

**THE WINSTON CHURCHILL  
MEMORIAL TRUST OF AUSTRALIA**

**INVESTIGATION OF CONTEMPORARY  
CONSERVATIVE MANAGEMENT PROGRAMS  
FOR ANTERIOR CRUCIATE LIGAMENT KNEE  
INJURIES**

JUNE 2018

PREPARED BY  
**JANE ROONEY**  
CHURCHILL FELLOW 2016

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Signed Jane Rooney

Dated 20 June 2016



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## DETAILS

### KEYWORDS

physical rehabilitation  
conservative management  
anterior cruciate ligament injury  
ACL management algorithms  
prehabilitation  
ACL prevention

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### QUALIFICATIONS

- Specialist Sports Physiotherapist (sub- specialty knee) – as awarded by The Australian College of Physiotherapists in 2009,
- Titled Musculoskeletal Physiotherapist

## RECOMMENDATIONS

The following recommendations are offered as a result of my observations throughout my fellowship:

1. Australian primary care providers (General Practitioners, Sports Physicians, Emergency Doctors and Physiotherapists) performing acute triage to people who have sustained an anterior cruciate ligament (ACL) injury, need education of current world best practice recommendations for ACL injury management.
2. Implementation of world best practice recommendations requires primary care practitioners to engage in a shared decision-making process informing the individual of all possible risks and benefits of a non-operative and operative management pathway for ACL injury. This ensures individual outcome goals and adequate informed consent, which is important in Australia's medicolegal climate.
3. Accessible education for patients of the possible disadvantages and advantages of non-operative and operative ACL injury management clinical pathways, will enable patients to make a better-informed decision about their individual management. This may require a multimedia approach.
4. Revised funding models from health funds to support both prehabilitation, non-operative, post-operative and long-term rehabilitation physiotherapy programs would be more cost effective than the high rates of expensive early ACL operative intervention, that is the current accepted standard practice model in Australia.
5. Early medical referral following ACL injury for prehabilitation programs will optimise post-surgical outcomes if the operative pathway is selected and is the start of the non-operative pathway. This prehab time may also enable the person to make a better-informed decision about their preferred management pathway.
6. Educating physiotherapists of appropriate prehabilitation and rehabilitation protocols. Selected Australian physiotherapy centres also need to have access to an adequate physical environment to conduct these programs.
7. Prevention programs need to be more broadly implemented to have an impact on ACL injury rates and public health, supported by coaches, teams, athletes, sporting and health insurance agencies, sporting federations, education facilities and governments.
8. Initiation of an Australian ACL register would provide a mechanism for accurate data collection, informing patient safety, quality improvement and identifying best clinical practice. A register is also imperative for evaluating ACL injury prevention initiatives.
9. Australian Health policy and health insurance bodies need to support the above recommendations to assist change in our current Australian ACL injury management algorithm to better align clinical pathways to world best practice.
10. A public awareness campaign would be beneficial to promote these recommendations

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## ACKNOWLEDGEMENTS

Thank you to the Winston Churchill Memorial Trust for the opportunity to travel to the United Kingdom, Ireland, The Netherlands, Denmark, Norway, Sweden and the United States to explore my chosen field of study. I am extremely grateful to all the researchers, clinicians and patients who gave up their valuable time to meet with me and share their knowledge and experiences in this field. I am also indebted to my family and colleagues at Lifecare Prahran Sports Medicine Centre who supported me to undertake this study. I am also very grateful to my surgical and medical colleagues who have mentored me over the past 30 years to develop my interest and expertise in anterior cruciate ligament knee injuries.

This report was prepared following visits to many institutions in the above-mentioned countries. The information was clarified as necessary and supplemented with additional resources provided to me by my hosts. Although best efforts have been made to accurately represent the material discussed with me and sent to me, any errors are mine alone.

## EXECUTIVE SUMMARY

“To investigate contemporary conservative management programs for Anterior Cruciate Ligament knee injuries”

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Australia has the highest rate of anterior cruciate ligament (ACL) injuries in the western world. The standard accepted ACL injury management in Australia is to have early ACL reconstructive surgery.

Current world best practice is to undergo an initial physical rehabilitation program for three months (prehabilitation) followed by a shared decision-making process to undertake a non-operative or operative management pathway. This fellowship is to investigate ACL injury management algorithms, prehabilitation, non-operative, ACL prevention and long-term ACL management rehabilitation programs.

## HIGHLIGHTS

Some of the highlights over the 6 weeks of my fellowship were

- The opportunity to meet with and interview the international research leaders informing world best practice recommendations in ACL injury management and prevention programs.
- Observing clinical leaders who are implementing world best practice in their ACL injury management programs. This included, but was not limited to, pre-operative, post-operative, non-operative, prevention and long-term management programs.
- Gaining an understanding of different health systems and their ACL injury management algorithm, enabling me to better appreciate the implementation barriers in the Australian health system to adopting world best practice. This knowledge informs possible strategies to optimise ACL injury management programs in Australia.
- Understanding anterior cruciate ligament injury prevention programs and barriers to implementation in Australia.
- Establishing worldwide networks of health care professionals interested in ACL injury management and prevention programs.

## CONCLUSIONS

1. Contemporary conservative programs observed for Anterior cruciate ligament knee injuries in the various countries I visited included prehabilitation or pre-operative, non-operative, prevention and long-term management programs.
2. Many of the countries I visited had public health systems. The standard accepted practice for managing acute ACL injuries varies slightly from one country to another (summarized in table 3) however generally non-operative management for first 6-12 weeks is usual care. A period of prehabilitation has been shown to improve long term outcomes, particularly for those with more severe initial knee impairment. This rehabilitation period also enables practitioners to identify the small percentage of people who develop dynamic knee stability, despite having an ACL deficient knee (Copers). It is possible this time also enables people with an ACL injury to consider their knee function and life priorities, enabling them to make a better-informed choice about their individual management pathway. Approximate operative rates in these countries are 50 % compared to Australia at 90%.
3. Very few early stage ACL rehabilitation programs exist with more research needed in this area. Norway has quite a defined prehabilitation program (the NAR program which is not government funded), whereas Denmark and Sweden generally less defined programs and The Netherlands advises general activity and quads exercises. The NAR program is a very progressive pre-operative or initial non-operative program which has been shown to be safe, however symptom monitoring and informed consent is important if using this program in the Australian medicolegal climate.
4. ACL reconstructive surgery is generally recommended in Denmark, Norway and Sweden if the person has instability with daily living or wishes to return to a level 1 pivoting or elite sport. The Netherlands recommends an ACL reconstruction if the person plays elite sport, has daily living instability or they are not satisfied with their knee function. People with an ACL injury need to understand the possible advantages and disadvantages of each management pathway and engage in a shared decision-making process between all stakeholders. A recent systematic review indicates there is weak evidence to suggest superiority of ACL reconstruction surgery over non-operative management. The Compare trial from the Netherlands and the NACOX trial from Sweden will add to our knowledge of non-operative and operative pathways for ACL injury management. see table 3
5. Appropriate questionnaires enable the practitioner to assess the impact of an ACL injury from the patient's perspective and to monitor progress and short, medium and long-term outcomes following an ACL injury.
6. Denmark, Norway and Sweden have effective ACL national registers which collect accurate injury and outcome data and contribute to quality and safety issues.
7. There are very few published non-operative programs. The Oslo-Delaware trial and The Kanon trial have published their non-operative programs. Success of these programs requires a motivated person with high compliance to exercise, some specific rehabilitation equipment combined with clear goal setting and progress monitoring. People completing a non-operative or post operative rehabilitation program should successfully pass a return to sport test before training or competing in their chosen sport. The test should include a battery of objective measures of lower extremity strength and control, functional movement patterns, and psychological readiness to return to sport.

## CONCLUSIONS

8. There are a number of published ACL prevention programs that have been shown to reduce the risk of non-contact ACL injuries. The barrier to their effectiveness is a lack of successful broad implementation. For optimal efficacy ACL injury prevention programs need to be designed specifically for the sport and population involved, based on injury data and delivered in conjunction with the deliverer and the end user considered.
9. Anterior Cruciate Ligament injuries result in degenerative change and associated symptoms in approximately 50% of affected knees at 10- 15 years post injury despite management chosen. The GLA:D® program from Denmark is an example of a physical rehabilitation and education program which has relevance to long term conservative management of ACL injuries.
10. The Barriers identified to implementing world best practice for ACL injury management in the Australian health care system include the many different practitioners providing triage for acute knee injury management including private and public hospital emergency departments, general practitioners and physiotherapists; patients may view prehabilitation as an additional irrelevant expense and time factor for an uncertain outcome, current standard accepted care and elite sport clinical pathway is for early ACLR ; the Australian medicolegal climate requires a shared decision making process with full disclosure of possible risks and benefits of a non-operative or operative pathway. Education of medical practitioners and patients of world best practice , prehab, non-operative, prevention and long term rehabilitation programs and shared decision making processes, supported by appropriate funding by health insurance bodies and government agencies is pertinent to the success of implementation.

I have already disseminated a number of my findings through;

- Blogs and posts whilst on my travels; [www.physioeducators.com](http://www.physioeducators.com) and linked in profile <https://www.linkedin.com/in/janerooney/>
- I have 3985 followers on linked in, 1450 on the physioeducators data base. The current statistics for the articles aimed at medical and allied health practitioners posted as of 28/5/18 are:
  - # 1 Kanon trial 54 views
  - # 2 Measurement of patient perception post ACL injury 54 views
  - # 3 Outcome questionnaire early ACL injury 59 views
  - #4 RCT no-operative vs operative ACL injury 79 views
  - #5 knee shape and ACL outcomes 41 views
  - #6 Degen changes post ACL injury 74 views
  - #7 non-op vs op meniscal tears in young people 106 views
  - #8 Dublin Sports Surgery Clinic 49 views
  - #9 last stop Chris Powers Clinic 51 views
- I have also posted a number of other general interest blogs to engage a broader audience on linked in. Statistics as of 28/5/18 are:
  - #1 Churchill Fellowship award 35 Likes
  - #2 We Work London 26 Likes
  - #3 Clinical Translator 52 Likes
  - #4 Erasmus Medical Centre 24 Likes
  - #5 Norwegian School Sports Sciences Clinic 28 Likes
  - #6 Churchill trivia 26 Likes
  - #7 May Arna Risberg meeting, Norway 29 Likes
  - #8 Norway Paralympic sled hockey team meeting 19 Likes
  - #9 St Patricks day, Dublin visit 28 Likes
  - #10 GLA:D program, Denmark 55 Likes
  - #11 Frank Noyes, Cincinnati, Ohio 37 Likes

## KNOWLEDGE DISSEMINATION

| Blog/ Site                     | Topic  | Views- Linked in |
|--------------------------------|--|------------------|
| Post 1 / Linked in/ PE/ FB     | Churchill Fellowship Introduction  | 1891             |
| Post 2 / Linked in/ PE/ FB     | Prognostic factors post ACL injury – meeting with Stephanie Filbay       | 3021             |
| Post 3/ Linked in/ PE/ FB      | We Work meeting space London   | 2030             |
| Post 4/ Linked in/ PE/ FB      | Introducing “The Clinical Translator “                                   | 4472             |
| Post 5/ Linked in / PE / FB    | Best Patient Outcome questionnaire post ACL injury                       | 1281             |
| Post 6/ Linked in/ PE/ FB      | Norwegian School of Sport Sciences                                       | 1646             |
| Post 7/ Linked in/ PE/ FB      | Churchill trivia   | 1377             |
| Post 8/ Linked in / PE/ FB     | May Arna Risberg Photo, Norway   | 1057             |
| Post 9/ Linked in/ PE/ FB      | Norway Paralympic sled hockey team                                       | 764              |
| Post 10/ Linked in/ PE/ FB     | St Patricks Day, Dublin  | 28 likes         |
| Post 11/ Linked in/ PE/ FB     | GLA:D program, Denmark   | 55 likes         |
| Post 12/ Linked in/PE/FB       | Frank Noyes, Cincinnati, Ohio  | 37 Likes         |
| Article 1/ Linked in/ PE/ FB   | Clinical Translator Kanon Trial  | 52 clicks        |
| Article 2/Linked in/PE / FB    | Measurement of patient perception of ACL injury and management           | 51 clicks        |
| Article 3/ Linked in / PE / FB | Outcome questionnaire comparison early ACLR – IKDC vs KOOS               | 56 clicks        |
| Article 4/ Linked in/ PE / FB  | Non-operative vs Operative management for ACL injury “The Compare Study” | 70 clicks        |
| Article 5/ Linked in/ PE/ FB   | Knee Shape and clinical outcomes after ACL ligament ruptures             | 32 clicks        |
| Article 6/ Linked in/ PE/ FB   | Degenerative changes post ACL injury                                     | 50 clicks        |
| Article 7/ Linked in/ PE       | non-op vs op meniscal tears in young people                              | 106 views        |
| Article 8 / Linked in / PE     | Dublin Sports Surgery Clinic   | 49 views         |
| Article 9 / Linked in/ PE      | Chris Powers   | 51 views         |

- Lecture Presentation at the Australian Physiotherapy Association, Melbourne, Vic, Level 2 Sports Course, 27th April 2018, to 60 post graduate Physiotherapists
- Lecture Presentation at the DJO Global Roadshow, Tuesday 22nd May, 2018 Melbourne Cricket Ground, Richmond, Vic to 100 post graduate Physiotherapists “ACL Injury: The Scandinavian Way “
- Sports Physiotherapy post graduate Master’s degree placements (100 hours) for La Trobe University, May 2018
- University of Melbourne Final year undergraduate student placement (30 hours), May 2018

- Lecture Presentation at Vic House Imaging for local Sports Physicians, General Practitioners, Physiotherapists and the Radiology department, June 8th, 2018 “Contemporary ACL injury Management Algorithms
- In my role as a Specialist Sports Physiotherapist working in a large multidisciplinary sports medicine clinic, I am applying new knowledge to my patient group (often secondary and tertiary referrals from other physiotherapist’s, GP’s and surgeons) and educating my physiotherapist and medical colleagues

Presentations to disseminate Fellowship findings and educate health care professionals regarding contemporary world best practice of ACL injury management and prevention programs, for the remainder of 2018 planned to date include:

- Lecture presentation “Contemporary ACL injury Management Algorithms” to the Victorian cohort of trainee sports physicians, Date TBC July 2018
- Lecture Presentation at the School of Physiotherapy, post graduate Sports Master’s Program, University of South Australia, Adelaide, Friday July 13<sup>th</sup>, 2018, “The Sporting Knee”
- Lecture Presentation at the Sydney Specialist Centre, July 27-28<sup>th</sup>, 2018, for post graduate, trainee Specialist Physiotherapists and Specialist Physiotherapists “Contemporary ACL injury Management Algorithms”
- Lecture presentation “Contemporary ACL injury Management Algorithms” with Orthopaedic Surgeon Tim Lording, Accredited General Practitioner Education meeting, Date 28<sup>th</sup> August 2018, Vic House Medical Imaging, South Yarra
- Course designer and Presenter: “The Acute Sporting Knee” 2-day course for post graduate Physiotherapists for The Australian Physiotherapy Association, October 13-14, 2018, Melbourne, Victoria

Other activities which I plan to further disseminate findings include

- Trial an ACL injury prevention program in a local private school to better understand barriers and implementation issues in an Australian school population
- Meet with Professor Ian Harris, Orthopaedic Surgeon, Sydney to discuss potential advocacy through local, state based and national health and government networks
- Create patient education material to educate people on the possible risks and benefits of non-operative and operative management options for ACL injury in a variety of formats (live and recorded lecture / written leaflet) to enable patients to make better informed choices as to their preferred individual management plan
- Continue to develop rehabilitation and return to sport testing protocols based on best available world evidence
- Educate and engage local orthopaedic surgeons to adopt shared decision making with people with acute ACL injuries and refer for prehab as either a non-operative or a pre-operative approach to optimise surgical outcomes.
- Further presentations at national conferences targeting health professionals to educate them on ACL management algorithms and prevention programs
- Presentation at the La Trobe Sports Master’s program 2019 to Physiotherapists undertaking post graduate training in Sports Physiotherapy.

