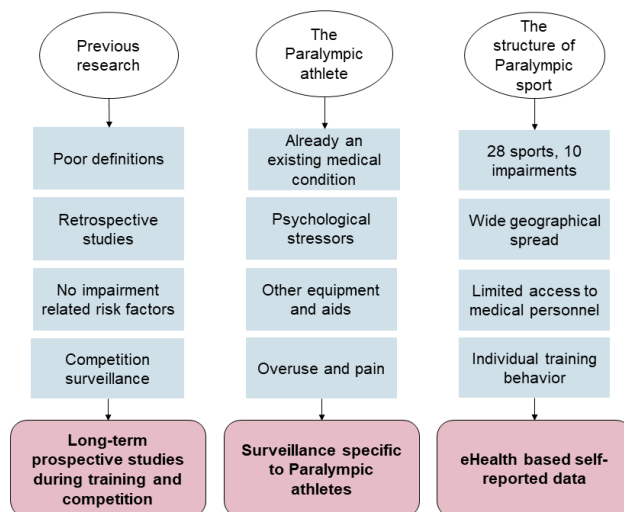


Figure 8. The requirements for epidemiological studies of sports-related injuries and illnesses in Paralympic sport based on previous research, Paralympic athletes' perceptions (Study I) and the structure of Paralympic sport are: long-term prospective studies over time, surveillance specific to Paralympic athletes and eHealth based self-reported data.

Prospective studies over time

In previous research, several studies have had a retrospective design, and have had a poor description of the methods and definitions. Based on the study design several studies had not analysed risk factors, with only a very few studies analysing impairment-related risk factors. Moreover, most studies have solely recorded injuries and illnesses during short competition periods. One of the primary requirements of athlete health monitoring in Paralympic sport is thus to conduct long-term prospective studies over time, to analyse risk factors based on sports exposure and to record injuries and illnesses both during training and competition.

Surveillance specifically for Paralympic athletes

In Study I, the Paralympic athletes revealed that impairment-related factors, pain, overuse symptoms, a risk behaviour and psychological stressors were common features in Paralympic sport. Another requirement is thus to conduct a surveillance study with questions, response alternatives and definitions adapted for Paralympic athletes. The use of sport and impairment-related aids and equipment such as

wheelchairs, prosthesis, blind folds, orthoses and guides also require the data collection and response alternatives to be adapted specifically for Paralympic athletes.

eHealth-based data

The structure of Paralympic sport in Sweden requires that epidemiological data on sports-related injuries and illnesses are collected online directly from the athletes themselves. The Paralympic athletes have at present the possibilities of competing in 28 different sports, spread all over Sweden, which is the largest country in Scandinavia. Several of the athletes have an individual training behaviour and the access to medical staff is limited. The final requirement for longitudinal athlete health monitoring in Paralympic sport is for the data collection to be eHealth-based.

Definitions of injury and illness

Definitions of injuries and illnesses were established in accordance with the definitions that have been used in previous injury and illness surveillance studies in athletics, football, rugby and during the Olympic Games.^{52,57,109,110} An injury was defined as:

“Any new musculoskeletal pain, feeling or injury that results from participation in Paralympic sport (training or competition) and cause changes in normal training/competition to the mode, duration, intensity or frequency, regardless of whether or not time is lost from training or competition.”

An illness was defined as:

“Any new illness or psychological complaint that causes changes in normal training/competition to the mode, duration, intensity or frequency, regardless of whether or not time is lost from training or competition.”

Survey design

Based on the requirements presented above, a weekly e-diary for longitudinal data collection of SRIIPS and athlete health data was structured (Figure 9) (Appendix 1). The weekly e-diary started with a question concerning participation in normal training, or whether an athlete was injured, ill or did not train for another reason. Exposure to sport was then reported as number of sessions, hours and minutes involved in sport and the rate of perceived exertion (RPE).⁴⁶ Thereafter the weekly e-diary contained questions regarding use of analgesics, general well being (Likert scale 1-7), weekly average hours of sleep per night, and self-reported anxiety/depression and pain (using the EQ-5D-3L).^{111,112} The final two questions in

the e-diary concerned any new injuries or illnesses and were based on the injury/illness definitions for these.

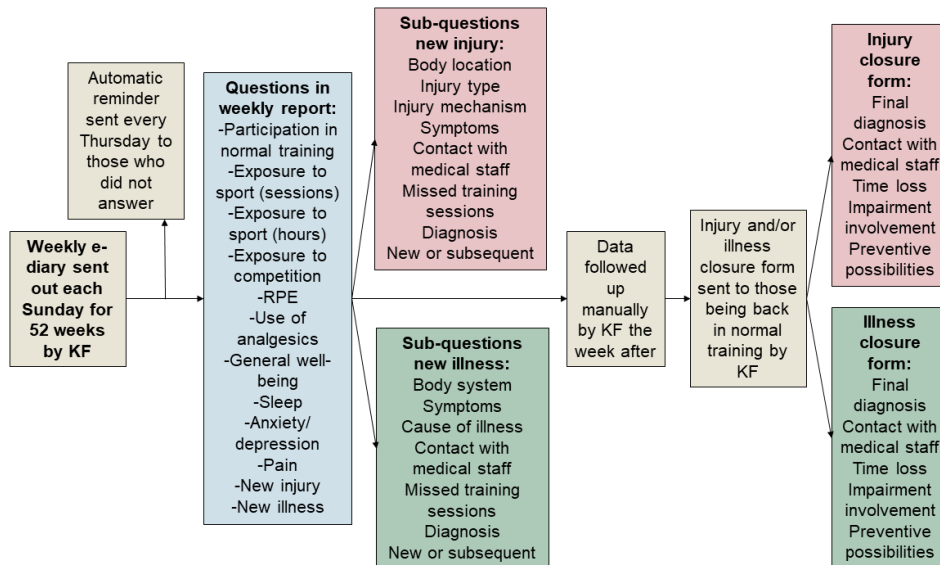


Figure 9. Flowchart of the weekly longitudinal data collection. Each week the athletes responded to twelve questions concerning their previous training week. If they reported an injury or illness additional sub-questions were automatically provided. The data were followed up every week and injury and closure forms were sent out to those reporting being back in normal training.

For a new injury, sub-questions concerning body location, injury mechanism, injury type, symptoms, missed training sessions, contact with medical staff and diagnosis were added. For a new illness, there were sub-questions concerning affected body system, symptoms, causes, missed training sessions, contact with medical staff and diagnosis. To monitor the incidents in real time and provide unbiased data on the final diagnosis, the e-diary was constructed in such a way that required a manual follow up each week. Injury and illness closure forms concerning final diagnosis, contact with medical staff, time loss, impairment involvement and possible preventive measures were developed with the aim of sending these when the athlete reported returning to normal training (Appendix 2 and 3) (Figure 9).

Furthermore, based on the study's requirements, a baseline survey concerning athlete demographics, athlete behaviour and previous injuries and illnesses was developed (Appendix 4). A psychological profile based on the Body Consciousness Scale, The Brief Coping instrument, The Perceived Motivational Climate in Sport Questionnaire, The Commitment to Exercise Scale and the hyperactivity definition in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) was also added. Further details about the different instruments can be found in the Study Protocol.¹¹³

Pilot feasibility and usability study (Study III)

Study design

Based on the results from Studies I and II, an eHealth application for self-reported longitudinal data collection of sports-related injuries and illnesses among Paralympic athletes was developed and evaluated in a pilot feasibility and usability study. The eHealth application was established together with Briteback survey tool®, a tool that is built on team communication research and integrated software development.¹¹⁴ The prototype eHealth application was developed and adapted for Paralympic athletes based on a theoretical foundation of Paralympic athletes' perceptions of experiences of sports-related injuries (Study I), the requirements from the study protocol (Study II), existing research within athlete surveillance^{24,95,115} and the Web Content Accessibility Guidelines 2.0 (WCAG 2.0). According to WCAG 2.0 an application should be robust, understandable, perceivable and operable (Figure 10).¹¹⁶

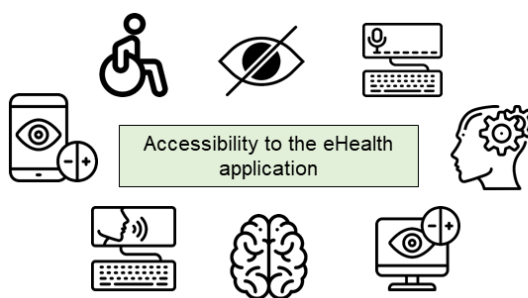


Figure 10. To improve accessibility for users with PI, VI and II, the eHealth application was adapted as follows: text alternative could be changed to large print or speech, all functionalities were available from a keyboard, users were provided with sufficient time to read and understand the content, which was designed in a way that would not cause seizure, the content was easy to read and understand, the user had the opportunity to see and hear the content including separating foreground from background, it was possible to correct mistakes, the application was adapted to current user agents (including assistive technologies), the application was adapted for both smartphones, tablets and computers.

Moreover, an eHealth based intervention should be easy to use, and target the population.^{97,117} It is therefore important to consider potential sources of errors, such as poor definitions, difficulties in interpreting questions, and failures in implementation and data collection before implementing an eHealth based intervention.¹¹⁷⁻¹¹⁹ In order to move towards evidence-based eHealth interventions it has thus been recommended that the feasibility and usability is evaluated.¹²⁰ In this context, feasibility refers to the ability of users to adopt a new system in their daily routines. Important feasibility features to evaluate were acceptability, demand, practicality, adaptation, integration, expansion, and implementation.¹¹⁸ Usability indicates whether a system easily can be used technically by the specified users to achieve goals with regard to learnability, efficiency, effectiveness, satisfaction and error recovery.^{120,121} To structure and present the data on feasibility and usability goals, The Fit between Individuals, Task, and Technology (FITT) framework of information technology (IT) adoption was used (Figure 11). The framework is based on the idea that IT adoption in a practical setting depends on the fit between the attributes of the individual users, attributes of the task and attributes of the technology.¹²²

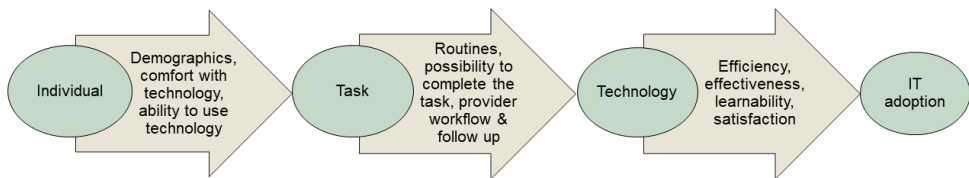


Figure 11. The FITT framework suggests that IT adoption in health sciences is dependent on socio-organisational-technical factors including the individual, the task and the technology. Adapted picture from Ammenweth et al. 2006.¹²²

Setting and recruitment

A pilot cohort of 37 athletes stratified to represent different impairments, gender, and sports were invited in June 2016 to participate in the study. The following inclusion criteria were used: age 18 to 55 years, being a registered athlete within the Swedish Paralympic Program, being classified according to the IPC, being able to communicate in Swedish, and being able to answer an e-diary weekly for four weeks. A total of 28 athletes (9 women and 19 men) aged 20 to 51 years with visual impairment ($n=11$), physical impairment ($n=15$), and intellectual impairment ($n=2$) accepted to participate. The athletes were active in 13 different Paralympic summer and winter sports.

Data collection and analysis

The athletes were asked to weekly report any new sports-related injury or illness and additional training and health data, according to the study protocol, during a four week study period (July-August 2016) (Figure 9).¹¹³ All data and any technical issues were followed up weekly by the PhD-student and Physiotherapist (KF). Closing reports concerning final diagnosis were sent to those reporting being back in normal training (Figure 9). After having completed the four week pilot period, the athletes were asked to assess the method using the Post-Study System Usability Questionnaire (PSSUQ)¹²³, and open ended questions concerning the feasibility and usability to Paralympic sport and athletes.

Quantitative data such as: athlete demographics, system use, completed self-reports, number of reported incidents, type of incidents, missing answers, and system errors were analysed using descriptive statistics. To analyse and report patterns of practical feasibility and usability data a qualitative thematic analysis were used.¹²⁴ The key parts of the data, including the athletes' observations, were first extracted. The focus was to identify opinions about the eHealth application, detecting methodological issues, and determining whether the method matched the users' needs and behavior. Sentences containing aspects of relevance to feasibility and usability were transformed to codes, themes and meaning units by all authors.¹²⁴

Feasibility and usability of athlete health monitoring

Quantitative feasibility and usability evaluation

A total of 1643 responses concerning athlete health were submitted by the 28 athletes during the four week pilot period. The overall weekly response rate was 95%. In the weekly reports, 2.3% of the data were missing. A majority (76%) of the missing answers were horizontally displayed checkboxes from athletes with VI. The average weekly time spent on training was 7.6 ± 2.1 hours. A total of 15 new injuries were reported, resulting in an IR of 18 injuries/1000 hours of sport exposure. Most injuries (80%) were related to overuse, and tissue inflammation and pain (67%) was the most common symptom. A total of 14 new illnesses were reported, resulting in an IR of 17 illnesses per 1000 hours of sport exposure. Upper respiratory tract infections were the most common illness (64%). During the four week pilot period, 37% of the athletes reported weekly anxiety/depression, 56% reported weekly pain, and 33% reported weekly use of analgesics.

Twenty one athletes provided complete post use feasibility and usability data. Two athletes with VI reported technical errors related to the use of a speech synthesiser. No other system use errors were reported. A majority (71%) of the athletes reported

that it was easy to complete the weekly task. However, more than one third (38%) of the athletes reported that the eHealth application was not optimally adapted for Paralympic athletes and sport. Moreover, 24% of the athletes found it difficult to define a new illness, and 48% found it difficult to define a new injury. Concerning the injury and illness closure forms, 76% of the participants reported that it was easy to use and understand them. Overall, most athletes (86%) were satisfied with the experience of performing the task, and a majority of the athletes (90%) found it important to conduct this study.

Qualitative feasibility and usability evaluation

The qualitative post study feasibility and usability evaluation revealed four different themes (health monitoring in Paralympic sport, survey design, impairment diversity and usability, and longitudinal athlete eHealth monitoring) related to athlete health monitoring in Paralympic sport (Figure 12).

First, the athletes expressed that some parts of the health monitoring were not fully adapted and feasible for Paralympic athletes. Several athletes found it difficult to know how to identify and define a new injury or illness when their impairment was involved in the cause or mechanism. The athletes' opinion were thus that more survey items and response alternatives related to the impairment were needed, as the perception was that sports-related incidents sometimes occur due to the impairment. The athletes also found it relevant to report all new injuries and illnesses, as some incidents that occurred due to the impairment affected their participation in sport.

Concerning the survey design, the athletes found it difficult to report complex incidents. The opinion was that there were insufficient options for describing multifactorial incidents, including for example an injury, and the impairment. The athletes made suggestions to improve the survey design, which had originally been developed for able-bodied athletes, these included opportunities to better describe their incidents through more multiple check box alternatives and free text.

Regarding impairment diversity and usability, athletes with PI or II did not report any usability problems. However, athletes with VI reported usability difficulties related to tasks involving horizontal reply alternatives and a visual analogue scale. These usability problems were found to be due to a technical problem with the connection between the eHealth application and their speech synthesiser.

Finally, most athletes stated that it was important to carry out longitudinal athlete eHealth monitoring. The athletes' opinion was that the use of the eHealth application was feasible, and easy to understand and use. Most athletes perceived that the terminology was intelligible, and that it was easy to understand which parameters they should report. They also stated that athlete health monitoring in Paralympic sport could be extended to longer periods of time.

Based on the findings in the quantitative and qualitative post study feasibility and usability evaluation, issues related to feasibility and usability were corrected. For example, the eHealth application was further adapted to athletes with VI, the injury definition was better adapted to the impairments, the visual analogue scale was removed and more answer alternatives were added.

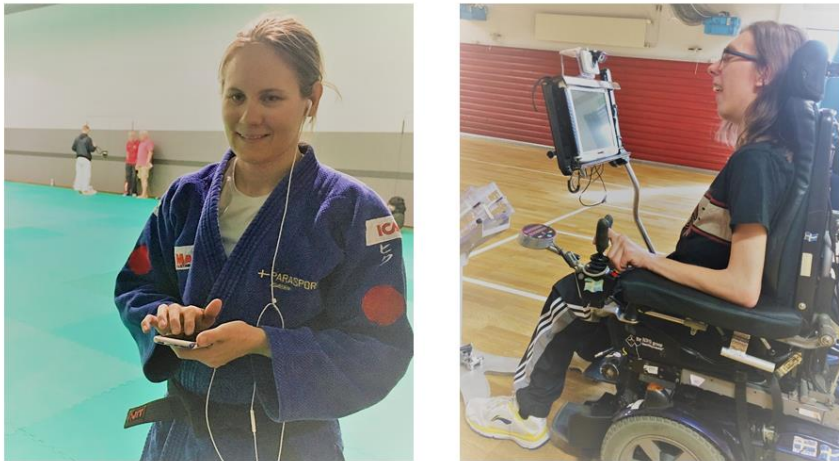


Figure 12. The athletes perceptions were that health monitoring in Paralympic sports needs to be adapted for athletes with an impairment. Moreover, the survey design should allow reporting for multiple and complex incidents. Concerning usability, athletes with VI requested better technical improvement. Finally, the athletes stated that it is important to carry out longitudinal athlete health monitoring in Paralympic sport. Photo: Kristina Fagher

The Sports-related injury and illness in Paralympic sport study (Studies IV and V)

Study design

After having conducted a qualitative study concerning the Paralympic athletes' own perceptions of sports-related injuries (Study I), a study protocol with requirements for future research in Paralympic sports medicine (Study II), and a feasibility and usability evaluation of epidemiological data collection (Study III), the epidemiological cohort study "The Sports-related injury and illnesses in Paralympic sport study" (SRIIPSS) was implemented and conducted. This study contained two parts, one prevalence study (Study IV) and one incidence study (Study V). Both studies followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines¹²⁵ and are registered at ClinicalTrials.gov [NCT02788500].

The ultimate goal of epidemiology is to study the distribution and occurrence of health incidents, and to understand its patterns, causes and risks in a population of interest.¹²⁶ This understanding can then be used to mitigate and prevent injury and illness and to promote health.¹²⁷

Setting and recruitment

Participants were recruited through the Swedish Paralympic Program, which includes all candidates (N=150) for the Summer and Winter Paralympic Games. The following inclusion criteria were used: i) age 18-65 years; ii) being able to communicate in Swedish; and iii) having the ability to respond electronically to the eHealth application. Parasport Sweden and the national team coaches were informed about the study prior to its commencement. The project was also presented to athletes participating in the elite sports school, and at the Paralympic pre-camps 2015 and 2017. Contact details were obtained from Parasport Sweden and national team coaches during the autumn 2016. All 150 athletes were invited and received written, and if needed, oral information about the study. A total of 107 (71%)

athletes accepted the invitation, 28 declined to participate and 15 did not respond (Figure 13). A closed cohort design was then applied.

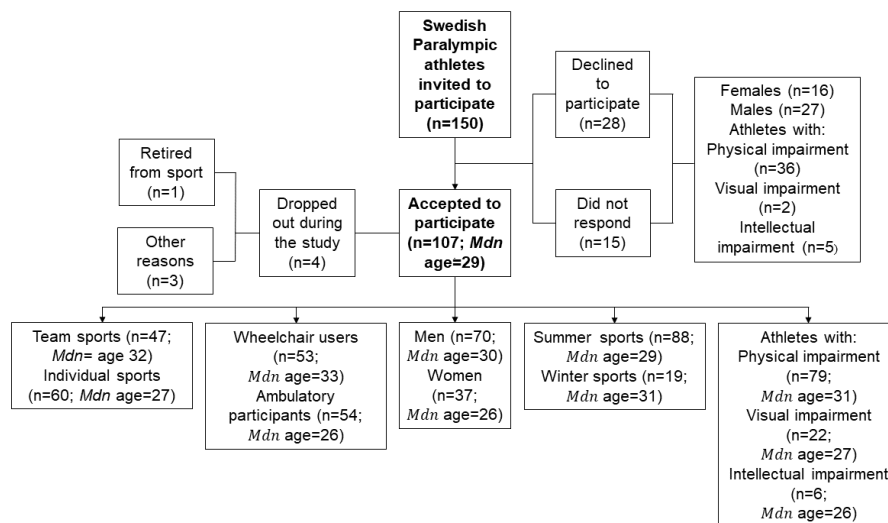


Figure 13. Flowchart of the recruitment process and demographics of the 107 athletes included in The Sports-related Injury and Illness in Paralympic Sport Study (SRIIPSS).

Prevalence study (Study IV)

A cross-sectional study was conducted to assess athlete demographics, to test hypotheses concerning athlete behaviour and to estimate the proportion of athletes affected by an injury or illness. The period prevalence of SRIIPS one year retrospectively was assessed to estimate the burden of severe long-term incidents (with a time loss from sport for ≥ 21 days), and the need and distribution of resources. Period prevalence has also the capability to capture incidents with insidious onset, for example overuse problems. Point prevalence was then used to estimate athlete availability and the need and distribution of resources at a single point in time, for example prior to a championship.^{60,96,126,128} The athletes were asked to report all existing injuries and illnesses at one single point in time.

The athletes were further asked about: i) socio-demographics; ii) impairment characteristics; iii) sport characteristics; iv) anxiety/depression; v) pain (pain in daily life and during sports participation, and use of analgesics) and vi) behaviour (excessive exercise and maladaptive behaviour). The Commitment to Exercise Scale (CtES)¹²⁹ was used to assess features of excessive exercise and maladaptive behaviour, and EQ-5D-3L¹¹¹ was used to assess pain and anxiety/depression. Furthermore, women were asked about their period and use of contraceptives. The

athletes filled in this baseline questionnaire in the beginning of January 2017 (Appendix 4).

Incidence study (Study V)

To estimate the incidence and risk factors of SRIIPS, a 52 week prospective longitudinal cohort study was conducted. The assumption of such studies is that the causal action of an exposure comes before the development of an incident as a consequence of the exposure. Thus, by measuring the incidence of new events and time to an event, data can be used to estimate the average risk for a population to suffer from an outcome. The design is also efficient in studying multiple outcomes from a single exposure.^{60,126} Prospective data were then collected weekly for a 52 week period, starting in January 2017. The athletes received a web survey via email and/or text message each Sunday containing questions concerning their training week. The weekly e-diary consisted of the 12 questions and additional sub-questions described in the study protocol. A reminder was sent to those who did not respond. The weekly data were followed up every week by the PhD-student and Physiotherapist (KF), and closure forms were sent to those reporting returning to normal training (Figure 9) (Appendix 1, 2 and 3).

Categorisation (Studies IV and V)

Athlete categorisation

The athletes were first categorised into sex and age group according to the categorisation that has been used in previous studies from the Paralympic games.^{76,86} In a second step, the athletes were categorised into impairment at a broad level (PI, VI and II), and into sub-classes that have been used in previous studies (visual impairment, intellectual impairment, limb deficiency, SCI, central neurological impairment and les autres). Furthermore, the athletes were categorised into using a wheelchair as their main transportation mode or being ambulatory. In a third step, the athletes were categorised into participating in either a summer or winter sport, or a team sport or individual sport. A total training load rank index (TLRI) was quantified for each athlete by multiplying the weekly rate of perceived exertion (RPE) with minutes of training during each week throughout the year.^{46,51} TLRI was categorised into low, middle or high, based on the 33rd and 67th percentiles.

Injury and illness categorisation

Injuries were categorised into a matrix based on the 10th revision of the International Statistical Classification of Disease and Related Health Problems (ICD-10) according to injury type, body location and diagnosis.¹³⁰ Two sports physiotherapists (KF and JJ) independently formed ICD-10 codes. For illnesses, KF

and one physician (JL) independently formed ICD-codes. The reported illnesses were thereafter categorised into affected body systems. Any variety in the classification was a matter for clarification and consensus between the authors.

Injury and illness severity

Injury and illness severity were determined by time loss (number of days) from regular participation in sports. The incidents were classified as follow: slight (0-3 days), minor (4-7 days), moderate (8-20 days), severe (≥ 21 days) and long-term (≥ 3 months).^{51,60} The onset of injury was categorised as traumatic (an injury caused by an identifiable single external transfer of energy), overuse with sudden onset (an injury to which no identifiable single external transfer of energy can be found) and overuse with gradual onset (an injury that manifests gradually over a period of time, without a single identifiable event being responsible for the injury).⁵² Furthermore, injuries were categorised as being primary, new subsequent, exacerbation, recurrent or multiple.¹³¹ The cause of illness was categorised as transmission, stress, overtraining, the impairment, medications, exacerbation, exhaustion/dehydration or other.⁵²

Statistical methods (Studies IV and V)

Descriptive data

Descriptive data were assessed for normality and were analysed with descriptive statistics (mean, median, frequency, proportion, standard deviation and a 95% confidence interval (CI)). Prevalence was calculated by dividing the proportion of athletes affected by an injury or illness divided by the total number of athletes studied at the given time point.¹²⁶ To assess the probability for an athlete to sustain a new injury or illness throughout the year the incidence proportion (IP) was calculated. IP was calculated by dividing the number of athletes who sustained an injury or illness by the total number of athletes followed in each category.¹²⁶ To examine the number of new cases in the population at risk, incidence rate (IR) was calculated by dividing all reported injuries and illnesses by the total time of exposure in each category.¹²⁶

Associations and risk factors

Chi-square statistics were used to examine differences in proportions of injuries and illnesses among athletes with different characteristics (Studies IV and V). Three-way interactions were analysed using log-linear analysis (Study IV). Comparisons of IR between different subgroups were analysed using the Mann-Whitney U test or the Kruskal-Wallis test (Study V). To measure the fraction of athletes training without an injury or illness during the 52-week period, the Kaplan Meier time-to-event methods was used (Study V). The primary endpoint was median time to first

injury and illness, respectively. The cumulative survival probability (SP) was estimated for each subgroup, and log-rank tests were performed to compare differences in survival times between the subgroups. Cox proportional hazard regression analyses were conducted to analyse the actual risk of sustaining an injury or illness. To test for risks associated with each variable, univariate models were first performed. Multivariate models with two explanatory variables and their interactions were thereafter examined to account for co-variables (sex, age, impairment (VI vs PI or II, ambulatory vs wheelchair user), sport (team vs individual, winter vs summer) training load and previous severe injury or illness) and differences in risk between different subgroups. A 5% significance level was used in all analyses. The IBM SPSS Statistics version 23, 24 and 25 were used for the analyses.

Sports-related injuries, illnesses and health among Paralympic athletes

Athlete demographics (Studies IV and V)

In total 107 athletes accepted to participate in SRIIPSS, the number of athletes in each category are presented in Figure 14. The athletes were engaged in 15 Paralympic (2016) summer sports; para athletics ($n=9$), boccia ($n=3$), canoe ($n=2$), cycling ($n=8$), equestrian ($n=7$), goalball ($n=13$), judo ($n=2$), shooting para sport ($n=4$), para swimming ($n=5$), sailing ($n=1$), table tennis ($n=7$), triathlon ($n=1$), wheelchair basketball ($n=10$), wheelchair rugby ($n=7$) and wheelchair tennis ($n=8$). The remaining athletes were active in four Paralympic (2018) winter sports; para alpine skiing ($n=2$), para cross country skiing ($n=2$), para ice hockey ($n=9$) and wheelchair curling ($n=7$).

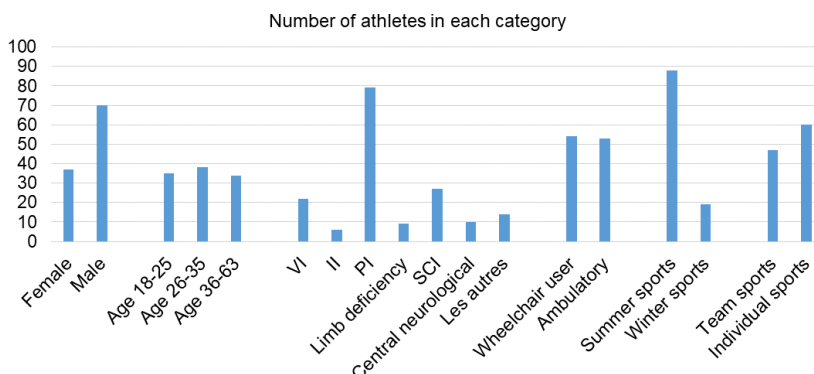


Figure 14. The number of athletes in each category that participated in SRIIPSS ($n=107$).

Concerning type of impairment and diagnoses, the athletes represented as many as 36 different diagnoses (Table 6).

Table 6. The athletes' diagnoses grouped into impairment categories.

Visual impairment	Intellectual impairment	Limb deficiency	Spinal cord injury	Central neurological impairment	Les autres
Anoridis	Attention deficit	Dysmelia	Myelitis	Cerbral paresis with diplegia	Arthrogryposis
Cataract	hyperactivity disorder	Hemiplevictomy	Spina bifida	Cerebral paresis with hemiplegia	Becker muscular dystrophy
Colubom	Autism	Spiral condyle fracture	Traumatic spinal cord injury at cervical level	Cerebral paresis with tetraplegia	Charcot-Marie-Tooth disease
Glaucoma	Develop-mental disability	Transfemorol amputation	Traumatic spinal cord injury at thoracic level	Functional paralysis	Duchenne muscular dystrophy
Microtalmi		Transtibial amputation	Traumatic spinal cord injury at lumbar level	Ischemic stroke	Nail patella syndrome
Ocular albinism				Multiple sclerosis	Perthes disease
Optic nerve injury				Traumatic brain stem injury	Plexus brachialis injury
Retinitis pigmentosa					
Retinoblastoma					
Stargardt's disease					

In total 104 athletes (97%) responded to the baseline questionnaire. At baseline, the athletes reported that their mean time of training was 10.0±3.9 hours per week. A majority of the athletes (96%) did some additional training to sport specific training; 69% did cardiovascular training, 76% trained strength, 50% did neuromuscular training, 39% trained flexibility and 8% trained yoga (Figure 15).

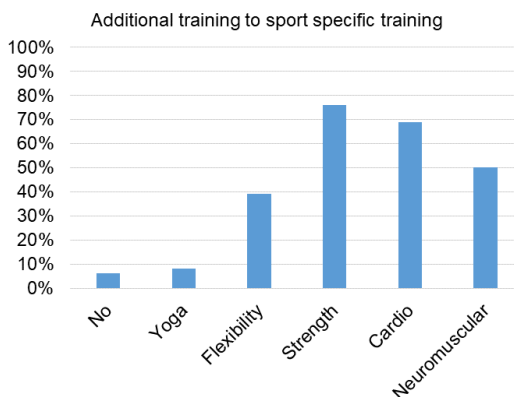


Figure 15. Proportion of athletes performing some additional training to sport specific training.

A total of 53% of the athletes had a congenital impairment, whereas 47% had acquired their impairment later in life. Half of all the athletes (50%) used a wheelchair as their main transportation mode, 11 % used a blind cane, and 11% used crutches. Two thirds of the athletes (66%) had a part-time or full-time employment, 23% were students, 3% had disability pension and only 8% were fulltime athletes. One third of the athletes (33%) used alcohol every month, and 22% reported use of supplements (Figure 16).

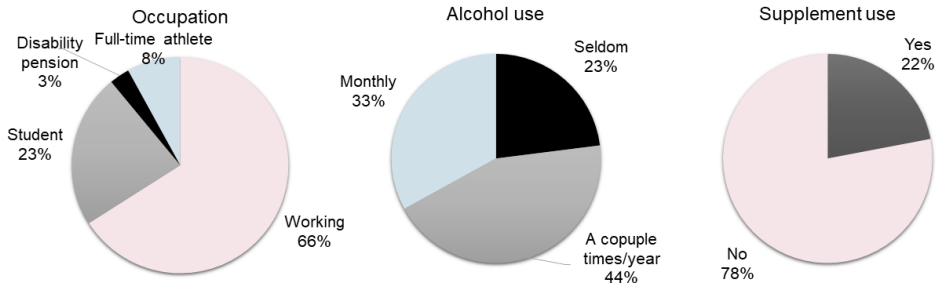


Figure 16. Illustration of Paralympic athletes (n=107) occupational status, alcohol use and supplement use.

About half (47%) of the athletes reported that they had a club coach with relevant knowledge about Para sport. Seventeen percent of the athletes did not have a club coach at all. One third of the athletes (32%) reported that their national team coach had no or some knowledge about Para sport (Figure 17).

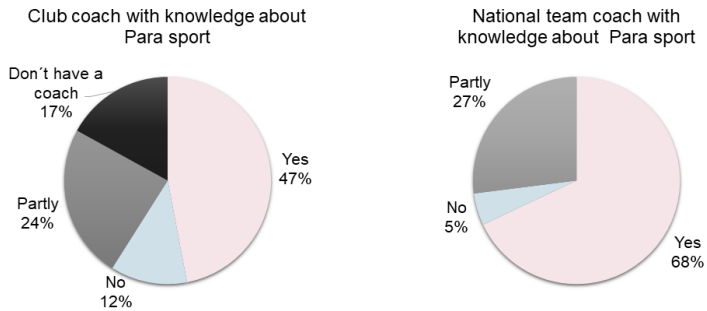


Figure 17. Illustration of the coaches' knowledge about Para sport reported by Paralympic athletes (n=107).

Approximately one fifth (23%) of the athletes had received help to plan their diet. Concerning health care, 59% of the athletes had regular contact and easy access to a known healthcare professional, and 47% used prescribed medication (Figure 18). Overall, the use of 71 different prescribed medications were reported, of which many require therapeutic use exemption.

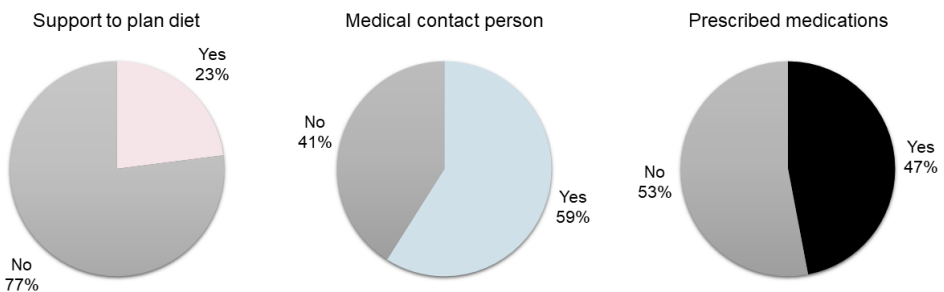


Figure 18. Illustration of Paralympic athletes (n=107) support to plan diet, and healthcare status.

Concerning women's health, almost one third (31%) reported amenorrhea, and 62% of the women used hormone contraceptives.

Athlete behaviour

Regarding athlete behaviour and commitment to exercise, 59% of the athletes reported that they continued to train while injured and 83% continued to train unwell or sick. A majority (82%) felt upset when unable to exercise and 77% felt guilt when missing a training session.

Prospective athlete health data (Study V)

The athletes provided weekly prospective data for 52 weeks after the baseline survey. A total of 4046 weekly reports were collected and analysed. Four athletes, all with physical impairment, dropped out during the year (Figure 13). The weekly response rate was 72%. The median of answered reports per athlete was 45 (IQR 25-52, min-max 1-52). The median of answered reports for athletes with VI was 47 (IQR 27-52, min-max 8-52), for athletes with II 23 (IQR 2-49, min-max 1-51), and for athletes with PI 45 (IQR 28-52, min max 1-52). The weekly training data is presented in Table 7.

Table 7. Average (mean, SD, range) weekly training data by impairment and sport reported from Swedish Paralympic athletes (n=107) during 4046 training weeks.	
Training sessions per week	4.9±3.1 (0-22)
Hours of training per week	6.8±4.8 (0-34)
Physical Impairment (n=79)	6.6±5.0 (0-34)
Les autres (n=14)	6.2±4.5 (0-26)
Spinal cord injury (n=36)	5.9±4.7 (0-37)
Limb deficiency (n=11)	5.9±5.0 (0-26)
Central neurological impairment (n=18)	8.8±5.4 (0-34)
Intellectual impairment (n=6)	6.3±3.5 (0-19)
Visual impairment (n=22)	7.5±4.4 (0-30)
Ambulatory athletes (n=54)	7.4±4.5 (0-30)
Wheelchair athletes (n=53)	6.2±5.0 (0-34)
Summer sports (n=88)	6.7±4.7 (0-34)
Winter sport (n=19)	6.9±5.2 (0-31)
Alpine skiing (n=2)	3.0±2.8 (0-14)
Athletics (n=9)	6.9±3.7 (0-20)
Boccia (n=3)	7.4±4.8 (0-20)
Canoe (n=2)	8.4±10.7 (0.8-16)
Cross country skiing (n=2)	10.4±5.6 (0-24)
Cycling (n=8)	6.5±3.8 (0-21.5)
Equestrian (n=7)	5.3±4.4 (0-22)
Goalball (n=13)	7.0±4.0 (0-30)
Judo (n=2)	8.5±3.7 (0-18)
Para ice hockey (n=9)	6.6±4.4 (0-28)
Sailing (n=1)	10.0±5.7 (0-24.)
Shooting (n=4)	5.7±6.4 (0-39)
Swimming (n=5)	11.3±4.6 (0-22)
Table tennis (n=7)	5.8±4.5 (0-22)
Triathlon (n=1)	10.9±4.2 (8-20)
Wheelchair basketball (n=10)	5.4±4.2 (0-26)
Wheelchair curling (n=7)	7.6±5.8 (0-31)
Wheelchair rugby (n=7)	5.6±4.6 (0-27)
Wheelchair tennis (n=8)	7.4±5.9 (0-34)

The weekly athlete health data concerning sleep, anxiety/depression, use of analgesics and pain are presented in Figure 18 and Figure 19. On average, 59% (95% CI 57-62) of all athletes reported that they slept 7 hours or less per night each week. One third of the athletes (34%; 95% CI 32-35) reported that they felt anxious/depressed each week (Figure 18).

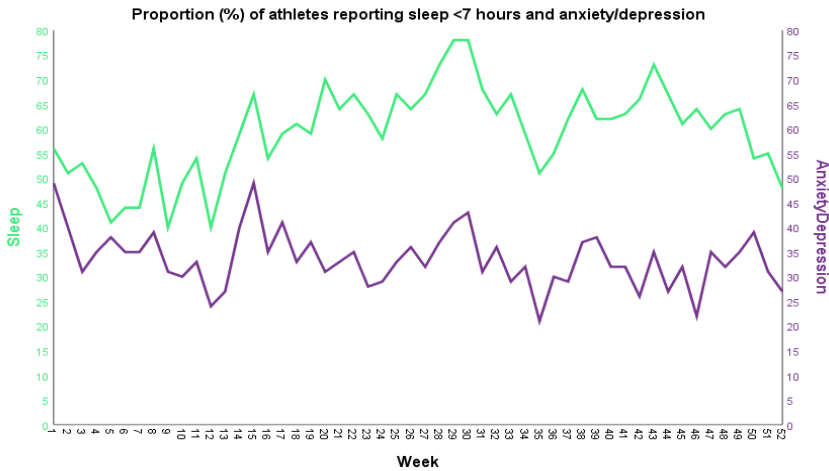


Figure 18. Proportion (%) of athletes (n=107) reporting weekly sleep ≤ 7 hours and symptoms of anxiety/depression during the 52 weeks.

On average, 17% (95% CI; 15-18) of the athletes reported weekly use of analgesics to handle sports-related pain, and 48% (95% CI 46-50) reported moderate or extreme pain (Figure 19).

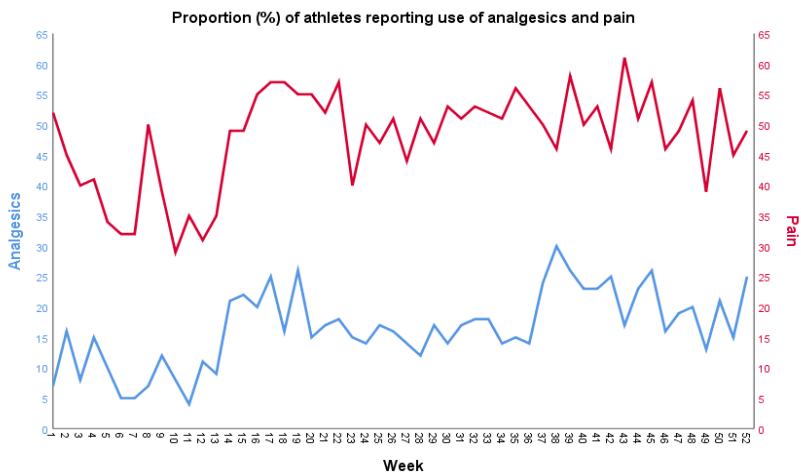


Figure 19. Proportion (%) of athletes (n=107) reporting weekly use of analgesics during sports and pain during the 52 weeks

Injuries – prevalence and incidence

The prevalence and incidence of injuries are presented in Table 8.

Period prevalence and point prevalence (Study IV)

Almost one third (31%; 95% CI 23-40) of the athletes suffered from a severe injury during the previous year. Athletes in the young age group, 18-25 years, reported a higher period prevalence (37%; 95% CI 23-54) compared to the other age groups. Athletes with limb deficiency were the impairment group that reported the highest period prevalence (40%; 95% CI 17-69). Ambulatory individuals also reported a higher prevalence (37%; 95% CI 25-50) compared to wheelchair users (25%; (95% CI 15-38). The period prevalence among athletes participating in summer sports was higher (39%; 95% CI 29-50) compared to athletes in winter sports (26%; (95% CI 11-49) (Table 8).

Table 8. Period prevalence, point prevalence, incidence proportion and incidence rate of sports-related injuries.				
Subgroups of athletes	Period prevalence (%) (95% CI)	Point prevalence (%) (95% CI)	Incidence proportion (IP) (%) (95% CI)	Incidence rate (IR)/1000 hours of exposure (95% CI)
All	31 (22-41)	32 (23-42)	68 (59-76)	6.9 (6.0-8.0)
Sex				
Male	32 (21-44)	38 (26-50)	74 (63-83)	6.9 (2.0-23.7)
Female	29 (15-46)	20 (8-37)	57 (41-71)	6.9 (1.2-40.1)
Age				
18-25	37 (21-55)	31 (17-49)	57 (41-72)	5.4 (1-30.1)
26-34	28 (14-45)	28 (14-45)	79 (63-89)	8.1 (1.3-50.7)
35-63	27 (13-46)	36 (20-55)	67 (51-81)	6.8 (1.3-35.1)
Impairment				
Visual	33 (15-57)	33 (15-57)	77 (56-91)	9.8 (0.9-110.2)
Intellectual	33 (4-78)	33 (4-78)	67 (29-91)	6.7 (0.5-1426.9)
Physical	30 (20-41)	31 (21-43)	66 (55-75)	5.9 (2.0-17.8)
Central neurological	37 (16-62)	26 (9-51)	56 (34-76)	4.7 (0.8-28.6)
Les autres	21 (5-51)	21 (5-51)	43 (21-68)	3.1 (0.5-19.4)
Limb deficiency	40 (12-74)	50 (19-81)	82 (50-97)	7.8 (0.2-318.0)
Spinal cord injury	26 (13-44)	32 (17-51)	75 (59-87)	7.5 (1.1-53.5)
Summer vs Winter				
Summer	32 (22-43)	33 (23-44)	66 (56-75)	6.7 (2.2-20.3)
Winter	26 (9-51)	26 (9-51)	79 (56-93)	7.4 (0.7-75.5)
Team vs Individual				
Team	34 (21-49)	34 (21-49)	81 (67-90)	8.3 (1.7-41.2)
Individual	28 (17-42)	30 (18-43)	58 (46-70)	5.6 (1.6-19.7)
Wheelchair vs Ambulatory				
Wheelchair	25 (14-39)	25 (14-39)	70 (56-81)	6.3 (1.6-25.3)
Ambulatory	37 (24-51)	38 (25-53)	67 (53-78)	7.5 (1.7-32.6)
Previous severe injury				
Yes	-	47 (31-64)	88 (71-96)	9.8 (1.1-88.7)
No	-	25 (16-36)	61 (50-72)	5.6 (1.9-16.6)

A majority of the severe injuries (91%) occurred during training, with the remaining 9% occurring during competition. In 64% of the injuries, the impairment was a contributing factor in the injury mechanism. One fourth (25%) of the injuries were traumatic. Of the remaining injuries, 50% had a gradual overuse onset and 25% a

sudden overuse onset. Concerning body location, the injuries were distributed to the lower extremities (44%), to the upper extremities (41%) and to the vertebral column and head (15%). The most single affected body location (25%) was the knee.

Furthermore, one third (32%; 95% CI 24-41) of the athletes had an existing injury when measuring the point prevalence. Male athletes reported a higher prevalence (38%; 95% CI 27-50) compared to female athletes (20%; 95% CI 10-37). For impairment groups, athletes with limb deficiency again reported the highest prevalence (50%; 95% CI 24-76). Similarly, ambulatory participants also reported a higher prevalence (39%; 95% CI 26-52) compared to wheelchair users (25%; 95% CI 15-38). Athletes in summer sports again had a higher prevalence (40%; 95% CI 30-51) compared to athletes in winter sports (26%; 95% CI 11-49) (Table 8).

Most injuries were related to overuse; 79% were overuse related with a gradual onset and 15% overuse with a sudden onset. Only 6% of the injuries were traumatic. More than half (58%) of all injuries were located in the upper extremity, 33% were in the lower extremity and 9% in the vertebral column and head. The most single affected body location (33%) was the shoulder.

Incidence rate and incidence proportion (Study V)

A total of 179 injuries were reported by 73 (68%) athletes during the 52 week study period (Table 8). The median number of reported injuries per athlete was two (IQR 1-3), and the median time to first injury was 19 weeks (95% CI 10-27). Forty-one percent of the injuries were primary, 37% new subsequent and 21% recurrent. The median number of reported injuries per week by all athletes was three (IQR 2-4) (Figure 20).

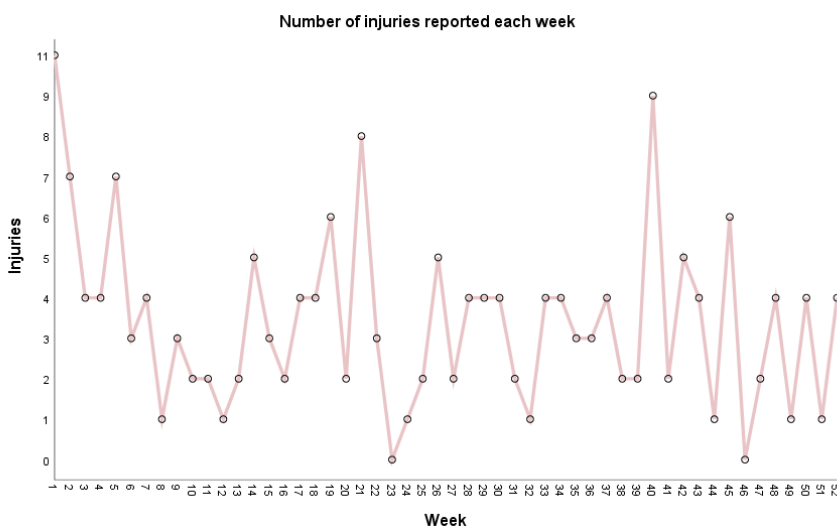


Figure 20. Total number of injuries reported each week by the 107 athletes during the 52 week study period.

The overall IR of injuries was 6.9 injuries/1000 hours of sports exposure. Athlete subgroups that reported a slightly higher IR were; athletes with VI (9.8; 95% CI 0.9-110.2), athletes aged 26-34 (8.1; 95% CI 1.3-50.7), athletes in team sports (8.3; 95% CI 1.7-41.2), athletes in the low TLRI category (8.1; 95% CI 0.8-86.4) and those with a previous severe injury (9.8; 95% CI 1.1-88.7) (Table 8).

A majority of the injuries occurred during training; 53% occurred during sports specific training, 17% during other training and 15% during competition. The remaining 16% of the injuries occurred outside sport, but was sports-related. Most injuries had an onset that was related to overuse; 52% was classified as overuse with gradual onset and 16% as overuse with sudden onset. Almost one third (32%) of the injuries were traumatic. The athletes reported that the impairment was a contributing factor in the injury mechanism in 59% of the injuries. Other contributing factors to the injury mechanism were collision with an object (12%), collision with other person (10%) and surface/weather (5%). Diagnoses linked to inflammation, pain and soft tissue disorders were most frequent (47%), followed by sprain, strain and rupture (15%). About one third (34%) of all injuries were classified as severe. Injury severity due to time loss from sport was as follows: 0-3 days (33%), 4-7 days (24%), 8-20 days (10%), ≥ 21 days (23%) and ≥ 3 months (11%).

Most injuries occurred in the upper extremities (40%), with the shoulder being the most single affected body location (23%), followed by the lumbar spine (12%) and the elbow/forearm (11%). The athletes reported that they sought medical care for 68% of the injuries. The athletes' opinion were that 32% of all injuries could have been prevented.

Associations and risk factors of injuries

Prevalence data (Study IV)

Athletes in the age group 18-25 reported significantly more severe traumatic injuries ($p=.025$) compared to the other age groups (Table 9). Moreover, athletes who did not use an assistive device ($p=.036$) reported more severe period prevalence injuries compared to athletes who used assistive devices such as a wheelchair, crutches or a blind cane. Furthermore, a history of reporting pain during sports ($p=.011$), and monthly use of paracetamol ($p=.015$) and non-steroid inflammatory drugs (NSAID) ($p=.003$) were associated with more severe injuries. Athletes who reported 'always feeling guilt due to missing an exercise session' ($p=.041$) and 'always continuing training when injured' ($p=.026$) also reported a significantly higher prevalence of severe injuries.

Reporting a previous severe injury was associated with an existing point prevalence injury ($p=.027$) (Table 9). There were also strong associations between an existing injury and a history of reporting pain during sports ($p=.001$) and pain in daily life ($p=.001$). Athletes who reported 'always being upset when unable to exercise' were

more likely to suffer from an existing injury ($p=.024$). There were no significant associations between an injury, a specific impairment or a sport, for any of the injury prevalence measures

Table 9. Significant differences in injury prevalence proportions, time to injury, injury incidence rate and multiple injuries.

Subgroups of athletes	Period prevalence (χ^2 test (p -value))	Point prevalence (χ^2 test (p -value))	Time to injury (log-rank test (p -value))	Comparisons of IR (Mann Whitney, Kruskal Wallis (p -value))	Comparisons of multiple injuries (Mann Whitney, Kruskal Wallis (p -value))
Sex					
Male			.024	.29	.41
Female	.729	.067			
Age					
18-25	.025	.745	.14	.13	.092
26-34					
35-63					
Impairment					
Visual	.795	.996	.83	.055	.004
Intellectual					
Physical					
Central neurological	.891	.733	.31	.54	.56
Les autres					
Limb deficiency					
Spinal cord injury					
Summer vs Winter					
Summer	.642	.575	.254	.66	.60
Winter					
Team vs Individual					
Team	.43	.552	.005	.20	.18
Individual					
Wheelchair vs Ambulatory					
Wheelchair	.202	.14	.723	.34	.12
Ambulatory					
Previous severe injury (yes)	-	.027	<.001	.38	.45

Incidence data (Study V)

Log-rank tests emerging from survival analyses revealed statistically significant variations in time to injury and survival probability (SP) with regard to gender ($p=.024$), type of sport ($p=.005$) and previous severe injury ($p<.001$) (Table 9). The median time to injury for men was 16 weeks (95% CI 10.3-21.7) with a SP of 26%, compared to women who had a median time of 46 weeks (95% CI 23.9-62.1) and a SP of 43%. Athletes in team sports had a median time to injury of 14 weeks (95% CI 1.9-26.1) and a SP of 19%, compared to individual sports that had a median of 33 weeks (95% CI 25.4-40.6) and a SP of 42%. The SP of athletes with a previous severe injury was 12% (median time to injury 6 weeks; 95% CI 1.4-10.6), compared to 39% (median time to injury 29; 95% CI 16.5-41.5) among athletes without a history of severe injury (Table 9) (Figure 21).

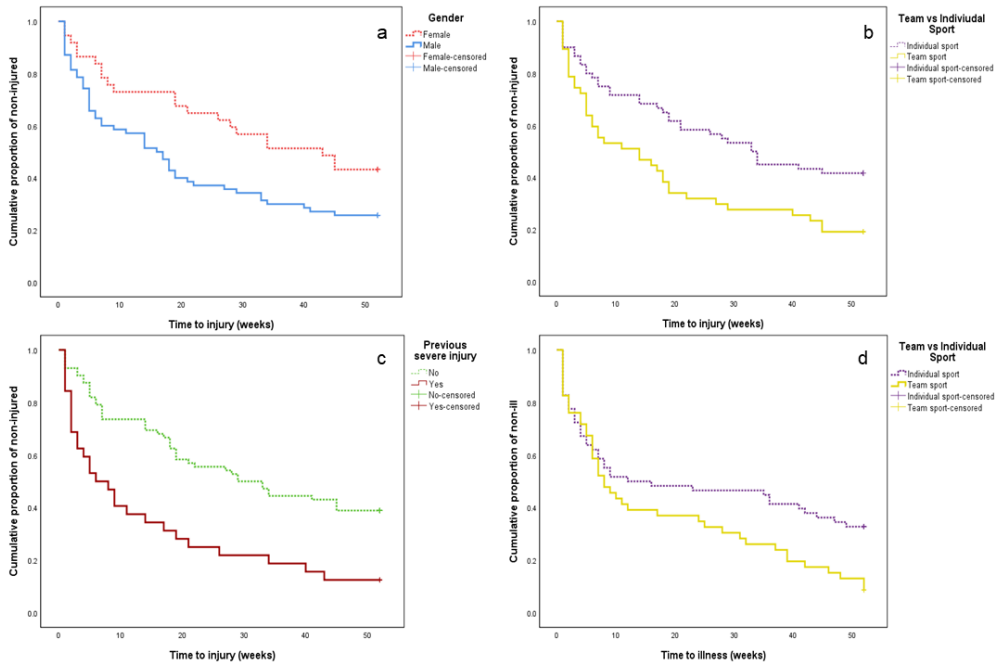


Figure 21. Kaplan-Meier curves for time to first injury (a-c) and illness (d) and survival probability displayed by subgroups with a significant difference revealed by log-rank tests ($p < .05$).

Cox proportional hazard regression analyses using univariate models revealed that athletes with a previous severe injury had more than twice the risk ($HR=2.37$; 95% CI 1.47-3.83) ($p < .001$) for suffering a new injury. Moreover, athletes in team sports had a higher risk for sustaining a new injury ($HR=1.88$; 95% CI 1.19-2.99) ($p = .007$), as well as male athletes ($HR=1.76$; 95% CI 1.06-2.93) ($p = .029$). No multivariate models including co-variables were statistically significant.

There were no significant differences in injury IR between the different subgroups (Table 9). Comparisons of multiple injuries revealed that athletes with VI suffered from more multiple injuries ($p = .004$) (Table 9). Concerning the distribution of injuries by body region and type of injury, athletes with SCI and wheelchair users suffered from significantly more injuries to the upper extremities and the shoulder ($p < .001$). Ambulatory participants had more injuries to the lower extremities ($p = .012$), with athletes with VI reporting more injuries to the lower leg/calf ($p = .018$). Furthermore, VI athletes suffered from more traumatic injuries ($p = .008$) compared to the other impairment groups.

Illnesses – prevalence and incidence

Period prevalence and point prevalence (Study IV)

The overall period prevalence of severe illnesses was 14% (95% CI 9-23). Athletes in the young age group 18-25 was the age category that reported the highest prevalence (23%; 95% CI 12-40) of severe illnesses. Regarding impairment category, athletes with an intellectual impairment was the impairment group that reported the highest prevalence (33%; 95% CI 9-71). Moreover, ambulatory participants had a slightly higher prevalence (17%; 95% CI 9-30) compared to wheelchair users (12%; 95% CI 5-24). Athletes in summer sports reported a slightly higher prevalence (15%; 95% CI 9-25) compared to those in winter sports (11%; 95% CI 1-34) (Table 10). Finally, athletes participating in endurance sports showed a higher prevalence (31%; 95% CI 9-61), when being compared to athletes in explosive sports (14%; 95% CI 7-25) and precision sports (5%; 95% CI 0-23). The most prevalent affected body system was the respiratory system (35%), followed by the psychological system (27%). The most common cause of illness was due to infection (53%). The athletes estimated that the impairment influenced the occurrence of illness in 42% of all illnesses.

Table 10. Period prevalence, point prevalence, incidence proportion and incidence rate of sports-related illnesses.

Subgroups of athletes	Period prevalence(%) (95% CI)	Point prevalence (%) (95% CI)	Incidence proportion (IP) (%) (95% CI)	Incidence rate (IR)/1000 hours of exposure (95% CI)
All	14 (8-23)	13 (8-22)	77 (68-84)	9.3 (8.2-10.6)
Sex				
Male	16 (8-27)	9 (3-18)	79 (42-61)	8.9 (2.2-36.1)
Female	11 (3-27)	23 (10-40)	70 (54-83)	10.1 (1.2-85.4)
Age				
18-25	23 (10-40)	14 (5-30)	66 (49-79)	9.6 (0.8-118.6)
26-34	14 (5-29)	8 (2-22)	84 (69-93)	12.9 (1.2-137.7)
35-63	6 (1-20)	18 (7-35)	79 (63-90)	7.3 (1.3-39.9)
Impairment				
Visual	24 (8-47)	19 (5-42)	86 (65-97)	12.4 (0.8-187.7)
Intellectual	33 (4-78)	17 (0-64)	50 (19-81)	13.7 (0.5-318.4)
Physical	10 (5-19)	13 (6-23)	76 (65-84)	8.0 (2.2-28.9)
Central neurological	0 (0-18)	0 (0-18)	72 (49-88)	6.6 (0.8-57.0)
Les autres	14 (2-43)	14 (2-43)	86 (58-98)	11.0 (0.4-347.3)
Limb deficiency	10 (0-45)	20 (3-56)	73 (43-91)	8.3 (0.9-384.0)
Spinal cord injury	15 (5-31)	15 (5-31)	75 (59-87)	7.5 (1.1-53.5)
Summer vs Winter				
Summer	15 (8-25)	13 (7-22)	75 (65-83)	9.4 (2.5-35.2)
Winter	11 (1-33)	16 (3-40)	84 (61-96)	8.8 (0.7-111.9)
Team vs Individual				
Team	13 (5-26)	11 (4-23)	89 (77-96)	10.8 (1.7-67.2)
Individual	16 (7-28)	14 (6-26)	65 (52-76)	7.9 (1.8-35-3)
Wheelchair vs Ambulatory				
Wheelchair	12 (4-23)	15 (7-28)	79 (66-88)	11.8 (1.8-78.5)
Ambulatory	17 (8-30)	12 (4-23)	74 (61-84)	6.9 (1.7-28.3)
Previous severe illness				
Yes	-	40 (20-64)	80 (54-94)	11.7 (0.3-439.4)
No	-	10 (4-17)	78 (68-85)	8.9 (2.6-30.6)

The point prevalence of existing illnesses was 13% (95% CI 8-22). Female athletes reported a higher prevalence (23%; 95% CI 12-40) compared to male athletes (9%; 95% CI 3-18). Athletes with limb deficiency was the impairment category that displayed the highest prevalence (20%; 95% CI 4-53). Wheelchair users reported a point prevalence of 15% (95% CI 8-28), and ambulatory participants a prevalence of 12% (95% CI 5-24). The prevalence of existing illnesses among athletes participating in winter sports was 16% (95% CI 4-39), whereas it was 13% (95% CI 7-22) among athletes in summer sports. The upper respiratory tract was the most commonly affected body system (57%), followed by the psychological system (29%). Fifty-seven percent of the illnesses was caused by an infection.

Incidence rate and incidence proportion (Study V)

A total of 241 illnesses were reported by 82 (77%) athletes throughout the year. The median number of reported illnesses per athlete was two (IQR 1-4), and the median time to first illness was nine weeks (95% CI 1-17). The median number of reported illnesses by all athletes per week was four (IQR 3-7) (Figure 22).

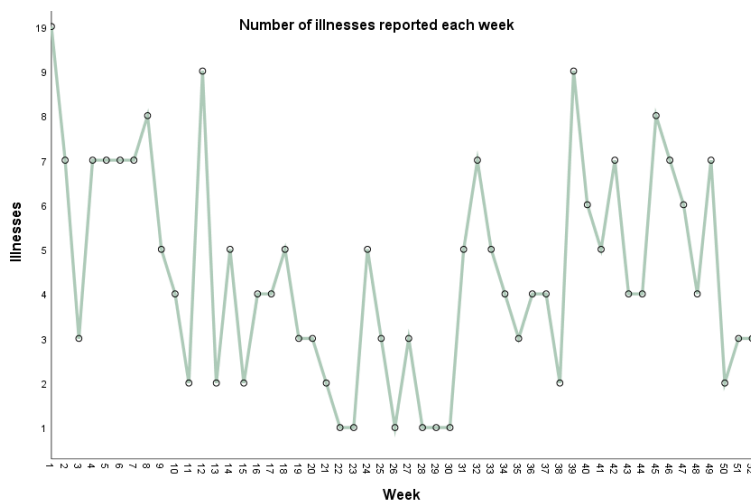


Figure 22. Total number of illnesses reported each week by the 107 athletes during the 52 week study period.

The overall IR of illnesses was 9.3 illnesses/1000 hours of sports exposure. Athlete subgroups who reported a slightly higher IR were; athletes with intellectual impairment (13.7; 95% CI 0.5-318.4), athletes with VI (12.4; 95% CI 0.8-187.7), athletes aged 26-34 (12.9; 95% CI 1.2-137.7), wheelchair athletes (11.8; 95% CI 1.8-78.5) (Table 10), and those in the middle TLRI category (22.0; 95% CI 0.9-562.4).

A majority (84%) of the illnesses were classified as infections, followed by spasticity (5%) and psychological illness (4%). Regarding affected body system, the

upper respiratory tract (68%) was the most affected body system, followed by the digestive/gastrointestinal body system (10%) and the urogenital/gynaecological system (7%). The most common symptom was sore throat (34%), followed by fever (25%) and coryza (10%). The cause of illness was reported to be related to overtraining and stress (45%), the impairment (28%) and transmission (17%). Illness severity due to time loss from sport were: 0-3 days (38%), 4-7 days (42%), 8-20 days (14%), ≥ 21 days (5%) and ≥ 3 months (2%). The athletes reported that they sought medical care for 22% of the illnesses. The athletes' opinion was that 15% of the illnesses could have been prevented.

Associations and risk factors of illnesses

Prevalence data (Study IV)

Female athletes suffered from significantly more existing illnesses than male athletes ($p=.046$). An existing illness was also associated with a previous severe illness ($p=.005$) (Table 11). Moreover, athletes who reported use of prescribed medications had a higher point prevalence ($p=.019$). There was also an association between an existing illness and a history of reporting anxiety/depression ($p=.001$). There were no significant associations between an illness, a specific impairment or a sport, for any of the illness prevalence measures. It is notable that athletes who reported moderate to extreme anxiety/depression also reported more psychological diagnoses for both illness prevalence measures ($p=.03$)

Incidence data (Study V)

Survival analyses with corresponding log-rank tests showed that athletes in team sports had a significantly lower SP (11%, median time to illness 8 weeks; 95% CI 4-12) compared to athletes in individual sports (35%, median time to illness 12 weeks; 95% CI 0-46) ($p=.022$) (Figure 21). Cox proportional hazard regression analyses using univariate tests showed that athletes in team sports had a significantly higher risk for illness (HR=1.64; 95% CI 1.05-2.54) ($p=.048$). Furthermore, cox regression multivariate analyses revealed that athletes in a summer team sport (goalball, wheelchair basketball and wheelchair rugby) had twice the risk for illness (HR=2.01; 95% CI 1.29-3.29) ($p=.005$). Finally, male athletes with a previous severe illness had twice the risk for a new illness (HR=2.13; 95% CI 1.29-4.36).

Regarding IR illness data, athletes in the middle TLRI reported a higher illness IR (22 illnesses/1000 hours) ($p=.019$) compared to those in the low and high TLRI groups. Athletes with SCI and wheelchair athletes had a higher proportion of illnesses in the urogenital/gynaecological system ($p=.002$) compared to ambulatory athletes and athletes with other impairments. Moreover, ambulatory athletes suffered from more multiple illnesses compared to wheelchair athletes ($p=.046$) (Table 11).