## Week 1:

*London, United Kingdom*

**Dr Stephanie Filbay** is a Postdoctoral Research Fellow in Sport, Exercise & Osteoarthritis at The University of Oxford who has a particular interest in ACL injury outcomes. She has many recent publications relevant to quality of life post ACL injury, degenerative change and knee function post ACL injury and outcome comparisons of non-operative and operative management strategies.

*Erasmus Medical Centre, Rotterdam, The Netherlands*

**Professor Sita MA Bierma-Zeinstra** is the Professor of Osteoarthritis and Related Disorders at Erasmus University in Rotterdam. Professor Bierma-Zeinstra is the supervisor of the musculoskeletal research projects conducted at the department of General Practice.

**Max Reijman, Physiotherapist** and **Dr Duncan Meuffels, Orthopaedic Surgeon** from Erasmus University are soon to publish the results of "The Compare Trial" which is the second RCT (random controlled trial) in the world, comparing non-operative and operative management for ACL injury. The Star Study is another exciting project at Erasmus, comparing operative to non-operative management for young people with traumatic meniscal injury conducted by **Dr Suzanne Eijgenraam**.

**Dr Belle van Meer** is researching ACL injury and bone density changes.

**Dr Vincent Eggerding** is an Orthopaedic Surgeon who has published research looking at knee shape and ACL injury outcomes.

## Week 2:

*Southern Denmark University, Odense, Denmark*

**Professor Ewa Roos** is a Professor and Head of Research at the Department of Sports Science and Clinical Biomechanics, Musculoskeletal Function and Physiotherapy, at The University of Southern Denmark, Odense. Her research interests include clinical care pathways and non-surgical and surgical treatment for knee osteoarthritis (OA), meniscal injury and ACL injury.

**Sarah Kroman**, Physiotherapist, Faaborg Physiotherapy, Faaborg, Southern Denmark.

## Week 3:

*Aalborg University Hospital, Aalborg, Denmark*

**Michael Rathleff** is an Associate Professor who coordinates the musculoskeletal research program at the Research Unit for General Practice in Aalborg. The research program is cross disciplinary and includes researchers with a background in general practice, rheumatology, orthopaedic surgery, physiotherapy, sports science, health economics and human centred informatics. Michael is the head of Research group OptiYouth at the Research Unit for General Practice in Aalborg. OptiYouth aims to improve health and function of adolescents through research.

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**Marie Pedersen**

Physiotherapist, Norwegian Athletic Institute (NIMI)

**Week 4:**

*Linköping, Sweden*

**Dr Joanna Kvist**

Professor and Physiotherapist  
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**Hanna Gaufin**, PhD, Physiotherapist, Division of Physiotherapy  
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**Sofi Sonessen**, PhD, Physiotherapist, Division of Physiotherapy  
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**Martin Hagglund**, PhD, Physiotherapist, Division of Physiotherapy  
Linköping University, Linköping, Sweden

**Week 5:**

*Malmö and Lund, Sweden,*

**Rickard Duhan**, Sports Physiotherapist, Kulan Idrottsskadecentrum, Eric Perssonsvag 5,  
Malmö.

[www.kulanic.se](http://www.kulanic.se)

**Eva Ageberg**, PhD, Associate Professor  
Head of research group, Musculoskeletal Function  
Department of Health Sciences  
Lund University

*Dublin, Ireland*

**Enda King**, PhD, Physiotherapist, Sports Surgery Clinic, Dublin,

Head of Performance

SSC Sports Medicine

Unit C10 Gulliver's Retail Park, Northwood, Santry, Dublin 9

[www.sportssurgeryclinic.com](http://www.sportssurgeryclinic.com)

**Week 6:**

*Cincinnati, Ohio, United States*

Sportsmetrics program

**Dr Frank Noyes**, Orthopaedic Surgeon

**Stephanie Tutalo Smith**, MS, Physical Therapist

Sportsmetrics Program Manager

Mercy Health- Cincinnati Sports Medicine & Orthopaedic Center

10663 Montgomery Rd.

Cincinnati, OH 45242

[e-mercy.com](http://e-mercy.com)

[Sportsmetrics.org](http://Sportsmetrics.org)

*Cincinnati Children's Hospital, Ohio, United States*

**Greg Myers**

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## PRESENTATIONS DELIVERED

### **Friday 2<sup>nd</sup> March, Oslo**

*"ACL Injury Management: The Australian Way "*

Presentation to Sports Medicine Group from Kiel, Germany

### **Friday 9<sup>th</sup> March, Linköping**

*"ACL Injury Management the Australian Way "and Physiotherapy Specialisation Pathway in Australia*

Presentation to Physiotherapy Department, Linköping University

## INTRODUCTION

Anterior Cruciate Ligament (ACL) injury is a serious knee injury resulting in short term pain, disability and activity limitation and significant long-term knee pain, disability and quality of life changes, due to accelerated osteoarthritic change.

The ACL is a ligament in the centre of the knee connecting the femur (thigh bone) and the tibia (leg bone). The ACL is the most important rotational stabiliser of the knee, preventing the tibia sliding forward off the femur.

Australia has one of the highest rates of ACL injury in the western world, compared to previously published nationwide and population incidences, including New Zealand (Gianotti et al., 2009), the United States (Csintalan, 2008; Lyman et al., 2009), Sweden (Granan et al., 2009), Norway (Granan et al., 2008) and Denmark (Lind et al., 2009).

Actual Australian incidence rates are higher than published rates as statistics are taken from Medicare ACL surgery data, which does not include non-surgically managed ACL injuries.

Unlike the Scandinavian countries (Denmark, Norway, Sweden), New Zealand and the United States which have effective national registers, publishing accurate statistics leading to improvement of ACL injury management procedures, currently there is no ACL national register in Australia (Lind et al., 2009).

Difference in playing surface characteristics, such as ground hardness (Orchard et al., 1999) and grass types (Orchard et al., 2005), and popular pivoting sports, may be implicated in the higher Australian incidences. Lower incidences in New Zealand may be partly due to the existence of a national body devoted to sports injury prevention (Orchard & Finch, 2002).

The incidence of ACL injury in Australia increased by 14% over 5 years between 2003-2008, with similar increases in males and females, consistent with worldwide statistics. The highest incidence is in 15-24 yr old males (3000 / yr), followed by 24-35 yr old males (2500/yr) and 15-34 yr old females (1000/yr).

Multiple previous studies have shown females have a threefold or higher, relative risk of ACL injury when playing similar sports to males. The increased published incidence rates in Australian males are reflective of exposure rates (Arendt & Dick 1995; Renstrom et al., 2008). The increased popularity of young women playing AFL may cause an increase in ACL incidence rates.

The ACL can be injured during a contact event with another player or object or a non-contact injury, usually sustained during a cutting, pivoting or landing manoeuvre. Females sustained 60% non-contact injuries compared with 41% non-contact injuries in males (Janssen et al, 2012).

The ACL ligament rarely heals after a complete rupture. This can cause knee instability with pivoting movements such as cutting and turning, or with jumping and landing. A small percentage of people can return to pivoting sports despite having an ACL deficient knee- these people are often referred to as "Copers". Currently there is no way of identifying "Copers" early post ACL injury.

Standard accepted ACL injury management practice in Australia is a surgical reconstruction of the ACL, using the persons own tendons. Janssen et al, 2012 found in Australia 10,000 knee reconstructions are performed annually (50 187 ACL reconstructions over the 5-year study period), 79.4% in the private health sector and 20.6% in the public health sector. ACL surgery costs the Federal Australian Government \$6223AUS per reconstruction, totaling 75 million \$AUS per year (in 2003-2008). Patient's with private health insurance pay approximately \$8000 AUS + per reconstruction and approximately \$1400 AUS in rehabilitation over a 12-month period.

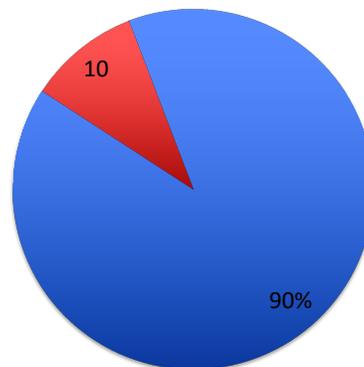
## INTRODUCTION

A trial conducted in Sweden over 5 years, has shown costs of early knee reconstruction were 4600 Euro more than delayed ACL surgery and conservative (physical rehabilitation) ACL rehabilitation costs were significantly cheaper (13,650 Euro) than early ACL reconstruction surgery with no other statistically significant quality life years benefits (Kiadaliri et al, 2015).

Australian data shows ACL reconstruction total operative rates at 90% compared to non-operative rates. Early physical rehabilitation programs (prehab) with the option of delayed reconstruction is not the current standard practice in Australia.

In countries such as Denmark, Sweden, The Netherlands and Norway, ACL reconstruction operative rates are approximately 50% compared to non-operative rates. This is despite the advice given to people in these countries to undergo ACL reconstructive surgery, if they are returning to a pivoting sport.

## Australia ACL Management



Mean time injury –  
ACLR =268 days , private  
80%

Harris et al, 2014  
Graph info : Moses and Orchard,  
2012

■ Surgical ■ Rehab

## INTRODUCTION

The only random controlled trial in the world comparing non-operative and operative management was published in 2010 in Sweden. A strategy of rehabilitation plus early ACL reconstruction was not superior to a strategy of rehabilitation plus optional delayed ACL reconstruction, in young active adults with acute ACL tears at 2 and 5 years (Frobell et al, 2010). Outcome measures were a knee osteoarthritis outcome score (KOOS- which measures knee pain and symptoms, function in sports and recreation, and knee quality of life), Tegner Activity Scale and the Medical Outcome Study 36.

The study also showed no difference in number of meniscal surgeries or return to sport level over a 5 year follow up period between the three groups (Frobell et al, 2013).

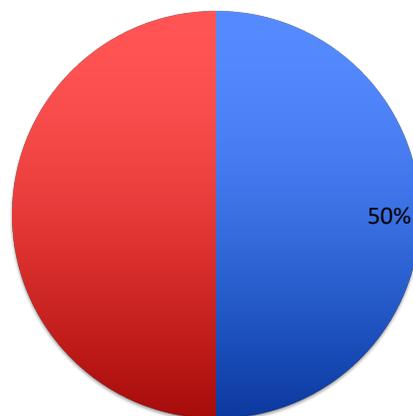
Anterior Cruciate Ligament injuries result in degenerative change and associated symptoms in approximately 50% of affected knees at 10- 15 years post injury despite management pathway chosen.

Anterior cruciate ligament injury prevention programs have been shown to reduce ACL injuries by up to 50%, if program compliance is sufficient (Myklebust et al, 2003, 2013).

Contemporary expert research consensus informs the current world best practice model which recommends an initial physical rehabilitation program for 3/12 (called prehabilitation) followed by a shared decision-making process to undertake a non-operative or operative management pathway. Considerations informing this decision are very individual including but not limited to, desired level of sporting participation, functional knee stability, occupational requirements, financial and time restraints and patient and practitioner knowledge and beliefs.

Recommended world best practice is **not** currently widely adopted in Australia evidenced by our very high operative rates.

## Scandinavia ACL management-



Mean time injury – ACLR =  
418 days , private 1%  
(Europe) Harris et al , 2014

## FELLOWSHIP AIMS

The aim of this fellowship was to investigate contemporary conservative management programs for anterior cruciate ligament knee injuries. It is relevant to this topic to identify contemporary ACL injury management algorithms used to select a patient for non-operative or operative management, in addition to the rehabilitation programs themselves.

The rehabilitation programs include pre-operative (sometimes called prehab), non-operative, prevention programs and long-term management programs.

Expert research consensus is to undertake a rehabilitation program (prehabilitation or pre-operative) for 3 months to assess if surgical intervention is required. This is not the standard accepted practice model currently in Australia.

Understanding different health systems and their algorithms of ACL injury management will help identify implementation barriers of world best practice in the Australian Health System.

**Dr Stephanie Filbay, London**

**Dr Stephanie Filbay** is a Postdoctoral Research Fellow in Sport, Exercise & Osteoarthritis at The University of Oxford who has a particular interest in ACL injury outcomes.