Table 11. Significant differences in illness prevalence proportions, time to illness, illness incidence rate and multiple illnesses.

Subgroups of athletes	Period prevalence (x ² test (p-value))	Point prevalence (x ² test (p-value))	Time to injury (log-rank test (p-value))	Comparisons of IR (Mann Whitney, Kruskal Wallis (p-value))	Comparisons of multiple illnesses (Mann Whitney, Kruskal Wallis (p-value))
Sex					
Male			0.405	.71	.59
Female	.536	.046			
Age					
18-25	.143	.481	.146	.59	.169
26-34					
35-63					
Impairment					
Visual	.142	.724	.15	.78	.11
Intellectual					
Physical					
Central neurological	.252	.551	.247	.81	.23
Les autres					
Limb deficiency					
Spinal cord injury					
Summer vs Winter					
Summer	.593	.742	0.995	.48	.81
Winter					
Team vs Individual					
Team	.721	.49	.022	.88	.24
Individual					
Wheelchair vs Ambulatory					
Wheelchair	.402	.566	0.683	.63	
Ambulatory					.046
Previous severe illness (yes)	-	.005	.578	.16	.24

Ethical considerations

While the primary purpose of medical research involving human subjects is to generate new knowledge, this purpose can never overhaul the rights and interests of individual research subjects. Medical research is thus subject to ethical standards that ensure and promote respect for all human research subjects. It is thus the duty of a medical researcher to protect the health, dignity, integrity, privacy, and confidentiality of human research subjects¹³², which has been considered in this project. First, the Sports-related Injury and Illness in Paralympic Sports Study was approved by the Regional Ethical Review Authority in Lund, Sweden (Dnr 2016/169) and (Dnr 2014/439). The project follows the World Medical Association's (WMA) Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects. Participation in the studies was voluntary and informed consent was obtained from all participants for Studies I, III, IV and V. The athletes could at any time terminate their study participation, without stating the cause.

An ethical concern that may occur in observational studies is observations of severe or life-threatening medical conditions. No life-threatening incidents were reported during the study period, and athletes with a severe SRIIPS were contacted and asked to take part in an examination by a physician or physiotherapist. Another ethical concern in medical research is that individuals with a severe disability sometimes are excluded from research due to the disability itself, co-morbidity or poor access to data collection instruments. All the athletes, regardless of disability, were invited to participate in this project to improve inclusion and equality. Moreover, the data collection methods were adapted for individuals with intellectual, visual and severe physical impairments. Personal assistance was also provided if necessary, and the PhD-student and Physiotherapist (KF) had in average contact with four athletes per week throughout the 52-week prospective data collection period.

We chose not to present sport specific data to protect athletes' integrity due to the small number of athletes in some of the Paralympic sports. Although data were collected with individual interviews in Study I and during 52 weeks in Study V, the participants did not report any discomfort. However, three athletes dropped out from the longitudinal study because of lack of time. The overall impression is that the participants' participation in this project will be beneficial for the athletes and future generations of athletes.

Discussion

General discussion

A methodological pluralism was used in this project to understand and describe sports-related injuries and illnesses in Swedish Paralympic athletes. By combining narrative and holistic methods with empirical and systematic ones, both science and practice can be influenced being as each methodological approach used to study a phenomenon will uncover new insights of the complexity in real-world issues.¹³³ The combination of qualitative and quantitative research is supported by current trends within sports medicine^{103,134}, and a strength of this project is that future prevention research will be based both on the athletes' own perceptions and on statistical data collected prospectively during 52 weeks. Overall, the Paralympic athletes reported a considerably high incidence and prevalence of sports-related injuries and illnesses, which is a concern as this athlete population already have an impairment.

Sports-related injuries: type, severity and risk factors

Overuse injuries

A large proportion of the injuries reported in this project were related to overuse, which are injuries to the muscle, tendon, bursa, bone or neurovascular structure due to repetitive loading without adequate recovery to allow for structural adaptation, and without an identifiable traumatic cause.^{135,136} Overuse injuries are a concern as they may lead to long-term time loss from sport and permanent disability related to, for example, tendon degeneration.¹³⁶ The injury nature is often multifactorial, and it is a challenge to understand an individual's risk for developing such an injury. It has been suggested that factors such as excessive and incorrect loading are risk factors¹³⁶, which are features that the athletes in this study perceived could lead to sports overuse.

In addition to sports overuse, Paralympic athletes are also at risk for overloading specific body parts due to the impairment. For example, a wheelchair athlete commonly loads the shoulders in all day activities, an amputee athlete may load one leg in all day activities and an athlete with CP may be exposed to constant use of the muscles due to spasticity.^{8,13,137} Previous studies have also proposed that overuse

injuries are related to a decrease in the sensory input leading to a dysfunction in the natural alarm system.³⁴ The sensory input is often reduced in athletes with, for example, a neurological impairment.¹⁰ An altered inflammation response due to chronic-low grade inflammation may also increase the risk for overuse injuries.¹³⁶ Further studies are thus warranted to evaluate the mechanisms of overuse injuries among athletes with neurological and inflammatory diseases.

It is notable that, despite a low weekly training load, several of the injuries were reported to be related to overuse. It could thus be hypothesised that the overuse phenomena, under preparedness and under loading because of insufficient training contribute to overuse injuries.¹³⁶ Recent research has shown that a high chronic training load can protect the athlete from injury whereas acute short time bouts of training and under loading increase the risk for injury.⁴⁶ This is supported by the results in this study showing that athletes with a high training load, in fact, reported a lower IR of injury compared to athletes reporting a low or middle training load. Under loading due to loss of function because of the impairment may also put the athlete at risk for overuse injuries such as tendon degradation and stress fractures.¹³⁶ Other factors that could have contributed to under preparedness are the high proportion of athletes with a severe injury, illnesses and insufficient support related to training, rehabilitation and nutrition. Altogether, some of the factors that may contribute to under preparedness are related to the prerequisites in Paralympic sport, and it is thus recommended that improvements are made to the Paralympic athletes' preparedness for elite sport, both at an individual and structural level. This is also an area for further research.

Traumatic injuries

Several traumatic injuries such as concussions, fractures, luxations and anterior cruciate ligament injuries were also reported. Collisions were the most common cause of traumatic injuries. A concern is that young athletes reported significantly more severe traumatic injuries, which may end their career too early. The International Olympic Committee has presented safeguarding measures to move towards the development of healthy, capable and resilient youth sport¹³⁸, and it is recommended that similar recommendations are composed within Para sport to protect young athletes. Furthermore, athletes with VI reported more traumatic injuries. Traumatic injuries among VI athletes have also been shown to be a concern in previous studies.^{139,140} Given that individuals with VI have a higher risk in general for unintentional injury, falls and fractures²⁰, action should be taken to evaluate the injury mechanisms more in detail in the blind sports.

Severity of injuries

As many as one third of the athletes reported a severe injury with a time loss from sport of more than 21 days, both one year retrospectively and one year prospectively. No differences in severity were present when adjusting for factors

such as impairment, sport, gender or type of injury. The high number of severe injuries reported in this project in comparison to the studies from Paralympic Games is a matter for concern. A majority of the injuries during the competition period of the Paralympic Games have not lead to any time loss from sport, with only 3% of the injuries classified as severe during the recent Paralympic Games.^{75,76} Further analyses are needed to evaluate whether severe injuries are more common during the athletes' normal season. The results also emphasise the need to conduct injury surveillance in different settings in order to provide optimal medical service and targeted prevention. Another aspect concerning severity and time loss due to an injury is the impact on performance. Recent research has shown that injuries, and their influence on training availability are major determinants of an athlete's chance of reaching the planned performance goals.¹⁴¹

Shoulder injuries

The shoulder was the most injured body location over time, which is in agreement with many other studies.⁷³⁻⁷⁶ In particular, wheelchair users and athletes with SCI suffered from shoulder injuries. The shoulder girdle is used in most tasks in both daily life and in sports among wheelchair users, which increases the risk for overuse injury.⁸² Factors such as loss of innervation to muscles and altered joint mobility due to contractures may also aggravate shoulder problems. The forward seated position in many wheelchair sports and sport specific activities, such as throwing and propulsion, may contribute to injury due to impingement (Figure 23).⁸²



Figure 23. Shoulder protraction, internal rotation, muscle imbalance, weak muscles, poor trunk control and overuse may contribute to the high proportion of shoulder injuries in wheelchair athletes. Photo: THE SWEDISH PARALYMPIC COMMITTEE.

Especially wheelchair propulsion leads to high peak muscle forces in the rotator cuff in particular, which is a muscle group that is easily fatigued during repetitive movements.^{142,82,143} Other symptoms such as subacromial pain, hypermobility and acromioclavicular pathology have been reported as common among wheelchair

users⁸², which is in accordance with the results from this project. Despite a common problem of shoulder complaints among Paralympic athletes there are few evidence-based prevention programs. This is an area for future study.

Injuries and athlete behaviour

The athletes' perceptions were that different behaviours, such as training while feeling pain or injured, negligence, use of analgesics, lack of patience and a risky behaviour, could cause injuries. This was supported by data from Study IV, in which an injury was associated with behaviours, such as feeling guilt when missing exercise, continuing training when injured, being upset when unable to exercise and using analgesics regularly. Previous studies among able-bodied athletes have also shown that athlete behaviours related to self-blame, excessive training and ineffective coping are associated with injuries.^{69,144} Based on these findings, it is recommended that future preventive measures include behavioural strategies related to psychological flexibility, coping and education.^{69,145}

Injuries among male athletes

Male athletes suffered a significantly higher risk for injuries over time. Such risk has not been demonstrated in the studies from the Paralympic Games.⁷³⁻⁷⁶ However, a recent study assessing injuries one year retrospectively among Paralympic judokas revealed that male athletes reported significantly more injuries.¹³⁹ There are also contradictory results concerning gender differences among able-bodied athletes, but a recent large cohort study from New Zealand showed that male athletes had an overall higher risk for sports injuries.¹⁴⁶ Moreover, it is well-known that males have a greater risk for unintentional injuries and accidents compared to women, and it has been suggested that a risk-taking behaviour contributes.¹⁴⁷ Several athletes in this project reported a risk-taking behaviour, and further analyses will assess if there are gender differences in risk-taking behaviours.

Previous injuries

A previous injury was associated with a new injury. A previous injury is also one of the strongest risk factors for a new injury among able-bodied athletes.^{51,148,149} Designing preventive measures that prevent injuries at a primary level before they occur is therefore crucial in injury prevention research.¹⁵⁰ It is also important to prevent injuries at secondary and tertiary levels as it has been suggested that changes in strength, biomechanics and motor control as well as early return to sport following an injury may affect the occurrence of a new injury.^{149,151} Based on this the importance of complete recovery, rehabilitation and testing should thus be emphasised before allowing the athlete return to sport. Moreover, there is a need for valid instruments to evaluate return to sport tailored for the specific population.¹⁵²

Injuries in team sports

Prospective data revealed that athletes in team sports had a higher risk for injury, even when adjusting for factors such as gender and type of injury. Team sports also had high injury IRs during the Paralympic Games, and it has been suggested that factors such as collisions, equipment and unawareness from coaches and officials may influence the risk.^{72,75,153} Successful injury prevention measures have so far been implemented in Para ice hockey. By adjusting the sledge height and introducing protective leg gear, the proportion of lower limb fractures have been greatly reduced.⁷² An ongoing project is aiming to reduce head injuries in football-5-a-side.¹⁴⁰ However, the results from this project show that athletes in the Paralympic team sports are still at risk for suffering an injury, and the Paralympic team sports should be in focus in the sports safety work within the Paralympic movement.

Injuries related to the impairment

Several of the athletes described that the impairment itself caused sports injuries, and the impairment was involved in the injury mechanism in a large part of the injuries. This is also supported by previous research, in which it has been suggested that impairment-related factors such as vision loss, orthopaedic defects, poor proprioception, pain and spasticity may be risk factors for injuries among Paralympic athletes.^{8,154,155} Notably, no impairment group had a higher risk for injury. Different impairment groups suffered, however, from different types of injuries. Wheelchair athletes and athletes with SCI suffered from significantly more upper extremity injuries, ambulatory athletes had more lower extremity injuries and VI athletes reported more injuries to the lower leg/calf, and multiple and traumatic injuries. Altogether, the results demonstrate that there is a need to prevent impairment-related injuries. Depending on the nature of impairment, different athletes will need different types of preventive measures.

The results also demonstrate the importance of designing injury and illness surveillance systems that are adapted to athletes with an impairment (Figure 24). Paralympic athletes may, for example, be exposed to internal risk factors such as overuse, pain, loss of function and spasticity. External risk factors may be mobility aids, technical aids other specific sports equipment such as sledges or straps, dependency on others (e.g. guides), non-adapted sport facilities and other prerequisites (e.g. limited coaching and medical service). Most of the previous injury surveillance systems used in Para sport have not included these risk factors.

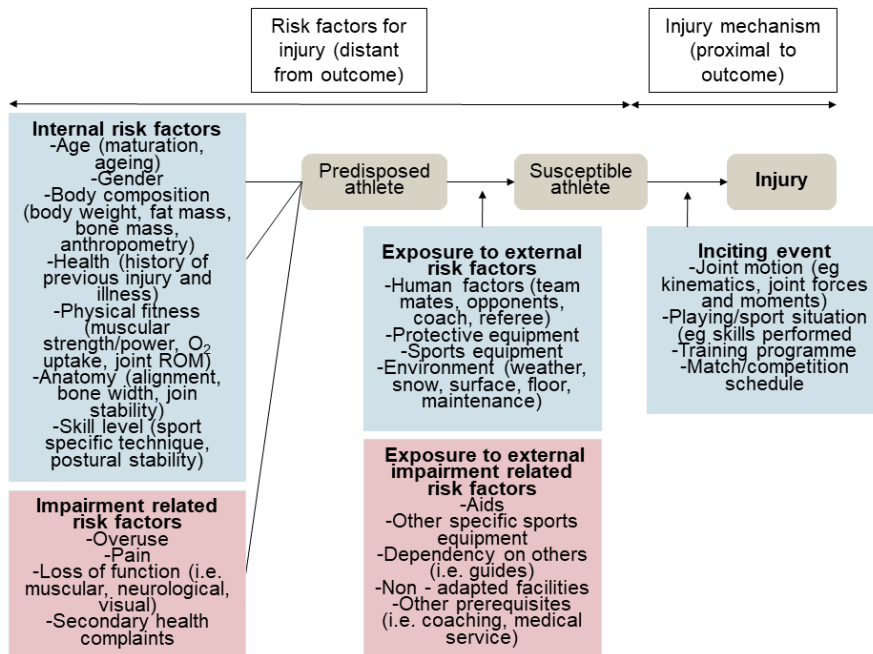


Figure 24. The dynamic, multifactorial model of sports injury aetiology from Meeuwisse (1994) and Bahr & Holme (2003), adapted to athletes with an impairment. Paralympic athletes may be exposed to other internal and external risk factors compared to able-bodied athletes. These risk factors should thus be included in athlete health surveillance systems and preventive measures.

Sports-related illnesses: type, severity and risk factors

This is the first study that has reported the incidence of illnesses in Paralympic athletes outside a competition period. A rather high illness incidence rate was reported, and a majority of the athletes (77%) reported an illness during the year. Similar studies among able-bodied athletes have reported illness IPs ranging from 60-75%^{95,156}. The athletes reported an average of 2.3 illnesses per year here compared to 0.8 per season (9 months) among elite male football players.¹⁵⁷ Higher illness IPs (12-17%) have also been reported during the Paralympic Games compared to the Olympic Games (5-9%).^{33,77,85-87} It is notable that more illnesses than injuries were reported over time, which emphasises the need for also including illnesses in athlete health surveillance and preventive measures.

Respiratory tract infections

A majority of the reported illnesses occurred in the respiratory tract and were related to infections, which is in agreement with studies among able-bodied athletes.^{91,156,157} A concern is that the median time to illness was only nine weeks. This could be explained by the study start in the middle of the Swedish flu and common cold

season.¹⁵⁸ It is considered normal to experience 1-3 common colds per year.¹⁵⁹ However, for athletes a common cold is of great concern as it leads to an impaired muscle metabolism and decrease of efficacy in the cardiopulmonary system.^{47,141} Other exercise-related complications that may follow respiratory tract infections are viral myocarditis and post-viral fatigue syndrome.⁴⁷

Transmission is the main cause of infections, but hard training in combination with life stress may lead to impairments in immunoregulatory hormones due to an activation of the hypothalamic pituitary adrenal axis, which puts the athlete at a higher risk for infections.⁴⁹ In this study, the athletes reported that the onset of illness was due to overtraining and stress in 45% of the illnesses, and it can be recommended to reduce such stress in order to prevent infections. Other recommendations to prevent infections among athletes are; avoiding use of shared water bottles, washing hands and/or use alcohol gel regularly, informing about good sleeping and eating habits, avoiding continuous exposure to polluted air and air-condition, early reporting of symptoms and early isolation of athletes with symptoms. Other effective preventive measures that have been used in elite sport settings are flu vaccination, easy access to medical staff, avoidance of crowds prior to competitions and screening for airway problems.^{160,161}

Illnesses related to the impairment

The athletes reported that the impairment was involved in the cause of illness in almost one third of the illnesses. A higher proportion of illnesses in the urogenital system was reported in this study compared to studies among able-bodied athletes.^{91,156,157} Athletes with SCI and wheelchair users reported significantly more illnesses in the urogenital systems, which can be explained by a neurogenic bladder.¹⁰ Other impairment-related risk factors that were reported to contribute to illness were respiratory problems, bowel dysfunction and an impaired immune system. It is notable that skin problems were not a specific concern in this population in comparison to data from the Paralympic Games.⁸⁷ This could possibly be explained by the Swedish National Quality Registry for Ulcer Treatment, which has led to a reduction in the prevalence of pressure ulcers as well as shorter treatment times.¹⁶²

Based on the results from this PhD-project, the screening and education of athletes about symptoms and prevention of impairment-related illnesses is recommended. The results also emphasise the need for quick and adequate medical support for Paralympic athletes.

Illnesses in team sports

Athletes in team sports had a higher risk for illness. Previous studies among able-bodied athletes have also shown that athletes in team sports are more often exposed to infectious disease due to close contact with other athletes and surfaces.¹⁶¹ In addition, both team wheelchair athletes and VI athletes are regularly exposed to

contaminated arena floors due to wheelchair propulsion and marked lines on the floor (Figure 25).



Figure 25. Athletes in the Paralympic team sports are often exposed to contact with each other, contaminated arena floors and balls, at the same time as they have to rely on their hands during navigation, eating, drinking and maybe using a catheter. Photo: THE SWEDISH PARALYMPIC COMMITTEE

At the same time the athletes often use their hands to drink, remove sweat and maybe use a catheter. Preventive measures such as discouraging the sharing of water bottles, regular hand washing and distance keeping have successfully been implemented among able-bodied team athletes.¹⁶³ It is thus recommended that similar prevention measures among Paralympic team athletes are reinforced, and that stakeholders are informed about the cleaning of arena floors and equipment more regularly.

Mental health and illness

Few studies have assessed the burden of mental illness among Paralympic athletes, which has been linked to barriers and insecurity of studying disabled individuals' mental health.¹⁶⁴ Prospective data here showed that 4% of all illnesses (reported by 6% of the athletes) were an ICD-10 by physician classified mental illness, which could be considered as relatively low. Similar studies among able-bodied elite athletes have reported proportions ranging from 5-35%.¹⁴⁵ A limitation of the present project is that the illness definition only included illnesses that changed participation in normal sports participation, which might have underestimated the burden. Recent research has shown that mental illnesses such as attention-deficit disorders, eating disorders and substance use tend to be more common among athletes compared to the general population⁵⁰, but these disorders may not cause changes in sports participation. It is notable that the athletes also registered a higher weekly rate of self-reported depression/anxiety compared to the general population in Sweden.¹⁶⁵ It is thus recommended that future studies evaluate mental health among Paralympic athletes.

Athlete health and well-being

Sleep

Almost 60 % of the athletes reported that they slept seven hours or less per night, which is a concern as low sleep quantity may affect athletic performance negatively.¹⁶⁶ Recent research has also shown that there are associations between insufficient sleep and the risk of pain, injury and illness in sports.¹⁶⁶⁻¹⁶⁸ It has been suggested that insufficient sleep is related to high training demands and lack of awareness among able-bodied athletes.¹⁶⁶ Poor sleep may also be related to the impairment in the population in the present study. Individuals with VI are more prone to circadian rhythm disturbances¹⁶⁹ and general sleep disturbances are common among individuals with SCI¹⁷⁰ and MS.¹⁷¹ Any associations between sleep, SRIIPS and the impairment will be analysed in future studies. Furthermore, it can be recommended to educate both the sports community and athletes about the importance of sleep.¹⁶⁶

Pain

The athletes described qualitatively that pain is a phenomenon that belongs to participating in Paralympic sport. Almost half of the athletes reported weekly moderate or extreme pain during the 52 weeks. Reporting pain during sports was associated with a history of a previous severe injury. Pain is also a common problem that compromises physical and mental health, and decreases performance among able-bodied elite athletes.¹⁷² It could be hypothesised that pain is a more widespread problem among Paralympic athletes since individuals with an impairment report a higher prevalence of pain in general.^{10,173,174} There are few other studies that have assessed the burden of pain among Paralympic athletes, and it is recommended to further address its nature, consequences and treatment.

Use of analgesics

Seventeen percent of the athletes reported weekly use of analgesics to handle sports-related pain, which is considerably high for a period of a year. It was also shown that a previous severe injury was associated with regular use of analgesics. The widespread use of analgesics in sports has recently been considered as a problem due to side effects such as prolonged healing, bleeding and substance abuse.¹⁷² Research has also shown that athletes who use analgesics are more prone to using doping substances.¹⁷⁵ The current recommendations are thus to only use analgesics at the lowest effective dose for the shortest period, and to combine medications with non-pharmacological treatment.¹⁷² The use of analgesics among Paralympic athletes could be motivated because of pain related to the impairment. However, a recent study highlighted that side effects and dependency should be considered when prescribing analgesics to Paralympic athletes since the athletes may already be exposed to other prescribed medications.¹⁷³

Training load

The athletes reported a low number of training hours per week (6.8 ± 4.8 hours) compared to, for example, Swedish able-bodied elite athletics athletes (12.5-18 hours)⁵¹ and swimmers (>20 hours).¹⁷⁶ Studies of international Paralympic judokas (12 hours/week) and German Para athletes (14.4 hours/week) have also reported more training hours.^{88,139} A concern is that there are few studies on how athletes with an impairment should train and how the training load influences the risk for injury and illness. It is thus recommended to further evaluate training load, performance and athlete health both objectively and subjectively in future studies.

Prevention and future research

What do these epidemiological data reveal?

This project focuses on the first and second steps in van Mechelen's 'sequence of injury prevention model'.⁶¹ The results revealed that the extent of injuries and illnesses are similar or higher when comparing with studies of able-bodied athletes^{33,51,95}. Concerning specific risk factors, male athletes and athletes with a previous injury had a higher risk for injury. Athletes in team sports had a higher risk for both injury and illness. No specific impairment group had a higher risk for SRIIPS. Several associations showed, however, that specific impairment groups reported specific injuries and illnesses to certain body parts or body systems. Moreover, athlete behaviours, pain and use of analgesics were associated with an injury. Furthermore, a variety of impairment-related injuries, overuse injuries, traumatic injuries, recurrent injuries, illnesses and other health problems were reported. Altogether the results indicate that there is a need to prevent several different incidents on primary, secondary and tertiary levels (Figure 26) according to the Haddon's injury prevention matrix, which was originally developed within motor-vehicle collision research.^{67,150}

More specifically, primary prevention aims to counteract the incidents before they occur. Nevertheless, injuries and illnesses that have already occurred also need attention during the injury/illness phase in terms of rapid diagnosis, treatment and prevention of morbidity (secondary prevention). Lastly, athletes that have suffered from an injury/illness will need appropriate help to return to full function and prevent re-injury/illness (tertiary prevention).^{60,67,177}

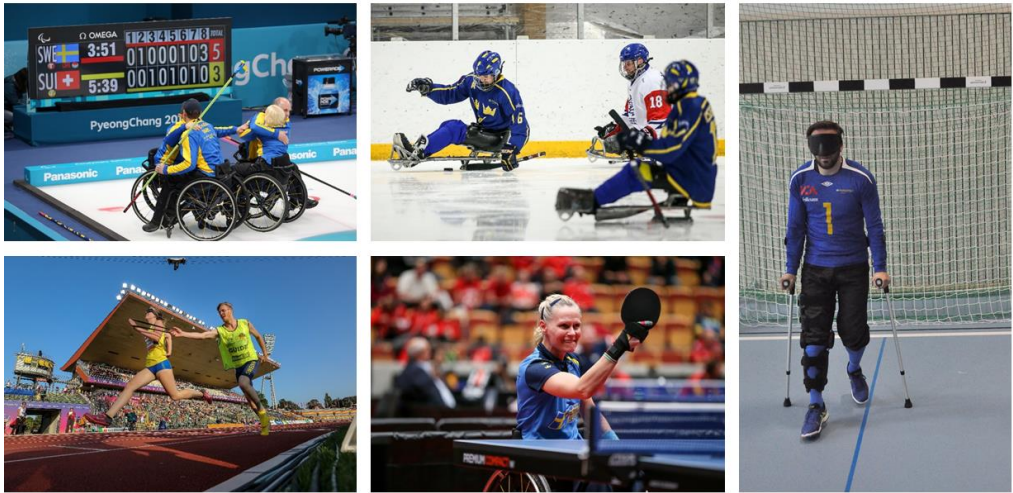


Figure 26. The results from this project show that there is a need to prevent a variety of impairment-related injuries, overuse injuries, traumatic injuries, recurrent injuries, illnesses and other health problems on primary, secondary and tertiary levels in different athlete, impairment and sport categories. Photo: THE SWEDISH PARALYMPIC COMMITTEE

Time for action, towards the development and implementation of preventive measures

What can be learnt from other sports?

Subsequently, the next step in this research process will be to develop, implement and evaluate preventive measures according to step three and four in the 'sequence of injury prevention model'.⁶¹ Most successful evidence-based injury prevention programmes in able-bodied sports have focused on neuromuscular training, strength, plyometrics, flexibility, balance, agility and feedback from coaches and medical staff.^{62,65} Recent programmes have also implemented general illness prevention strategies.¹⁷⁸ There is, however, a challenge in that many existing preventive measures are effective in a controlled scientific setting, but are less effective in the real-world as they are not used by the sports context in the way that was intended.¹⁷⁹⁻¹⁸¹ The reasons have been linked to factors such as lack of time, lack of knowledge and difficulties in motivating behavioural changes in the sports context.^{34,182,183}

It was originally suggested already in Haddon's injury prevention matrix that most injuries are a sequence of events representing a continuum of different factors related to the individual, the physical environment and the social environment.¹⁷⁷ To improve the use of preventive measures in sports medicine, Finch (2006) added two steps to the 'sequence of injury prevention model'.¹⁸² In the Translating Research into Injury Prevention Practise framework (TRIPP) it is recommended to

also consider factors related to the implementation context such as the environment, social factors and the possibility for the sport to deliver the prevention measure.^{103,182} Still, prevention programmes have been difficult to establish in many sports settings^{103,183,184}, and recent research has shown that athletes and coaches themselves prioritise performance enhancement rather than injury prevention.¹⁰³ To move forwards, Bollinger et al. 2018 proposed that each sport's context and complexity need to be considered in the development of preventive measures.¹⁸¹ Moreover, it is important to understand the possibilities for the individual athlete to perform the proposed prevention measures¹⁸¹, which will be crucial among Paralympic athletes as the athletes have different impairments and abilities. It has also been emphasised to define a sports injury in the specific athlete population, as the perception of what a sports injury is may differ between different athletes, which is a strength of this project. Taken together, preventive measures should be developed based on the athletes' perceptions, possibilities and needs.^{103,181}

Moreover, it has been proposed that the policies, attitudes and involvement in prevention work of sports organisations matter.^{134,179,181} Research has shown that many gaps in the implementation of preventive measures in sports are due to failures in reach and adaptation within the sports organisations.¹⁸⁵ Dahlström et al. 2015 suggested that in order to overcome the organisation-practise barrier in sports-injury prevention the sport will benefit from: i) a reduction of the organisational hierarchy allowing different professions within the sport community plan prevention; ii) a routine collection of injury and illness data to obtain a scientific overview of the need of prevention; and iii) open forums allowing all participants within the sport to discuss safety issues.¹³⁴ Another concern is that there often are gaps between academia and sports organisations, which limits the implementation of preventive measures.¹⁸⁶ It is therefore recommended that the attributes from the academia, such as understanding, questioning and exploring are utilised together with the attributes from the sport such as progression, acting and urgency.

The socioecological model as a framework for prevention

To improve the success of preventive measures it has recently been proposed that sports safety work should facilitate development, communication and education of prevention at all levels including the athlete, the sports context and the sports organisation.^{103,134,187,188} To succeed with this, the use of the socioecological framework, originally developed within public health to identify how different levels in a setting influence each other with respect to a given health complaint and it's possibilities for prevention, have been emphasised (Figure 27).¹⁸⁷⁻¹⁹¹ Behavioural change strategies and education rather than environmentally focused interventions have in particular been emphasised.¹⁸⁷⁻¹⁸⁹

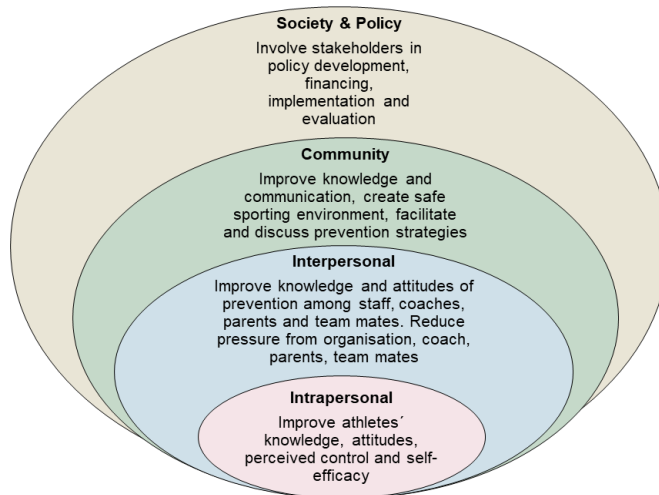


Figure 27. A socioecological model including a multifactorial approach to prevent injuries in sport, modified from Regsiter-Mihalik et al. 2017 and Jacobsson et al. 2017.

Towards a socioecological prevention approach in Paralympic sport

To move towards prevention of sports-related injuries and illnesses in Paralympic sport it can, based on the results from this thesis, be suggested that a prevention framework formed around the socioecological model would be useful (Figure 27 and 28). Policies need to be housed from the highest level within the organisation in order to increase the awareness of preventive measures. These policies will most likely influence the possibilities, knowledge and attitudes concerning preventive measures at all levels within the sports.^{134,187} Recent research has shown that there are correlations between insufficient leadership and the injury burden.¹⁹² It is thus crucial that routines regarding sports safety are established and supported by a sustainable and supportive leadership.^{134,192} Closer cooperation with academia would also be beneficial for developing evidence-based preventive measures and enabling support for implementation, evaluation and grant applications (Figure 28).

Furthermore, the awareness, acceptance, knowledge, development and use of preventive measures need to be conceptualised within the sports community.¹⁸⁷ In order to bridge the gap between science and practice it has been suggested that the identification of and solution for problems can be done through collaboration between sports practitioners and researchers.^{134,186} It could therefore be suggested that focus group discussions including stakeholders, coaches, researchers, medical staff and athletes would be beneficial for improving communication and facilitating preventive measures adapted for Paralympic athletes. Moreover, it could be recommended that regular athlete health surveillance is continued with in order to facilitate awareness and scientific data to all levels within the sports community.¹³⁴

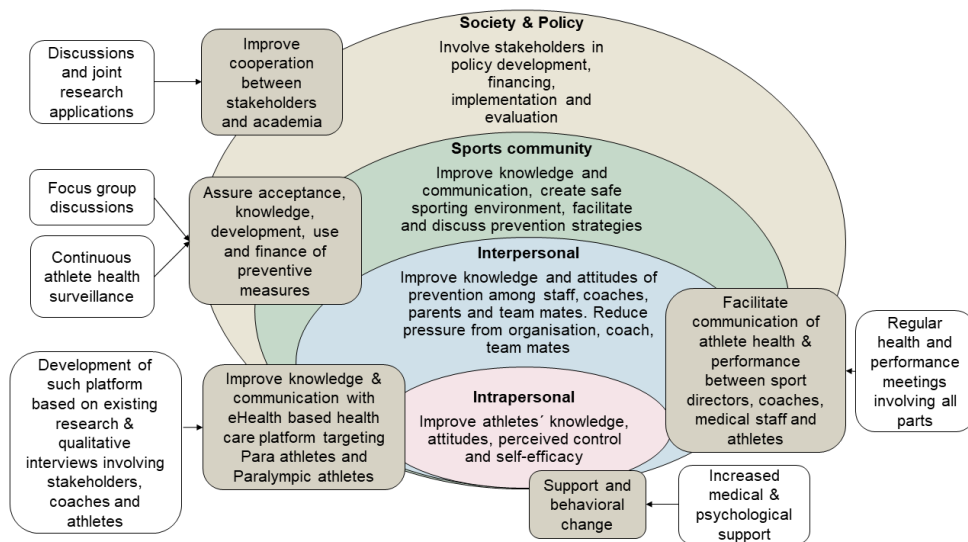


Figure 28. A sociocological model including a multifactorial approach to prevent injuries and illnesses in Para sport and Paralympic sport.

The need to improve knowledge about preventive measures to the persons working around the individual athlete has also been emphasised.¹⁹¹ There are thus possibilities for preventing injuries both directly and indirectly. For example, it has been proposed that an improved interpersonal control of training and injury prevention may reduce the pressure on the individual athlete.¹⁸⁷ To facilitate communication and improvement of the individual athletes' health it could therefore be proposed that regular health and performance meetings including sport directors, coaches, medical staff and possibly the individual athlete would be beneficial. A hypothesis could be made that this is of extra importance in the Para sport population as there are sometimes other prerequisites related to, for example, finance, accessibility, knowledge and abilities (Figure 28).

Finally, the individual athletes' behaviour, knowledge, perceptions and motivation most likely influence the possibilities for preventing sport-related injuries and illnesses.^{103,134,187} It has been shown that especially education plays a crucial role in improving and facilitating athletes' knowledge, perceptions, motivation and self-efficacy of prevention.¹⁸⁷ Thus in order to facilitate the education and communication of the prevention of injuries and illnesses it could be suggested that an eHealth-based platform specifically developed and adapted for Swedish Para athletes and Paralympic athletes, based on the results from this thesis and further qualitative interviews could generate such knowledge. In addition, there is a need for more individual medical and psychological support providing accurate treatment and individualised preventive measures (Figure 28).

Methodological considerations

Definitions and data collection

One could argue that the broad injury and illness definitions including partial time loss SRIIPS could lead to the over-reporting of incidents. However, previous studies have proposed that definitions, including only time loss and incidents reported by medical staff, underestimate overuse related conditions⁵¹, psychological complaints as well as the overall burden of injuries and illnesses.^{92,193} Such definitions would possibly also underestimate impairment-related health complaints. A strength of the data collection is that definitions, questionnaires, the surveillance system and classification of SRIIPS were adapted for Paralympic athletes. Popular surveillance and classification systems, such as the Oslo Sports Trauma Research Centre Questionnaire and the Orchard Injury Classification System^{95,194} do not consider diagnoses, risk factors or special needs related to Paralympic athletes' impairment or equipment, which may lead to biased results.

A limitation in the data collection method is that training-load data were not validated objectively, which could be performed through global positioning systems and heart rate monitors in the future.¹⁹⁵ Another limitation is that not all the invited athletes in the cohort chose to participate, which could lead to participation bias.¹²⁶ However, response rates above 70% are considered sufficient in epidemiological studies¹²⁶, and the response rates are also comparable to similar studies.^{156,51}

Trustworthiness and validity

Credibility, confirmability, dependability and transferability were considered to establish trustworthiness of the qualitative data.¹⁹⁶ A variety of different athletes were interviewed, variations in the data were presented and triangulation of other methods were used to assure credibility. To establish confirmability, citations were shown and all authors had access to the raw data and were involved in the categorisation. The methods were reported in depth to ensure dependability. Regarding transferability, it is believed that the qualitative results can be applied to other settings of Paralympic athletes since many underlying assumptions can be explained by the literature.

Concerning the validity of quantitative data, conclusions drawn from the results are that the instruments measure what they were intended to measure.⁶⁰ A strength is that four studies were conducted prior to the quantitative data collection to assure that the measurements corresponded accurately to the real world.¹²⁶ Moreover, feasibility and usability were assessed in order to improve the eHealth application and users' needs and desires.¹²⁰ A limitation is that reliability was not specifically evaluated in this project, which also is a limitation of many similar studies within

the field. This is an area for future research. Altogether it could be estimated that the results correspond to the reality of Paralympic sport in Sweden, but repeated measures as well as studies from other regions would improve the generalisability.

Epidemiological data

A limitation is the relatively small study sample. Large multicenter studies would therefore be valuable in the future to improve the statistical power in this research field. For example, to obtain a 25% risk reduction of injuries in a future intervention study based on the observed effect in Study V, a study sample of 262 athletes would be required in a study that applies a significance level of 5% and 80% power.

A strength of this project is that both injuries and illnesses were included. One should, however, be aware of the presence of competing risk that may impede or affect the occurrence of either injury or illness.¹⁹⁷ One option could be to impute the weekly exposure data in future studies in order to control for competing risks and missing data.¹⁹⁸ However, there is always a great uncertainty about dealing with missing data when several outcomes and exposures are involved. Another strength of this project is that time-to-event analyses that estimate time to SRIIPS and allow analyses of time dependant changes in a risk factor's hazard ratio were conducted.⁶⁰ A dilemma in sports medicine research is, however, that the subject can be affected by different injuries and/or illnesses during a study period. No attempts were made to model times between repeated SRIIPS in this project, which is a limitation. Such attempts have not been conducted in any of the studies within Paralympic sports medicine, and it is recommended that future research establish how subsequent events within Para sport and Paralympic should be classified.

Other epidemiological biases that could be present in this project are recall bias, and non-differential and differential misclassification of exposure, injuries and illnesses. Furthermore, it is important to consider the confusion of effects (confounding) in all epidemiological research.¹²⁶ For example, the exposure to sport could possibly be mixed with the exposure to wheelchair use in daily life, which could lead to a biased outcome of injury. The concept of causation in epidemiological research is based on observations, with effects that are immediately apparent. In medicine there are often multiple mechanisms acting in concert that cause an incident, and factors such as the sum of attributable fractions and induction time may influence the outcome.¹²⁶ Consequently, no simple answer can determine whether epidemiological observations are causal, and in order to assess the evidence of the epidemiological research within this project, the causal criteria of Bradford Hill have been used.^{126,199}

Conclusions

This thesis has provided new knowledge and understanding about sports-related injuries and illnesses among Swedish Paralympic athletes that can be used in the development and implementation of evidence-based preventive measures.

- Paralympic athletes' perceptions of experiences were that the impairment itself, overuse and a risk behaviour were involved in the causes and mechanisms of sports-related injuries. Moreover, the perceptions were that sports-related injuries as well as the possibilities and prerequisites for preventing them differ in several ways from able-bodied athletes. This complexity needs to be accommodated in the development and implementation of athlete health surveillance and preventive measures.
- The primary requirements for epidemiological research of sports-related injuries and illnesses in Paralympic athletes are to: i) allow prospective studies over time collecting data both during training and competition; ii) adapt surveillance systems to Paralympic athletes' pre-existing impairments; iii) and allow data collection that suits the sports context.
- It is feasible and usable to use an eHealth application based on self-reports and adapted to Paralympic athletes' various impairments for collecting epidemiological data about sports-related injuries and illnesses among Paralympic athletes.
- The retrospective 1-year prevalence of severe injuries was 31%, which is a concern. The point prevalence of existing injuries was 32%, indicating that only 68% of the athletes are not injured and are available at one point in time. Regarding illnesses, 14% of the athletes reported a severe illness 1-year retrospectively and 13% reported an existing illness. Previous incidents, pain, and behavioural and psychological aspects were associated with the occurrence of a sports-related injury or illness in Paralympic athletes.
- The incidence proportion of a new sports-related injury was 68% and the incidence rate was 6.8 injuries/1000 hours of sports exposure, which is considered as high. A majority of the injuries occurred during training, 68% were related to overuse and 34% were classified as severe injuries. The athletes impairment was involved in the injury mechanism in 59% of the injuries.

- Athletes in team sports, males and those with a previous severe injury had a higher risk for a new sports-related injury. Athletes with visual impairment reported significantly more multiple and traumatic injuries, ambulatory athletes reported a higher proportion of lower extremity injuries, and wheelchair athletes and athletes with spinal cord injury reported a higher proportion of shoulder injuries. Subsequently, these athlete categories should in particular be targets for future preventive measures.
- The incidence proportion of a new illness was 77% and the incidence rate was 9.3/1000 hours of sports exposure, which is also considered as high. The most commonly affected body system was the respiratory tract, and a majority of the illnesses were categorised as an infection. The athletes reported that the impairment was involved in the cause of illness in 28% of all illnesses.
- Athletes in team sports and males with a previous severe illness had a higher risk for a new illness. Wheelchair athletes and athletes with spinal cord injury reported a higher proportion of illnesses in the urogenital system, and it is recommended that all these athlete categories are targeted in future preventive measures.
- In addition, 59% of the athletes reported prospectively that they slept seven hours or less per night, 48% reported moderate to severe pain each week, 34% reported that they felt moderately to severely anxious/depressed and 17% used analgesics weekly.
- Altogether, there is an urgent need to prevent sports-related injuries and illnesses among Swedish Paralympic athletes at primary, secondary and tertiary levels.

Practical implications

The knowledge generated from this thesis can in a first step be used by stakeholders, medical staff, coaches and athletes themselves to inform the prevention of sports-related injuries and illnesses. Ultimately, the practical relevance of this thesis is to allow safe sports participation and to maximise athletic performance by developing measures to prevent sports-related injuries and illnesses among Swedish Paralympic athletes.

- Paralympic athletes' perceptions of their experiences of sports-related injuries are complex and differ in several ways from those of able-bodied athletes, this thus needs to be considered in resource allocation, training planning, medical support and prevention work.
- Most athletes stated that athlete health monitoring is important to carry out, it is thus recommended to continue with athlete health monitoring of Swedish Paralympic athletes.
- To prevent the high rate of overuse injuries better monitoring of excessive training as well as under loading and over loading is recommended, both in sports and in daily life. Moreover, the training should be adapted to the athletes' abilities and body structures, and their preparedness for elite sports needs to be improved.
- There is also a general need for adequate medical support during the athletes' training periods since most injuries occurred outside competition.
- To prevent shoulder injuries among wheelchair athletes, it can be recommended to screen for shoulder complaints, to ensure optimal loading and training of the shoulder girdle, and to customise equipment.
- To prevent traumatic and multiple injuries among athletes with visual impairment, it is recommended to strive for safety both during competition, training and in daily life by ensuring appropriate guiding, sports equipment and rules.

- To reduce the burden of subsequent injuries, it is recommended that both medical staff, coaches and athletes themselves ensure that complete recovery and rehabilitation have been conducted before returning to sport.
- To prevent the high rate of infections, it is suggested based on current recommendations to proactively work with education concerning precautions that can help the athletes to avoid becoming ill in an infectious disease.
- To prevent illnesses in the urogenital system among wheelchair athletes and athletes with spinal cord injury, it is recommended to ensure optimal bladder management as well as accurate medical support.
- To inform a change in athlete behaviours, such as continuing training injured or sick, it is recommended to educate athletes and coaches about training load and recovery as well as symptoms and consequences of sports-related injuries and illnesses.
- The high proportion of athletes reporting pain and use of analgesics suggest that causes of pain, its treatment and side effects, and its impact on athletic performance are better understood. Also, general non-pharmacological strategies described in the literature that can be recommended are: improved sleep quality, mindfulness-based stress reduction, education and physical therapy techniques.
- To improve the quantity of sleep, it is recommended to educate athletes and coaches about the importance of sleep, and to identify sleep disorders that could be related to stress or the impairment.
- To address the reporting of anxiety/depression, it is important to foster a positive climate within the sports context, to screen for mental illness, to review and improve psychological support, and to educate athletes about symptoms and coping strategies.
- To inform the prevention of injuries and illnesses among Swedish Paralympic athletes, it is further recommended to improve athletes' medical and nutritional support and possibilities to reach the health care system.

Future perspectives

- Results from this project revealed that it is feasible and usable to use eHealth based athlete health monitoring for scientific use. However, there is no data evaluating the athletes' perceptions of continuous eHealth based data collection over time. We therefore plan to evaluate the athletes' perceptions of benefits, facilitators and barriers to continuous athlete health monitoring within the sports context.
- It could also be suggested that future studies should evaluate the development and use of eHealth-based, athlete-centered medicine and training planning in Para sport. It could, for example, be beneficial to encourage eHealth-based access to personal records, education and communication between athletes, coaches and medical staff.
- Future studies should also focus on evaluating Paralympic athletes' mental health, pain, use of analgesics and sleep in more detail. Based on the results from this project we are planning to explore if these biopsychosocial factors are risk factors for injuries and illnesses in future studies.
- Future studies emerging from this project will also focus on evaluating specific types of injuries, for example, head injuries and overuse injuries.
- More in-depth analyses of injury and illness mechanisms are also needed to evaluate underlying risk factors in the specific athlete, impairment and sport specific categories. Larger multi-centre studies would thus be valuable to obtain more sport and impairment specific data.
- Lastly, the results from this thesis infer that factors leading to sports-related injuries and illnesses are complex and call for injuries and illnesses to be prevented on primary, secondary and tertiary levels. To succeed with this, it could be hypothesised that it would be feasible to implement multifactorial and adapted preventive measures based on a socioecological model including both the sports organisation, researchers, coaches, medical staff and the athletes themselves. Accordingly, the next step in this research process will be to develop and implement such preventive measures, and to follow up and evaluate their effectiveness.

Populärvetenskaplig sammanfattning

Intresset för parasport fortsätter att öka och de Paralympiska spelen är numera ett av världens största idrottsevenemang. Trots flera allvarliga olyckor under Paralympics samt det faktum att all idrott innebär en risk för att drabbas av en idrottsrelaterad skada eller sjukdom är kunskapen om idrottsrelaterade skador och sjukdomar inom parasport begränsad, och det finns inga evidensbaserade förebyggande program.

Det övergripande syftet med detta projekt var därför att få en fördjupad förståelse och kunskap om idrottsrelaterade skador och sjukdomar hos svenska elitaktiva paraidrottare för att kunna främja utvecklingen av evidensbaserade förebyggande program.

Både kvalitativa och kvantitativa metoder användes i det här forskningsprojektet för att få en holistisk och systematisk kunskap om ämnet. I en första studie intervjuades 18 idrottare för att få en bättre förståelse om paraidrottares egna uppfattningar och erfarenheter av idrottsrelaterade skador. Baserat på dessa resultat utvecklades ett studieprotokoll för epidemiologisk forskning. En e-hälsoapplikation för datainsamling av egenrapporterad hälsodata utvecklades sedan, och dess användbarhet och genomförbarhet utvärderades i en pilotstudie. Därefter fyllde 104 idrottare i ett baslinjeformulär om sin idrott, sin funktionsnedsättning, sitt träningsbeteende, nuvarande idrottsrelaterade skador och sjukdomar samt allvarliga idrottsrelaterade skador och sjukdomar ett år tillbaka i tiden. Slutligen rapporterade 107 idrottare varje vecka prospektiv data gällande nya idrottsrelaterade skador och sjukdomar, träningsmängd, träningsintensitet, sömn, oro/nedstämdhet, smärta och användning av smärtstillande läkemedel under 52 veckor.

Resultaten visar att paraidrottares uppfattningar och erfarenheter av idrottsrelaterade skador är komplexa och delvis skiljer sig från skador hos idrottare utan funktionsnedsättning. Det var vanligt med skador relaterade till funktionsnedsättningen, överbelastning, smärta, ett riskfyllt beteende samt otillräckliga förutsättningar för att kunna förebygga skador. Således bör forskning, resurstilldelning och förebyggande program anpassas till paraidrottare, vilket gjordes i studieprotokollet och i utvecklingen av e-hälsoapplikationen. Även resultat från användar- och genomförbarhetsstudien påvisade att definitioner, frågor, svarsalternativ och tekniska plattformar bör anpassas till idrottare med olika funktionsnedsättningar.

Omkring en tredjedel (31%) av idrottarna rapporterade att de hade haft en allvarlig idrottsskada med en tidsförlust från idrott i mer än tre veckor ett år tillbaka i tiden. Även omkring en tredjedel (32%) rapporterade att de hade en nuvarande skada, vilket innebär att man kan räkna med att endast 68% av idrottarna är skadefria vid en specifik tidpunkt. Mer allvarliga skador rapporterades av unga idrottare i åldern 18-25 år, bland idrottare som regelbundet rapporterade smärta under idrott samt bland de som regelbundet använde smärtstillande läkemedel. Att fortsätta träna fast man hade en skada samt att känna skuld vid utebliven träning var även associerat till en svår skada. Att regelbundet rapportera smärta i vardagen och under träning, att regelbundet använda smärtstillande läkemedel samt att känna sig upprörd över att inte kunna träna var associerat till en nuvarande skada. Sjukdomsdata visade att 14% hade haft en svår sjukdom ett år tillbaka i tiden, och 13% hade en nuvarande sjukdom. Att ha haft en tidigare svår sjukdom, att vara kvinna samt känna sig regelbundet orolig/deprimerad var associerat med en pågående sjukdom.

Data som rapporterades in varje vecka under ett år visade sedan att 68% av idrottarna ådrog sig en skada och att 6.9 skador/1000 träningstimmar rapporterades. En majoritet av alla skador inträffade under träning, 68% av skadorna klassificerades som överbelastningsrelaterade och 34% av skadorna klassificerades som allvarliga idrottsskador. För 59% av skadorna var funktionsnedsättningen en bidragande faktor i skademekanismen. En ökad skaderisk observerades bland idrottare med en tidigare allvarlig skada, hos lagidrottare samt bland manliga idrottare. Rullstolsidrottare rapporterade en signifikant högre frekvens av axelskador och idrottare med synnedsättning rapporterade mer traumatiska skador.

Totalt sett rapporterade 77% av idrottarna en sjukdom under året. Mediantid till en sjukdom var endast nio veckor och sjukdomsincidensen var 9.3 sjukdomar/1000 träningstimmar timmar. Den vanligaste sjukdomstypen var infektion (84%) i luftvägarna. Lagidrottare och män med en tidigare svår sjukdom hade en högre sjukdomsrisk. Rullstolsidrottare och idrottare med ryggmärgsskada rapporterade en signifikant högre frekvens av urinvägsinfektioner. För övrigt rapporterade 59% av idrottarna att de i snitt sov sju timmar eller mindre, 48% rapporterade varje vecka måttlig till svår smärta, 34% kände sig oroliga eller nedstämda och 17% använde varje vecka smärtstillande läkemedel i samband med träning.

Sammanfattningsvis visar resultaten att förekomsten av idrottsrelaterade skador och sjukdomar är hög hos svenska elitaktiva paraidrottare. Resultaten visar även att det är möjligt att använda en anpassad e-hälsobaserad plattform för att samla in data om paraidrottarens hälsa och träningsbeteende. Avhandlingen bidrar med helt ny kunskap och förståelse som kan användas för att designa och implementera förebyggande strategier med fokus på att förbättra idrottarnas hälsa samt optimera den idrottsliga prestationen. För att göra detta föreslås det att preventiva åtgärder implementeras på flera olika nivåer inom idrotten.

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Appendix

Appendix 1. Study-specific questionnaire used for prospective weekly data collection in SRIIPSS (not validated to English).

Hej! Välkommen att fylla i veckorapporten (mån xx-sön xx) om skador och sjukdomar.

Fråga 1. Tränade du normalt (fullt) under den gångna veckan xx-xx?

- Ja, helt normalt
 - Nej, jag hade en skada, känning, smärta eller sjukdom som gjorde att jag inte kunde träna fullt ut och som påverkade mig i min normala träning eller tävlingsgenomförande
- Vad är orsaken till att du inte har kunnat träna fullt ut (du kan välja flera alternativ)?

Ny skada/känning/smärta orsakad av idrott som påverkade mig i min normala träning eller tävlingsgenomförande

Ny skada/känning/smärta orsakad av min funktionsnedsättning som påverkade mig i min normala träning eller tävlingsgenomförande

Ny skada/känning/smärta orsakat av något annat, tex i vardagen, som påverkade mig i min normala träning eller tävlingsgenomförande

Pågående eller redan rapporterad skada/känning/smärta

Ny sjukdom (tex förkyllning, urinvägsinfektion, psykiska bekymmer)

Pågående eller redan rapporterad sjukdom

Nej, jag tränade inte på grund av annan orsak, tex semester, skolarbete

Fråga 2. Hur många pass tränade du under veckan (tex 1, 2, 5)?

Fråga 3. Hur mycket tränade du totalt den här veckan (ange i timmar:minuter tex 1:05)?

Fråga 4. Tävlade du under den gångna veckan?

- Ja
- Nej

Fråga 5. Hur ansträngande upplevde Du att veckans träning var (skatta ett genomsnitt för veckan)?

- 0 Ingen ansträngning alls
- 1 Extremt lätt
- 2 Mycket lätt
- 3 Lätt
- 4 Lätt-måttligt ansträngande
- 5 Ganska ansträngande
- 6 Ansträngande
- 7 Mycket ansträngande
- 8 Kraftig ansträngande
- 9 Extremt ansträngande
- 10 Maximalt ansträngande

Fråga 6. Har du använt något eller några smärtstillande eller inflammationshämmande läkemedel för att hantera besvär under eller efter träning den senaste veckan?

- Ja
- Nej

Fråga 7. Hur upplevde du ditt allmänna välbefinnande under den senaste veckan?

Ange en siffra mellan 1 och 7, där 1 är mycket dåligt och 7 är mycket bra

- 1
- 2
- 3
- 4
- 5
- 6
- 7

Fråga 8. Hur många timmar har du i genomsnitt sovit per natt den senaste veckan?

- 0-5 h
- 6-7 h
- 8-9 h
- 10-11 h
- fler än 11 h

Fråga 9. Oro/nedstämdhet senaste veckan?

- Jag har inte varit orolig eller nedstämd
- Jag har varit orolig eller nedstämd i viss utsträckning
- Jag har i högsta grad varit orolig eller nedstämd

Fråga 10. Smärtor/besvär senaste veckan?

- Jag har inte haft smärtor eller besvär
- Jag har haft måttliga smärtor eller besvär
- Jag har haft svåra smärtor eller besvär

Fråga 11. Har du en NY SKADA/SMÄRTA/KÄNNING som gjorde att du inte kunde träna fullt ut och som påverkade dig i din normala träning/tävling?

- Ja
- Nej

Fråga 11a. När inträffade skadan/smärtan/känningen (ange MÅNAD-DAG tex. 03-28)?

Fråga 11b. I vilket sammanhang inträffade/kände du av skadan/känningen/smärtan?

- Tävling

- Idrottsspecifik träning (ex friidrott, simning)
- Annan träning (ex styrketräning, konditionsträning)

Annat (ex, på jobbet, skolan, hemma)

Fråga 11c. Vilken kroppsdel har huvudsakligen blivit skadad (du kan ange flera alternativ)?

- Armbåge, underarm
- Axel, skuldra, nyckelben
- Bröstrygg, bröstorg, revben
- Båken, svanskota
- Fot/Tå
- Hand/Finger
- Huvud
- Höft
- Knä
- Ljumske
- Lår
- Ländrygg, bål
- Nacke
- Underben/Vad
- Ögon
- Öron
- Annat, ange vad

Fråga 11d. Har du innan skadan känt något i det nu skadade området?

- Nej, inte alls
- Ja, viss smärta/stelhet den senaste veckan
- Ja, viss smärta/stelhet i mer än 1 vecka

Fråga 11e. Vilken är den preliminära skadan (du kan ange flera alternativ)?

- Blåmärke, lårkaka
- Fraktur
- Hjärnskakning
- Impingement/inklämning
- Muskelbristning/sträckning
- Muskelkramp/spasm
- Nervskada/nervsmärtor
- Ledinflammation
- Senbekymmer (akut skada, tex bristning)
- Senbekymmer (överbelastning, tex inflammation)
- Slemhäcksinflammation
- Skada på brosk/menisk
- Smärta
- Stressfraktur
- Stukning, vrickning, ledbandsskada
- Sår, blåsa, sittsår
- Urledvridning/luxation
- Annat, ange vad

Fråga 11f. Vad anser du vara den primära orsaken till skadan/smärtan/känningen (du kan ange flera alternativ)?

- Överbelastning (smygande start)
- Överbelastning (plötslig start)
- Kollision med annan person
- Kollision med föremål (ex boll, mål, sarg, rullstol)
- Icke kontaktskada (vridning/stukning)
- Orsakad av underlag eller väderförhållanden
- Orsakad av utrustningsfel (ex skida, protes, rullstol, kälke)
- Orsakad av regelbrott eller domarbeslut
- Orsakad av trötthet eller utmattning
- Återfall av tidigare skada
- Annat

Fråga 11g. Uppfattar du att din funktionsnedsättning påverkade uppkomsten av skadan?

- Ja
- Nej

Fråga 11h. Om du under det senaste året har haft en liknande skada/känning/smärta, hur länge har du varit tillbaka i normal träning innan du fick bekymmer igen (välj det alternativ som stämmer bäst)?

- Jag har inte haft denna skada/känning/smärtan tidigare i år
- 2 veckor eller färre
- 3-4 veckor
- 5-6 veckor
- 7-8 veckor
- 2 månader eller fler

Fråga 11i. Hur många ordinarie träningspass missade du förra veckan på grund av skadan/känningen/smärtan?

- 0
- 1
- 2
- 3
- 4
- 5 eller fler

Fråga 11j. Vem har bedömt skadan under veckan (du kan ange flera alternativ)?

- Jag själv
- Tränare
- Sjukgymnast/Fysioterapeut
- Läkare
- Sjuksköterska
- Massör
- Naprapat
- Kiropraktor/osteopat
- Annan

Fråga 12. Har du en NY SJUKDOM som gjorde att du inte kunde träna fullt ut och som påverkade dig i din normala träning/tävling.

- Ja
- Nej

Fråga 12a. När inträffade din sjukdom (MÅNAD-DAG, tex 03-28)?

Fråga 12b. Vilket är/var det huvudsakliga symtomet (du kan ange flera alternativ)?

- Diarré
- Domningar, muskelsvaghet
- Feber, frossa
- Förstoppning
- Halsont
- Hjärtklappning, oregelbunden puls, högt/lågt blodtryck
- Hosta
- Illamående, kräkning
- Känsla av nedstämdhet, oro, ångest, stress
- Smärta, värk
- Snuva, nysning
- Spasticitet
- Svårigheter att andas
- Trötthet, matthet
- Utslag, klåda, eksem
- Viktminskning eller uttorkad
- Yrsel, ostadighet
- Annat, ange vad

Fråga 12c. Vilken är/var den preliminära diagnosen på sjukdomen?

- Allergi
- Astma
- Autonom dysreflexi
- Depression, ångest, utmattning

- Diabetes, bekymmer med blodsocker
- Förkylning, luftvägsinfektion
- Hjärt/lungbekymmer
- Hormonella eller reproduktiva bekymmer
- Hudbekymmer
- Huvudvärk, migrän
- Mag/tarmbekymmer
- Maginfektion
- Neurologiska bekymmer, tex spasticitet
- Tandbekymmer
- Urinvägsinfektion
- Ögonbekymmer
- Annan infektion
- Annat, ange vad

Fråga 12d. Vem har ställt diagnosen?

- Jag själv
- Tränare
- Sjukgymnast/Fysioterapeut
- Sjuksköterska
- Läkare
- Naprapat
- Annan

Fråga 12e. Vad anser du vara den främsta orsaken till sjukdomen (du kan ange flera alternativ)?

- Min funktionsnedsättning
- Förvårdning av redan existerande bekymmer

- Smitta
- Stress, oro, psykiska bekymmer
- Orsakad av läkemedel
- Överträning
- Utmattning, vätskebrist
- Vet ej
- Annat

Fråga 12f. Hur många ordinarie träningspass missade du förra veckan på grund av sjukdomen?

- 0
- 1
- 2
- 3
- 4
- 5 eller fler

Fråga 12g. Om du under det senaste året har haft en liknande bekymmer, hur länge har du varit tillbaka i normal träning innan du blev sjuk igen (välj det som stämmer bäst)?

- Jag har inte haft dessa bekymmer tidigare i år
- 2 veckor eller färre
- 3-4 veckor
- 5-6 veckor
- 7-8 veckor
- 2 månader eller fler

Tack för dina svar! Om det är något annat du vill rapportera eller undrar över kan du skriva det här eller kontakta oss: kristina.fagher@med.lu.se / 070-29 70 764. Mvh Kristina & Parasportforskargruppen.

Appendix 2. Injury closure report used in the prospective weekly data collection in SRIIPSS (not validated to English).

Det här är en slutrapport för den skada, smärta eller känning du rapporterat för en eller ett par veckor sedan.

Fråga 1. Hur lång tid har du varit borta från normal (full) träning?

- 0 dagar
- 1-3 dagar
- 4-7 dagar
- 8-21 dagar
- mer än 21 dagar
- mer än 3 månader

Fråga 2. Vilken är den slutliga diagnosen (tex muskelbristning, stukning, inflammation, smärta)?

Fråga 3. Vem har ställt diagnosen?

- Jag själv
- Tränare
- Sjukgymnast/Fysioterapeut
- Läkare
- Sjuksköterska

- Massör
- Naprapat
- Kiropraktor/osteopat
- Annan

Fråga 4. Uppfattar du att din funktionsnedsättning spelade någon roll gällande uppkomsten av skadan?

- Nej
- Ja

På vilket sätt?

Fråga 5.

Tror du att man hade kunnat förebygga den här skadan?

- Nej
- Ja

På vilket sätt?

Tack för dina svar. Om det är något annat du vill rapportera eller undrar över kan du skriva det här eller kontakta oss: kristina.fagher@med.lu.se / 070-29 70 764. Mvh Kristina & Parasportforskargruppen.

Appendix 3. Illness closure report used in the prospective weekly data collection in SRIIPSS (not validated to English).

Det här är en slutrapport för den sjukdom rapporterat för en eller ett par veckor sedan.

Fråga 1. Hur lång tid har du varit borta från normal (full) träning?

- 0 dagar
- 1-3 dagar
- 4-7 dagar

- 8-21 dagar
- mer än 21 dagar
- mer än 3 månader

Fråga 2. Vilken är den slutliga diagnosen (tex förkylning, maginfektion, annan sjukdom)?

Fråga 3. Vem har ställt diagnosen?

- Jag själv
- Tränare
- Sjukgymnast/Fysioterapeut
- Läkare
- Sjuksköterska
- Massör
- Naprapat
- Kiropraktor/osteopat
- Annan

Fråga 4. Uppfattar du att din funktionsnedsättning spelade någon roll gällande uppkomsten av sjukdomen?

- Nej
 - Ja
- På vilket sätt?

Fråga 5. Tror du att man hade kunnat förebygga den här sjukdomen?

- Nej
 - Ja
- På vilket sätt?

Tack för dina svar. Om det är något annat du vill rapportera eller undrar över kan du skriva det här eller kontakta oss: kristina.fagher@med.lu.se / 070-29 70 764. Mvh Kristina & Parasportforskargruppen.

Appendix 4. Study-specific baseline questionnaire for SRIIPSS (not validated to English).

Hej! Det här är en enkät med bakgrundsfrågor till Parasportstudien, du behöver bara svar EN gång på denna enkät. Totalt sett är det 41 frågor. Alla svar är anonyma.

Del 1: Om dig (9 frågor)

Fråga 1. Vilket år är du född?

Fråga 2. Kön?

- Man
- Kvinna

Fråga 3. Hur många år har du hållit på med parasport (exempel 7 år)?

Fråga 4. Vilken är din huvudsakliga sysselsättning?

- Studerande
- Förvärvsarbetande
- Arbetssökande
- Sjukersättning
- Min idrott

Fråga 5. Vilken omfattning har din huvudsakliga sysselsättning?