*Clinical Recommendations of ACL management from post hoc analysis of Kanon data*

Dr Filbay's research on the 5 year post hoc analysis of the Kanon trial identified subgroups and prognostic factors post ACL injury (Filbay SR, et al, 2017).

Surprisingly at the 5 year follow up, people who underwent early ACL reconstruction and exercise had worse outcomes than those people who undertook physical rehabilitation programs alone. This group is reflective of current standard accepted practice in Australia.

Worse preoperative knee function scores in the early ACL reconstruction group lead to more knee symptoms at 5 years, which was not the case for individuals treated with exercise therapy plus delayed reconstruction.

Baseline meniscal or osteochondral injury and worse knee function was associated with more knee symptoms, reduced sport/ recreation function and decreased quality of life (QOL) at 5 year follow up in the early ACL reconstruction group. Clinically relevant recommendations from this research include:

- Patients presenting with an acute ACL injury + baseline meniscal or osteochondral injury or more severe knee pain, swelling and /or impaired knee function may benefit from undertaking a physical rehabilitation program initially, before considering the need for surgical reconstruction. Dr Filbay suggested the delayed surgery in this group may enable better resolution of initial joint trauma and recovery of muscle strength and neuromuscular control, prior to undergoing the surgical trauma of an ACL reconstruction.
- This approach ensures more successful outcomes both for the patient and also the surgeon if ACL reconstruction is required. Education of the Australian medical community of the findings from this paper and the ACL injury subgroups identified, may inform management algorithms and improve outcomes for people with ACL injury in Australia.

*Cross over group from non-operative to operative group in Kanon trial*

Dr Filbay discussed the research conducted by Thorstensson et al, (2009) on the cross over group from physical rehabilitation to the operative group in the Kanon trial. This highlights patient's perceptions and may inform challenges of implementing prehabilitation programs in Australia.

Sixty-Four per cent (22 of 34 people) crossed over from the physical rehabilitation group to the surgical group. Reasons given were very varied:

- Finding the rehabilitation exercises time consuming and boring and provided insufficient results within a reasonable time frame
- Some said their knees had given way or they described a lack of trust in their knee, whilst others experienced new knee injuries
- Some patients believed surgery would provide better joint stability
- Some patients joined the study because they knew they could bypass the long Swedish surgical wait list after 3 months

Despite good evidence for prehabilitation programs, the success of these programs does rely on patient compliance. This may be a barrier to implementing world best practice in the Australian Health System.

*Measurement Of Patient Perception Of ACL Injury On Their Quality Of Life*

Another interesting discussion with Dr Stephanie Filbay was appropriate questionnaires to assess the **patient's perception** of the impact of ACL injury and management, on their knee quality of life. ACL injury has both short and long-term effects on the knee itself and the person as a whole. As clinicians we often focus primarily on objective clinical testing rather than combining this with the patient's perception of their injury experience or management progress.

The Mohtadi Quality of Life (QOL) Assessment in Anterior Cruciate Ligament Deficiency (sometimes referred to as the ACL- QOL) was developed by Nick Mohtadi and published in The American Journal of Sports Medicine in 1998. The ACL- QOL is a simple valid, reliable and responsive tool which scored highest as endorsed by patients with an ACL injury, as compared to many other questionnaires commonly used in this population (IKDC, KOOS, HSS, Cincinnati, Lysholm, VAS, ADL and AAOS) (Lafave et al, 2017).

The ACL-QOL can allow us to have greater insights into the impact an ACL injury is having on that individual person and their life including Symptoms and Physical Complaints, Work-Related Concerns, Recreational Activities and Sport Participation or Competition, Life Style and Social and Emotional Effects. This information is very relevant in a shared decision-making model, utilising a biopsychosocial approach and can be used to monitor management progress.

Dr Filbay is soon to publish her research on long term quality of life outcomes after ACL injury. The study found osteoarthritis is associated with worse knee related quality of life in symptomatic ACL reconstructed individuals. Diagnosis of radiographic osteoarthritis may be valuable to target management and appropriate activity participation to potentially improve quality of life.

**Erasmus Medical Centre, Rotterdam**

Erasmus Medical Centre is the largest Medical Centre and academic teaching hospital in the Netherlands. It houses the Children's Hospital, main multi trauma centre and medical school, including a large medical research faculty.

**Professor Sita MA Bierma-Zeinstra** is the Professor of Osteoarthritis and Related Disorders at Erasmus University in Rotterdam and is the supervisor of the musculoskeletal research projects conducted at the department of General Practice. Prof Sita Bierma Zeinstra was very generous, organising many meetings with her research team to discuss current projects. Thank you to Professor Kay Crossley, La Trobe University, Melbourne for the introduction to Professor Sita Bierma Zeinstra.



*ACL Injury Management Algorithm In The Netherlands*

The health system in the Netherlands is predominately public. People pay a levy per family member depending on the level of government insurance selected, with a 350 Euro (approx. 550 AUS) excess payable per 12-month period. General practitioners are free to visit and are the gate keepers of the system. Private health insurance is optional but not common.

GP Guidelines in The Netherlands for ACL injury recommends that GP's wait for 3 months post initial ACL injury before a surgical referral is indicated. During this time physiotherapy including quads exercises and physical activity is recommended, rather than a formal prehab program. Imaging is only recommended if presenting with a locked knee or if a fracture is suspected.

ACL reconstruction surgery for non-elite athletes is recommended if despite physiotherapy and lifestyle changes, knee instability is persistent.

ACL prevention programs are not common in the Netherlands.

*Monitoring Patient Progress In Early ACL Injury – IKDC Versus KOOS Outcome Questionnaires*

Monitoring a patient's progress post ACL injury is important regardless of the management selected. Patient completed questionnaires assist to provide a more accurate insight to the patient's perception of their knee function following ACL injury and can be used at intervals during the recovery period to evaluate progress. The short and long-term effects of an ACL injury on a patient's knee function differ.

I was fortunate to meet with Dr Max Reijman, Physiotherapist, who is the primary investigator of many projects at Erasmus Medical Centre. We discussed appropriate patient completed outcome questionnaires to measure impairment in the early stage post ACL injury.

Research conducted by Belle van de Meer et al, 2013 evaluated which questionnaire, the Knee Injury and Osteoarthritis Outcome Score (KOOS) or the International Knee Documentation Committee Subjective Knee Form (IKDC subjective), is most useful to evaluate patients with recent anterior cruciate ligament (ACL) ruptures or those **within 1 year of an ACL reconstruction**. The following measurement properties of the KOOS and IKDC subjective were assessed: content validity, construct validity, test-retest reliability and responsiveness.

The findings revealed the IKDC subjective is more useful than the KOOS questionnaire to evaluate both patients with recent ACL ruptures and those in the first year after ACL reconstruction. The IKDC Knee forms are freely available at the AOSSM web site [www.sportsmed.org/tabs/research/ikdc.aspx](http://www.sportsmed.org/tabs/research/ikdc.aspx)

Lafave et al, 2017 found the ACL-QOL scored highest as endorsed by ACL patients compared to both the IKDC and the KOOS, however the IKDC was also rated favorably by ACL deficient patients.

*The Compare Study: Non- Operative Versus Operative Management For ACL Injury*

The Compare Study is a very exciting project currently being conducted at Erasmus Medical Centre, Rotterdam. This will be the second RCT in the world comparing non-operative to operative management effectiveness for ACL ligament injury informing our knowledge of evidence-based treatment selection for ACL injured patients. I met with Dr Max Reijman, Physiotherapist, Primary Investigator and Mr Duncan Meuffels, Orthopaedic Surgeon to discuss this trial.

The Compare trial has similar inclusion and exclusion criteria and rehab protocols to the KANON trial (conducted by Frobel et al, 2010) and has a 2 year follow up period, using the IKDC score as an outcome measure. Data pooling from both the Compare and the Kanon trials will examine the cost effectiveness of operative versus non-operative ACL management. Final data collection for the Compare trial is almost completed. The conservative rehabilitation program will be published with the results of this trial.

Dr Reijman discussed the advantages and disadvantages of each treatment option. Please see a summary in **table 1** presented.

**Table 1: Advantages and disadvantages of non-operative and operative management of ACL injuries**

| ACL injury management protocol | Non-operative management   | Early Operative management   |
|--------------------------------|--|--|
| Possible Advantages            | Shorter rehabilitation, prevention of unnecessary surgery  | Successful intervention, less instability, less secondary meniscal tears,  |
| Possible Disadvantages         | Risk of secondary knee damage, risk of instability, risk of delayed surgery, risk of second rehab post operatively | 4-25% failure rates ACLR, surgical complications 3.5%, additional surgical intervention risk, longer rehabilitation time |

*Knee Shape and Clinical outcome post ACL injury*

I met with Dr Vincent Eggerding, MD, who is a researcher in Sports Medicine, Traumatology and Orthopaedic Surgery for the Dept of Orthopaedics at Erasmus MC. He has published an interesting paper on knee joint shape possibly predicting clinical outcome after ACL ligament rupture (Eggerding et al, 2014)

The bony shape of the knee is a fixed non-modifiable factor which may influence inherent knee joint stability, outcome post ACL injury and subsequent success of either operative or non-operative management. The authors of this study found at least 30 different shape variations of the knee joint.

Knee shape was then associated with International Knee Committee Subjective Scores (IKDC) at 2 years follow up. They found that 2 shapes were significantly associated with subjective score at 2 years, one for the operative group and one for the non- operative group.

**Operative patients** who **scored better** on the IDKC at 2 years had a **smaller intercondylar notch** and a **smaller width of the intercondylar eminence**.

**Non -operative patients** who **scored better** on the IDKC at 2 years had a **more pyramidal intercondylar notch** as opposed to a more dome shaped notch.

The Clinician must remember though it is only one of many important factors when considering ACL injury outcomes.

*Degenerative Changes In The Knee 2 Years  
Post ACL Ligament Rupture & Related Risk Factors*

Another important study conducted at Erasmus was “Degenerative changes in the Knee 2 years after ACL ligament rupture and related risk factors”-Belle L van Meer was the primary author (Belle Van Meer et al, 2016).

Anterior Cruciate Ligament injuries result in degenerative change and associated symptoms in approximately 50% of affected knees at 10- 15 years post injury. Early identification of those patients at risk and early identification of the process of ACL rupture leading to osteoarthritis may aid in preventing the onset or progression of osteoarthritis.

This cohort study found early degenerative change on MRI at 2 years post injury in several subgroups including those people who had;

- concomitant medial cartilage defects and meniscal injury,
- male gender
- persistent bone marrow lesions in medial tibiofemoral compartment and
- joint effusion at 1-year post trauma.

No significant relationship was found between the treatment options (non-operative and operative) and the development of early degenerative changes. Interestingly in this cohort study, 50 of 154 patients were managed non-operatively (35%).

Considering this evidence, it would seem important to monitor symptoms carefully especially in the above mentioned sub-groups during the rehab phase, optimise muscle strength / power whilst respecting joint symptoms and possibly delaying high impact loading. In a shared decision-making model this depends on the desired outcome expressed by the patient; early return to high level / elite sport OR optimising long term knee quality of life and possibly slowing joint degenerative change.

*Bone Density Changes Post ACL Injury*

Another study by Van Meer et al, (2014) was to determine bone mineral density (BMD) changes in the knee after ACL rupture and to compare the injured and healthy contralateral knee over a 2-year period, using a DXA scanner. They found bone density loss in the injured knee following ACL injury, particularly in the operated group and in the first-year post ACLR. After 2 years, bone density was significantly increased, but remained lower than the baseline levels in the operative group.

This may be another important consideration for clinicians when deciding appropriate timing of high load plyometric exercises in rehabilitation programs, particularly for operatively treated patients.

### **Southern University, Odense, Denmark,**

**Professor Ewa Roos** research interests include clinical care pathways and non-surgical and surgical treatment for knee osteoarthritis, meniscal injury and ACL injury. Professor Roos has developed the GLA:D® program (Good Life with Osteoarthritis in Denmark), which is an outstanding example of successful translation and implementation of evidence based clinical guidelines in primary health care practice. Anterior Cruciate Ligament injuries result in degenerative change and associated symptoms in approximately 50% of affected knees at 10- 15 years post injury despite management chosen. The GLA:D® program is a physical rehabilitation and education program which has relevance to long term conservative management of ACL injuries.

#### *ACL Injury Management Algorithm In Denmark*

The health system in Denmark is predominately public, funded by mandatory taxation payments. A wait list guarantee ensures conditions are seen within a time period, dependent on the condition. Knee injuries have lower priority, however will be seen in the private system, if not reviewed within the guaranteed time.

GP visits and hospital admissions are free with some physiotherapy paid partially by government. People have the option of additional private health insurance, funding a number of services/interventions per year with shorter wait list times.

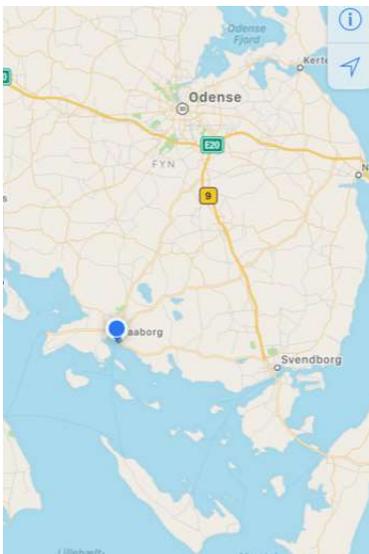
A person sustaining an acute knee injury in Denmark will generally visit emergency and then be reviewed at an orthopedic clinic. Orthopedic Surgeons will often advise rest for 6-8 weeks to see if symptoms settle, unless a fracture or bucket handle meniscal tear is suspected. Pre-rehabilitation programs are reportedly rare. ACL reconstruction surgery is generally recommended if the person wishes to return to pivoting sports.

Denmark has a nationwide ACL registry which collects data on epidemiology, surgical techniques, pre-operative, intraoperative and 1-year post-operative outcome data. Data submission is mandatory from the public and private hospitals, with a recorded 93% participation rate. The electronic data base was initiated in 2005 and by 2014 had over 23,000 patients' information.

#### *Long Term ACL injury outcomes: Osteoarthritis and the GLA:D® program*

The GLA:D® program, designed by Ewa Roos and Soren Skou from the University of Southern Denmark, Denmark, has been running in Denmark since 2013, with over 30,000 patients having participated in the program to date.

I was very fortunate to be hosted by Sarah Kroman, Physiotherapist and "a GLA:D® super-user" in her family clinic in Faaborg , Southern Denmark.



Despite research evidence advocating exercise as a safe and effective intervention for the symptom management of osteoarthritis, issues of patient compliance have been barriers to effective implementation and success of this modality. The GLA:D® program is a very user friendly, physiotherapist supervised, safe, evidence based group exercise program which increases the success of exercise therapy outcomes for hip and knee osteoarthritis. An accompanying education program teaches patients about Osteoarthritis and symptom management. The 12-session standardised exercise program can be individualised as required, within specific guidelines. Measures of knee and hip function, pre and post intervention are collected on an electronic register. Physiotherapists teaching the GLA:D® program have all undergone a standardised 2 day training program – see <https://gladaustralia.com.au>.

Research has shown GLA:D® users report high levels of satisfaction, 25% pain reduction, less pain medication intake, less sick leave, increased levels of physical activity 12 months after starting the program and have been able to delay surgical intervention, due to symptom management. (Skou and Roos, 2017).

<https://www.ncbi.nlm.nih.gov>

The GLA:D® program is now being taught in China, Canada and more recently in Australia. There are now 40 centres around Australia offering the GLA:D® program -GLA:D® provider's in Australia <https://gladaustralia.com.au>. The GLA:D® program is an appropriate conservative physical rehabilitation program to manage the long term effects of an ACL injury.

See Appendix 1 for specific exercises taken from the GLA:D program.



**Aalborg University, Aalborg, Denmark**

**Michael Rathleff** is an Associate Professor and the head of Research group OptiYouth at the Research Unit for General Practice in Aalborg. OptiYouth aims to improve health and function of adolescents through research.

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I met with Michael Rathleff in snowy Aalborg, Northern Denmark to discuss his thoughts about knee injuries in children and adolescents. The rates of ACL injuries are increasing in children. This has many implications including the immediate knee dysfunction, reduced sports/ activity participation and the social implications of this at a difficult developmental stage and the long-term knee degenerative changes 10-15 yrs post injury.

I interviewed Associate Professor Rathleff about his knowledge and experiences of the challenges of injury prevention programs, particularly in the adolescent population. This may assist in understanding the challenges to implementing ACL injury prevention programs in Australia.

Professor Rathleff spoke of the convincing evidence for the efficacy of injury prevention programs. He also spoke of significant barriers to the effectiveness of these programs, due to implementation and compliance issues. Professor Rathleff suggested promoting these programs as “performance enhancing” rather than “injury prevention” may improve compliance, both with coaches and athletes. Group classes, coach, athlete and parent education and engagement with technology were all identified as measures likely to improve injury prevention compliance success. Educating adolescent athletes of realistic expectations and time frames may also assist in program engagement.

Program funding was also identified as a potential challenge. Funding a nationwide injury prevention program may result in large savings in the health care sector with lower injury rates and fewer hospital admissions. Reducing lower limb injury also has the potential for significant savings due to the burden of early knee osteoarthritis and the associated comorbidities for the health sector.

Michael and his research team together with the Danish Centre for Health Improvement are about to publish some exciting research examining the cost of a Danish wide injury prevention program implementation compared with the costs of injuries. Injury prevention programs for children involve many stakeholders; coaches, schools and teachers, parents and the children themselves.

Barriers include

- Development of programs in conjunction with the stakeholders including the coaches, parents and children themselves to optimise engagement
- Cost of programs and education of coaches, teachers, schools, parents and children to improve efficacy of the program
- Cost spend (government/ sports commission) and savings (hospital: public and private) in different government sectors
- Jesper Rimestad And Lars Ehlers are the primary researchers of this exciting project to be published soon

Governments, health and education policy makers need to find a solution to enable these programs to exist in our education system or community sporting groups.

**Ms Annemette Bech, Physiotherapist,****Arkadens Fysioterapi & Sundhedscenter, Aalborg**

Arkadens Physiotherapy Clinic is a private physiotherapy clinic in Aalborg, Denmark. I observed several GLA:D® classes with Ms Annemette Bech, Physiotherapist. Arkadens Physiotherapy Clinic has a large gymnasium area and another large space for teaching group exercise classes. Rehabilitation programs for Anterior cruciate ligament injury were conducted as group classes with 3 different levels in the program, early, mid and late stage rehabilitation. Many of the physiotherapy centres in Denmark have gymnasiums with a group exercise space, compared to many Australian physiotherapy centres which have more individual treatment room's. This is possibly a barrier to conducting these types of programs in some physiotherapy centres in Australia.



**Norwegian School Sports Sciences, Oslo University Hospital, Oslo, Norway**

**Professor May Arna Risberg** is a respected leader in ACL research nationally and internationally, having published over 100 original research articles. Her main research area is active rehabilitation of knee injuries and hip and knee osteoarthritis. Professor Risberg has a formal collaboration with The University of Delaware, United States. May Arna was my host at the Norwegian School Sport Sciences in Oslo, Norway.

**Grethe Mykleburst** is a Professor at the Oslo Sports Trauma Centre and a Specialist in Sports Physiotherapy. Grethe is responsible for the Masters in Physiotherapy course and her main research area is related to team handball and soccer injuries and injury prevention.

**Hege Grindhem** is a Physical Therapist and has a PhD Sports Medicine. Her main area of interest is anterior cruciate ligament injuries and she is a member of the Norwegian research centre for Active Rehabilitation (NAR).

*ACL Injury Management Algorithm In Norway*

The health system in Norway is predominately public, funded by mandatory taxation payments. A total excess of 2000 NK (approx 330 AUS) per year is payable on eligible government health services, after which an exemption card entitles people to free treatment for the remainder of the year for specific diagnosis (i.e osteoarthritis) and postoperative treatment. Many athletes are covered by sports insurance.

A person sustaining an acute knee injury in Norway will generally visit an emergency center, part of the primary health care system or an emergency center at a hospital. There are no strict Norwegian clinical guidelines for acute knee injury management. Practitioners recommend evidence-based practice guidelines and clinical pathways.

An X ray will be taken if a fracture is suspected. If an ACL is suspected the person will be referred for an MRI, which incurs a very small gap fee. The person is then generally referred to physiotherapy for a 6-8-week prehabilitation program. Prehabilitation physiotherapy programs are generally privately funded whilst post-operative programs are publicly funded and provided by clinics with contracts with the health region. Post-operative ACL rehabilitation is provided both as individual sessions and group classes.

ACL reconstruction surgery is generally recommended if the person wishes to return to pivoting sports, as a shared decision involving all stakeholders.

The Norwegian registry was the first national ACL registry, starting in 2004 and by 2014 had collected 20,000 patients' data. Although initially voluntary and paper based, it is now an electronic mandatory registry for both public and private hospitals. The registry collects data on epidemiology, surgical techniques, non-operative, pre-operative, intraoperative, post-operative, 10-year outcome data.

### ACL Prehabilitation programs

#### Norwegian Research Centre for Active Rehabilitation (NAR) programme (Eitzen et al, 2010)

##### *Pre-op optimisation program or 1<sup>st</sup> stage non-operative program*

Very few early stage ACL rehabilitation protocols exist (Eitzen et al, 2010). May Arna Risberg and Hege Gridem discussed the NAR program, a progressive ACL prehabilitation program. The 5-week, 10 session program is ideally commenced soon after resolution of initial impairments, following an ACL injury. ACL rehabilitation is divided into 3 phases, the NAR program is the second phase. see table 2 for details

The progressive physical prehabilitation program combines strength training, plyometric exercises, balance and stability exercises and perturbation training (see appendix 2) At the conclusion of the program, a decision is made to continue non-operative management, or to undergo ACL reconstruction if returning to pivoting sports.

Patients who were not referred to surgery continued rehabilitation in phase 3, whereas patients who elected ACL surgery continued progressive rehabilitation in phase 2 with restrictions against participation in pivoting sports. It is recommended that the patient has 90% quads and hamstring muscle strength and hopping ability on the injured leg compared to the uninjured leg prior to ACLR surgery.

Of the 100 patients in the study (Eitzen et al, 2010), 64 had ACL Reconstruction within the first 6 months after the post-test (64%) and 36 (36%) continued nonoperative management. The operative group had higher levels of activity pre-injury compared to the non-operative group. This operative rate is significantly less than current Australian ACL operative rates (90%).

Significant improvements in muscle strength and hop performance were found in the group of 100 people with an isolated ACL injury, after completion of the 5-week NAR program (Eitzen et al, 2010). Adverse events were experienced in only 4% of participants. These were predominately pain and swelling experienced during the plyometric exercises, or instability during post program hop tests. None of the study participants reported pain during muscle strength exercises, balance and stability exercises, or perturbation sessions.

Australian Physiotherapists should exercise caution, monitor symptoms and obtain informed consent if they choose to do the NAR program and tests.

Eitzen et al (2009) found that preoperative quadriceps strength was the single most important predictor for knee function 2 years after ACL reconstruction, and that preoperative deficits were persistent 2 years after surgery. These findings seem to justify postponing the decision for ACLR for a short period, to optimize preoperative knee function.

Success of this program requires a motivated person with high compliance to exercise therapy, some specific rehabilitation equipment combined with clear goal- setting, repeated testing and patient education.

A recent RCT showed that a 6 week pre-operative (prehabilitation) program lead to improved outcomes 12 weeks after ACLR surgery (Shaarani et al, 2013). The NAR program had more intensive strength training, perturbation and plyometric training comparatively, but more studies are needed to understand the optimal pre-operative program. The NAR program was also more intensive than the pre-operative program in the Kanon trial.

A prospective cohort trial in Norway for patients who underwent progressive pre-operative (NAR program) and post-operative rehabilitation showed superior patient reported outcomes both pre-operatively and 2 years post operatively compared to usual care (Grindem et al, 2014).

**Table 2 : Phases of ACL rehabilitation Norway**

| Prehab Phase | Aim   | Specific exercises   | Outcomes  |
|--------------|---|--|---|
| Phase 1      | Resolve initial knee impairments  | standard care<br>Physiotherapy   | Full range of movement, minimal swelling within 3 months of commencing phase 1  |
| Phase 2      | restore muscle strength and adequate neuromuscular responses  | <b>NAR program:</b> intensive muscle strength training 3-4 sets of 6-8 reps x 2 weekly, supervised plyometric exercises, advanced neuromuscular exercises inc closed kinetic chain, open kinetic chain exercises, isometric exercises, perturbation training | > 90% symmetry index for quadriceps strength, hamstrings strength and 90% symmetry four single-legged hop tests<br>>80 % KOS-ADLS<br>>60 Global Rating<br>Max 1 giving way episode since injury |
| Phase 3      | Continued rehab for non-operative patients, operative patients continue in phase 2 with no pivot activities | Continue with advanced NAR program   | As above  |

**ACL Prevention Programs**

**Roald Bahr, Professor Grethe Myklebust and Hege Grindem**

I was fortunate to be invited to join the Kiel 2018 Sports Medicine Meeting at The Norwegian School of Sports Sciences. **Roald Bahr, Professor in Sports Medicine**, Oslo Sports Trauma Research Centre, presented on injury prevention programs in Norway. The Oslo Sports Trauma Research Centre was established in 2000 with an aim to prevent injuries and other health problems in sports, through multidisciplinary research on risk factors, injury mechanisms and prevention methods. It is funded by the regional health authority, Norwegian Government, Norwegian Olympic and Para Olympic Committee, the International Olympic Committee and the Norway National Lottery.

Professor Bahr discussed general design concepts of an injury prevention program. An initial investigation of the magnitude of the problem, the cause, risk factors and injury mechanisms, informs the components of the specific prevention program. The program is then applied, its efficacy assessed and then adjusted as necessary. Research across a range of sports shows that a structured prevention training program can reduce sports injury risk by up to 50%.

**Professor Grethe Mykebust** (2003) presented the results of her research study, applying a neuromuscular ACL prevention program to group of handball players. This was a 5 phase, 15-minute program combining balance exercises, jumping and landing drills. The focus of the program was core stability, knee awareness and control during standing, cutting, jumping and landing. The injury prevention program had 3 different sets of exercises with 5 step progressions of each exercise, was conducted 3 x weekly, for 5-7 weeks and then 1 x per week after the initial program concluded. Teams were provided with an instructional video and posters, balance mats and wobble boards, in addition to a supervising ACL prevention trained physiotherapist.

This program was further developed as a 20-minute structured warm up and tested in a random controlled designed trial. The programme reduced the risk of lower extremity injuries by 49% in the intervention group of boys and girls aged 15-17, and the risk of severe knee ligament injuries was also reduced substantially, compared with the control group doing regular warm-up exercises (Olsen et al, 2005). **See appendix 3 for specific exercises**

The FIFA, 11+ is another injury prevention program which has been shown to reduce ACL injury incidence (Soligard et al, 2008).

The success of an ACL prevention program relies on accessible information and compliance by the team, coach and athlete. To improve access and encourage broad implementation of prevention programs, the Oslo Sports Trauma Research Centre has designed a website [www.skadefri.no](http://www.skadefri.no) or [fittoplay.org](http://fittoplay.org) in English. Skadefri provides information based on contemporary world research on common sports injuries, injury risk factors and specific injury prevention exercises. The injury prevention exercises are presented either by specific body part or sport and have 3 progressed levels of exercises displayed in video format for 52 different sports. This website is free to access, with a free mobile App called "Get Set" available in 7 languages. Many sports popular in Australia are included, accepting netball and Australian Rules Football. **See appendix 4**

**Hege Grindem** discussed optimal prevention program compliance requires action by many stakeholders including coaches, teams, athletes, parents, health and sports insurance bodies, sports federations and governments.

A recent study looking at the effect of these ACL prevention programs over a 10-year period has reported that despite the promising findings from the ACL Injury Prevention Study (Myklebust et al, 2003, the programme was not being implemented as a regular part of training by coaches or players.