- 100%
- 75%
- 50%
- 25%

Fråga 6. Vilken typ av fysisk ansträngning har din sysselsättning?

- Huvudsakligen stillasittande arbete
- Arbete som i stor utsträckning kräver att stå, gå, rulla, men ej kräver fysisk ansträngning
- Arbete som innebär att stå, gå, rulla, men också innebär måttlig fysisk ansträngning, tex lyfta och bära
- Tungt kroppsarbete

Fråga 7. Hur är din fysiska ansträngning på fritiden och i vardagen (utöver arbete och träning)?

- Huvudsakligen stillasittande
- Fritid/vardag som i stor utsträckning kräver att stå, gå, rulla, men ej kräver fysisk ansträngning
- Fritid/vardag som innebär att stå, gå, rulla, men också innebär att lyfta, bära eller rulla tungt

Fritid/vardag som innebär tungt kroppsarbete

Fråga 8. Längd (cm)?

Fråga 9. Vikt (kg)?

Del 2: Om dig och din idrott (11 frågor)

Fråga 10. Vilken är din huvudsakliga idrott (ange en)?

Fråga 11. Upplever du att din tränare i klubben har kunskap/utbildning som är relevant för din parasport?

- Ja
- Nej
- Delvis
- Vet ej
- Jag har ingen tränare

Fråga 12. Upplever du att din tränare i landslaget har kunskap/utbildning som är relevant för din parasport?

- Ja
- Nej
- Delvis
- Vet ej

Fråga 13. I genomsnitt hur många timmar tränade du per vecka det senaste året under en normal träningsvecka (tex 7 timmar)?

Fråga 14. I genomsnitt, hur många vilodagar per vecka har du under en normal träningsvecka?

- Ingen
- En
- Två
- Tre eller fler

Fråga 15. Hur långt brukar ett träningspass vara i genomsnitt inklusive uppvärmning och nedvärmning (ange det svar som passar bäst)?

- Mindre än 45 min
- 1 tim
- 1.5 tim
- 2 tim
- 2.5 tim
- Mer än 3 tim

Fråga 16. Hur lång tid brukar uppvärmningsdelen vara?

- 0 min
- 15 min
- 30 min
- 45 min

Fråga 17. Tränar och tävlar du i någon annan idrottsgren?

- Nej
- Ja

Vilken?

Fråga 18. Utöver din idrott, tränar du något av följande (du kan ange flera alternativ)?

- Nej, jag tränar endast idrottsspecifik träning
- Ja, jag tränar konditionsträning (tex cykling, löpning, rodd)
- Ja, jag tränar styrketräning
- Ja, jag tränar balans-, stabilitets- eller koordinationsträning (tex bål-, axel-, knäkontroll)
- Ja, jag tränar rörlighetsträning
- Ja, jag tränar yoga
- Ja, jag tränar något annat

Fråga 19. Har du någon medicinsk kontaktperson du kan vända dig till vid problem?

- Nej
- Ja

Vilken kategori (du kan ange flera alternativ)?

- Sjukgymnast/Fysioterapeut
- Läkare
- Sjuksköterska
- Massör
- Naprapat
- Kiropraktor/osteopat
- Annan

Fråga 20. Har du någon gång använt dig av Folksamns elitidrottsförsäkring?

- Ja
- Nej

Del 3: Om din funktionsnedsättning (4 frågor).

Fråga 21a. Ange vilken funktionsnedsättning/diagnos du har?

Fråga 21b. Om du har en klassificering, ange (tex B1, S, T, U)?

Fråga 22. Har du haft din funktionsnedsättning sedan födseln?

- Ja
- Nej, den har utvecklats gradvis
- Nej, den uppstod vid en olycka

Fråga 23. Använder du något hjälpmedel eller liknande?

- Nej
- Ja

Vilket/vilka hjälpmedel använder du (du kan ange flera alternativ)?

- Rullstol
- Permobil
- Rullator
- Kryckor/käpp
- Protes
- Ortos
- Blindkäpp

Fråga 24. Om du använder rullstol, i genomsnitt, hur många timmar per dag rullar du (både i vardag och träning)?

Del 4: Om tidigare och nuvarande skador (2 frågor).

Fråga 25. Har du under de senaste 12 månaderna haft en skada/smärta/känning som fått dig att helt eller delvis avstå från träning eller tävling i en sammanhängande period mer än 3 veckor?

- Nej
- Ja

25a. Vilken/vilka diagnoser hade skadan/smärtan/känningen och i vilken kroppsdel var den (du kan ange flera alternativ)?

- Armbåge, underarm
- Axel, skuldra, nyckelben
- Bröstrygg, bröstorg, revben
- Båken, svanskota
- Fot/Tå
- Hand/Finger
- Huvud
- Höft
- Knä
- Ljumske
- Lår
- Ländrygg, bål
- Nacke
- Underben/Vad
- Ögon
- Öron
- Annat, ange vad

25b. I vilken situation uppstod skadan/smärtan/känningen?

- Tävlning
- Idrottsspecifik träning (ex friidrott, simning)
- Annan träning (ex styrketräning, konditionsträning)
- Annat (ex, på jobbet, skolan, hemma)

25c. Vad anser du vara den främsta orsaken till skadan/smärtan/känningen?

- Överbelastning (smygande start)
- Överbelastning (plötslig start)
- Kollision med annan person
- Kollision med föremål (ex boll, mål, sarg, rullstol)
- Icke kontaktskada (vridning/stukning)
- Orsakad av underlag eller väderförhållanden
- Orsakad av utrustningsfel (ex skida, protes, rullstol, kälke)
- Orsakad av regelbrott eller domarbeslut
- Orsakad av trötthet eller utmattning
- Återfall av tidigare skada
- Annat

25d. Hur många dagar var du borta från träning på grund av skadan/smärtan/känningen?

- 0 dagar
- 1-3 dagar
- 4-7 dagar
- 8-21 dagar
- mer än 21 dagar
- mer än 3 månader

25e. Tror du din funktionsnedsättning spelade någon roll i uppkomsten av skadan/smärtan/känningen (om JA, beskriv hur i fri text)?

- Nej
- Ja

Fråga 26. Är du helt skadefri idag?

- Ja
- Nej

26a. Vilken/vilka diagnoser hade skadan/smärtan/känningen och i vilken kroppsdel var den (du kan ange flera alternativ)?

- Arm/båge, underarm
- Axel, skuldra, nyckelben
- Bröstrygg, bröstorg, revben
- Båken, svanskota
- Fot/Tå
- Hand/Finger
- Huvud
- Höft
- Knä
- Ljumske
- Lår
- Ländrygg, bål
- Nacke
- Underben/Vad
- Ögon
- Öron
- Annat, ange vad

25b. I vilken situation uppstod skadan/smärtan/känningen?

- Tävlning
- Idrottsspecifik träning (ex friidrott, simning)
- Annan träning (ex styrketräning, konditionsträning)
- Annat (ex, på jobbet, skolan, hemma)

25c. Vad anser du vara den främsta orsaken till skadan/smärtan känningen?

- Överbelastning (smygande start)
- Överbelastning (plötslig start)
- Kollision med annan person
- Kollision med föremål (ex boll, mål, sarg, rullstol)
- Icke kontaktskada (vridning/stukning)
- Orsakad av underlag eller väderförhållanden
- Orsakad av utrustningsfel (ex skida, protes, rullstol, kälke)
- Orsakad av regelbrott eller domarbeslut
- Orsakad av trötthet eller utmattning
- Återfall av tidigare skada
- Annat

26d. Hur många dagar har du varit borta från din träning?

- 0 dagar
- 1-3 dagar
- 4-7 dagar
- 8-21 dagar
- mer än 21 dagar
- mer än 3 månader

Del 5: Om tidigare och nuvarande sjukdomar (2 frågor).

Fråga 27. Har du under de senaste 12 månaderna haft en sjukdom, operation, psykiska bekymmer eller liknande som fått dig att helt eller delvis avstå från din träning i en sammanhängande period mer än 3 veckor?

- Nej
- Ja

27a. Ange vilken eller vilka diagnoser samt de huvudsakliga symtomen (du kan ange flera alternativ)?

- Diarré
- Domningar, muskelsvaghet
- Feber, frossa
- Förstoppning
- Halsont
- Hjärtklappning, oregelbunden puls, högt/lågt blodtryck
- Hosta
- Illamående, kräkning
- Känsla av nedstämdhet, oro, ångest, stress
- Smärta, värk
- Snuva, nysning
- Spasticitet
- Svårigheter att andas
- Trötthet, matthet
- Utslag, klåda, eksem
- Viktminskning eller uttorkad
- Yrsel, ostadighet
- Annat, ange vad

27b. Hur många dagar var du borta från träningen pga sjukdomen/sjukdomarna?

- 0 dagar
- 1-3 dagar
- 4-7 dagar
- 8-21 dagar
- mer än 21 dagar
- mer än 3 månader

27c. Tror du din funktionsnedsättning spelade någon roll i uppkomsten av sjukdomen (om JA, beskriv hur i fri text)?

- Nej
- Ja

27d. Vad anser du vara den främsta orsaken till sjukdomen?

- Min funktionsnedsättning
- Förvärring av redan existerande bekymmer
- Smitta
- Stress, oro, psykiska bekymmer
- Orsakad av läkemedel
- Överträning
- Utmattning, vätskebrist
- Vet ej
- Annat

Fråga 28. Är du helt sjukdomsfri idag?

- Ja
- Nej

28a. Vilken sjukdom/sjukdomar har du, ange diagnos och de huvudsakliga symtomen (du kan ange flera alternativ)?

- Diarré
- Domningar, muskelsvaghet
- Feber, frossa
- Förstoppning
- Halsont
- Hjärtklappning, oregelbunden puls, högt/lågt blodtryck
- Hosta
- Illamående, kräkning
- Känsla av nedstämdhet, oro, ångest, stress
- Smärta, värk
- Snuva, nysning
- Spasticitet
- Svårigheter att andas
- Trötthet, matthet

- Utslag, klåda, eksem
 - Viktminskning eller uttorkad
 - Yrsel, ostadighet
 - Annat, ange vad
- 28b. Hur många dagar har du varit borta från din träning?

- 0 dagar
- 1-3 dagar
- 4-7 dagar
- 8-21 dagar
- mer än 21 dagar
- mer än 3 månader

28c. Vad anser du vara den främsta orsaken till sjukdomen?

- Min funktionsnedsättning
- Förvärring av redan existerande bekymmer
- Smitta
- Stress, oro, psykiska bekymmer
- Orsakad av läkemedel
- Överträning
- Utmattning, vätskebrist
- Vet ej
- Annat

Del 6: Hur var ditt allmänna hälsotillstånd under föregående år? (3 frågor).

Fråga 29. Upplevde du regelbundet några smärtor eller besvär under träning?

- Jag hade inga smärtor eller besvär
- Jag hade måttliga smärtor eller besvär
- Jag hade svåra smärtor eller besvär

Fråga 30. Upplevde du regelbundet några smärtor eller besvär i vardagen?

- Jag hade inga smärtor eller besvär
- Jag hade måttliga smärtor eller besvär
- Jag hade svåra smärtor eller besvär

Fråga 31. Hur upplevde du ditt allmänna välbefinnande?

- Jag var inte orolig eller nedstämd
- Jag var orolig och nedstämd i viss utsträckning
- Jag var i högsta grad orolig eller nedstämd

Del 7: Om kost och läkemedel (6 frågor).

Fråga 32. Brukar du planera din kost utifrån din träning?

- Ja
- Ibland
- Nej

Fråga 33. Har du haft hjälp med upplägg av kosten av tex dietist, sjukvårdspersonal eller tränare under föregående år?

- Nej
- Ja

Fråga 34. Använde du under föregående säsong kosttillskott?

- Nej
- Ja

Vilket/vilka?

Fråga 35. Använde du under föregående säsong några mediciner?

- Nej
- Ja

Vilken/vilka?

Fråga 36. I samband med träning eller efter träning, har du det senaste året använt något/några inflammationshämmande läkemedel för att hantera besvär (ex Voltaren, Ipren, Naproxen)?

- Dagligen eller nästintill
- 1-4 gånger/vecka
- 1-4 gånger per månad
- 1-2 gånger varannan månad
- 1-2 gånger under ett år
- Aldrig

Fråga 37. I samband med träning eller efter träning, har du det senaste året använt något/några smärtstillande läkemedel för att hantera smärta (ex Panodil, Alvedon, Citodon, Tramadol)?

- Dagligen eller näst intill
- 1-4 gånger/vecka
- 1-4 gånger per månad
- 1-2 gånger varannan månad
- 1-2 gånger under ett år
- Aldrig

Fråga 38. Använder du någon form av tobak regelbundet?

- Nej
- Ja

Vilken form av tobak?

Fråga 39. Hur ofta dricker du alkohol?

- Aldrig
- Sällan
- Några gånger per år
- Någon gång i månaden
- Ett par gånger i månaden
- Någon gång i veckan
- Så gott som dagligen

Del 7: Till dig, som är kvinna (2 frågor).

Fråga 40. Har du haft en längre period (mer än 2 månader) med mycket sparsamma eller inga menstruationer (undantag graviditet)?

- Nej
- Ja

Hur ofta har mensen då kommit?

- Jag har inte fått mens/jag har inte mens
- Någon gång om året
- Ett par gånger om året
- Ungefär var varannan månad

Fråga 41. Använder du hormonbaserade preventivmedel som p-piller, p-stav, p-ring eller liknande?

- Nej
- Ja

Tack för dina svar. Om det är något annat du vill rapportera eller undrar över kan du skriva det här eller kontakta oss: kristina.fagher@med.lu.se / 070-29 70 764. Mvh Kristina & Parasportforskargruppen.

Paper I





Paralympic athletes' perceptions of their experiences of sports-related injuries, risk factors and preventive possibilities

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ORIGINAL ARTICLE

Paralympic athletes' perceptions of their experiences of sports-related injuries, risk factors and preventive possibilities

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Abstract

Our knowledge of sports-related injuries in para-sport is limited and there are no data on how Paralympic athletes themselves perceive an injury. The aim of this qualitative study was to explore Paralympic athletes' perceptions of their experiences of sports-related injuries, risk factors and preventive possibilities. Eighteen Swedish Paralympic athletes with vision impairment, intellectual impairment, spinal cord injury, cerebral palsy, myelomeningocele, dysplasia and neuromuscular disorder, representing 10 different para-sports, were interviewed. The qualitative phenomenographic method was used to interpret the data. The analysis revealed nine categories of perceptions of experiences. The athletes perceived that their impairments were involved in the cause and consequential chains associated with a sports-related injury. Other categories that denoted and described these injuries were: sport overuse, risk behaviour, functional limitations, psychological stressors, the normalised pain, health hazards, individual possibilities to prevent sports-related injuries and unequal prerequisites. This qualitative study revealed that Paralympic athletes' perceptions of their experiences of sports-related injuries are complex and multifactorial, and in several ways differ from able-bodied athletes. This needs to be considered in the sports health and safety work within the Paralympic Movement as well as in the design of future injury surveillance systems and preventive programmes.

Keywords: *Qualitative research, athletic injuries, sports for persons with disabilities, sports medicine, primary prevention*

Introduction

Para-sport allows people with disabilities to achieve extraordinary heights of functional capability (Willick & Lexell, 2014). During the last decades para-sport has in many ways become elite sport, with increased training intensity, sports performance and improved technology (Vanlandewijck & Thompson, 2011). With the development of para-sport and the growing number of para-athletes, there is an increased interest in their health and safety, both to enhance sports performance and to prevent injuries (Webborn & Van de Vliet, 2012).

It is well established that participation in sports involves a substantial risk of injuries. In sports for able-bodied athletes injuries can negatively impact on training and competitions, and sometimes it may

compromise entire careers and cause life-long disabilities (Ljungqvist et al., 2009). Injury prevention measures have been an area of interest over the past years and there are today injury prevention programmes for a range of sports (Verhagen, 2015). Our knowledge of sports-related injuries in para-sport (SRIP) is, however, limited and data regarding the nature of injuries, sports-related and impairment-related risk factors, and preventive possibilities are scarce.

The overall injury rates in para-sport seem to be high and comparable with rates in able-bodied athletes (Fagher & Lexell, 2014; Webborn & Emery, 2014; Weiler, Van Mechelen, Fuller, & Verhagen, 2016). Several reports emerging from the specific injury surveillance system implemented during the Paralympic Games 2012 (Derman et al., 2013) have

shown that some injuries are similar to those in able-bodied athletes (Willick et al., 2013). However, it has also been suggested that patterns of injuries in Paralympic athletes may be different (Derman et al., 2013). For example, many Paralympic athletes have long-standing and non-modifiable impairments, sometimes combined with complex medical issues, which could lead to injuries not encountered in sports for able-bodied athletes (Webborn & Van de Vliet, 2012). Understanding the nature of SRIP, and the development and implementation of preventive programmes is therefore an important area to allow safe para-sport participation (Weiler et al., 2016).

In addition, there are no data on how Paralympic athletes themselves perceive an injury and how their impairments influence their perceptions of the experiences of SRIP. Sports-related injuries can be a major stressor for athletes and lead to various psychological responses (Putukian, 2016). Also, different types of behaviour related to injury risk factors and mechanisms have recently been noted as a key factor in sports injury research among able-bodied athletes (McGlashan & Finch, 2010; Verhagen & van Mechelen, 2010; Verhagen, van Stralen, & van Mechelen, 2010). Athletes' beliefs of the causes of their injuries have been linked to psychological, social and training factors, as well as their coach (van Wilgen & Verhagen, 2012). However, such knowledge is non-existing regarding Paralympic athletes.

One way to increase our understanding of SRIP is to use qualitative research methods. Sjöström and Dahlgren (2002) suggested that qualitative research might be the first step towards quantitative research, as the reality may vary between populations (Sjöström & Dahlgren, 2002). To the best of our knowledge, no study has explored Paralympic athletes' own perceptions of their experiences of SRIP. Such study will explore the athletes' own perspective and thereby lead to a more in-depth knowledge of SRIP.

The aim of this qualitative study was therefore to explore Paralympic athletes' own perceptions of their experiences of SRIP, risk factors and preventive possibilities.

Methods

Research design

The present study used a qualitative research design based on phenomenography. This is a qualitative method for exploring different ways that individuals experience a phenomenon and their surrounding world (Marton, 1981). The basic assumption is that it is the experiences that precede the perceptions.

Within health care research the interest is the perceptions that stem from the experiences of, for example, an injury or a disability. These perceptions are most likely possible to affect or support by various interventions. Phenomenography was developed within educational research and stems from the assumption that the only world we can communicate is the world we experience (Sjöström & Dahlgren, 2002). Participants in this study are likely to differ in terms of how they perceive the world, and these differences can be described, understood and communicated by others (Patton, 2002).

Participants

In total, 25 athletes from the Swedish Paralympic programme were invited to participate. To be eligible for the study, the participants had to be between 18 and 45 years of age and have had at least one self-defined SRIP. A purposive sampling was used to ensure variation in gender, impairments and sports.

The first 18 athletes (11 men and 7 women with a mean age of 27 years, range 18–40 years) who accepted the invitation were interviewed. Two athletes denied participation. Already after 14 interviews no new information was revealed. However, to be confident that the data were sufficient, four more interviews were performed. These interviews added very little extra information and with the 18 participants the interview process was discontinued. Athletes with the following impairments were interviewed: vision impairment ($n = 8$), intellectual impairment ($n = 1$) and physical impairment ($n = 9$). The 18 represented the following summer ($n = 16$) and winter ($n = 2$) para-sports: goalball ($n = 5$), wheelchair rugby ($n = 2$), athletics ($n = 2$), cycling ($n = 1$), alpine skiing ($n = 1$), boccia ($n = 1$), ice sledge hockey ($n = 1$), judo ($n = 1$), table tennis ($n = 1$) and swimming ($n = 3$). The average time spent on training was 12.1 hours/week. Seven athletes used a wheelchair as their main mode of transportation.

Ethics

The study followed the WMA Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects. Ethical approval was obtained from the Regional Ethical Review Board in Lund (2014/439). As there are relatively few Swedish Paralympic athletes and therefore a risk of identification, demographics are presented on a group level to protect the integrity of the participants.

Data collection

Data were collected through individual interviews (September–November 2014) using a semi-structured interview guide centred on a few entry questions about the athletes' perception of experiences of SRIP, risk factors of SRIP and possibilities to prevent SRIP. The athletes were contacted by phone and an appropriate place for the interview was chosen. Seven interviews were conducted in connection with the Swedish Paralympic elite school, 10 were conducted in connection with the athletes' training and 1 was performed through a video call. All interviews were performed by a registered physiotherapist (KF), trained in qualitative methods and with experience in para-sport. Two pilot interviews were conducted to ensure appropriateness of the method; after those the interview guide was slightly revised. All interviews were audiotaped and analysed verbatim. The mean length of the interviews was 20 min (range 11–39 min).

Data analysis

The interviews were analysed using phenomenography, according to the 7-step model described by Sjöström and Dahlgren (2002) (Table I). The interviews were first read through several times by the first author (KF) (step 1) and were then consolidated by all authors, who read the interviews separately and then discussed together the understanding of the interview content. The first-order perspective, presented as domains, is formed by "what" the participants talk about (step 2). The second-order perspective (the perceptions of experiences) identifies "how" the participants talk about the "what" and involves the qualitatively different variations in perceptions (steps 3 and 4). The categories are an abstraction of the perceptions and constitute the main results. The essence represents the core meaning, that is, the experiences that form the basis for the perceptions. Phenomenography was chosen, as it is the only suitable qualitative method for the research question that was posed, that is, exploring

the perceptions of experiences. All authors had access to the raw data in order to ensure the validity of the data and the Consolidated criteria for reporting qualitative research (COREQ) was followed (Tong, Sainsbury, & Craig, 2007).

Results

Based on the analysis, the Paralympic athletes' perceptions of their experiences are described in three parts: the causes of SRIP (Table II), the consequences of SRIP (Table III) and the possibilities to prevent SRIP (Table IV).

The causes of SRIP

The analysis revealed three different categories of the perception of the athletes' experiences of the causes of SRIP (Table II).

Secondary effects of the impairment

The athletes perceived that their impairments influenced the causes of SRIP. The perception was that factors such as spasticity, vision impairment, altered biomechanics, different body movements and intellectual impairment influenced and exacerbated the occurrence of SRIP. It was described that different impairments affect the injury pattern depending on bodily functions. For example, athletes with vision impairment perceived that their problems were mainly related to collisions and falls:

When you are visually impaired and take part in tough sport, you have to accept that you get more injuries. (Athlete 13)

Injuries in athletes with intellectual impairments were perceived to be related to lack of attention. Athletes with neurologic impairments perceived that spasticity and weak muscles lead to injuries. Moreover, the perception was that Paralympic athletes are exposed harder during elite sport, have a reduced recovery function and are more tired

Table I. The 7-step model described by Sjöström and Dahlgren (2002) used for the qualitative phenomenographic analysis of the interview data

-
1. *Familiarization*, the interviews were read through.
 2. *Compilation*, the most important parts of the informants' responses were identified.
 3. *Condensation*, the individual responses were reduced in order to identify the most central parts of longer responses or dialogues.
 4. *Grouping*, similar responses were tentatively grouped or categorised
 5. *Comparison*, a preliminary comparison of the categories was made to find associations between them after which they were revised.
 6. *Naming*, the categories were named for the purpose of highlighting their essence.
 7. *Contrastive comparison*, the unique character or essence of each category and the linkage between them were described.
-

Table II. The causes of SRIP. The perceptions of experiences among Swedish Paralympic athletes ($n = 18$)

Domains	Perceptions of experiences	Categories	Essence
The impairment	Injuries occur because of the impairment A disabled body can never be better than a normal body Different body movements can cause injury	Secondary effects of the impairment	Awareness
Excessive training	Too tough training cause injuries Injuries get worse the more you train Injuries occur when you train incorrectly	Sport overuse	Incapacity
One's behaviour	Injuries occur when you continue to train injured Injuries may be caused by negligence and inattention Impatience cause injury	Risk behaviour	Guilt

because of poor vision, weak muscles, spasticity and energy demanding activities both in sport and daily life, and that this could predispose SRIP:

I spend three times as much energy as you when I go the same distance, so I push myself much harder.
(Athlete 16)

Especially wheelchair athletes described that pain could be related to too demanding wheelchair driving both in daily life and in sport:

I have overuse problems in my shoulder, it's because I expose it more than its capacity and I have no innervation to the muscles around my shoulder blades.
(Athlete 18)

In conclusion, the perception was that secondary effects from the impairment should be seen as a risk factor of SRIP. The essence of this category was interpreted as awareness.

Sport overuse

Another perception was that too much and too strenuous training leads to SRIP. The perceptions in this category emerged from overuse injuries being common in para-sport. The athletes perceived that sport overuse was related to training beyond one's capacity, continuous training with pain and too much monotonous training. Athletes also expressed that intense training during youth was related to continuous problems with injuries later in life:

Table III. The consequences of SRIP. The perceptions of experiences among Swedish Paralympic athletes ($n = 18$)

Domains	Perceptions of experiences	Categories	Essence
Impact on physical functioning	SRIP causes decreased sports performance SRIP causes difficulties in everyday life	Functional limitations	Burden
Impact on mental well-being	SRIP causes stress, frustration, lack of motivation and anxiety	Psychological stressors	Concern
Occurrence of pain	Pain is something you have to live with To stop participating in sport can ease the pain Too hard training cause pain	Normalised pain	Adjustment
The risk of elite sport	Elite sport is always harmful and risky Elite sport is not healthy Being an elite athlete is a choice	Health hazards	Hazard acceptance

Table IV. The possibilities to prevent SRIP. The perceptions of experiences among Swedish Paralympic athletes ($n = 18$)

Domains	Perceptions of experiences	Categories	Essence
General possibilities for prevention	One's own responsibility for the body and equipment can prevent injuries Preventive training can reduce injuries Important with knowledge	Individual possibilities to prevent SRIP	Assets
Preconditions in Paralympic sports	Paralympic athletes do not have the same conditions Coaches have limited knowledge of specific impairments and training Access to medical personnel is sometimes insufficient	Unequal prerequisites	Inequality

I have had problems with my shoulders during my entire career, I believe it is because I've been training too much when I was a kid. (Athlete 12)

One athlete expressed the importance of being careful with elite investment during youth, and to spare the body during these years in order to be able to maximise performance at the senior elite level. Other perceptions were that absence of recovery, too rapid increase in training volume, training sessions without quality and too much sport-specific training could cause SRIP. The athletes also had the experience that incorrect training and poor knowledge of training could influence the occurrence of SRIP.

The perceptions of this domain are explained by excessive training, the category emerged in sport overuse and the essence was interpreted as incapacity.

Risk behaviour

The athletes perceived that SRIP sometimes occur because of their own behaviour, as they chose to continue to train even though they had pain or were injured, but at the same time they described an awareness of the problem. However, they continued to train because of lack of time prior to a competition, negligence of the injury, decrease in psychological well-being because of absence of training, and lack of knowledge. They also expressed that a decrease in training gave a feeling of failure and guilt, and therefore they continued to train despite having an injury. A perception was that it is hard to admit to yourself that you are injured:

I had pain, but I continued to train. I could easily have prevented the injury if I had listened to myself and stopped in time. (Athlete 9)

Also one's own carelessness could lead to an injury, for example, forgetting protection equipment as well as stupidity and inattention during training or competition. Moreover, the perception was that a lack of patience during rehabilitation and not performing injury prevention programmes could cause SRIP. The athletes also admitted that they use analgesics to be able to continue training with SRIP. In a second-order perspective the athletes talked about risk behaviour and themselves sometimes causing SRIP. The essence of this category was interpreted as guilt:

I think I have caused the injury myself, because I have not trained correctly. (Athlete 2)

The consequences of SRIP

In this section the athletes' perception of the experiences of the consequences of SRIP are described (Table III).

Functional limitations

In this category the athletes experienced that SRIP caused functional limitations that influenced them both in their sports performance as well as in their daily life. The perception was that life became more difficult, tasks in daily life consumed more energy and that it was extremely impractical to have a permanent disability in addition to SRIP. Especially wheelchair athletes and athletes with physical impairments described that household tasks and transportation became more demanding:

It's hard with an injury, when you are already disabled, you feel like you have a disability even before you start. (Athlete 13)

For athletes with vision impairment logistic concerns occurred with SRIP. For example, they found it difficult with transportation and new environments during rehabilitation.

In terms of sport, the perception was that SRIP affected the performance, both individually and sometimes in the team. Another perception was the fear of a re-injury after a previous SRIP, which was linked to cautiousness to maximise training and a perceived decrease in performance. The athletes perceived that a disabled body is exposed physically tougher during exercise, compared to a non-disabled body. They expressed the importance that their impairments sometimes have a large impact on their performance and also SRIP, and that this must be considered in Paralympic sports medicine. The essence of this category was interpreted as burden:

Don't forget that we are disabled, we are not just athletes. (Athlete 3)

Psychological stressors

SRIP was also closely related to various psychological perceptions. An important perception was the fear and insecurity of what SRIP could result in, especially the consequences related to what would happen with one's own body:

I'm often thinking, what will happen if I get an injury to my non-disabled side, I wouldn't be able to

manage my daily life. That's what I am afraid of. (Athlete 16)

Other psychological perceptions related to SRIP were: anxiety, depression, stress, sadness and concentration difficulties. The athletes expressed that they became socially withdrawn and lost their motivation to train. The perceptions of this domain were explained by impact on mental well-being and the essence was interpreted as concern.

Normalised pain

This category emerged from the athletes' perception of pain related to sport and SRIP. All athletes had at some point experienced pain during sport and expressed that pain is something that belongs to Paralympic sports. The general perception was that pain was related to hard training. The athletes perceived that pain initiated fear and anxiety, and should be seen as a warning signal for a more severe injury. However, they continued to train even though they had pain. They also experienced that pain persisted in daily life and that impairment-specific factors such as wheelchair use, altered biomechanics in limbs, poor posture and spasticity contributed to pain. In contrast, one athlete with cerebral palsy and severe spasticity expressed that pain only depends on the impairment and is not sports-related.

Other factors that were perceived to cause pain were weak muscles, and too much and too monotonous training. The general perception was that pain is something that Paralympic athletes have to live with:

What can reduce my pain is to stop doing sport or to stop using my wheelchair. (P6)

The underlying essence was interpreted as adjustment, that is, in the meaning of a processing balance of conflicting needs of an experienced phenomenon.

Health hazards

The athletes perceived that elite sport is unhealthy, dangerous and risky. Another perception was that the training intensity and competitiveness in para-sport has increased during the last years. In a first-order perspective, they talked about the risk of SRIP in elite sport and in a second-order perspective about health hazards and hazard acceptance in elite sport:

Elite sport is not healthy, you are close to the limit of your body, it's a lot of high forces. (Athlete 5)

I would be ashamed if I recommend anyone to participate in elite sport, because I know the risks and it's harmful. (Athlete 9)

The perception was that elite sport could cause harmful incidents to muscles, joints and cardiovascular system. The athletes expressed a concern about future SRIP and health-related consequences of being an elite athlete.

I'm thinking, I already have pain, I wonder what consequences will it have for me in the future. (Athlete 8)

However, the athletes thought it was worth to continue being an elite athlete, and it was a choice they had made, but they also requested better information about health-related concerns that could pertain to sport.

The possibilities to prevent SRIP

In the last section, the athletes' perceptions of the possibilities to prevent SRIP are described (Table IV).

Individual possibilities to prevent SRIP

In this domain the athletes talked about general possibilities to prevent SRIP. In a second-order perspective it emerged as individual possibilities to prevent SRIP. The athletes own attitudes were that several SRIP could be prevented. A frequent perception was that oneself should take responsibility over the body and use optimal equipment. The athletes emphasised the importance of listening to the body and take responsibility not to train, to alternate the training and to seek help when they had SRIP. Another perception was that a healthy life-style could prevent SRIP. Further individual possibilities to prevent SRIP were to take one's responsibility to train core stability, balance and flexibility, and to warm up. The athletes also expressed the importance to gain information about training and its effects on one's own impairment.

The athletes emphasised the importance of injury prevention training at group level led by a coach or physiotherapist. Their perception of experiences was that it is valuable to start with preventive training in the youth and that it should be included in all ages and disciplines. The perception was that it is important to have a physiotherapist close to hand in order to provide help quickly and to prevent more severe SRIP.

Moreover, athletes requested information about preventive measures to improve their knowledge. The essence of this category was interpreted as assets.