Learnings from the 10-year Norwegian experience have been published (Myklebust et al, 2013) and coaches have been identified as the key partners for successful delivery and effectiveness of prevention programs. More research needs to be done on individual risk factors and ideal exercise prescription in the prevention program however, the three key messages for team sport prevention program success are

1. Include prevention exercises in the warm up
2. Tailor the exercise programme to the specific sport
3. Focus on coach education as a key factor

**Maria Pedersen, Physiotherapist, Norwegian Athletic Institute (NIMI) Ullevaal Stadion, Oslo**

I visited NIMI, a leading private sports medicine centre, hosted by May Arna Risberg and Maria Pedersen to observe the Norwegian pre-operative and post-operative rehabilitation programs for people with an ACL injury.

### **Division of Physiotherapy, Linköping University, Linköping, Sweden**

I met with **Dr Joanna Kvist**, Professor and Physiotherapist and her team at Linköping University including **Hanna Gauffin, Martin Hagglund, Sofi Sonesson** and **Dr Christer Andersson**. We discussed ACL injury management clinical pathways in Sweden and related research being conducted at Linköping University, including the NACOX (Natural Course and Recovery after ACL injury) study. This prospective cohort trial specifically aims to evaluate the physical, psychological and contextual factors affecting recovery following ACL injury. Specifically, factors affecting the decision for nonoperative or operative pathways, return to sports, development of knee osteoarthritis, risk factors for new knee injuries and epidemiology of acute knee trauma will be evaluated. The research cohort will undergo 3 months of prehabilitation before deciding on non-operative or operative management. The target follow up duration is 4 years and the primary outcome measures will be return to sports timeframe, the IKDC, osteoarthritis development on imaging, reported new knee injuries and factors related to treatment choice. Data collection will be completed in 2020 after which the results of this study will be published, informing us of the natural course of recovery post ACL injury in this cohort.

### **ACL injury management algorithm in Sweden**

The health system in Sweden is predominately public, funded by mandatory taxation payments. A total excess of 1100 SK (approx 170 AUS) per year is payable on eligible government health services, after which people are entitled to free treatment for the remainder of the year. Physiotherapy services are approximately 200SK per visit. Many private physiotherapy clinics have contracts with the region to provide a number of services per year.

A person sustaining an acute knee injury in Sweden will generally visit an emergency clinic or a sport / work clinic. An X ray will be taken if a fracture is suspected. If an ACL is suspected the person may be referred for an MRI initially, region dependent. The person is then generally referred to an orthopedic clinic (6-12 weeks post injury) and physiotherapy for a 6-12-week prehabilitation program. Prehabilitation is generally conducted as individual sessions rather than group classes.

There are no strict Swedish clinical guidelines for acute knee injury, no standard prehabilitation program or post prehab testing. The 3-month rehabilitation trial enables some assessment of whether the person may be a "Coper" and have functional knee stability despite a ruptured ACL and thus pursue a non-operative clinical pathway.

If the person has a repairable meniscal tear in addition to ruptured ACL they are referred immediately for a surgical opinion. Approximately 50% of people with an ACL injury have an ACL reconstruction within the first-year post injury.

ACL reconstruction surgery is generally recommended if the person wishes to return to pivoting sport or occupation or has knee instability despite the prehab program, as a shared decision involving all stakeholders. ACL reconstruction surgery is funded by the government, the majority of Orthopedic Surgeons working as salaried public health employees. More private Orthopedic surgery is becoming available in the bigger cities of Sweden; Stockholm and Gothenburg, where ACL reconstruction rates are reportably higher and done earlier post injury.

ACL Prevention programs in Sweden have been trialed and have been effective in the short term however broad implementation has the challenges of inadequate funding and poor program compliance.

The Swedish ACL registry started collecting data in 2005 and by 2014 had 30,000 patient data. It is voluntary for both public and private Surgeons with a 90% reporting rate. The registry collects data on epidemiology, surgical techniques, pre-operative, intraoperative, post-operative 1,2 and 5-year outcome data (ACL Study group).

**Richard Dulan, Physiotherapist, Malmo,**

I visited Richard Dulan at his clinic "Kulan Sports Injuries Centre" in Malmo. Kulan is a private clinic but serves local authority activities through the consumer choice system in Region Skone. Richard also sees patients who have sports injuries through their sports club insurance. Richard is the Physiotherapist to the Swedish national football team and treats many other elite athletes.

Kulan Sports Injuries clinic has a large fully equipped gym in addition to traditional physiotherapy treatment rooms.

We discussed acute ACL injury management for elite athletes in Sweden. Most will have an ACL reconstruction within 1-2 weeks of injury, unless their knee condition and function requires time to settle.

Richard has a very unique, interesting and evolutionary approach to lower limb physical rehabilitation, based on phases of the gait cycle, motor control theories and human function. This approach is apparently common in Sweden and aims to address neuromuscular consequences resulting from ACL injury and is used in pre-operative, non-operative and post-operative phases.

Rehab phases are

1. Single leg stand exercises –progressed through levels of resistance
2. Heel strike exercises
3. 1 leg squat exercises
4. Toe off exercises,
5. Swing phase exercises

The exercises prescribed are based on the persons presenting levels of function and specific dysfunction. Adjuncts to the program may be joint mobilisation, neuromuscular facilitation as required, balance exercises, dynamic strength exercises and plyometric sports specific exercises. Most of the exercises appeared to be multi joint exercises and good form, alignment and function were a focus. I enjoyed learning Richard's approach to correcting human movement dysfunction.

### Eva Ageberg, Lund University

I met with **Associate Professor Eva Ageberg**, PhD, from Lund University to discuss her research on ACL injury prevention programs.

Professor Ageberg discussed the evidence for the efficacy of the ACL prevention programs at lowering the risk of a non-contact ACL injury, if they are implemented. Professor Ageberg highlighted the importance of key stakeholders having an understanding, ownership and belief in the program and their ability to deliver it - "self-efficacy", for successful program implementation.

Anecdotal evidence from interviewing experts I visited, reported coaches feel time pressured, rate skill development more highly than injury prevention and are concerned about the risk of soreness or injury due to the program. Coaches also expressed the need to understand the rationale for the exercises within the program for themselves and the participants.

For optimal efficacy "ACL injury prevention programs" need to be designed specifically for the sport and population involved, based on injury data and delivered in conjunction with the deliverer and the end user considered.

Alex Donaldson (2016), a researcher from Australia published a generalizable 6-step intervention development process:

- **Step 1** Use the research evidence and clinical experience
- **Step 2** Consult the experts to ensure sport specificity and injury mechanisms of interest by consensus of experts
- **Step 3** Engage the end users to ensure the program is relevant and acceptable to the deliverers of the program and the participants
- **Step 4** Test the intervention
- **Step 5** Evaluate against theory
- **Step 6** Obtain feedback from early implementers

"Following each step, intervention content and presentation should be revised to ensure that the final intervention includes evidence-informed content that is likely to be adopted, properly implemented, and sustained over time by the targeted intervention deliverers.

This systematic yet pragmatic and interactive intervention development process is potentially applicable to any injury prevention topic across all sports settings and levels. It will guide researchers wishing to undertake intervention development. <sup>11</sup>SEP

The success of this approach relies upon accurate injury data and specific sport knowledge, excellent communication and education skills creating motivation for long term behavior change, supported by sporting associations, policy and appropriate funding.

There are a number of published programs which have been shown to reduce ACL injuries in different populations which could be used as a guide to develop a sports specific program for the team or community in question; ie FIFA 11 and FIFA 11+, PEP program, Sportsmetrics, Mayometrics ACL prevention, Footy First, KNEE and Get Set.

Emphasizing the Performance enhancement results of these programs may assist for more widespread adoption. Ayala et al, 2017 <https://lnkd.in/gvG4GjU>

showed the FIFA 11+ when carried out 3 x weekly for 4 weeks significantly improved 10 m and 20 m sprint times and vertical jump performance compared to a "usual" warm up in male soccer players.

### **Kanon Trial 10 year outcome data**

Dr Richard Frobell, was an Associate Professor at the Department of Orthopedics at Lund University, Sweden, when the Kanon Trial was published in 2010. The 10-year Kanon trial results will be published shortly, adding to our understanding of the long-term implications of osteoarthritis (OA), meniscal tear and instability rates and treatment options for our ACL patients.

### **Sports Surgery Clinic, Dublin,**

*Enda King, PhD, Physiotherapist*

Thank you to **Dr Enda King**, Physiotherapist and Head of Performance, for generously sharing his time and amazing facility, the Sports Surgery Clinic in Dublin. **Dr Ray Moran**, Orthopaedic Surgeon and **Dr Enda King** and his team have an amazing collaborative approach to optimising outcomes post ACL injury.

Patients attend the SSC for testing at 3, 6, 9 and 12 months post op ACL reconstruction. The testing includes a clinical knee examination in addition to:

3 months post op: isokinetic strength test quads /hamstring at 60 and 180 speeds, and drop jump analysis

6, 9 and 12 months post op: isokinetic strength test, biomechanical analysis of movements using a 15 camera 3 D image capture system, landing assessment using force plate technology, hop tests

Patient completed questionnaires including the IKDC, Cincinnati score, ACL- RSI score, ACL-QOL, Marx activity score and return to play are completed. The results are discussed with the patient and sent electronically to the surgeon for their post-operative review appointment. The patient's rehabilitation program is reviewed with recommendations sent to the referring physiotherapist or sporting club. Physiotherapists and bio mechanists have been trained in a standard approach to the testing and analysis.

Dr Enda King has published research on "Optimal testing battery to assess ACL rehabilitation status", 2017. This test battery could be used for assessing people with either non-operatively or operatively managed ACL injured knees.

Anecdotally SSC tests a much greater percentage of operatively managed ACL injuries for people with private insurance or sports club insurance. ACL prevention programs are apparently uncommonly implemented in Ireland. The SSC is a unique clinical facility with significant investment in high tech testing equipment, where Surgeons, Physiotherapists, Bio mechanists and patients work closely together to optimise outcomes for all post ACL injury.

### **Sportsmetrics Course, Cincinnati, Ohio, United States**

*Dr Frank Noyes and Stephanie Tutalo Smith, PT*

I completed the Sportsmetrics 2-day training course and passed the written and practical examination to become a certified Sportsmetrics Trainer. **See appendix 5**

Sportsmetrics is a non-profit organisation funded by research and the Noyes Knee Institute and Cincinnati SportsMedicine Foundation. The Sportsmetrics program has been shown to decrease serious knee ligament injuries in female athletes (Hewett et al, 1999). It includes a neuromuscular training program consisting of a dynamic warm up, strength and flexibility program and graduated levels of plyometric exercises, teaching safe jumping and landing techniques. It is designed to be done 3 x weekly for 6 weeks.

The Sportsmetrics program has also been condensed into the WIPP program (warm up for Injury Prevention and Performance) which is a 20-minute program designed to be easily used as an on field warm up program. The WIPP program has 3 intensity levels and time options for pre-season or in season training and consists of a dynamic warm up, plyometrics, strength and agility drills focused on ACL injury risk factors. **See appendix 6**

### **Cincinnati Children's Hospital, Cincinnati, Ohio, United States**

*Dr Greg Myers, Dr Dustin Grooms, Dr Mark Paterno*

I visited the biomechanics research laboratory at Cincinnati Children's Hospital.

I was fortunate to have a phone interview with Dr Dustin Grooms, who has a PhD in neuroscience and is interested in neuroplasticity following ACL injury. Dr Grooms has discovered that neurological factors may contribute to the multifactorial ACL injury risk paradigm and the increased female injury susceptibility.

Dr Grooms has discovered that ACL deficient individuals have an increased reliance on visual processing for motor planning. This brain plasticity change is individual and people who are "Copers" have different brain effects than "Non-Copers". Dr Grooms is currently conducting a research project to see if visual obscuration can improve the efficiency of the impaired motor system post ACL injury.

Dr Grooms has suggested ACL injury prevention programs should consider neurocognition and its role in movement, neuromuscular control, and injury risk. Adding dual tasks such as memory recall, environmental stimulus (ball or partner perturbations), or direct visual perturbations may possibly improve intervention effectiveness.

**Dr Greg Myers** and **Dr Dustin Grooms** are also conducting a very interesting project looking at the effectiveness of a standard neuromuscular ACL prevention program supplemented by virtual reality technology.

### Non operative Programs ACL injury management

Dr Mark Paterno at the Cincinnati Children's Hospital Medical Centre has published a recent review of "Non-operative care of the patient with the ACL deficient knee (2017)".

A continuum of functional instability exists in patients after ACL injury, ranging from grossly unstable to functionally stable with no giving way.

Dr Paterno's review suggests patients who live a more sedentary lifestyle, have a less physically demanding occupation or are happy to modify activities to primarily straight-line sporting activities (jogging, cycling) have a greater likelihood of succeeding with a non-operative course of management.

Furthermore, patients who have an isolated ACL injury with no concomitant injuries are typically the best candidates to trial this management option. If patients elect the non-operative pathway, their rehabilitation is focused on addressing post-acute injury impairments, maximising strength, and insuring the patient is able to participate in their desired activities without episodes of functional instability or giving way.

Non-operative management for the ACL deficient individual has several phases from

1. Post-acute injury phase
2. Neuromuscular training phase
3. Return to sport phase

The **acute recovery phase** is focussed on correcting impairments from the ACL injury. Patients usually present with an acute hemarthrosis, loss of motion, acute quads reflex inhibition and weakness. Cryotherapy, muscle stims, quads activation and strength exercises including both open and closed kinetic chain exercises, hamstring, hip, core and trunk strength and control exercises are important interventions in this phase. Progression to the neuromuscular training phase can occur when the patient has full knee range of motion, minimal swelling and sufficient muscle strength to participate in more dynamic weight bearing exercises.

The **neuromuscular training phase** focus is on maximising lower extremity and core strength, advanced balance and proprioception, cardiovascular conditioning and neuromuscular interventions. Perturbation training as described in the NAR program (**see appendix 2**) is a type of neuromuscular training exercise designed specifically and proven to improve knee stability in patients with ACL deficiency. Prior to progression to the return to sport phase people must have completed the neuromuscular training with no episodes of giving way and have sufficient quads and hamstring strength (90% strength of unaffected limb on an isokinetic test).