Unequal prerequisites

To better prevent SRIP, the athletes perceived that para-sport needs other prerequisites. In their opinion, there are today some unequal prerequisites. These are linked to para-sport organisations, local sport clubs, health care systems and the environment. The athletes expressed that it is difficult to find coaches who have knowledge about para-sport, impairments and physical training. They emphasised that coaches and medical personnel must have knowledge both about para-sport and specific impairments to be able to provide optimal support:

The more my coach knows about how the body works in relation to my impairment, the more he can adapt my training. (Athlete 10)

Another perception was that access to medical personnel is sufficient during competitions, but not between them. Other perceived unequal prerequisites were that it is harder to find a health insurance because of an innate impairment and that the health care system sometimes does not take SRIP seriously:

If you go to the primary health care centre they just tell you to rest or continue to train. (Athlete 1)

The athletes perceived that the attitudes from the environment, that is, media and the general population, are that Paralympic sport is not always considered to be elite sport:

Paralympic sports is sometimes not seen as elite sport, people don't understand that we train as much as able-bodied elite athletes. (Athlete 17)

Also, the athletes perceived they have very high demands from the environment and para-sport organisations to achieve sporting excellence, and that sometimes these expectations are not linked to optimal resources. The essence of this category was interpreted as inequality.

Discussion

This is, to the best of our knowledge, the first qualitative study exploring Paralympic athletes' perceptions of sports-related injuries. The athletes perceived that their impairments were involved in the cause and consequential chains associated with a sports-related injury. Other categories that denoted and described these injuries were: sport overuse, risk behaviour, functional limitations, psychological stressors, normalised pain, health hazards, individual possibilities to prevent sports-related injuries and unequal prerequisites.

The causes of SRIP

A common perception was that SRIP occur because of the athletes' impairments and that already existing medical issues worsened the experience of SRIP. In addition, the athletes' perception was that injury patterns seem to differ between different impairment types. Today, there is limited knowledge about impairment-specific risk factors of SRIP. This highlights the need for future injury surveillance systems to target impairment-specific risk factors in order to understand patterns of SRIP and move towards more specific injury prevention programmes. It also raises the question how a sports-related injury should be defined in this athlete population. As there is no clear definition of SRIP, the present study is based on "self-defined sports-related injuries" as it covers a broad spectrum of injuries. This is also supported by a recent consensus statement used in individual sports for able-bodied athletes (Timpka, Alonso, et al., 2015).

Another perception was that SRIP are sometimes caused by one's behaviour, which is in agreement with a study of able-bodied athletes (van Wilgen & Verhagen, 2012). One of the behavioural traits among the Paralympic athletes was that some injuries were experienced as being self-inflicted. Recently, Timpka et al. (2015) showed that the maladaptive behaviour "self-blame" should be seen as an injury risk indicator in able-bodied athletes (Timpka, Jacobson, Dahlström, et al., 2014). It has been suggested that using self-blame as a coping strategy may lead to a vicious circle with unwarranted acceptance of pain and task persistence (Armstrong & VanHeest, 2002; Gould, Finch, & Jackson, 1993). This is in agreement with other studies that have suggested that psychological factors and individual behaviour are commonly associated with especially overuse injuries in sport (Tranaeus, Johnson, Engström, & Skillgate, 2014; van Wilgen & Verhagen, 2012). In particular, reduced performance and chronic maladaptation may occur when prolonged, excessive training is applied concurrent with inadequate recovery (Armstrong & VanHeest, 2002). As athletes in this study perceived that both sport overuse and different behaviour could be linked to SRIP, this needs to be further addressed.

The consequences of SRIP

An important result from this study was that SRIP are perceived as a psychological stressor. Different psychological responses to sports injury are common. However, some responses can trigger more serious psychological issues including anxiety, depression, substance abuse and eating disorders. It

is therefore important for clinicians, as well as trainers and coaches, to recognise common symptoms and signs and to provide support for injured athletes (Putukian, 2016). Based on these findings it is recommended that actions are taken to support and to educate athletes, trainers and coaches how to manage SRIP and the psychological stressors that may arise.

Another consequence that should be noted is the athletes' perception of the occurrence of pain. Pain is prevalent in populations with disabilities, both in daily life and in para-sport (Bernardi et al., 2003; Masri & Keller, 2012). From an inside perspective, this study revealed that pain was also accepted as an adjustment in para-sport. From an outside perspective it needs to be further addressed if pain can be seen as normality in this population.

Pain tolerance has been shown to be strongly modulated by psychological factors (Chen, Dworkin, Haug, & Gehrig, 1989; Tesarz, Schuster, Hartmann, Gerhardt, & Eich, 2012), and factors such as anxiety and fear have been linked to pain-sensitive individuals (Chen et al., 1989). Moreover, pain should be seen as a warning signal of injury and overuse (Bahr, 2009; Clarsen, Myklebust, & Bahr, 2013). However, it is not yet fully known how sensations of pain and loss of function are interpreted and related to actual damages (Timpka, Jacobsson, Bickenbach, et al., 2014). Recent neuroscience models suggest that humans perceive feelings from the body that provide an awareness and summation of their physical condition, underlying mood and emotional states (Craig, 2009). Tesarz et al. (2012) showed in a meta-analysis of pain perception that able-bodied athletes have consistently higher pain tolerance compared to normally active controls. It was suggested that athletes need to develop efficient pain-coping skills because of repeated exposure to pain during brief periods of intense pain or very exhausting activities (Tesarz et al., 2012). A hypothesis may be that para-athletes have a different pain perception because of repeated exposure to pain also in daily life, for example, because of spasticity, incorrect posture and use of assistive devices.

Thus, as the athletes perceived that various psychological stressors and pain were linked to para-sport and SRIP, it is recommended that these variables are included in future injury surveillance systems.

Another consequence of SRIP was that life overall becomes more difficult with SRIP and that the athletes experienced loss of functioning both in sport and in daily life. This is an important aspect as it possibly differs from able-bodied athletes, and suggests that the para-athlete may need extra support during sports injury rehabilitation. The athletes in this study perceived that they sometimes do not receive

the support they need from the health care system. This is in agreement with Kroll, Jones, Kehn, and Neri (2006) who reported that persons with disabilities experience a variety of barriers that prevents them from receiving primary preventive services from the health care system (Kroll et al., 2006).

The possibilities to prevent SRIP

The athletes described a great willingness to take responsibility for the prevention of injuries. However, the perception was that one does not have enough knowledge about injury prevention. It is therefore recommended that injury prevention strategies should be emphasised in para-sport, especially as the athletes expressed a concern about SRIP and its future health-related consequences. Also, the perception was that coaches sometimes do not have enough knowledge of impairments, training and how the body is exposed during hard training. Based on these results, the first step towards injury prevention programmes in para-sport could be specifically designed educational programmes regarding injury prevention and training physiology.

van Wilgen and Verhagen (2012) proposed that injury preventive measures may be more successful when synchronised with the athletes' and coaches' own beliefs (van Wilgen & Verhagen, 2012). A strength of the present study is that future preventive measures can be based on the para-athletes' own perceptions of SRIP, and not only be evaluated from the researchers' and clinicians' perspective (Verhagen, Voogt, Bruinsma, & Finch, 2014). It is also worth noting that different impairments seem to affect injury patterns differently and, therefore, a diversity of preventive measures will be needed.

Methodological considerations

Some of the Paralympic athletes' perceptions in this study may be Swedish phenomena. Regardless of that, we believe that the transferability to other para-athletes is good since the main focus of the study was the perceptions of SRIP. One might argue that the interviews were short. However, we covered a wide range of impairments and para-sports, and the athletes were very informative. The credibility is therefore considered to be good. A concern in phenomenographic research is the researchers understanding of what the participants are trying to communicate (Sjöström & Dahlgren, 2002). To assure dependability and pose relevant follow up-questions, the present interviewer is familiar with para-

sport and SRIP. The ever-changing context within the research process was considered and all authors participated in the analysis.

Conclusions

The findings from this study reveal that Paralympic athletes' perceptions of their experiences of SRIP are complex and multifactorial with causes, risk factors and consequences that are not always present in able-bodied athletes. It is recommended that these perceptions are considered in the design of future injury surveillance systems and preventive programmes. The results from this study can also be used as a base for educational interventions within the Paralympic Movement. Further qualitative as well as quantitative epidemiological research is, however, required to enable generalisation and to allow more specific analysis of injury risk factors. Taken together, these findings may assure that future para-sport medicine research and interventions consider the athlete's own perspective and not only outer perspectives based on pathophysiology.

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Paper II



STUDY PROTOCOL

Open Access



The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS): a study protocol for a prospective longitudinal study

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Abstract

Background: Paralympic sport provides sporting opportunities for athletes with a disability, with the Paralympic Games as the main event. Participation in sport is, however, associated with a significant risk for sustaining injuries and illnesses. Our knowledge of sports-related injuries and illnesses in Paralympic sport is very limited and there are no large-scale epidemiological cohort studies. The purpose here is to present a protocol for a prospective longitudinal study: The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS).

Methods/design: An argument-based method for investigation of design problems was used to structure the study protocol. The primary requirement of the protocol is to allow prospective studies over time and include exposure to both training and competition. To reflect the complexity of Paralympic sport with athletes' pre-existing impairments, use of assistive equipment, pain and other and medical issues, it is required that the data collection system is specifically adapted to Paralympic sport. To allow the collection of data, at the same time as there is limited access to coaches and medical personnel, it is advantageous that data can be collected online directly from the athletes. Based on this a self-report athlete monitoring system will be developed, where the athletes can enter data weekly via their mobile phones or lap-tops. Data will be collected from around 100 Swedish Paralympic athletes for approximately 1 year, which will allow us to i) prospectively estimate the annual incidence of sports-related injuries and illnesses and ii) explore risk factors and mechanisms for sustaining sports-related injuries and illnesses based on athlete exposure and training loads.

Discussion: For effective implementation of injury and illness prevention measures, comprehensive epidemiological knowledge is required. This study will be the first prospective longitudinal self-report study of sports-related injuries and illnesses in Paralympic sport over a longer period of time. The results will eventually contribute to the development of evidence-based preventive measures specifically adapted to Paralympic sport in order to provide safe and healthy sport participation. Thereby, the project will be of relevance for Paralympic athletes at all levels and to the Paralympic Movement.

Trial registration: The study is registered at ClinicalTrials.gov (Identifier: NCT02788500; Registration date: 22 May 2016).

Keywords: Athletic injuries, Epidemiology, Research protocol, Sports for persons with disabilities, Sports medicine

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Background

Sport for athletes with disabilities has existed for more than 100 years. Today, the global network 'The Paralympic Movement' provides sporting opportunities for Paralympic athletes with physical, visual or intellectual impairments, from grassroots to elite level, with the Paralympic Games as the main event. During the past decades, Paralympic sport has seen a large development in both the number of athletes, sports performance and technology [1], and many Paralympic athletes have reached performances similar to able-bodied elite athletes [2].

It is well-known that physical activity and participation in sport generates several positive health effects [3, 4]. Low physical fitness and reduced physical activity is associated with many adverse health events, including major non-communicable diseases [5]. Participation in sport is therefore of great importance, especially for persons with disabilities, as individuals with a chronic disease or disability have lower physical fitness compared to non-disabled individuals [6]. Sport is today included in most rehabilitation programs for people with disabilities, to promote both physical and psychological well-being [7, 8].

Injuries and illnesses in Paralympic sport

Participation in sport is, however, associated with a significant risk for sustaining injuries and illnesses that may have long-lasting effects, including mortality, morbidity and high costs for society [9, 10]. Remaining free of injury and illness has therefore become a fundamental component of successful performance in sport [11].

Previous research has shown that injury rates in Paralympic sport are generally high with a trend towards more injuries compared with sport for able-bodied athletes [12]. Injury patterns related to the impairment, the equipment involved and the specific mechanics of the sport have been proposed to be related to the injuries [13]. Maintaining health in athletes with already existing disabilities can be problematic. The athletes may have complex pre-existing medical conditions, such as neurodegenerative disorders, spinal cord injury, amputations, rare syndromes with anomalies in different body systems, vision loss and intellectual impairments, and medical issues like autonomic dysreflexia, infections, hyperthermia, skin lesions, spasticity, fatigue, pain and epilepsy can be present [13]. Moreover, the athletes may be exposed to repetitive and sometimes improper biomechanical load in their daily life [14, 15]. Based on the facts that the Paralympic Games is now one of the world's largest multi-sport events [1] and that training intensity and performance levels have increased during the past years [16], there are surprisingly few epidemiological studies covering sports-related injuries and illnesses in Paralympic

sport. Thus, further studies are needed to ensure the development of safe participation in Paralympic sport.

Sports injury research

Recent research has shown that several categories of sports-related injuries are preventable [17–19]. However, for effective implementation of injury prevention measures, comprehensive epidemiological knowledge is required [9, 20]. To reduce overtraining, injuries and illnesses, regular monitoring of athletes is an important aspect in athletic preparation [21, 22]. Although the International Paralympic Committee (IPC) has successfully implemented an epidemiological surveillance system during the Paralympic Games [23], there is still a lack of longitudinal prospective data following Paralympic athletes over entire training seasons [12]. A recent review identified large differences in injuries across sports and highlighted the need for sport-specific studies [24]. Current studies within Paralympic sport vary in quality and have mainly recorded injuries related to trauma, medical attention or time loss. Most studies are retrospective and have only recorded injuries during competitions. In addition, a diversity of injury definitions have been used and most studies have not examined impairment-related risk factors and injury severity [12, 25]. Thus, there is a need for further longitudinal epidemiological studies that prospectively assess sports-related injuries and illnesses in Paralympic sport based on risk exposure.

Today, most injury surveillance systems exist in professional and commercial able-bodied elite sport settings [26], for example soccer, tennis and rugby [27–29]. In addition, many of the surveillance systems require that medical practitioners complete the injury report form [23, 28–30]. However, the characteristics, preconditions and contexts differ between sports [31, 32]. For example, medical attention injuries may be difficult to apply when there is limited access to medical personnel [33]. It has also been proposed that some methods for injury registration may underestimate overuse injuries [34]. Also, in terms of injury capture rates, medical staff may underestimate the injury burden compared to athletes themselves [32].

Athlete monitoring in Paralympic sport

In Paralympic sport everyday access to coaches and medical personnel is scarce [15] and sport, especially in the Scandinavian countries, is primarily based on voluntary dependency [35]. Moreover, Paralympic sport has a wide geographical spread, both in Sweden and internationally, and involves more than 28 different sports and 10 different impairments types [1] (Table 1). In addition, patterns of sports-related injuries and illnesses differ in some ways from those among able-bodied athletes, as the impairment itself is involved in the cause and consequential chains [15]. The impairment that the athlete has may

Table 1 Eligible impairment types and sports in The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS)

Impairments	Summer sports		Winter sports
Impaired muscle power Impaired passive range of movement	Archery	Athletics	Alpine Skiing
	Boccia	Canoe	Biathlon
	Cycling	Equestrian	Cross Country Skiing
Limb deficiency	Football-5-a-side	Football-7-a-side	Ice Sledge Hockey
Leg length difference	Goalball	Judo	Snowboard
Short stature	Powerlifting	Rowing	Wheelchair Curling
Hypertonia	Sailing	Shooting	
Ataxia	Sitting volleyball	Swimming	
Athetosis	Table tennis	Triathlon	
Vision impairment	Wheelchair basketball	Wheelchair fencing	
Intellectual impairment	Wheelchair rugby	Wheelchair tennis	

also cause difficulties in the definition and interpretation of sports-related injuries and illnesses. However, health should not only be related to the absence of a disease or an injury. It also includes the individuals' capacity to carry out activities in relation to their self-perceived functioning and health [36].

Today, there is growing evidence that self-report measures are sensitive and reliable tools to monitor athletes' health [22, 37, 38]. For example, Jacobsson and co-workers [33] reported the development of a web-based self-report system for the Swedish Athletics study. They found that to allow specific analyses of overuse injuries, recording of partial time-loss injuries and regular collection of self-reported data over time was necessary in order to find searches for complex aetiological patterns. It is well-known that many injury-related musculoskeletal incidents result from the cumulative effects of smaller amplitude of micro-traumatic forces developing over time [39]. Therefore, to prevent injuries and overuse problems to develop into chronic conditions, it is useful to have self-report data that highlights the small and early decrements in functioning [40]. Also, data on other medical conditions, such as illnesses, training availability and training load, are important to allow us to understand health conditions beyond injuries [41, 42]. For example, loss of training time due to a health problem has recently been proposed to be a major determinant of success and failure [42]. Recent research in able-bodied athletes also indicates that a high chronic workload seems to decrease the risk of injuries, whereas excessive and rapid increases in training loads are likely to cause a large proportion of injuries [43].

With a systematic longitudinal self-report surveillance system based on exposure it would be possible to observe trends and risk factors of sports-related injuries and illnesses in Paralympic sport and thereby have a basis for the development of specific preventive measures. However, for injury surveillance data to be useful for

prevention, a theoretical framework is required to understand how factors representative of the target population influence injuries and illnesses [44]. Moreover, to improve reach, implementation and maintenance it has been recommended that surveillance systems are user friendly and accessible in a wide range of form [45], in this case adapted for persons with physical, visual or intellectual impairments. To capture all sports-related injuries and illnesses in Paralympic sport, to obtain valid data and to allow specific injury prevention measures, there is a need for injury surveillance systems to be specifically tailored to Paralympic sport, targeting a wide range of para-athletes.

Purpose

The purpose here is to present a protocol for a prospective longitudinal study: The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS). In this study we will develop a web-based system that allows self-report data to be collected from Paralympic athletes. Based on these data, we will subsequently: i) record and prospectively estimate the annual incidence of sports-related injuries and illnesses among Swedish Paralympic athletes and ii) explore risk factors and mechanisms for sustaining sports-related injuries and illnesses based on athlete exposure and training loads.

Methods

Study design and rationale

The SRIIPSS is an epidemiological cohort study aimed to prospectively collect self-report data on the incidence and risk exposure of sports-related injuries and illnesses during training and competition during approximately 1 year among Swedish Paralympic athletes. The study will follow the STROBE (Strengthening the Reporting of Observational studies in Epidemiology) guidelines [46] and is registered at ClinicalTrials.gov (Identifier: NCT02788500; Registration date: 22 May 2016).

The research team, comprising sports injury epidemiologists, physicians and physical therapists, used an argument-based method for investigation of complex design problems to structure the study protocol. In this operational research process, an interdisciplinary approach is used to find logical conclusions, test formal soundness, and thereafter establish a design rationale [47, 48]. The focus of the design rationale is to document both the development process and resulting design [48]. The argumentation included discussions about the types of data that will be collected, data storage, and ethical and logistical considerations. Examination of requirements was followed by iterated drafting of protocol specifications based on previous research [12, 13, 24, 25], the athletes' own perceptions of sports-related injuries and illnesses [15] and the context of Swedish Paralympic sport [49] (Fig. 1).

The primary requirement of a protocol for longitudinal epidemiological studies in Paralympic sport is to allow prospective studies that cover at least an entire season and include exposure to both training and competition. Second, to reflect the complexity of Paralympic sport, for example pre-existing impairments, use of assistive equipment, pain and other and medical issues, it is required that the design of a surveillance system is specifically adapted to Paralympic sport. Third, to allow the collection of epidemiological data and individual training behaviors, at the same time as there is limited access to coaches and medical personnel, it is advantageous that longitudinal data can be collected online directly from the athletes. There is also increasing evidence that psychological and behavioral factors contribute to the process leading to several sports injuries [50, 51]. Therefore, a psychological profile will be added to identify factors and behaviors related to pain and other activity-limiting sensations [50].

Setting and participants

Potential participants will be recruited through the Swedish Paralympic Program, which covers candidates for the Summer and Winter Paralympic Games. The total number of athletes in the Swedish Paralympic program is around 100. All potential participants will be invited by post or email. They will receive information about the proposed study, a request for a contact e-mail and phone number, a consent form for participation and a prepaid return envelope. To be eligible for the study the athlete should belong to one of the ten eligible impairment types, according to the IPC classification system, and participate in either a Paralympic summer or winter sport (Table 1). The following inclusion criteria will be used: age 18–55 years, being a registered athlete within the Swedish Paralympic Program, being able to communicate in Swedish and having the opportunity to respond weekly to a web-based questionnaire. As the number of Swedish Paralympic athletes is small and this is an understudied topic, a total population design will be applied.

Protocol implementation

The SRIIPSS will employ approaches similar to those that have been used in previous sports injury research [9, 23, 30, 33, 52]. It is, however, hypothesized that sports-related injuries and illnesses among Paralympic athletes differ from sport for able-bodied athletes [13, 15]. Existing research has shown that the accessibility, compatibility, interface and design of questions influence the outcome of athletes' self-report measures [38]. Therefore, we will specifically adapt the protocol to Paralympic sport and thereafter implement the data collection.

For the data recording a commercial product for collection of survey data online (Briteback AB, Norrköping, Sweden; www.briteback.com) will be used. The research team participates in the development of the system to

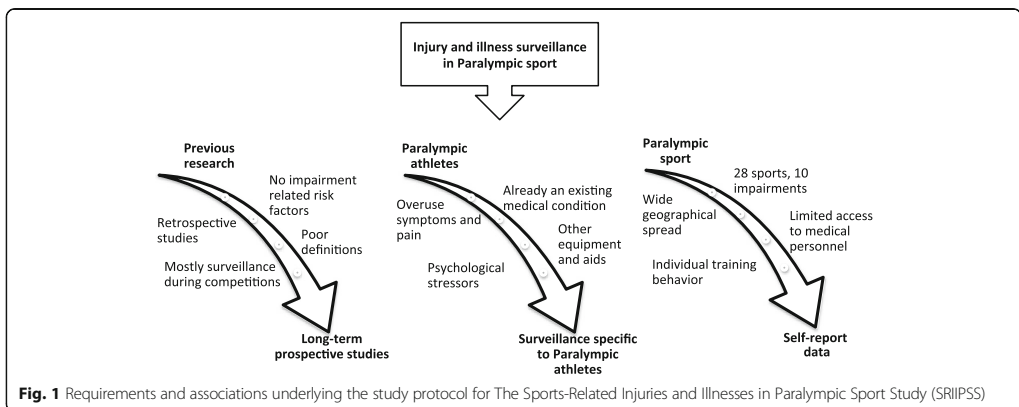


Fig. 1 Requirements and associations underlying the study protocol for The Sports-Related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS)

specifically adapt it to, for example, visually impaired athletes. The product enables definition of personal usernames and passwords to protect data from unauthorised use.

A pilot study is planned where we will enroll approximately twenty athletes with different impairments through a convenience sample from the Swedish Paralympic Program. The pilot study aims to evaluate the feasibility of the data collection system, to assure that it works for athletes with physical, visual and intellectual impairments, and to recognize and solve potential problems. The athletes will be asked to fill in the survey during 4 weeks. The pilot study period will end with a cognitive walk-through to review the primary protocol and also validate the data. This is an evaluation method that aims to assess usability problems of a new tool early in the design process [53]. The athletes and researchers will be asked to evaluate and provide solutions for the proposed system.

Data will be collected from the end of 2016 and continue for approximately 1 year. At the start of the study the athletes fill in baseline information and a psychological profile. The athletes will thereafter be asked to report sports-related injuries and illnesses weekly. The primary outcome of the study is the incidence of injuries and illnesses, divided into a sports-related injury or illness. All data will be based on sport exposure and analyzed for the mechanism of sports-related injuries and illnesses. A closure form will be used when the athlete is back in full training following an injury or illness (Table 2).

Definitions of injury and illness

The main injury definition in the SRIIPSS follows, with some alterations, the definitions previously used for soccer, rugby union, the Olympic Games and athletics [27, 29, 30, 52]:

Any new musculoskeletal pain, feeling or injury that result from participation in Paralympic sport (training or competition) and cause changes in normal training/competition to the mode, duration, intensity or frequency, regardless of whether or not time is lost from training or competition.

An illness including psychological complaints will be defined as:

Any new illness or psychological complaint that cause changes in normal training/competition to the mode, duration, intensity or frequency, regardless of whether or not time is lost from training or competition.

The reported incidents will be categorized as ‘sudden onset’ or ‘gradual onset’. A sudden onset incident refers to an incident caused by a specific identifiable episode resulting in a rapid onset of experienced distress. Subsequently, sudden onset injuries will be categorized according to the cause of the incident as: i) traumatic injuries – a condition caused by an identifiable single external transfer of energy (for example, a bone fracture caused by a fall or a ligament tear caused by contact with an obstacle), or ii)

Table 2 Overview of the outcome measures of the SRIIPSS

Outcome measure	Parameter	Measurement
Baseline data	Gender, age, impairment, sport, training hours, previous injury/illness, medication, aids, anthropometrics, pain	SRIIPSS protocol for baseline data
Psychological profile	Perceived motivational climate	Perceived Motivational Climate in Sport Questionnaire (PMCSQ)
	Active coping	BRIEF COPE
	Body consciousness and body competence	Body Consciousness Questionnaire Scale (BCQ-s)
	Hyperactivity	Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)
	Psychological commitment to exercise	Commitment to Exercise Scale (CTeS)
Weekly athlete report	General well-being	Likert-scale
	Injuries, illnesses, pain, psychological stressors, amount of training and competition, training intensity, sleep	SRIIPSS protocol for weekly athlete data Likert-scale
Injury report	Onset of injury, mechanism of injury, present symptoms, type of injury, impairment-related factors, medical contacts	SRIIPSS protocol for weekly injury data
Illness report	Onset of illness, present symptoms, type of illness, impairment-related factors, medical contacts	SRIIPSS protocol for weekly illness data
Injury/illness closure form	Diagnosis of injury/illness, severity of injury, treatment, perceived risk factors	SRIIPSS protocol for injury/illness closure data

overuse injuries – a condition to which no identifiable single external transfer of energy can be associated (examples of overuse sudden onset injuries include tendon tears).

A gradual onset incident refers to a condition that manifests itself over a period of time, or when there is a gradual increase in the intensity of experienced distress, without a single identifiable event being responsible for the condition. Examples of gradual onset conditions include overtraining syndromes and overuse injuries, such as tendinosis and tendinopathies [52].

The arguments for using these definitions are based, first, on that the incidents will be recorded from the athlete's own subjective perspective, feelings and experiences of pain, injury and illness. Second, these definitions support the concept of partial time-loss injury [33, 54]. In order to capture these injury events it is important to identify complex background patterns for overuse injuries [33, 34]. Third, this athlete population already has an existing impairment and is exposed to elements not present in abled-bodied athletes. To allow for a better understanding of sports-related injuries and illnesses in this population, we believe that it is important to assess various factors such as pain, injuries, illnesses, and psychological stressors in order to obtain a comprehensive picture of Paralympic athletes' health. To allow comparisons with previous studies of Paralympic athletes and non-disabled athletes, the incidents will at a secondary level of the analysis be identified by time-loss and tissue damage.

In agreement with previous injury surveillance studies [28, 52] a recurrent condition will be defined as:

An incident of the same type and at the same site linked to an index incident and which occurs after an athlete's return to full function and participation ("full recovery") from the index recordable incident.

The incidents will be subcategorized into re-injuries and exacerbations. Categorization of subsequent injuries – new, recurrent, exacerbation or multiple – will be taken into account using the Subsequent Injury Categorization (SIC) model before analysis [55].

Outcome measures

Baseline data

Baseline data will be collected using a web-based questionnaire including: i) participant characteristics (i.e., gender, age, height and weight); ii) demographic data; iii) impairment characteristics (i.e., type of impairment, use of assistant devices, medications); and iv) sport characteristics (i.e., type of sport, preconditions, hours per week involved in training and competition). The athletes will also be asked about existing injuries, illnesses

and pain. In addition, women will be asked about menstruation and use of contraceptives.

Psychological profile

Data for a psychological profile will be collected at baseline and at the end-point of the study based on the affective adaptation framework [56] and the psychological flexibility model [57]. These models are based on behavioral risk factors including awareness and explanatory processes of sensory information, affective reactions, enduring psychological factors and maladaptive thoughts and capacity to change behavior.

Measurement of body consciousness and body competence will be based on the Body Consciousness Scale (BCS) [58]; six items from the hyperactivity definition in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) were added. The Brief Cope instrument (Kristiansen 2008) will be used to measure active coping including planning, mood, acceptance and maladaptive behavior. The Perceived Motivational Climate in Sport Questionnaire (PMCSQ) will be used to assess perceived demands of the social sporting environment including performance orientations and mastery/task accomplishment [59]. The individual's psychological commitment to the activity of exercising and tendencies to rigidity in training will be measured by the Commitment to Exercise Scale (CTES) [60]. All psychological measures have shown satisfactory measurement properties when used in sports medicine research [50].

Athlete weekly e-diary

To collect data on new sports-related injuries and illnesses as well as on exposure, the athletes will be asked to fill in a weekly e-diary based on one developed by Jacobsson et al. [33] and adapted for Paralympic sport. Each week, an alert is automatically sent to the participants' email address and mobile phone, asking them to fill in the weekly questionnaire about their current health status (injuries, illnesses and pain), the amount of training, intensity of training, whether the training is performed at full capacity, competitions, sleep, general well-being and medical contacts. In addition, anxiety/depression and pain/discomfort will be evaluated using two questions from EQ-5D [61].

If the athlete reports a new injury or illness in their weekly e-diary, a link to an injury or illness report form will be provided, where additional information on the incident are to be reported. The study coordinator (KF) monitors the reported data. If a participant is absent from training because of an undiagnosed injury or illness lasting longer than 3 weeks, the participant will be contacted by phone or email. The athletes will be asked to go through an examination by a sports physician or sports physiotherapist to confirm the clinical diagnosis, in order to validate the data.

Internal training loads will be recorded based on a modified version from Gabbett & Jenkins [62] and Foster et al. [63]. The athletes will be asked to estimate their total rating of perceived exertion (RPE) during the past week on a 0–10 point RPE-scale [62]. Previous research has demonstrated that the RPE method is a valid method to quantify exercise training during a wide variety of exercise types [63], and the method has also been shown to provide valid estimates when compared to heart rate and blood lactate concentration. The training load will be calculated by multiplying the training session intensity with the duration of the training during the week and will be further analysed with the relationship of injury/illness, acute loads and chronic loads [43, 62, 64].

Assistance will be provided, if necessary, for athletes with vision or intellectual impairment, or severe physical impairment. At the start of the study the athletes will be educated about the importance of monitoring. Feedback will be given, if desired, to allow data to be used to the athletes' benefit.

Injury report form

The injury report form is a modified version of the form described by Jacobsson et al. [33], originally based on the soccer consensus by Fuller et al [27] and the International Olympic Committee (IOC) groups [30]. This injury report system has been shown to be feasible for self-report data in other individual sports, such as athletics [31]. The athletes will be asked about the onset of injury, mechanism of injury, contributing factors, anatomical site and recurrence of earlier injury. The athletes will also be asked about presenting symptom(s) or sign(s) and suspected aetiology (a list of common categories of causes is provided). The system is further adapted to be applicable to athletes with impairments. For example, questions will be added regarding the impairment and equipment used.

Illness report form

Illnesses will be recorded based on a combination of data collection procedures for epidemiological studies in athletics and during the Paralympic Games [52, 65]. The athletes will be asked about presenting symptom(s) or sign(s), affected system, mode of onset and suspected aetiology (a list of common categories of causes is provided). The report form is further adjusted to be applicable to athletes with impairments.

Injury closure form

When the athletes report that they are back in normal training following an injury, they will be asked to fill in an injury closure form with: i) time off full training; ii) final diagnosis; iii) person who made the diagnosis; iv) treatment(s) received; and v) perceived risk factors of

injury including impairment related factors. Additionally, there will be the possibility to provide personal comments about the incident reported. The assessment of severity starts on the following day, if the athlete is unable to take part in full and/or normal training and/or competition. Severity will be reported as days absent from training: minor (1–3 days); mild (4–7 days); moderately serious (8–28 days); serious (>28 days-3 months); long-term (3–6 months); and catastrophic injuries [9].

Finally, to describe the patterns of injury, a matrix adjusted to Paralympic sport will be used to categorize the coded injury data according to injury type (nature of injury) and anatomic location (body region). This is based on the Borell Injury Diagnosis Matrix [66] and modified for overuse injuries by Hauret et al. [39] and Jacobsson et al. [31]. The incidents will be classified by mode of onset and will be further analyzed by athlete classification and specific impairment type. A group consisting of two physiotherapists and two physicians with a background in sports medicine and Paralympic sport will classify each self-reported diagnosis of sports-related injuries and illnesses into a diagnostic code according to The International Classification of Diseases (ICD). To confirm the diagnosis of fracture/stress fracture, an x-ray will be required.

Statistical analysis plan

The primary variables for the descriptive analyses are records of the incidence of sports-related injuries and illnesses, i.e., recordings of injury or illness events that are conditioned on that the participant is 'healthy' at the start of data collection period. Incidences will be calculated separately for injuries and illnesses. The incidence rates will be calculated as the number of new incidents divided by total athlete exposure hours (per 1000 h of sport participation). Health-incidents not related to sport will be analyzed separately. All events will be evaluated according to the mechanism of sports-related injuries and illnesses (independent variables). The data will be assessed for normality and will be presented using quantitative descriptive statistics (mean, median, standard deviation, minimum and maximum for continuous data and frequency and proportion (%) for categorical data). Differences in proportions between different categories (e.g., age-groups, gender, impairments, previous injury, competition frequency and level of severity of impairment) will be analyzed as covariates using chi-square statistics. The primary end point for the injury risk analyses will be time to injury. The incidence data will be further analyzed with the Kaplan-Meier survival analysis method, the log-rank test and Cox proportional hazards regression. To analyze the relationship between training loads and injury and illness incidence, Pearson product moment correlation coefficients will be used. A

significance level of 0.05 and 95 % confidence intervals will be used in all tests. The data will be analyzed using IBM SPSS Statistics version 23.

Discussion

We here present a protocol for a prospective epidemiological study of sports-related injuries and illnesses in Paralympic sport and provide arguments related to its design. To the best of our knowledge, no study has prospectively and comprehensively assessed the epidemiology of sports-related injuries and illnesses in Paralympic sport over a longer period of time. Health related problems, in particular musculoskeletal injuries, are common in sport [10]. Previous studies have indicated that sports-related injuries and illnesses is a major concern also within Paralympic sport [23, 24]. Moreover, few studies have analyzed the onset and diagnosis of sports-related injuries and illnesses and further analyzed impairment-related and sport specific risk factors. The proposed study protocol will be used to assess injuries and illnesses over time and between different sports and populations. With sports-related injuries and illnesses incident cause data based on athlete exposure it will be possible to observe trends, potential interactions and risk factors over time, and thereby target sports with a higher risk.

It could be argued that a limitation is that no data on clinical examinations are included at baseline. However, self-report systems have previously been shown to enable valid and reliable recordings of sports-related incidents [67] and to monitor changes in athletes' well-being [68]. This longitudinal research project covers a complex and understudied field. To move forward, basic and feasible research is required. In particular, long-term analyses of possible cause-relationships of sports-related injuries and illnesses by athlete classification and specific impairment type are of importance, as it is hypothesized that injuries and illnesses may be specific for athletes' sport and impairment type [14]. Other challenges that long-term self-report studies may face are drop-out of participants, low response rates, and problems understanding and interpreting the questions. Moreover, this is the first study among Paralympic athletes with various physical, visual, and intellectual impairments, which requires that the proposed system work for all types of impairments.

The SRIIPSS is expected to lead to an in-depth understanding of the epidemiology of sports-related injuries and illnesses. The results will eventually contribute to the development of evidence-based preventive measures specifically adapted to Paralympic sport in order to provide safe and healthy sport participation. Thereby, the project will be of relevance for Paralympic athletes at all levels and to the Paralympic Movement.

Abbreviations

BCS: Body consciousness scale; CtESm: Commitment to exercise scale; DSM-IV: Diagnostic and statistical manual of mental disorders; ICD: The International Classification of Diseases; IOC: International Olympic Committee; IPC: International Paralympic Committee; PMCSQ: The Perceived Motivational Climate in Sport Questionnaire; RPE: Rating of perceived exertion; SIC: Subsequent injury categorization; SRIIPSS: The Sports-Related Injuries and Illnesses in Paralympic Sport Study

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Availability of data and materials

No data are presented, as this is a study protocol.

Authors' contribution

Conceptualization of the project: KF, JL. Design of the study protocol, contribution to manuscripts drafts and review of the final manuscript: KF, JJ, TT, ÖD, JL. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

The study is approved by the Regional Ethical Review Board in Lund, Sweden (Dnr 2016/169) and follows the WMA Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects. Participation in the study is voluntary and informed written consent will be collected from all participants, including those in the pilot study.

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Paper III



Original Paper

An eHealth Application of Self-Reported Sports-Related Injuries and Illnesses in Paralympic Sport: Pilot Feasibility and Usability Study

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Abstract

Background: Sport participation is associated with a risk of sports-related injuries and illnesses, and Paralympic athletes' additional medical issues can be a challenge to health care providers and medical staff. However, few prospective studies have assessed sports-related injuries and illnesses in Paralympic sport (SRIIPS) over time. Advances in mobile phone technology and networking systems offer novel opportunities to develop innovative eHealth applications for collection of athletes' self-reports. Using eHealth applications for collection of self-reported SRIIPS is an unexplored area, and before initiation of full-scale research of SRIIPS, the feasibility and usability of such an approach needs to be ascertained.

Objective: The aim of this study was to perform a 4-week pilot study and (1) evaluate the monitoring feasibility and system usability of a novel eHealth application for self-reported SRIIPS and (2) report preliminary data on SRIIPS.

Methods: An eHealth application for routine collection of data from athletes was developed and adapted to Paralympic athletes. A 4-week pilot study was performed where Paralympic athletes (n=28) were asked to weekly self-report sport exposure, training load, general well-being, pain, sleep, anxiety, and possible SRIIPS. The data collection was followed by a poststudy use assessment survey. Quantitative data related to the system use (eg, completed self-reports, missing responses, and errors) were analyzed using descriptive statistics. The qualitative feasibility and usability data provided by the athletes were condensed and categorized using thematic analysis methods.

Results: The weekly response rate was 95%. The athletes were of the opinion that the eHealth application was usable and feasible but stated that it was not fully adapted to Paralympic athletes and their impairments. For example, it was difficult to understand how a new injury or illness should be identified when the impairment was involved. More survey items related to the impairments were requested, as the athletes perceived that injuries and illnesses often occurred because of the impairment. Options for description of multifactorial incidents including an injury, an illness, and the impairment were also insufficient. Few technical issues were encountered, but athletes with visual impairment reported usability difficulties with the speech synthesizer. An incidence rate of 1.8 injuries and 1.7 illnesses per 100 hours of athlete exposure were recorded. The weekly pain prevalence was 56% and the impairment contributed to 20% of the reported incidents.

Conclusions: The novel eHealth-based application for self-reported SRIIPS developed and tested in this pilot study was generally feasible and usable. With some adaptation to accommodate Paralympic athletes' prerequisites and improved technical support for athletes with visual impairment, this application can be recommended for use in prospective studies of SRIIPS.

Trial Registration: ClinicalTrials.gov NCT02788500; <https://clinicaltrials.gov/ct2/show/NCT02788500> (Archived by WebCite at <http://www.webcitation.org/6v56OqTeP>)

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KEYWORDS

epidemiology; feasibility studies; sports medicine; sports for persons with disabilities; telemedicine

Introduction

Paralympic sport continues to grow and attracts athletes from all around the world. However, participation in Paralympic sport is, like all sport, associated with a risk of sports-related injuries and illnesses, and Paralympic athletes' additional medical issues are challenging to health care providers and medical staff [1].

Knowledge of sports-related injuries and illnesses in Paralympic sport (SRIIPS) is limited, and few prospective studies have assessed SRIIPS over time [2-4]. During the Paralympic Games in London 2012 and Sochi 2014, considerably higher injury incidences were recorded compared to the corresponding Olympic Games [5,6]. Paralympic athletes also have higher illness incidence rates compared to Olympic athletes [7]. To improve health and safety in Paralympic sport, there is a need for prospective longitudinal monitoring of SRIIPS over entire training seasons to determine distributions and etiological mechanisms [8,9]. To advance knowledge of the incidence and risk factors of SRIIPS, we have initiated a prospective longitudinal study using eHealth-based data collection of self-reports [10].

To allow data collection over longer periods of time and in heterogeneous populations, athlete monitoring through self-reports is an established method of observing athletes' health, including both sports-related injuries and illnesses [11-13]. Self-reports enable collection of information on overall health based on simultaneous recording of injuries, physical and mental illnesses, sports exposure, training load, and risk factors, specifically adapted to the sports population of interest [8,14,15]. Moreover, self-reports provide more realistic data than reports by medical personnel who may underestimate the injury rates compared to athletes themselves [16].

By collecting data electronically, self-reports can be used with minimal memory bias and constitute real-time personalized data [17]. Advances in mobile phone technology and networking systems offer novel opportunities to develop innovative eHealth applications to collect data [18]. However, most studies have only included able-bodied athletes, and studies using eHealth applications in Paralympic athletes with various physical, intellectual, and visual impairments are lacking.

For successful implementation of an application, it is important to consider methodological and practical challenges [19,20]. Pilot studies allow the development and testing of the method and give advance warnings about where the forthcoming main research project could fail [21]. Potential sources of errors could be poor definitions, difficulties in interpreting questions and

data, and failure to use the system. Establishing a user-friendly surveillance system that targets the population is therefore a key factor [8,22]. Thus, before initiation of full-scale research, a pilot study focusing on feasibility and usability issues is needed to ascertain the ability to use the new application for future data collection [23]. As Paralympic sport includes athletes with a wide range of impairments [1], the eHealth application must allow adaptation to users' specific needs and circumstances [24]. This is to ensure that they will be able to adopt the new monitoring system in daily procedures, regardless of their impairments, and that the output is experienced as useful for them [8,22].

The aim of this study was to perform a 4-week pilot study and (1) evaluate the monitoring feasibility and system usability of a novel eHealth application for longitudinal epidemiological research on self-reported SRIIPS and (2) report preliminary data on SRIIPS.

Methods

Development of the eHealth Application

The purpose of the eHealth monitoring is to enable Paralympic athletes to self-report SRIIPS, exposure to sport, and general health parameters in an e-diary. For the data collection, the Briteback survey tool was used. This tool is integrated with software built on team communication research. The tool allows researchers to construct specific surveys, which are sent automatically as Web links in emails and text messages. The surveys are adapted to computers, tablets, and mobile phones, and participants can choose how to enter their data. Automated system-generated statistics are provided immediately after reporting of data.

The prototype eHealth application was developed and adapted to Paralympic athletes based on a theoretical foundation of existing research within sports medicine [12,13,25], Paralympic athletes' own perceptions of experiences of sports-related injuries [26], our study protocol [10], and the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) [27]. The main focus was to include features that are specific to Paralympic athletes. For example, pain, involvement of the impairment, and already existing medical issues may be present [26]. The research team, consisting of sports injury epidemiologists, physicians, physical therapists, and disability researchers together with computer scientists and athletes adapted and tested the system for Paralympic athletes.

To evaluate a Web tool as feasible and usable for users with disabilities, the WCAG 2.0 guidelines require it to be perceivable, operable, understandable, and robust for all categories of users [27]. Therefore, a central requirement of the eHealth application was that athletes with a visual impairment, physical impairment, or intellectual impairment (Figure 1) could use it at the same conditions. To make the content usable to the athletes, the eHealth application was developed to meet the WCAG 2.0 accessibility guidelines. Principles related to user interface design, screen resolution, keyboard navigation, avoidance of seizure-causing content, and avoidance of content that causes mistakes were considered in the development. The application should also appear and operate in predictable ways, and the users should have enough time to read and use the content [27].

The final weekly e-diary consisted of 12 questions for athletes to respond to pertaining to the following topics:

- Participation in normal training
- Exposure to sport (sessions)
- Exposure to sport (hours)
- Exposure to competition
- Rate of perceived exertion
- Use of analgesics
- General well-being
- Sleep
- Anxiety
- Pain

- New injury
- New illness

Depending on responses, subquestions related to reported SRIIPS could also appear.

Study Population

A pilot study cohort stratified to represent the different impairments, genders, and sports was selected in June 2016 from the Swedish Paralympic Program. The following inclusion criteria, adopted from the study protocol [10], were used: age 18 to 55 years; being a registered athlete within the Swedish Paralympic Program; being classified as an eligible International Paralympic Committee athlete with visual impairment, physical impairment, or intellectual impairment; being able to communicate in Swedish; and having the opportunity to answer an e-diary weekly during 4 weeks. A total of 37 elite athletes were invited to participate, and 28, 9 women and 19 men (aged 20 to 51 years) with visual impairment (n=11), physical impairment (n=15), and intellectual impairment (n=2), accepted the invitation. The athletes were active in the following para-sports: shooting, canoeing, goalball, athletics, judo, swimming, boccia, cycling, table tennis, wheelchair rugby, cross-country skiing, wheelchair curling, and ice hockey. Four athletes, all with physical impairment, declined participation because of lack of time prior to the Paralympic Games 2016. Five athletes never responded, 3 with physical impairment and 2 with intellectual impairment.

Figure 1. Survey design and technology formulated for use among able-bodied athletes need adaptations to Paralympic athletes with a broad range of impairments. (A) Visually impaired athlete using speech synthesizing technology adapted to the eHealth application, (B) Wheelchair basketball player with individual training behavior often without coach and medical staff, (C) Athlete often traveling using the eHealth application in her training environment, (D) Athlete with cerebral palsy and tetraplegia using a joystick to navigate the eHealth application.



Ethical Considerations

The study followed the ethical principles for medical research involving human subjects per the World Medical Association Declaration of Helsinki and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and is registered at ClinicalTrials.gov [NCT02788500]. The entire study was approved by the Regional Ethical Review Board in Lund, Sweden (Dnr 2016/169). Participation in the study was voluntary, and informed written consent was collected from all participants.

Feasibility and Usability: Theoretical Framework

Feasibility studies enable researchers to assess if a study design and preliminary results can be shaped into relevant findings and future interventions. It is necessary to pursue a feasibility study if (1) there are few previously published studies in the research area, (2) a specific intervention is used, and (3) the study population requires unique consideration of the method.

Feasibility can be referred to as the ability of users to adopt a new system in daily procedures with focus on the questions: Can it work? Does it work? and Will it work? Important aspects of feasibility in this study were acceptability (Is the application suitable?), demand (Is the application likely to be used?), practicality (Can the application be used outside the intervention?), adaptation (Will the application work for this

population?), integration (Can the application be integrated in an existing system?), expansion (Can the application be expanded?), and implementation (Can the application be successfully delivered to the participants?) [19].

Usability is a characteristic of quality in use, according to the International Organization for Standardization [28]. It denotes whether a system can be used technically by specified users to achieve goals with regard to (1) learnability (how easy users can learn the system), (2) efficiency (being able to complete a task), (3) effectiveness (the amount of effort required to complete a task), (4) satisfaction (the degree to which the user was happy with the experience while performing a task), and (5) error recovery (the users should make few errors, and errors should be easy to recover from) [28,29]. An important context of usability in this project was to ensure that an athlete with the expected ability due to their impairment can use the system and that the application is technically available to all potential users [30].

The Fit between Individuals, Task, and Technology (FITT) framework of information technology (IT) adoption was used to structure and present the data on feasibility and usability goals (Table 1). FITT suggests that IT adoption in health care is dependent on socio-organizational-technical factors including task-technology fit, individual-task fit, and individual-technology fit [31].

Table 1. Feasibility and usability goals structured according to the Fit between Individuals, Task, and Technology framework and the Post-Study System Usability Questionnaire.

Conceptual framework and measure	Data source
Feasibility	
Individual	
Demographics (gender, age, sport, impairment)	Athlete information
Fit to individual	PSSUQ ^a Data from the eHealth application (ie, missing answers, impairment related problems)
Task	
Fit into daily routines	PSSUQ Data from the eHealth application (ie, answer frequency)
Fit into Paralympic sport	PSSUQ Data from the eHealth application (ie, number of reported incidents, type of reported incidents). Interest from athletes and organization
Usability	
Technology	
Efficiency	PSSUQ Data from the eHealth application (ie, athlete workflow)
Effectiveness	PSSUQ
Learnability	PSSUQ
Satisfaction	PSSUQ
Error recovery	Reported and detected errors

^aPSSUQ: Post-Study System Usability Questionnaire.

Textbox 1. Definitions of an injury and an illness.

Injury:

Any new musculoskeletal pain, feeling, or injury that causes changes in normal training or competition to the mode, duration, intensity, or frequency, regardless of whether or not time is lost from training or competition

Illness:

Any new illness or psychological complaint that causes changes in normal training or competition to the mode, duration, intensity, or frequency, regardless of whether or not time is lost from training or competition

For example, IT adoption in an athletic environment may depend on the fit between the attributes of the individual user (ie, motivation, experience, computer anxiety), attributes of the technology (ie, functionality, usability), and attributes of the task (ie, complexity, task, organization).

Data Collection

A 4-week SRIIPS pilot study was performed with an integrated poststudy feasibility and usability assessment [18,24]. The athletes were asked to weekly report sport exposure, training load, general well-being, pain, sleep, anxiety, and possible SRIIPS, according to the definitions in the SRIIPS study protocol (Textbox 1) [10]. The first author (KF) followed up on all data and any technical issues every week. After having completed the 4-week pilot study, the athletes were asked to assess the method using open questions related to the feasibility and usability (Table 1) [19,29] and a modified version of the Post-Study System Usability Questionnaire (PSSUQ) [32]. This is a questionnaire that was developed to assess user satisfaction after participation in scenario-based usability studies. With the PSSUQ, the researchers can understand which aspects of the computer system the users are particularly concerned with and which aspects they are satisfied with [32].

Data Analysis

Quantitative data related to demographics, system use, completed self-reports, number of reported incidents, missing answers, and system errors were analyzed using descriptive statistical methods.

The qualitative feasibility and usability data were condensed and categorized using a thematic analysis method. Thematic analysis is a flexible method for identifying, analyzing, and reporting patterns within various data sets (eg, texts, webpages, and interviews). The method provides rich and detailed information that is associated with the specific research question [33]. The focus here was on identifying opinions about the eHealth application, detecting methodological issues, and determining if the method matched the users' needs and behavior. Sentences containing aspects of relevance to feasibility and usability were transformed to themes, codes, and meaning units.

Data on SRIIPS collected during the 4-week period were analyzed using basic descriptive statistics. The incidence rates were calculated as the number of new incidents divided by total athlete exposure hours (per 1000 hours of sport participation) [10].

Results

Quantitative Poststudy Feasibility and Usability Evaluation

A total of 1643 self-reports, 1354 weekly e-diary reports, and 289 responses to follow-up questions were collected. The average weekly response rate was 95%. A total of 37 instances of missing data were noted in the weekly e-diary reports; 28 were observed among athletes with visual impairment, 7 from athletes with physical impairment, and 2 from athletes with intellectual impairment. Questions concerning pain, anxiety, and training load generally had a high response rate (96% to 100%). The questions with most missing answers (n=11) were about general well-being with horizontally displayed check boxes. The follow-up questions, for example, concerning SRIIPS symptoms, diagnosis, and injury severity, had on average 1 to 2 missing answers every week; 11 of these were from athletes with visual impairment and 2 from athletes with physical impairment. A total of 21 athletes, 8 with visual impairment, 12 with physical impairment, and 1 with intellectual impairment, provided complete postuse feasibility and usability data. Two technical errors related to the system and the speech synthesizer were reported by athletes with visual impairment. No system use errors occurred. Almost three-quarters (15/21, 71%) of the athletes reported that it was easy to complete the task. About three-quarters (16/21, 76%) of the athletes found it easy to define a new illness, and 52% (11/21) found it easy to define a new injury. About three-quarters (15/21, 76%) of the athletes reported that it was easy to use the closure form, and 62% (13/21) reported that the application was adapted to Paralympic sport. Most (18/21, 86%) of the athletes were satisfied with the experience of performing the task, and 90% (19/21) found it important to perform this study.

Qualitative Poststudy Feasibility and Usability Evaluation

A summary of the thematic analysis is presented in Table 2.

Health Monitoring in Paralympic Sport

The athletes' opinion was that some parts of the eHealth application were not fully adapted to Paralympic athletes. For example, the athletes found it difficult to know how to define and identify a new injury or illness, especially when their impairment was involved. In addition, more survey items related to an impairment were requested, as the perception was that some incidents occurred because of the impairments. The athletes also found it important to be able to report all new injuries and illnesses (ie, also injuries that had not been sustained during sports participation).

Table 2. Summary of the thematic analysis of the Paralympic athletes' feasibility and usability evaluation of the eHealth application.

Theme	Code	Meaning unit
Health monitoring in Paralympic sport	Feasibility to Paralympic athletes	The application is not specifically adapted to Paralympic sport
		It is difficult to define a new SRIIPS ^a
		Some injuries occur because of the impairment
Survey design	Complex incidents	It is difficult to report several injuries or illnesses
		Insufficient description of multifactorial incidents
		More free text alternatives and multiple check box alternatives would be good
Impairment diversity and usability	Usability to visually impaired athletes	It is not trouble-free to use a screen reader
		Horizontal questions do not work with VoiceOver
		It is easier to use free text alternatives
Longitudinal eHealth monitoring	Sustainability	It is easy to understand and follow the weekly e-diary
		The terminology used is intelligible
		It is important that this kind of study is conducted

^aSRIIPS: sports-related injuries and illnesses in Paralympic sport.

Survey Design

Identified issues were also related to the survey design and were associated with the reporting of complex incidents using the survey design originally developed for able-bodied athletes. For example, if an athlete wanted to report 2 new injuries in the weekly report, they did not easily understand how to accomplish this task.

The perception was also that there were insufficient options for describing multifactorial incidents including an injury, an illness, and the impairment. To improve the design, the athletes asked for opportunities to better describe their incidents through free text or more multiple check box alternatives.

Impairment Diversity and Usability

Athletes with visual impairment had usability difficulties with tasks involving a visual analog scale and horizontal reply alternatives due to a technical problem with the connection between their speech synthesizer and the eHealth application. Some athletes with visual impairment chose instead to write free text at the end of the questionnaire or not leave a response at all. The questions using vertically displayed response alternatives worked well for the athletes with visual impairment. Athletes with physical impairment or intellectual impairment did not report any functionality problems.

Longitudinal eHealth Monitoring

The athletes stated that the use of the eHealth application was feasible and could be extended to longer periods of time. They perceived that it was easy to understand and use the application. Most of the athletes were of the opinion that the terminology was comprehensible and that it was easy to understand which dates and week they should report. A majority also stated that it is important that health monitoring is performed.

Data on Sports-Related Injuries and Illnesses in Paralympic Sport

One athlete dropped out during the study period; thus, 4-week data were available from 27 athletes. A total of 10 athletes (37%) reported anxiety, 15 (56%) reported pain, and 9 (33%) reported use of analgesics weekly. The median self-rated general well-being score was 4 (1-7). The average time spent on training each week was 7.6 hours. The median weekly rated perceived exertion was 6 (1-10). In total, 15 new injuries (reported by 12 athletes) and 14 new illnesses (reported by 12 athletes) were reported, giving an incidence rate of 1.8 injuries per 100 hours and 1.7 illnesses per 100 hours of athlete exposure, respectively. For 71% (5/7) of the injuries and 60% (6/10) of the illnesses, the athlete reported a higher mean training load than the week before. Tissue inflammation and pain (10/15, 67%) and upper respiratory tract infections (9/14, 64%) were the most common preliminary causes. A total of 80% (12/15) of the injuries were related to overuse, 66% (10/15) of the injuries were reported from athletes with visual impairment, and 57% (8/14) of illnesses were reported from wheelchair athletes. The typical injury severity was 1 to 3 days of time loss of training and 2.6 missed training sessions for illnesses. In 20% (3/15) of the injuries and 21% (3/14) of the illnesses, the impairment was perceived to be involved in the cause.

Discussion

Principal Findings

Advances in eHealth technology for athlete self-reporting and monitoring [34] have been rapid; however, the sport-specific functionality and usefulness of surveillance measures have rarely been established. Data with poor quality may thereby in the end cause problems with developing preventive measures [22]. Therefore, considering design quality and the meaning of data along with effective utilization of technology is crucial in the implementation of self-report measures [11]. Especially smaller feasibility studies with mixed methods have been shown to yield

innovative results [19]. This led us to develop and test the eHealth application of self-reported SRIIPS specifically adapted to Paralympic athletes in this pilot study with particular focus on feasibility and usability. In summary, we found eHealth-based monitoring of self-reports of Paralympic athletes' health to be generally feasible and usable with regard to fitting into daily routines and using technology. However, the study revealed some critical factors, mostly related to the fit to Paralympic sport, which should be accommodated before this application can be used in full-scale research. It is also recommended that these critical factors be considered in existing and future injury and illness surveillance systems.

Feasibility and Usability

A critical conceptual issue related to feasibility and the fit between the individual, task, and technology was how to define and report new SRIIPS, especially when the impairment was involved. The athletes perceived that the eHealth application was not fully adapted, as some SRIIPS may occur because of the impairment. This observation corroborates the reports from a recent qualitative study where Paralympic athletes perceived that their impairments played an important role in the etiology of SRIIPS [26]. Moreover, a high prevalence of pain may complicate the process of defining and distinguishing a new sports injury from existing pain related to the impairment. This emphasizes the importance of adaptations of surveillance systems to the specific sport population, here Paralympic athletes' various and complex impairments. Thus, the use of questionnaires developed for able-bodied athletes cannot directly be transferred to Paralympic athletes without specific adaptations, such as, for example, visual impairments [35].

Regarding usability efficiency, the athletes described that there were not enough options for description of multifactorial incidents including injuries, illnesses, and impairments. The construction of questions and terminology has previously been reported to be a main issue identified by athletes, and athletes are more willing to complete surveillance systems if they can recognize themselves in the questions asked [20]. Accordingly, the survey design has been further developed following this pilot study. The definition of SRIIPS has been clarified, the survey items better adapted to Paralympic sport, additional alternatives related to the impairment have been added, the possibilities to report multifactorial incidents extended, and more examples and free text alternatives provided to improve athlete satisfaction and motivation. One of the most important objectives in self-report measures is to collect meaningful data in relation to the needs of the athletes [11]. Thus, it is crucial that data related to the impairment are routinely collected when SRIIPS are monitored in order to ensure study feasibility and usability.

Another usability design issue related to task completion was the human-computer error of the audible feedback system used by the athletes with visual impairment. Even though there have been developments of touch screen devices, many are still inaccessible to visually impaired users who often adopt error recovery compensatory strategies [36]. Electronic questionnaires that are too difficult to use may discourage responses and reduce data quality [37]. Some of the parameters (eg, the visual analog

scale and horizontal Likert scales) will be slightly modified for athletes with visual impairment. The system worked well for athletes with physical impairment and athletes with intellectual impairment without any major learnability or error recovery issues. The relative lack of technical problems and barriers encountered is not surprising as the application met most of the accessibility criteria recommended in WCAG 2.0 and was adapted to Paralympic athletes' own perceptions of experiences of sports-related injuries [26,27].

Monitoring Sustainability

Possible explanations for the high response rate are the short study period and system usability adaptation for easy use on mobile phones and other platforms. A restriction in athlete monitoring using self-reports is the workload assigned to the athlete, implying that collection of as little and as relevant data as possible is important in long-term surveillance [11].

The athletes were of the opinion that the application was easy to understand and could be extended to longer periods of time. Thus, we considered the application to be feasible for Paralympic athletes and believe that it can be adopted in their daily procedures with regard to the ability of the users [38]. Finch et al [34] recently described that, along with the development of digital tools, data can favorably be collected in real time from athletes and not by the medical teams, which has also proven feasible in other studies [12,13].

Data on Sports-Related Injuries and Illnesses in Paralympic Sport

Only 2 similar studies within Paralympic sport have included athlete exposure based on time [39,40]. For effective implementation of prevention strategies, incidence based on athlete exposure is a key factor [41]. A limitation of these 2 studies [39,40] is that the inclusion of injuries only referred to trauma and medical attention. In our study, 80% of the reported injuries were related to overuse, which indicates the importance of using an injury definition in Paralympic sport that also includes these types of injuries. In addition, the observed high prevalence of pain and relatively high use of analgesics raises concerns about Paralympic athletes' health. Few studies have assessed the prevalence, causes, and behaviors associated with pain among Paralympic athletes, and further research on this topic is warranted.

Only a handful of studies have assessed the incidence of illnesses among Paralympic athletes. Studies at the Paralympics Games indicate that illness rates are similar to injury rates [25]. This was also found in our study as well. It is therefore important that illnesses are included in athlete monitoring, well in line with the recommendations of future research priorities [34].

Strengths and Limitations

A strength of this study is the detailed preparatory work undertaken to develop the eHealth application and specifically adapt it to Paralympic athletes with visual impairment, physical impairment, and intellectual impairment. Another strength is the subsequent evaluation and correction of feasibility and usability indicators of the monitoring system before the start of full-scale long-term studies. A limitation is that we only

evaluated poststudy reported feasibility and usability issues and that the qualitative analysis included only written answers and no interviews. Another limitation is that the pilot study period was relatively short, and it is therefore not possible to distinguish long-term results and response rates. A larger study sample including athletes from all Paralympic sports may also have provided further insights into the feasibility and usability of this novel eHealth application.

Conclusion

The novel eHealth-based application for self-reported SRIIPS developed and tested in this pilot study was generally feasible and usable. With some adaptation to accommodate Paralympic athletes' prerequisites and improved technical support for athletes with visual impairment, this application can be recommended for use in prospective studies of SRIIPS. This will advance our knowledge of the incidence and risk factors of SRIIPS and facilitate the development of evidence-based prevention measures adapted to Paralympic sport.

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Authors' Contributions

KF and JL conceptualized the project. KF, JJ, ÖD, TT, and JL contributed to the design of the study, drafting of the manuscript, and review of the final manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

None declared.

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Abbreviations

FITT: Fit between Individuals, Task, and Technology

IT: information technology

PSSUQ: Post-Study System Usability Questionnaire

SRIIPS: sports-related injuries and illnesses in Paralympic sport

STROBE: Strengthening the Reporting of Observational Studies in Epidemiology

WCAG: Web Content Accessibility Guidelines

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Paper IV





Original Research

Prevalence of Sports-Related Injuries and Illnesses in Paralympic Athletes

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Abstract

Background: With increased participation in Paralympic sports, the burden of sports-related injuries and illnesses may increase. However, there is limited knowledge about the epidemiology of sports-related injuries and illnesses in Paralympic sports (SRIIPS). **Objective:** To describe among Swedish Paralympic athletes the 1-year retrospective period prevalence of severe SRIIPS and the point prevalence of all SRIIPS and to examine differences in prevalence proportions between athletes with different impairments, behaviors, and sport characteristics.

Design: Cross-sectional study.

Setting: Swedish Paralympic Programme.

Participants: One hundred and four Paralympic athletes with visual, physical, and intellectual impairment.

Methods: An eHealth application adapted to Paralympic athletes was used to collect self-report data on existing and previous SRIIPS, as well as impairment, behavior, and sport characteristics.

Main Outcome Measurements: One-year retrospective period prevalence and point prevalence.

Results: The period prevalence of severe injuries was 31% (95% CI 23-40) and the point prevalence 32% (95% CI 24-41). The period prevalence of severe illnesses was 14% (95% CI 9-23), and 13% of the athletes (95% CI 8-22) reported a current illness. More severe injuries ($P < .05$) were reported by athletes aged 18 to 25 years, not using assistive device, having pain during sport, using analgesics, continuing training injured, and feeling guilt when missing exercise. Athletes who reported a previous severe injury, having pain in daily life and during sport, using analgesics, and being upset when unable to exercise had a higher prevalence of current injuries ($P < .05$). Being female, reporting previous severe illness, using prescribed medication, and feeling anxious/depressed were features associated with ongoing illnesses ($P < .05$).

Conclusion: Paralympic athletes report a high prevalence of SRIIPS. Behavioral and psychological aspects as well as pain and use of medication appear to be associated with the occurrence of SRIIPS. The results imply that factors leading to SRIIPS are complex and call for a broad biopsychosocial approach when developing preventive measures.

Level of Evidence: III.