The **final rehabilitation phase** is focused on a sports specific re-integration into their individual desired level of activity. A brace may be helpful for those people returning to a sport involving cutting and pivoting. Agility tasks need to be progressed from slower straight-line tasks to more dynamic unanticipated cutting and turning tasks at high speed. Incorporation of sports specific equipment with agility tasks and complex sport decision making is necessary to achieve mastery. The athlete should successfully complete a **return to sport test assessment**. This assessment must objectively measure lower extremity strength, functional movement patterns and psychological readiness to return to sport.

The rehabilitation protocol including non-operative and post operative pathways used in the Kanon study (Frobell, 2010) can be viewed in Supplementary Appendix of the published article Frobell et al, 2010. A randomised trial of treatment for acute anterior cruciate ligament tears. N Eng J Med 2010; 363:331-42.

**Chris Powers, Movement Performance Institute  
Los Angeles, CA, United States**

I visited the Movement Performance Institute to observe Dr Powers return to sport testing post ACL injury. ACLR surgery rates in the United States are similar to Australia.

The return to sport test involves

1. A running test
2. 2D motion capture and force plate cutting and deceleration maneuver
3. 2D motion capture step down and Drop jump
4. 2D Lateral shuffle
5. Isokinetic strength testing hamstrings, quads and hip abductors, extensors
6. Triple jump test

Results are rated for risk as high / medium / low considering hip stability, pelvis stability, trunk stability, shock absorption and hip strategy. The results are discussed with the patient and rehabilitation strategies discussed with a report being sent to the referring Physiotherapist or Surgeon.

## CONCLUSION

The aim of this fellowship was to investigate contemporary conservative management programs for anterior cruciate ligament knee injuries.

It was relevant to this topic to identify contemporary ACL injury management algorithms used to select a patient for non-operative or operative management, in addition to the rehabilitation programs themselves for the countries visited.

Please see **Table 3**

**Table 3: Health System comparisons and Acute traumatic knee injury management algorithms**

| Country         | Health System  | Acute knee injury management   |
|-----------------|--|--|
| The Netherlands | Public >> private; choice of basic / full government insurance payment based on family members - GP gatekeeper & free, 350(\$550 AUS) Euro excess per 12/12<br><br>No ACL register   | acute knee trauma: 3 mths of initial non-operative management with physical activity / quads exercise advice- referral to orthopaedic clinic for review + MRI after this time if not satisfied with knee function/ stability (unless Ottawa knee rules dictates X Ray or acute locked knee immed surgeon referral or elite athlete)<br><br>ACL prevention prog not common  |
| Denmark         | Public >> private through mandatory payments; GP free, hospital free, can take out additional private insurance to skip wait lists, some physio paid partially by government- insurance pays number of interventions per year, wait list guarantee condition dependent<br><br>ACL register   | Emerg – ortho clinic - Orthopedic surgeons will often advise to rest for 6-8 weeks to see if will settle unless fracture / bucket handle tear suspected, pre hab rare, wait list guarantee for all injuries; knee injuries lower priority however will be seen in the private system if not seen in public system within the guarantee time. If elite or wishes to RT pivoting sports ACLR recommended<br><br>ACL prevention prog not common   |
| Norway          | Public>> private health system, private physio > public physio pre – op , public physio >> private for post op ACLR who have contracts with the community , Once you pay 2000 N Kroner / yr (330AUS) then free treatment rest of year for specific diagnosis/ post op care , many athletes covered by sports insurance<br><br>ACL register | Traumatic knee injury – emerg centre which is part of primary health care system or emerg at hospital, Ottawa Knee rules – X Ray or if ACL suspected MRI within 2/ 52 ( v small gap fee), then referred to physio for prehab for 6-8 wks, ACLR generally suggested if elite or wanting to RT pivoting sport ,no strict guidelines but evidence based recommendations,  |
| Sweden          | Public >>> private health system, 1100 S Kroner (170 AUS) out of pocket with 200 SK per physio visit but free after this spend / year, region specific , Ortho surgeon generally salaried position , some private surgeons clinics in Stockholm/ Gothenberg<br><br>ACL register  | Traumatic knee injury – emerg clinic or sport / work clinic, Xray to exclude fracture (Ottawa knee rules) MRI depends on region, 1 <sup>st</sup> visit 6 weeks later at Ortho Clinic with referral to physio immed for pre hab , General advice is to do 3/12 prehab programs which is practitioner choice . Need then assessed for surgery at 2 <sup>nd</sup> ortho visit- elite or high demand pivoting sport or ADL instability- early ACLR |

## CONCLUSION

|                  |   |   |
|------------------|---|---|
| <b>Australia</b> | <p>Public and private health systems although most sports/ musculoskeletal injuries are managed in private system. Many people have private health insurance (47% hospital cover and 56% extras). Medicare pays recommended fee, patient pays gap fee which can be quite large dept on private surgeon/ hospital charge</p> <p>V little post op physio provided in public system, private physio appts approx. \$75 per visit.</p> <p>No ACL register</p> | <p>Traumatic knee injury – see emerg public or private hospital, GP or physiotherapist. MRI acute knee injury paid by government if referred by GP. Triage practitioner choice to refer onto ortho surgeon or rehab however 90% have early ACLR. 80% these ACLR in private system with patient choice of surgeon at an average cost of \$8000 AUS. Public system wait times often 12 months for ACLR.</p> <p>Prevention programs not common</p> |
|------------------|---|---|

World best practice for ACL injury management informed by expert research consensus is to undertake a rehabilitation program (prehabilitation or pre-operative) for 3 months to assess if surgical intervention is required. This is not the standard accepted practice model currently in Australia. The countries I visited which were using world best practice recommendations for ACL injury management had predominately public health systems.

The Australian health system, multiple acute knee injury triage practitioners and the lack of an ACL register pose unique difficulties to implementation of world best practice in ACL injury management.

Education of knee injury triage practitioners about the benefits of early referral for a prehabilitation program post-acute ACL injury is necessary, in addition to health insurance funding and health policy support. At the conclusion of this program a shared decision making model where the patient is encouraged to think about their priorities and what is important to them is more likely to result in achieving mutually desirable and positive outcomes for all stakeholders.

This approach requires a partnership in health care consultation reliant on the clinicians' technical, interpersonal and communication skills. It also relies on accurate knowledge of the specific risks and benefits of different clinical management pathways. **See table 4** for ACL injury clinical management pathways risks and benefits in the Australian health care system.

## CONCLUSION

**Table 4 : Summary of advantage and disadvantages of clinical management pathway for ACL injury in Australian Health System**

| Management pathway          | Possible advantages   | Possible disadvantages  |
|-----------------------------|---|---|
| Physical Rehabilitation     | <ul style="list-style-type: none"> <li>- Shorter rehab time with earlier RTS and less time off work</li> <li>- Avoid operation/ risks with? Similar outcome at 2/5/10 years post op</li> </ul>  | <ul style="list-style-type: none"> <li>-Instability with possible secondary damage to meniscus / chondral / bone / ligaments with increased long-term osteoarthritis (OA) risk</li> <li>-Possible longer time out of sport/ occupation/ family life if fails rehab</li> <li>-In Australia increased costs to patient with prehab then delayed ACLR</li> </ul> |
| Operative management (ACLR) | <ul style="list-style-type: none"> <li>-Generally better knee stability</li> <li>-Potentially less time out of sport / job than rehab and delayed ACLR</li> <li>-Generally algorithm recommended for Elite pivoting sport / function</li> </ul> | <ul style="list-style-type: none"> <li>-Increased up-front costs</li> <li>-Failure rate up to 25%</li> <li>-Infection rate 1%</li> <li>-RTS rates similar to rehab group statistically</li> <li>-OA rates similar to rehab alone unless instability problems</li> </ul>   |

The rehabilitation programs observed included pre-operative (sometimes called prehab), non-operative, prevention programs and long-term management programs. I have included specific examples of these programs where possible in the appendices of this document. More research is necessary to confirm the superiority of one program over another for each of these types of conservative programs. Australian Physiotherapists need to update their knowledge particularly for ACL prehabilitation, non-operative and prevention programs which are uncommonly employed in Australia.

## APPENDIX 1 GLA:D PROGRAM EXERCISES

### Exercise circle 1 : Core stability/postural function

This circle includes exercises with focus on core stability and postural function.

#### Level 1 Exercises

##### A. Pelvic-lift



With flexed knees and short lever arm, putting load on both legs

##### B. Sit-ups



With flexed knees, both legs on ball, arms along the sides (short lever arm)

#### Level 2 Exercises

##### A. Pelvic-lift



With semi-flexed knees and long lever arm, putting load on both legs.

**B. Sit-ups**



With flexed knees, both legs on ball, arms crossed over chest (medium lever arm).

*Level 3 Exercises*

**A. Pelvic-Lift**



As above, alternatively putting load on the affected and non-affected legs.

**B. Sit-ups**



With flexed knees, both legs on ball, hands behind neck (long lever arm).

## APPENDIX 1 GLA:D PROGRAM EXERCISES

### Exercise circle 2: Postural orientation

This circle includes exercises with emphasis on an appropriate position of the joints in relation to each other (postural orientation), i.e., with the hip, knee and foot joints well aligned.

#### Level 1 Exercises

##### A. Slide-exercise forward-backward:

Standing, weight-bearing on one leg, other leg on sliding surface. Slide backwards – forwards with “sliding leg”, while flexing – extending the knee of the weight bearing leg and keeping an appropriate position of the joints in relation to each other.



## APPENDIX 1 GLA:D PROGRAM EXERCISES

### B. Slide=exercise sideways:

Standing, weight-bearing on one leg, other leg on sliding surface. Slide sideways with “sliding leg”, while flexing – extending the knee of the weight-bearing leg and keeping an appropriate position of the joints in relation to each other.



### Level 2 Exercises

#### A. Slide-exercise forwards – backwards:

As above, standing on uneven surface (e.g. foam pillow or thick mattress).



#### B. Slide-exercise sideways:



As above, standing on uneven surface.

# APPENDIX 1 GLA:D PROGRAM EXERCISES

## Level 3 Exercises

### A. Forward lunge:

Standing position, take a large step forward and then return. Hand support for balance if needed.



### B. Sideway lunge:

Standing position, take a large step sideways and then return. Hand support for balance if needed.



## APPENDIX 1 GLA:D PROGRAM EXERCISES

### Exercise circle 3: Lower extremity muscle strength

This circle includes exercises in open and closed kinetic chains to improve strength of hip and knee muscles and band resistance is also added in increasing difficulty

Yellow→Red→Green→Blue is in increasing resistance.

#### Level 1 Exercises

##### A. Hip abductors/hip adductors:

Standing on one leg, rubber band other leg. Pull rubber band out (hip abductors) and in (hip adductors). Make sure there is tension in the rubber band also in resting position. Focus is on the hip abductors of the standing leg, keeping an appropriate position of the joints in the lower extremity in relation to each other and in relation to the trunk, i.e. without lateral displacement of the hip-pelvis region.



2.



# APPENDIX 1 GLA:D PROGRAM EXERCISES

## B. Knee extensors/knee flexors:

Sitting position. Rubber band around one foot. Pull rubber band forward (knee extensors) and backwards (knee flexors). Make sure that there is tension in the rubber band also in resing position.

1.



2.



### Level 2 Exercises

#### A. Hip abductors/hip adductors:

As above, rubber band with increasing resistance.



# APPENDIX 1 GLA:D PROGRAM EXERCISES

## B. Knee extensors:

## Knee flexors:

1.



2.



3.



As above, rubber band with increasing resistance.

# APPENDIX 1 GLA:D PROGRAM EXERCISES

## Level 3 Exercises

### A. Hip abductors

Hip adductors:



As above, standing on an uneven surface (e.g. foam pillow or thick mattress).

# APPENDIX 1 GLA:D PROGRAM EXERCISES

B. Knee extensors

Knee flexors:



As above, rubber band with increasing resistance.

# APPENDIX 1

## GLA:D PROGRAM EXERCISES

### Exercise circle 4: Functional exercises

This circle includes exercises resembling activities of daily life.

#### Level 1

##### *Exercises*

#### A. Chair stands:

Start in a seated position, feet parallel, putting load on both legs, slight hand support for balance.



#### B. Stair climbing:

Step-up (concentric muscle activation) and step-down (eccentric muscle activation) on low step-board, with or without slight hand support for balance.



## APPENDIX 1 GLA:D PROGRAM EXERCISES

### *Level 2 Exercises*

#### **A. Chair stands:**

Start in a seated position, feet parallel, putting load on both legs, without hand support.



#### **B. Stair climbing:**

Step-up and step-down on medium high step-board, with or without bar bells.



## APPENDIX 1 GLA:D PROGRAM EXERCISES

### *Level 3 Exercises*

#### **A. Chair stands:**

Start in a seated position, one foot in front of the other, with or without slight hand support for balance.



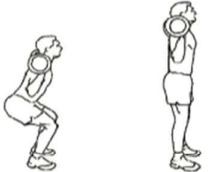
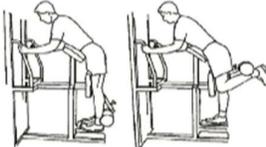
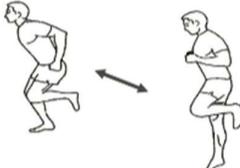
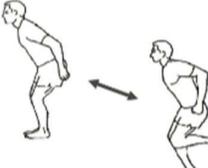
#### **B. Stair climbing:**

Step-up and step-down on high step-board, with or without bar bells.