Introduction

Paralympic athletes' performances are steadily improving.¹ As a result, athletes are exposed to more strenuous training and pressure to stay competitive.² Increases in training loads in combination with pressure to perform may eventually lead to sports-related injuries and illnesses that may compromise athletes' health.^{2,3} This, in turn, can add further concerns to Paralympic athletes' unique preexisting medical conditions.⁴ Data from

the latest Summer and Winter Paralympic Games (2012-2016) show that the incidence proportion of both injuries and illnesses are higher compared to the Olympic Games.⁵⁻¹³ Thus, there is a need to improve our knowledge of sports-related injuries and illnesses in Paralympic sport (SRIIPS) in order to develop preventive measures. According to the van Mechelen model of injury prevention, the first step in the sequence of prevention is to describe the extent and severity of SRIIPS. Thereafter, preventive measures can be developed.¹⁴

Most previous efforts to collect epidemiological data in Paralympic sport have primarily focused on SRIIPS during competitions.^{15,16} Therefore, studies that assess SRIIPS during extended periods, including both training and competitions, are needed. Data are also limited regarding sports-related illnesses and overuse symptoms, variations between sport and impairment types, and potential intrinsic and extrinsic risk factors for SRIIPS. Moreover, psychological behaviors, such as self-blame and excessive training, have been reported to be related to sports injuries among able-bodied athletes.^{17,18} Yet, few studies have examined behavioral variables and personal habits that may be related to SRIIPS among Paralympic athletes.⁴

To improve our knowledge, we have initiated the Sports-related Injuries and Illnesses in Paralympic Sport Study (SRIIPSS).¹⁹ The overall objective is to prospectively estimate the burden of SRIIPS among Swedish Paralympic athletes using an eHealth application specifically developed for Paralympic athletes.²⁰ At the start of this prospective study, the athletes completed a baseline questionnaire on existing and previous SRIIPS during the past year, as well as athlete demographics, impairment, behaviors, and sport characteristics. This allowed us to analyze the prevalence of SRIIPS as an overall indicator of disease status by measuring the proportion of the outcome in this understudied population at different time points.²¹⁻²³ In addition, such analyses also capture symptoms with insidious onset, for example, overuse-related problems and pain, and generate new hypotheses and questions for future research.^{21,22,24}

The objective of this study was to describe among Swedish Paralympic athletes the 1-year retrospective period prevalence of severe SRIIPS, to identify the point prevalence of all SRIIPS, and to examine differences in prevalence proportions between athletes with different impairments, behaviors, and sport characteristics.

Methods

Study Design and Definitions

This cross-sectional retrospective prevalence study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The study is part of SRIIPSS, which is a prospective (1-year) longitudinal study of self-reported SRIIPS.¹⁹ The eHealth application used for data collection has previously been described and tested in a feasibility and usability pilot study.²⁰ The study was approved by the Regional Ethical Review Board in Lund (Dnr 2016/169) and followed the ethical principles for medical research involving human subjects per the World Medical Association Declaration of Helsinki. Participation in the study was voluntary and written informed consent was obtained. The study is registered at ClinicalTrials.gov [NCT0278500].

To estimate the proportion of athletes that had an injury or illness at some point during a given period, here 1-year retrospectively, period prevalence was used. In this study, period prevalence was used to measure the burden of severe SRIIPS during one year, less severe SRIIPS were excluded to minimize the risk of recall bias.²⁵ The definition of severe SRIIPS used in the present study and in accordance with other studies^{23,26} was:

Any new musculoskeletal pain, feeling, injury, illness or psychological complaint that made the athlete partially or completely abstain from training or competition for a 3-week minimum period during the past year.

To determine the estimated athlete availability and need for medical service at a specific point, point prevalence was used.^{21,25} All injuries and illnesses, both severe and minor, were included to obtain an estimate of the overall burden of ill health at a given time, for example prior to a major competition. The definition of current SRIIPS used in the present study was^{19,27}:

Any new musculoskeletal pain, feeling, injury, illness or psychological complaint that caused changes in normal training or competition to the mode, duration, intensity, or frequency, regardless of whether or not time is lost from training or competition.

Study Population and Recruitment

Participants were recruited through the Swedish Paralympic Program, which comprises candidates for both the Summer and Winter Paralympic Games. The following inclusion criteria were used: (1) age 18 to 65 years; (2) being able to communicate in Swedish; and (3) having

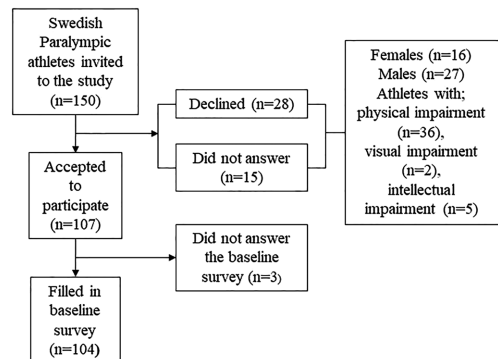


Figure 1. Flowchart of the recruitment of study participants.

the ability to respond electronically to the eHealth application. A total of 150 athletes were invited (Figure 1) by email during autumn 2016 and received written, and if needed, oral information about the study. Those who did not respond were contacted by phone.

Data Collection

The prevalence data were collected as described previously in our study protocol¹⁹ and obtained from a baseline questionnaire at the start of SRIIPSS (January 2017). The participants were asked about severe SRIIPS 1 year retrospectively and about current SRIIPS. If the athletes reported an injury, they were asked about body location, type of injury, injury mechanism, diagnosis, and contribution of the impairment. For a reported illness the athletes were asked about affected body system, diagnosis, and contribution of the impairment.

The participants also provided the following baseline data: (1) athlete demographics (gender, age, height, weight, occupation, use of alcohol and tobacco); (2) impairment characteristics (type of impairment, sports classification, use of assistive devices, current prescribed medication, medical contact person); (3) sport characteristics (years active in Paralympic sport, type of sport, additional training, use of supplements, nutritional counseling, hours per week engaged in training and competition); (4) anxiety/depression (EQ-5D)²⁸ and (5) behavior and pain (excessive exercise, maladaptive behavior, pain in daily life and during participation in sport [EQ-5D]²⁸ and use of pain medication). To assess features of excessive exercise and maladaptive behavior, the Commitment to Exercise Scale (CtES) was used.^{17,18} In addition, women were asked about menstruation and use of contraceptives.

Data Categorization and Statistical Analyses

The reported injuries were categorized in a matrix for classification of musculoskeletal diagnoses into body location, injury type, and diagnosis from the 10th revision of the International Statistical Classification of Disease and Related Health Problems (ICD-10).²⁶ Injuries were independently classified by the project's two sports physiotherapists (KF and JJ) and any disagreements were resolved by the two authors, and illnesses were independently classified by the project's physician (JL) and one physiotherapist (KF).^{8,19,27} Each athlete could report several SRIIPS, but only the first reported SRIIPS were used in the analyzes. The rationale is that prevalence is a measure of disease status. It describes the proportion of athletes of a particular population affected by a medical condition divided by the total number of athletes studied at the given time point.²² To avoid overinterpretation of the data, a period prevalence injury could not be reported as a point prevalence injury.

The data were assessed for normality and are presented using descriptive statistics. The prevalence is presented together with a 95% confidence interval (CI), computed with the Clopper-Pearson method.

For the analyses, the athletes were first categorized according to age and impairment at a broad level (ie, physical, visual, or intellectual). Thereafter, the athletes were classified into subgroups of impairments and whether their main transportation mode in daily life was wheelchair or if they were ambulatory. Finally, the athletes were categorized into their specific sport; into summer or winter sport; into explosive, endurance, or precision sport; and into individual or team sport.

To examine differences in SRIIPS among the athletes regarding their characteristics and behaviors, the analyses were conducted in six steps and separately for injuries and illnesses. Differences in period prevalence and point prevalence of SRIIPS were examined between (1) athletes with different demographics; (2) different impairment characteristics; (3) different sport characteristics; (4) anxiety/depression; (5) athletes' behavior and pain; and

Table 1
Athlete demographics and impairment among Swedish Paralympic athletes (n = 104)

Gender (%)	
Men	66
Women	34
Age, y, median (IQR)*, min-max	29 (23-36), 18-63
Body mass index, median (IQR)*, min-max	
Female	22.6 (20.4-24.4), 17.8-35.2
Male	23.4 (20.1-25.1), 15.6-30.3
Occupation (%)	
Student	23
Working	66
Disability pension	3
Full-time athlete	8
Alcohol intake (%)	
Every month	33
A couple of times/y	44
Tobacco use past year (%)	
Yes, smoking	1
Yes, snuff	15
Type of disability (%)	
Congenital	53
Acquired	47
Use of assistive device (%)	
Wheelchair	50
Prosthesis	4
Blind cane	11
Crutches	11
Use of prescribed medications (%)	47
Regular contact and easy access to a known health professional [†] (%)	59
Women's health (n = 35) (%)	
Normal menstruation	69
Amenorrhea	31
Use of contraceptives	62

*Interquartile range.

[†]A physician, nurse, or physiotherapist.

Table 2
Sport and behavior characteristics among Swedish Paralympic athletes (n = 104) 1 year retrospectively

Active in Paralympic sport, y, median (IQR)*, min-max	10 (5-16), 1-32
Training h/wk, median (IQR), min-max	9 (7-12), 3-23
Additional training to sport specific training (%)	
Cardiovascular training	69
Strength training	76
Neuromuscular training	50
Flexibility	39
Yoga	8
No	6
Support to plan diet (%)	23
Use of supplements (%)	22
Use of paracetamol medication related to sport (%)	
Every month	14
A couple of times/yr	35
Use of anti-inflammatory medication related to sport (%)	
Every month	19
A couple of times/yr	48
Pain/discomfort (EQ-5D) related to sport (%)	
No pain/discomfort	50
Moderate pain/discomfort	43
Extreme pain/discomfort	7
Pain/discomfort in daily life (EQ-5D) (%)	
No pain or discomfort	47
Moderate pain or discomfort	48
Extreme pain or discomfort	5
Feeling of anxiety/depression (EQ-5D) (%)	
Not anxious or depressed	67
Moderate anxious or depressed	31
Extremely anxious or depressed	2
Commitment to Exercise Scale (CtES) [†] (%)	
Upset when unable to exercise	82
Continue train unwell or sick	83
Continue train injured	59
Guilty when missing exercise session	77

*Interquartile range.

[†]The answers are sometimes/always from a modified scale of Commitment to Exercise Scale adapted to persons with visual impairment.

(6) interactions between pairs of different characteristics and/or behavior (ie, 3-way interactions including SRIIPS).

For the first four steps, pairwise comparisons were conducted between the subgroups in Tables 3-5, using chi-square statistics for homogeneity with Cramer's V as

a measure of effect size. In cases where more than 20% of expected frequencies were less than five, Fisher's exact test was used. For the fifth step, three-way interactions were analyzed using log-linear analysis.²⁹ The IBM SPSS Statistics version 24 was used. As the aim in this new field of research was to generate new hypotheses for future research, all *P* values <.05, uncorrected for multiple comparisons, were reported.

Results

Study Population

A total of 107 (71%) athletes participated in the study. Three athletes did not respond; thus, in total, 104 athletes (97%) completed the questionnaire (Figure 1). The median age of the athletes was 29 years (interquartile range 23-36). Data on athletes' demographics, impairment, behavior, and sport characteristics are presented in Tables 1 and 2.

Prevalence of Sports-Related Injuries

Period Prevalence

The overall retrospective 1-year period prevalence of severe injuries was 31% (95% CI 23-40). The prevalence among males and females was 32% (95% CI 22-44) and 29% (95% CI 16-45), respectively. Athletes in the age group 18 to 25 years reported the highest prevalence (37%; 95% CI 23-54) (Table 3). Ninety-one percent of the injuries had occurred during training and 9% during competition. The impairment was a contributing factor in 64% of the injuries. Two of the injuries were not specifically sports related. The prevalence of severe injuries among athletes participating in summer and winter sports was 39% (95% CI 29-50) and 26% (95% CI 11-49), respectively (Table 4).

Regarding the impairment categories, the prevalence ranged from 21% (95% CI 6-49) among athletes classified as "les autres (other)" (eg, arthrogryposis, Duchenne muscular dystrophy) to 40% (95% CI 17-69) among athletes with limb deficiency; all of the latter athletes

Table 3
Period prevalence and point prevalence of sports-related injuries and illnesses by gender and age group among Swedish Paralympic athletes (n = 104)

Gender and age group	Total number and % of all	Injury				Illness			
		Period prevalence		Point prevalence		Period prevalence		Point prevalence	
		Prevalence (%) n (95% CI)	% of all n	Prevalence (%) n (95% CI)	% of all n	Prevalence (%) n (95% CI)	% of all n	Prevalence (%) n (95% CI)	% of all n
All	104 (100)	32 31 (22-41)	31	33 32 (23-42)	32	15 14 (8-23)	14	14 13 (8-22)	14
Female	35 (34)	10 29 (15-46)	10	7 20 (8-37)	7	4 11 (3-27)	4	8 23 (10-40)	8
Male	69 (66)	22 32 (21-44)	21	26 38 (26-50)	20	11 16 (8-27)	11	6 9 (3-18)	6
Age group (y)									
18-25	35 (34)	13 37 (21-55)	13	11 31 (17-49)	13	8 23 (10-40)	8	5 14 (5-30)	5
26-34	36 (35)	10 28 (14-45)	10	10 28 (14-45)	10	5 14 (5-29)	5	3 8 (2-22)	3
35-63	33 (32)	9 27 (13-46)	9	12 36 (20-55)	9	2 6 (1-20)	2	6 18 (7-35)	6

Table 4
Period prevalence and point prevalence of sports-related injuries and illnesses by type of sport among Swedish Paralympic athletes (n = 104)

Sport	Total number and % of all	Injury		Illness					
		Period prevalence		Point prevalence					
		n	Prevalence (%) (95% CI)	n	Prevalence (%) (95% CI)	n	Prevalence (%) (95% CI)		
All	104	32	31 (22-41)	33	32 (23-42)	15	14 (8-23)	14	13 (8-22)
Summer sports	85 (82)	27	32 (22-43)	28	33 (23-44)	13	15 (8-25)	11	13 (7-22)
Winter sports	19 (18)	5	26 (9-51)	5	26 (9-51)	2	11 (1-33)	3	16 (3-40)
Individual sports	57 (58)	16	28 (17-42)	17	30 (18-43)	9	16 (7-28)	8	14 (6-26)
Team sports*	47 (45)	16	34 (21-49)	16	34 (21-49)	6	13 (5-26)	5	11 (4-23)
Endurance sports†	13 (13)	4	31 (9-61)	3	23 (5-54)	4	31 (9-61)	1	8 (0-36)
Explosive sports‡	69 (66)	22	32 (21-44)	24	35 (24-47)	10	14 (7-25)	8	12 (5-22)
Precision sports§	22 (21)	6	27 (11-50)	6	27 (11-50)	1	5 (0-23)	5	23 (8-45)

*Team sports: goalball, para ice hockey, wheelchair basketball, wheelchair rugby, wheelchair curling.

†Endurance sports: cycling, para athletics (middle/long-distance), para cross-country skiing, triathlon.

‡Explosive sports: canoe, goalball, judo, para alpine skiing, para ice hockey, para athletics (short distance, jumping, throwing), para swimming, table tennis, wheelchair basketball, wheelchair rugby, wheelchair tennis.

§Precision sports: Boccia, Equestrian, Sailing, Shooting Para sport, Wheelchair Curling.

used a prosthesis but participated in wheelchair sports. The prevalence among ambulatory participants was 37% (95% CI 25-50) and 25% (95% CI 15-38) among wheelchair users (Table 5). Concerning type of injury, 25% of the injuries were traumatic. Of the remaining non-traumatic injuries, 25% had sudden onset and 50% gradual onset. Forty-four percent of the injuries were located in the lower extremities (LE), 41% in the upper extremities (UE), and 15% in the vertebral column (VC). The knee was the most single affected body location (25%). The most common ICD-10 diagnosis was “soft tissue disorder related to use, overuse and pressure” (M70).

Athletes who did not use an assistive device ($P = .036$), reported pain during sports ($P = .011$), used nonsteroid inflammatory drugs (NSAID) monthly

($P = .003$), and used paracetamol monthly ($P = .015$) had a higher period prevalence of severe injuries than their peers. Also, athletes in the age group 18 to 25 years reported more traumatic injuries ($P = .025$). The CtES items “always continuing training when injured” ($P = .026$) and “always feeling guilt of missing an exercise session” ($P = .041$) were associated with a higher prevalence of severe injury (Table 6).

Point Prevalence

The overall point prevalence of injuries was 32% (95% CI 24-41), affecting 38% of male athletes (95% CI 27-50) and 20% of female athletes (95% CI 10-37). Athletes in the age group 35 to 63 years reported most injuries (36%; 95% CI 22-54) (Table 3). Five of the injuries were not specifically sports related. Athletes participating in

Table 5
Period prevalence and point prevalence of sports-related injuries and illnesses by impairment type among Swedish Paralympic athletes (n = 104).

	Total number and % of all	Injury				Illness			
		Period prevalence		Point prevalence		Period prevalence		Point prevalence	
		n	Prevalence (%) (95% CI)	n	Prevalence (%) (95% CI)	n	Prevalence (%) (95% CI)	n	Prevalence (%) (95% CI)
All impairments	104	32	31 (22-41)	33	32 (23-42)	15	14 (8-23)	14	13 (8-22)
Physical impairment*	77 (74)	23	30 (20-41)	24	31 (21-43)	8	10 (5-19)	10	13 (6-23)
Limb deficiency†	10 (10)	4	40 (12-74)	5	50 (19-81)	1	10 (0-45)	2	20 (3-56)
Spinal cord injury	34 (33)	9	26 (13-44)	11	32 (17-51)	5	15 (5-31)	5	15 (5-31)
Central neurological injury‡	19 (18)	7	37 (16-62)	5	26 (9-51)	0	0 (0-18)	0	0 (0-18)
Les autres§	14 (14)	3	21 (5-51)	3	21 (5-51)	2	14 (2-43)	2	14 (2-43)
Intellectual impairment	6 (6)	2	33 (4-78)	2	33 (4-78)	2	33 (4-78)	1	17 (0-64)
Visual impairment	21 (20)	7	33 (15-57)	7	33 (15-57)	5	24 (8-47)	4	19 (5-42)
Wheelchair athletes	52 (50)	13	25 (14-39)	13	25 (14-39)	6	12 (4-23)	8	15 (7-28)
Walking athletes	52 (50)	19	37 (24-51)	20	38 (25-53)	9	17 (8-30)	6	12 (4-23)

*Physical impairment: limb deficiency, spinal cord injury, central neurological, and les autres.

†Limb deficiency: amputation, dysmelia, congenital deformity.

‡Central neurological injury: cerebral palsy, traumatic brain injury, stroke, other neurological.

§Les autres: nonspinal polio myelitis, ankylosis, leg shortening, joint movement restriction, nerve injury resulting in local paralysis.

Table 6

Results from chi-square statistics with corresponding *P* values and Cramer's *V* measures of effect size, showing significant differences in prevalence proportions of sports-related injuries and illnesses, between athletes with different characteristics and athlete behaviors among Swedish Paralympic athletes (*n* = 104)*

	Injury		Illness	
	Period prevalence, <i>P</i> value, (effect size)	Point prevalence, <i>P</i> value, (effect size)	Period prevalence, <i>P</i> value, (effect size)	Point prevalence, <i>P</i> value, (effect size)
Gender female	.729	.067	.536	.046, (0.20)
Age 18-25	.025 [†] , (.27)	.745	.143	.481
Previous severe injury	-	.027 (.22)	.224	.121
Previous severe illness	.224	.378	-	.005 [‡] (.32)
Monthly use of nonsteroidal anti-inflammatory medication	.003, (.29)	.027 [†] (.22)	.954	.062
Monthly use of paracetamol	.015, (.29)	.460	.643	.919
Prescribed medication	.213	.817	.280	.019, (.25)
No use of assistive device	.036, (.21)	.141	.376	.686
Pain during sport	.011, (.25)	<.001, (.60)	.402	.085
Pain in daily life	.238	<.001, (.42)	.245	.400
Anxiety/depression	.021 [§] (.28)	.214	.056	<.001 [‡] , (.27)
Continuing training when injured [¶]	.026, (.30)	.671	.569	.696
Feeling guilt about missed exercise session [¶]	.038, (.28)	.984	.453	.154
Feeling upset when unable to exercise [¶]	.255	.024, (.29)	.553	.485

*Chi-square statistics shown for tests where *P* < .05 (tests [*P* > .05] for different impairments, sports, body mass index, occupation, use of alcohol and tobacco, women's health, medical contact person, years in Paralympic sport, average time spent on training and competitions, additional training, use of supplement, and help with nutrition are not shown).

[†]Traumatic injury.

[‡]Fisher's exact test.

[§]Nontraumatic injury.

[¶]The answer always in Commitment to Exercise Scale.

summer sports had a prevalence of 40% (95% CI 30-51), and athletes in winter sports a prevalence of 26% (95% CI 11-49) (Table 4).

Regarding the impairment, athletes with limb deficiency had the highest prevalence (50%; 95% CI 24-76) (Table 5). The prevalence among ambulatory participants was 39% (95% CI 26-52) and 25% (95% CI 15-38) among wheelchair users. Regarding type of injury, 6% of the injuries were traumatic, 15% nontraumatic with a sudden onset, and 79% nontraumatic with gradual onset. Fifty-eight percent of the injuries were in the UE, 33% in the LE, and 9% in the VC. The shoulder was the most single affected body location (33%). The most common diagnosis was again M70. Athletes who reported a previous 1-year retrospective severe injury were more likely to report a point prevalence injury (*P* = .027). There were strong significant associations between having an injury and reporting pain in daily life (*P* = .001) and pain during sports (*P* = .001). There were also significant associations between a nontraumatic injury and use of NSAID (*P* = .027) and with the CtES item "always being upset when unable to exercise" (*P* = .024) (Table 6).

Prevalence of Sports-Related Illnesses

Period Prevalence

The retrospective 1-year period prevalence of severe illnesses was 14% (95% CI 9-23). Male athletes reported a prevalence of 16% (95% CI 9-27), whereas females

reported a prevalence of 11% (95% CI 3-27). Athletes in the age group 18 to 25 years had the highest prevalence (23%; 95% CI 12-40) (Table 3). The impairment was reported to influence the occurrence of illnesses in 42% of the incidents. Athletes participating in summer sports had a prevalence of 15% (95% CI 9-25), and athletes in winter sports a prevalence of 11% (95% CI 1-34) (Table 4).

Athletes with an intellectual impairment reported the highest prevalence 33% (95% CI 9-71). The prevalence among ambulatory participants was 17% (95% CI 9-30) and 12% (95% CI 5-24) among wheelchair users (Table 5). The most commonly affected physiological system was the respiratory system followed by psychological diagnoses.

Point Prevalence

The overall point prevalence of illnesses was 13% (95% CI 8-22); ranging from 9% (95% CI 3-18) among male athletes to 23% (95% CI 12-40) among females. The age group 35 to 63 years displayed the highest prevalence (18%; 95% CI 8-35) (Table 3). The prevalence of illnesses among athletes participating in summer sports was 13% (95% CI 7-22) and 16% (95% CI 4-39) in winter sports (Table 4).

The prevalence ranged from no illnesses among athletes with central neurological injury to 20% (95% CI 4-53) among athletes with limb deficiency. The prevalence among ambulatory participants was 12% (95% CI 5-24) and 15% (95% CI 8-28) among wheelchair users (Table 5). The most commonly affected body system was

upper respiratory tract, followed by psychological diagnoses.

Female athletes had a higher prevalence of illnesses than male athletes ($P = .046$) (Table 6). Also, athletes with a previous severe illness ($P = .005$), athletes who used prescribed medications ($P = .019$), and athletes who reported feeling anxiety/depression ($P = .001$) had a higher point prevalence of illnesses (Table 6).

Athletes who reported moderate or extreme anxiety/depression on the EQ-5D item anxious/depressed also reported ($P = .03$) more psychological diagnoses for both illness prevalence measures. There were no 3-way interactions of SRIIPS and any of the prevalence measures for characteristics related to athlete demographics, impairment, behavior, or sport.

Discussion

This study presents prevalence data on SRIIPS from 104 Swedish Paralympic athletes using two different prevalence measures. The main findings were that 31% of the athletes reported having sustained a severe injury during the past year and 32% reported a current injury, whereas 14% reported a recent severe illness and 14% a current illness. Many of the severe injuries had occurred outside competition and the impairment was a contributing factor in several incidents. Differences between prevalence proportions of SRIIPS were mainly related to a history of previous incidents, pain, use of medication, and behavioral factors. No significant differences in prevalence proportions of SRIIPS between different sports, impairments, or exposure to sport were present.

Sports-Related Injuries

About one third of the athletes reported a severe injury during the past year, and a concern is the high prevalence of severe injuries among younger athletes. An injury in young age may affect an athlete's future career and can potentially also have lifelong consequences in daily life.³⁰ Sports performance during young age is underpinned by various physical and psychological health challenges related to maturation.³¹ Most body systems are structurally and functionally fully developing during adolescence and early adulthood,³² with the brain continuing to develop until adulthood.³³ In addition, young Paralympic athletes may already have existing medical challenges related to their impairments that may predispose them to injury. For example, the combined impact of daily wheelchair use and sport wheelchair use can put an athlete at high risk for overuse injuries.³⁴ For the young visually impaired athlete, it takes longer to adapt to the maturation that occurs in coordination and balance as vision plays an important role in providing sensory information to these systems.³⁵ Consequently, this could predispose these athletes to injuries.³⁶ Despite this, young Paralympic athletes are understudied in sport

medicine.³⁷ The International Olympic Committee has established a consensus statement on athletic development with the aim to develop healthy and resilient young athletes.³¹ Based on our results, a similar consensus statement and surveillance of young Paralympic athletes, also below 18 years old, is advocated, as well as education of coaches and governing bodies to maintain safe and sustainable parasport participation.

Both in the present study and the recent one from the 2016 Paralympic Games, athletes with limb deficiency reported the highest proportion of injuries.⁹ Most of the injured athletes with limb deficiency in this study had a prosthesis in daily life but participated in a wheelchair sport. A possible explanation for the high prevalence of injuries is that these athletes may be exposed to higher intensities in wheelchair sports, compared to an athlete with, for example, a cervical spinal cord injury (SCI). This has also been described by Bauerfind et al.³⁸ Also, athletes who did not use any assistive devices had a higher injury prevalence. Further studies are needed to understand associations between use of an assistive device or prosthesis and how this affects biomechanics and optimal loading. Similar to able-bodied athletes, a previous injury among Paralympic athletes was associated with a new injury,³⁹ emphasizing the importance of focusing on primary prevention.

Half of the athletes reported pain during sports participation and these athletes also reported significantly more injuries. A majority of the reported injuries in this study were related to overuse. Pain and overuse related symptoms are common problems among elite athletes, often associated with altered performance,^{26,40} and analgesics are frequently used to handle sports-related pain.⁴⁰ In the present study, about two thirds of the athletes reported use of analgesics on a regular basis during the past year. This is a concern as regular intake of analgesics may negatively affect the health.⁴ Previous studies have suggested that pain management in elite athletes should instead include strategies that address underlying biomechanical issues, pathophysiology, and psychosocial issues.⁴⁰ For Paralympic athletes who already have existing impairments that may cause pain, it is particularly important to address these issues.³⁴ Further studies of pain and the impact from the impairment are needed to better understand the management of pain in Paralympic sport. It is also recommended to adapt surveillance systems, definitions, and prevention strategies to accommodate pain and existing impairments.

Another concern is the training behavior of Paralympic athletes. A majority of the athletes reported that they felt upset when unable to exercise, felt guilty when missing an exercise training session, and continued to train sick and injured. The athletes who continued training when injured and felt guilt when missing training and reported anxiety/depression reported also significantly more injuries. Paralympic athletes' own perceptions of experiences of sports-related injuries have earlier been

linked to excessive training, guilt, and one's behavior.⁴¹ The results from the present study indicate that there are similarities with patterns found among able-bodied athletes, where psychological well-being may be dependent on compulsory and regular training. Such behavior may eventually lead to unhealthy training, even though there is a risk for negative health outcomes.¹⁸ A previous study also showed that Paralympic athletes have lower levels of self-acceptance and body-image perception and are training in a greater mastery-oriented climate compared to Olympic athletes.⁴² Hence, it is recommended that future epidemiological studies and prevention strategies for Paralympic athletes also address mental and behavioral aspects.

Sports-Related Illnesses

In the present study, 14% of the athletes reported an illness, which is similar to the results from the latest Summer and Winter Paralympic games.^{6,8,43} Female athletes had significantly more existing illnesses, both in the present study and in the study from the 2016 Summer Paralympic Games. Thus, a focus on this athlete group with regard to illness prevention is recommended.⁸

The respiratory system was the most affected by illness, which is in agreement with results from both the Paralympic Games and Olympic Games.^{6,8,10,44} Previous studies have indicated that especially athletes with SCI are more susceptible to infections.^{8,43,44} However, in the present study, athletes with SCI did not have significantly more illnesses when compared to other impairment groups. Still, almost half of all severe illnesses were reported to occur because of the impairment. Further studies are therefore warranted to examine intrinsic and extrinsic impairment related factors.

The second most common illness domain was mental health. It is now recognized that elite athletes are at risk of psychological distress, such as overtraining, burnout, loss of personal autonomy, stress, eating disorders, and risk behavior.⁴⁵ Few studies have specifically assessed the existence of psychological and behavioral distress among Paralympic athletes. Taken together, these results suggest the need for a multidisciplinary biopsychosocial approach when coaching and treating Paralympic athletes. In the present study, athletes that reported moderate or extreme anxiety/depression on the EQ-5D item had also significantly more mental health diagnoses, which indicate good sensitivity on an easily used question.¹⁹

Limitations

A limitation of this study is the diverse sample of athletes and a relatively low number of athletes in each group, which do not allow more detailed analyses. A total population design was used, and given that this is an understudied population, we considered it important to report the results in as much detail as possible. As the

prevalence of pain was higher than the prevalence of injury, information bias, and differential misclassification of exposure and outcome of injury should be considered. Because of self-report data selection bias, recall bias, and correctness of diagnoses should also be considered. As this is a cross-sectional study, it is not possible to establish causality because of lack of epidemiological temporality and limited generalizability. To explain risk factors in more detail and provide stronger evidence for prevention, parameters need to be monitored repeatedly based on exposure and over a longer period. Also, the study design is less sensitive to SRIIPS that are seasonal or reoccur and prevalence may be underrepresented in conditions with short duration and overrepresented in conditions with long duration.²² Finally, no corrections for multiple comparisons were made, and findings should therefore primarily be interpreted as suggestions of hypotheses and research questions for future research. For clinical implications, interpretations should at least take effect sizes into consideration. There are also several strengths with this study. One is the use of clear definitions of injury and illness, which has been emphasized in other studies.^{15,16,37} Another strength is the high response rate. Also, we included athletes with physical, visual, and intellectual impairments as well as athletes representing both Summer and Winter sports, which gives a representative sample of Paralympic athletes.

Conclusion

Paralympic athletes report a fairly high prevalence of both injuries and illnesses. Young Paralympic athletes report a particularly high prevalence of severe incidents, indicating that they should be a target for future research. Also, pain, use of medication, and mental and behavioral aspects seem to play important roles in the occurrence of SRIIPS. Accordingly, the interplay between associated factors appears to be complex and calls for a broad biopsychosocial approach when developing preventive measures in Paralympic sports. Further large prospective studies following Paralympic athletes over time are needed to identify risk factors and causations in order to provide stronger evidence for preventive strategies.

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Data Availability Statement

All data are archived according to the Swedish Act concerning the Ethical review of Research Involving Humans to attain confidentiality and are available on reasonable request.

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Disclosure

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As Paralympic athletes' performances and professionalism are steadily improving, there is an increasing need to understand the epidemiology of sports-related injuries and illnesses in Paralympic athletes. Being injured or ill when you already have an existing impairment, sometimes even acquired from sports, can be particularly challenging for the athlete. Therefore, the overall aim of this thesis was to describe and gain an in-depth understanding of the epidemiology of sports-related injuries and illnesses in Swedish Paralympic athletes, in order to assist the future development of evidence-based preventive measures adapted for Paralympic athletes.



Kristina Fagher (born 1986) is a certified Sports Physiotherapist from Sweden. She started her studies in Physiotherapy at Lund University in 2007, was an exchange student at Melbourne University in 2009, and completed her bachelor degree in 2010. She has been working as a clinical Physiotherapist within orthopedics, sports medicine and primary care since 2010, and she is since 2014 employed

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