## APPENDIX 2 NAR PROGRAM EXERCISES (FITZEN ET AL.)

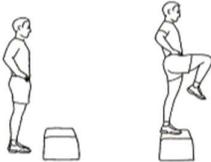
### APPENDIX A

| Exercise                   | Description  | Sets by Number of Repetitions | Figures   |
|----------------------------|--|-------------------------------|---|
| Single-limb knee extension | Start in 90° knee flexion  | 4 × 6 (+2)                    |    |
| Squats                     | Squat slowly down to 90° knee flexion, stop, lift quickly up again   | 3 × 8 (+2)                    |    |
| Leg curl                   | Lift quickly up, stop, and then slowly down to full extension  | 3 × 8 (+2)                    |   |
| Hamstring on Fitball       | One foot on top of the ball, lift back and pelvis up, pull ball towards you                                | 3 × 6                         |  |
| Single-leg hop             | Hop up on step, stop, continue down and directly 1 hop forward with a soft controlled landing              | 1 × 15                        |  |
| Sideways single-leg hop    | Start on 1 side of a board. Hop quickly sideways and stop after 3 hops. Continue and stop 5 times          | 3 × 15                        |  |
| Skating                    | Start on 1 leg, hop sideways, perform a soft, deep and steady landing on 1 leg, hop back to the other side | 2 × 20                        |  |

*All exercises are to be performed at each training session. Two to 3 series in each session. Training sessions minimum 2, maximum 4 times a week. Progression from increasing loads on the strength exercises and for higher steps, longer/higher jumps, movement in several directions and more wobbly surfaces for the neuromuscular and plyometric exercises. ©2010 Exercise Organizer®*

## APPENDIX 2 NAR PROGRAM EXERCISES (FITZEN ET AL.)

### APPENDIX A

| Exercise              | Description   | Sets by Number of Repetitions | Figures   |
|-----------------------|---|-------------------------------|---|
| Stationary cycle      | Continuous warm-up at your preferred resistance                       | 10 min                        |    |
| Treadmill             | Continuous warm-up at your preferred speed                            | 10 min                        |    |
| Elliptical trainer    | Continuous warm-up at your preferred resistance                       | 10 min                        |   |
| Single-limb squat     | Maintain knee-over-toe position                                       | 3 × 8                         |  |
| Step-up               | Maintain knee-over-toe position                                       | 2 × 10                        |  |
| Squat on BOSU         | Maintain knee alignment and core stability. Squat quickly down and up | 2 × 20                        |  |
| Single-limb leg press | Start in 90° knee flexion   | 3 × 6 (+2)                    |  |

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All exercises are to be performed at each training session. Two to 3 series in each session. Training sessions minimum 2, maximum 4 times a week. Progression from increasing loads on the strength exercises and for higher steps, longer/higher jumps, movement in several directions and more wobbly surfaces for the neuromuscular and plyometric exercises. ©2010 Exercise Organizer®

**APPENDIX B**

**PERTURBATION TRAINING PROTOCOL**

**Sessions 1-4. Early Phase**

*Progression by adding perturbations in all directions and minimizing of verbal cues*

| Activity |   |  |  |
|----------|---|--|--|
| Session  | Rocker Board  | Roller Board/Platform  | Roller Board   |
| 1        | <ul style="list-style-type: none"> <li>• Bilateral stance</li> <li>• 2 sets, anterior/posterior</li> <li>• 2 sets, medial/lateral</li> </ul>                    | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior</li> </ul>   | <ul style="list-style-type: none"> <li>• Bilateral stance</li> <li>• 2 sets anterior/posterior</li> </ul>                                    |
| 2        | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior direction</li> <li>• 2 sets medial/lateral direction</li> </ul> | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral</li> </ul>                             | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior</li> </ul>                                   |
| 3        | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets medial/lateral direction</li> <li>• 2 sets diagonal direction</li> </ul>           | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> </ul> | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior plus medial/lateral</li> </ul>               |
| 4        | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets medial/lateral direction</li> <li>• 2 sets diagonal direction</li> </ul>           | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> </ul> | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior plus medial/lateral plus rotation</li> </ul> |

**Sessions 5-7: Middle Phase**

*Progression by adding light sport-specific activity during perturbations*

| Activity |   |   |   |
|----------|---|---|---|
| Session  | Rocker Board  | Roller Board/Platform   | Roller Board  |
| 5        | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior direction</li> <li>• 2 sets medial/lateral direction</li> <li>• 2 sets diagonal direction</li> <li>• Ball against wall</li> </ul>       | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall</li> </ul> | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall</li> </ul>       |
| 6        | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior direction</li> <li>• 2 sets medial/lateral direction</li> <li>• 2 sets diagonal direction</li> <li>• Ball against wall/floor</li> </ul> | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral</li> <li>• Ball against wall/floor</li> </ul>                       | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall/floor</li> </ul> |
| 7        | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets medial/lateral direction</li> <li>• 2 sets diagonal direction</li> <li>• Ball thrown by other</li> </ul>   | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral</li> <li>• Ball thrown by other</li> </ul>                          | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball thrown by other</li> </ul>    |

**APPENDIX B**

| <b>PERTURBATION TRAINING PROTOCOL (CONTINUED)</b>   |  |  |  |
|---|--|--|--|
| <b>Sessions 8-10: Late Phase</b>  |  |  |  |
| <i>Progression by adding sport-specific stances combined with sport-specific activity</i> |  |  |  |
| <b>Activity</b>   |  |  |  |
| <b>Session</b>  | <b>Rocker Board</b>  | <b>Roller Board/Platform</b>   | <b>Roller Board</b>  |
| 8   | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior direction</li> <li>• 2 sets medial/lateral direction</li> <li>• 2 sets diagonal direction</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul> | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul> | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul> |
| 9   | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets medial/lateral direction</li> <li>• 2 sets diagonal direction</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul>  | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul> | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul> |
| 10  | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets medial/lateral direction</li> <li>• 2 sets diagonal direction</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul>  | <ul style="list-style-type: none"> <li>• 2 sets with injured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• 2 sets with uninjured limb on roller board, anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul> | <ul style="list-style-type: none"> <li>• Unilateral stance</li> <li>• 2 sets anterior/posterior plus medial/lateral plus rotation</li> <li>• Ball against wall/floor, thrown by other</li> <li>• Other individually adjusted relevant sport-specific activities</li> </ul> |

All exercises are to be performed at each training session. Two to 3 series in each session. Training sessions minimum 2, maximum 4 times a week. Progression from increasing loads on the strength exercises and for higher steps, longer/higher jumps, movement in several directions and more wobbly surfaces for the neuromuscular and plyometric exercises. ©2010 Exercise Organizer®

**Box 2: Programme of warm-up exercises used to prevent injuries**

**Warm-up exercises**

(30 seconds and one repetition each)

Jogging end to end

Backward running with sidesteps

Forward running with knee lifts and heel kicks

Sideways running with crossovers (“carioca”)

Sideways running with arms lifted (“parade”)

Forward running with trunk rotations

Forward running with intermittent stops

Speed run

**Technique**

(One exercise during each training session; 4 minutes and 5×30 seconds each)

Planting and cutting movements

Jump shot landings

**Balance**

(On a balance mat or wobble board, one exercise during each training session; 4 minutes and 2×90 seconds each)

Passing the ball (two leg stance)

Squats (one or two leg stance)

Passing the ball (one leg stance)

Bouncing the ball with eyes closed

Pushing each other off balance

**Strength and power**

(2 minutes and 3×10 repetitions each)

One quadriceps exercise:

Squats to 80° of knee flexion

Bounding strides (*Sprunglauf*)

Forward jumps

Jump shot—two legged landing

“Nordic hamstring lowers” (2 minutes and 3×10 repetitions each)

# APPENDIX 4 GET SET MOBILE APP

## GET SET – Train Smarter APP

Get Set – Train Smarter was created to help prevent sports injuries by providing the most effective workout routines for your needs.

This app was created for the International Olympic Committee by the Oslo Sports Trauma Center, Norwegian School of Sports Science, Oslo and Making Waves AS on the occasions of the 2014 Summer Youth Olympic Games in Nanjing, China and the 2016 Winter Youth Olympic Games in Lillehammer, Norway.



INTERNATIONAL OLYMPIC COMMITTEE

## Credits

### CONTENT

Prof Roald Bahr MD PhD, A/Prof Grethe Myklebust PT PhD, Kathrin Steffen PhD and Ben Clarsen PT PhD, Oslo Sports Trauma Research Center

### VIDEO & PHOTO

Lasse Nettum, Norwegian School of Sport Sciences



### APP DEVELOPMENT BY MAKING WAVES

For more information visit [Makingwaves.com](http://Makingwaves.com)



### ROLE MODELS

Karoline Aase Bahr, Katarina Bjørnskau Berens, Daniel Fallahinejad, Peter Høyslæen, Helle Kjellberg-Line, Even Krogsæther, Tron Krosshaug, Jonas Engebret Larsen, Emil Nedregård, Martin André Nilsen, Håkon Nordenstrøm, Sindre Remman, Leah Røste, Simon Sandbakken, Kristin Simonsen, Mina Simonsen, Erle Sivertsen, Kajsja Lian Spanic, Kathrin Steffen, Eva Stensrud, Maria Kulen Strømmen, Emma Suhonen, Frederik Willer

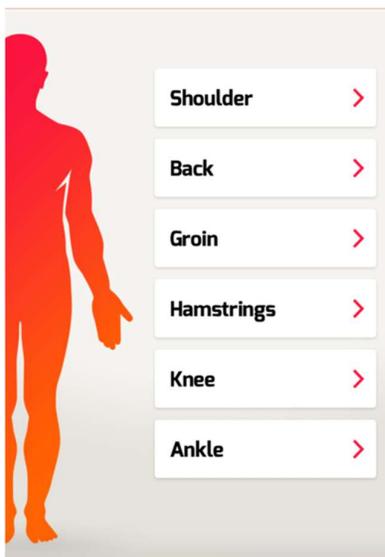
Version 2.0

Copyright © 2014 International Olympic Committee & Oslo Sports Trauma Research Center

FIFA 11+ videos are Copyright © 2014 FIFA



# APPENDIX 4 GET SET MOBILE APP

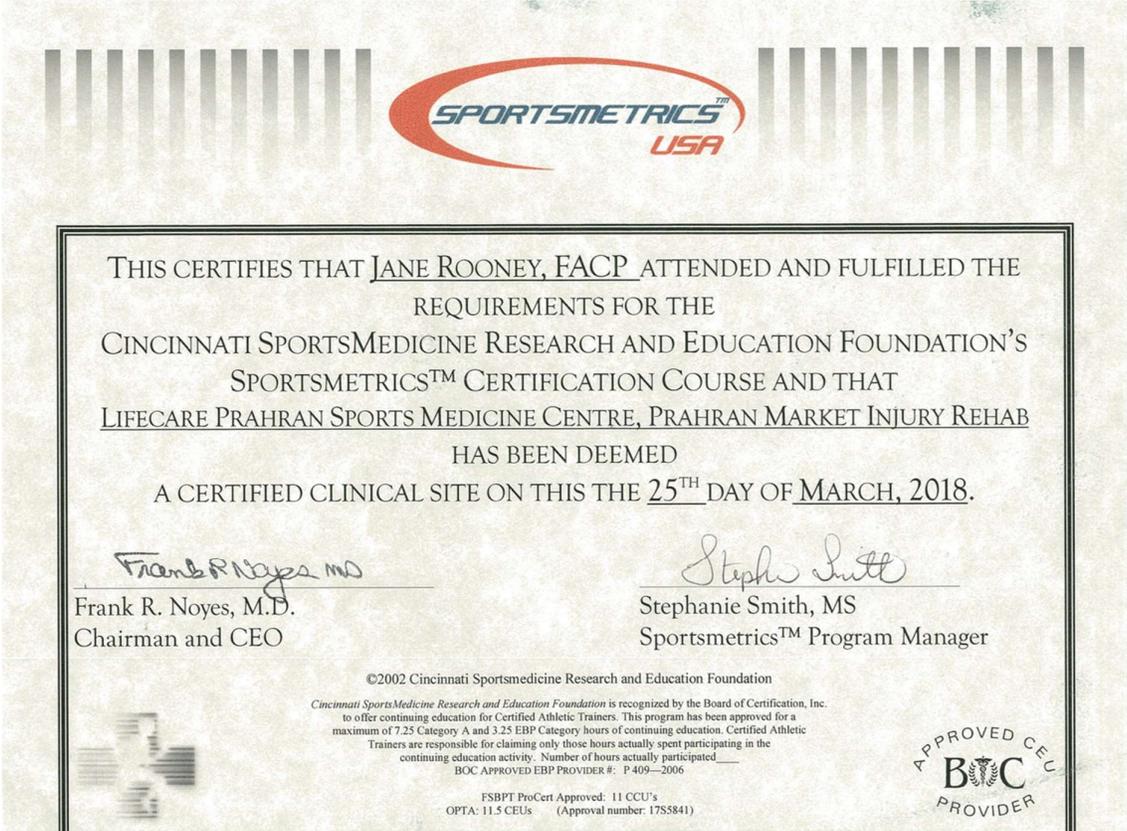


| LEVEL 1   | LEVEL 2   | LEVEL 3 |
|---|---|---------|
|  | <b>Box jumps</b><br>3 x 30 seconds              | >       |
|  | <b>Squat</b><br>3 x 8-16 repetitions            | >       |
|  | <b>The diver</b><br>3 x 8-16 repetitions        | >       |
|  | <b>Forward lunges</b><br>3 x 8-16 repetitions   | >       |
|  | <b>Side lunges</b><br>3 x 8-16 repetitions      | >       |
|  | <b>Nordic Hamstrings</b><br>3 x 3-5 repetitions | >       |

| LEVEL 1   | LEVEL 2  | LEVEL 3 |
|---|--|---------|
|   | <b>Backwards lunges</b><br>3 x 8-16 repetitions                  | >       |
|  | <b>Forward lunges with rotation</b><br>3 x 8-16 repetitions      | >       |
|  | <b>Single-leg squat</b><br>As many as possible with good control | >       |
|  | <b>Jump with 90 degree turn</b><br>10 jumps in each direction    | >       |
|  | <b>Double-leg bridge with ball</b><br>3 x 8-16 repetitions       | >       |

| LEVEL 1   | LEVEL 2  | LEVEL 3 |
|---|--|---------|
|   | <b>Telemark jumps</b><br>3 x 10-20 repetitions each side         | >       |
|  | <b>Flyer with rotation</b><br>3 x 6-8 repetitions                | >       |
|  | <b>Side lunges</b><br>3 x 8-16 repetitions                       | >       |
|  | <b>Single-leg squat</b><br>As many as possible with good control | >       |
|  | <b>Jump &amp; Push</b><br>3 x 8-16 repetitions                   | >       |
|  | <b>Nordic Hamstrings</b><br>3 x 8-12 repetitions                 | >       |

**APPENDIX 5: SPORTSMETRICS  
CERTIFIED TRAINER CERTIFICATE**



**Sportsmetrics™ WIPP**

Preseason: Components 1-4 In Season: Components 1, 2, & 4



**Warm Up for Injury Prevention & Performance**

**Low Intensity Day**

**Medium Intensity Day**

**High Intensity Day**

**Component 1: Dynamic Warm Up**

**HEEL WALK/TOE WALK**  
20s/sideline to sideline/50'  
Walk half the distance with a toe walk, then switch to heel walk for the rest of the distance.



**KNEE HUGS**  
20s/sideline to sideline/50'  
Take a step with right leg and grab left knee straight up toward chest. Repeat on other side taking a step forward each time.



**FORWARD LUNGE**  
20s/sideline to sideline/50'  
Step forward into lunge with left foot. Both knees should be bent. Return to standing position by pushing off with left leg. Repeat on right leg.



**CRADLE WALK**  
20s/sideline to sideline/50'  
Walking forward, lift one leg in front of the body, bending at the knee. Rotate the knee outward and the foot inward. Hold leg at the shin with both hands, standing on one leg. Hold for 3 seconds and repeat on other leg.



**HIGH KNEES/BUTT KICKS**  
20s/sideline to sideline/50'  
Jog forward driving knees to chest for 20 seconds or to the opposite sideline. Turn around and jog back kicking heels back for 20 seconds or back to the starting sideline.



**Component 2: Jumps**

**WALL JUMPS**  
30s  
Jump with knees slightly bent and arms overhead. The knees should be soft and the knees and ankles hip-distance. Push off with toes for max jump height.



**SQUAT JUMP**  
30s  
Begin in squat position with chest/head up and back straight. Reach hands to the outside of heels, then jump up reaching as high as possible. Return to squat position and repeat. Keep knees behind toes and weight in the heels during squat. Maintain feet and knees at hip distance throughout entire jump.



**BARRIER JUMP SIDE/SIDE**  
30s  
Using a 4-8" barrier or the sideline, jump side to side over the barrier by tucking knees to the chest. Maintain feet and knees hip distance apart, keep knees bent on landing and point toes and knees forward on landing.



**HEISMAN JUMPS**  
30s/sideline to sideline/50'  
Start on left leg with knee slightly bent and right knee lifted toward chest. Hop forward and to the right landing on right leg bringing left knee to the chest. Repeat back and forth moving in a zig zag pattern.



**BOUNCE**  
30s/sideline to sideline/50'  
Stand on right leg with left leg extended behind you. Swing left leg forward and upward. Simultaneously jump vertically off the right leg and land on the left. Now extend the right leg behind you and repeat the sequence.



**Component 1: Dynamic Warm Up**

**HEEL WALK/TOE WALK**  
20s/sideline to sideline/50'  
Walk half the distance with a toe walk, then switch to heel walk for the rest of the distance.



**STRAIGHT LEG MARCH**  
20s/sideline to sideline/50'  
Keeping the right leg straight, swing the leg as high as possible without jeopardizing form (no bent knees) or leaning backward. The entire body should remain tall and facing forward. As soon as the right foot is back on the ground, swing the left leg.



**BACKWARD LUNGE**  
20 seconds/sideline to sideline/50'  
Step backward into lunge with left foot. Both knees should be bent. Return to standing position by pushing off with the right (forward) foot and step back to meet the left foot. Repeat on their side.



**CROSSBODY KNEE HUG**  
20s/sideline to sideline/50'  
Take step with right leg and grab left knee toward chest and across body. Hold for 1-2 seconds and return to start. Take step forward with left leg and repeat the knee hug on the right side.



**HIGH KNEES/BUTT KICKS**  
20s/sideline to sideline/50'  
Take step with right leg and grab left knee toward chest and across body. Hold for 1-2 seconds and return to start. Take step forward with left leg and repeat the knee hug on the right side.



**Component 2: Jumps**

**CROSS JUMPS**  
30s  
Same as wall jumps except jump in a cross pattern: forward, backward, side to side, then repeat. Make sure knees and toes remain hip-distance apart throughout the pattern.



**SCISSOR JUMP**  
30s  
Start in a deep lunge position with front knee directly over ankle. Jump straight up and land with opposite leg in front. Keep knees and toes pointed forward and both knees bent.



**BARRIER HOP SIDE/SIDE**  
15s/leg  
Perform a single leg hop side to side over a 4-8" barrier or the sideline. Keep knee bent and toes and knees forward.



**BROAD JUMPS**  
30s/sideline to sideline/50'  
Starting from a squat stance, jump forward for distance, taking off with both feet. Land on ball of foot and quickly rock back to heels in a deep crouch position. Continue moving forward.



**SPEED SKATER**  
30s/sideline to sideline/50'  
Starting on left leg with knee bent, push off and hop forward and to the right, landing on the right leg with knee bent. Now push off the right leg and hop forward and to the left, landing on the left leg with knee bent. Continue advancing forward staying low to the ground.



**Component 1: Dynamic Warm Up**

**HEEL WALK/TOE WALK**  
20s/sideline to sideline/50'  
Walk half the distance with a toe walk, then switch to heel walk for the rest of the distance.



**WALKING RDL**  
20s/sideline to sideline/50'  
Step onto right leg, hinge at the hip until body forms a "T" shape with a flat back, rest the hands on right knee or ground. Hinge back up, then step onto the left leg and repeat.



**SIDE LUNGE**  
20s/sideline to sideline/50'  
Step forward and to the left side into lunge with left foot. The left knee will be bent, the right knee will be straight. Return to standing position by pushing off with the front leg. Repeat on other side.



**OPEN GATE/CLOSE GATE**  
20s/sideline to sideline/50'  
Pretend that there is a hurdle beside you. Facing forward and keeping shoulders and hips square, bring your right knee to the chest, then rotate out and over the hurdle, come back over the hurdle bringing the knee to the chest and then take a step forward. Repeat with other leg.



**HIGH KNEES/BUTT KICKS**  
20s/sideline to sideline/50'  
Jog forward driving knees to chest for 20 seconds or to the opposite sideline. Turn around and jog back kicking heels back for 20 seconds or back to the starting sideline.



**Component 2: Jumps**

**CROSS HOPS**  
15s/leg  
Hop on one leg forward, backward, then side to side in a cross pattern. Keep the knee slightly bent and knee and toe pointed forward.



**TUCK JUMPS**  
30s  
Begin in an upright neutral stance with the feet shoulder-width apart. Jump up, bending the knees to bring the thighs up toward the chest as high as possible. Land softly with knees bent. Repeat.



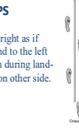
**180° SQUAT JUMP**  
30s  
Start in squat position, jump straight up and make 180° rotation in mid air then land in a squat position. Repeat the jump in the opposite direction. Torso and legs should extend fully. Make sure knees and toes remain hip distance apart throughout the entire jump.



**CROSSOVER STEP VERTICAL JUMP**  
20s/sideline to sideline/50'  
Pushing off with the left leg, jump forward and to the right, landing on both feet at the same time with flexed knees, striking the ground with toes first. Immediately explode up into a max vertical jump. Repeat now pushing off the right leg, forward and to the left.



**SINGLE LEG CROSSOVER HOPS**  
30s/sideline to sideline/50'  
Begin on one leg, hop forward and to the right as if crossing over a line. Now hop forward and to the left over the line. Stay low in a squat position during landing. Keep toe and knee forward. Repeat on other side.



**Warm Up for Injury Prevention & Performance**

**Sportsmetrics™ WIPP**

Preseason: Components 1-4 In Season: Components 1, 2, & 4



Low Intensity Day

Medium Intensity Day

High Intensity Day

**Component 3: Strength**

**SINGLE LEG HEEL RAISE**

15s/leg  
Balancing on one leg, raise the heel off the ground as high as possible. Repeat for specified time.



**SINGLE LEG SUPINE HAM BRIDGE**

15s/leg  
Lie flat on back, bend one knee and place heel close to the glute. Extend other leg straight up in the air. Push with the heel to lift glute off the ground and the extended leg higher in the air. Keep abs tight and shoulder blades on ground. Repeat then switch legs.



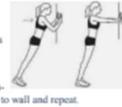
**SQUATS**

30s  
Squat down as far as possible not allowing knees to come forward. Explode up quickly and return to squat. Sit hips down and keep chest up. Keep knees from pushing forward passed toes. Repeat.



**PLYO WALL PUSH UPS**

30s  
Stand 2-3 ft. from wall with hands on wall at chest level. Keep elbows low and bend toward the wall keeping body straight. Explode away from the wall by pushing off with hands. Return hands to wall and repeat.



**PLANK**

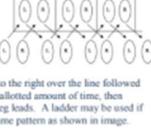
30s  
Lie facedown placing elbows under shoulders and forearms on the ground. Place legs hip-distance apart and curl the toes under. Lift the body up onto elbows and toes. Maintain a neutral position with back flat and neck straight.



**Component 4: Agility**

**QUICK FEET: Up-Up/Back-Back**

30s/direction  
Using the baseline or sideline, step right foot forward and diagonally to the right over the line followed quickly by the left. Next step right foot backward and diagonally to the right over the line followed by the left. Repeat for the allotted amount of time, then switch direction so other leg leads. A ladder may be used if available, following the same pattern as shown in image.



**ZIG ZAG DRILL**

2-4 reps  
Set 20 cones in a straight line about 2-5 feet apart. Weave in and out of cones keeping hips, knees and toes pointed forward and shuffling feet without crossing over. Move as quickly as possible and keep knees slightly bent throughout the entire drill.



**TIPS:**

- Perform low-intensity days on game days
- When performing jumps, land softly, keep knees bent throughout the entire landing, maintain feet and knees hip-distance apart with toes and knees facing forward.

**Component 3: Strength**

**SINGLE LEG HEEL RAISE**

15s/leg  
Balancing on one leg, raise the heel off the ground as high as possible. Repeat for specified time.



**SINGLE LEG DEADLIFT**

15s/leg  
Starting on right leg with knee slightly bent, hinge at the hip, keeping the back straight and reaching hands toward the ground. You should be able to draw a straight line from the back of your head down through your heels. Return to starting position and repeat.



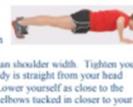
**LATERAL STEP w/ SQUAT**

30s  
Place hand around ankles. Start with feet hip width apart in a modified squat position. Step out to the side approx. 10 to 12". Slowly and under control, follow with the other foot to return to the initial position. Perform a deep squat and repeat in opposite direction.



**PUSH UPS**

30s  
Begin in plank position with arms straight and hands on the ground slightly wider than shoulder width. Tighten your core and make sure your body is straight from your head down through your heels. Lower yourself as close to the ground as possible keeping elbows tucked in closer to your body. Push yourself back up to start position and repeat.



**SIDE PLANK**

15s/side  
Lie on your side placing elbow on the ground under the shoulder. Place one foot on top of the other and raise up onto elbows and side of foot. Keep body straight, no twisting, and hold.



**Component 4: Agility**

**QUICK FEET: In-In/Out-Out**

30s/direction  
Using the baseline or sideline, step the right foot forward and in close to the line followed by the left foot. Next, step forward with the right foot out away from the line followed by the left. Continue pattern for the allotted amount of time, then switch the lead foot allowing the left foot to lead followed by the right. A ladder may be used if available, following the same pattern as shown in image.



**SIDE SHUFFLE**

30 seconds, 2-4 reps  
Line players up on the left sideline, facing half court/mid field. Begin in a squat position and shuffle right to the other sideline. When reaching the sideline, touch both hands to the ground by squatting and keeping the chest up. Immediately begin shuffling to the left until the left sideline is reached again. Maintain a squat position, keep toes and knees pointed forward and do not allow feet to cross.

**Component 3: Strength**

**SINGLE LEG HEEL RAISE**

15s/leg  
Balancing on one leg, raise the heel off the ground as high as possible. Repeat for specified time.



**RUSSIAN HAM CURL**

(alt. WALK-OUT HAM BRIDGE) 30s/5-10 reps  
Begin in kneeling position with partner holding feet to the ground. Keeping your body straight, lean forward as far as possible and hold. When you can no longer hold, lower yourself onto the ground into a pushup position and repeat.



**SINGLE LEG SQUAT**

15s/leg  
Begin on one leg, knee slightly bent and hips even. Begin to bend at the hip and knee into a single leg squat position. Sit hips back and down to avoid knee moving forward. Keep the chest up. Toe and knee should point straight forward. Return to start and repeat.



**TRICEP PUSH UPS**

30s  
Begin in push up position, this time with elbows in close to chest and hands directly under shoulders. Lower yourself as close to the ground as possible keeping elbows in and body straight. Push yourself back up to start position.



**SUPERMAN PLANK**

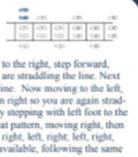
30s  
Start in standard plank position with either hands or elbows on the ground. Lift your body up off the ground keeping back flat. Now alternate lifting right arm and left leg at the same time, then left arm and right leg. Maintain a tight core and keep body as straight as possible.



**Component 4: Agility**

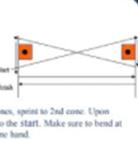
**QUICK FEET**

30 seconds/direction  
Start at left side of a sideline, in front of the line, facing the field/court. Moving to the right, step forward, right foot first then left so you are straddling the line. Next step right foot away from the line. Now moving to the left, step forward, left foot first then right so you are again straddling the line. Finish pattern by stepping with left foot to the left, away from the line. Repeat pattern, moving right, then left, shuffling feet as follows: right, left, right, left, right, left. A ladder may be used if available, following the same pattern as shown in the image.



**NEBRASKA DRILL**

2-4 reps  
Set 2 cones 30' apart. Begin on right side of 1st cone, sprint to left side of 2nd cone. Pivot around cone until facing 1st cone. Sprint to right side of 1st cone. Pivot around cone until facing 2nd cone (make a figure 8). Sprint on right side of both cones, sprint to 2nd cone. Upon reaching the 2nd cone, backpack to the start. Make sure to bend at knees and touch every cone with one hand.



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