Snow Sports Research

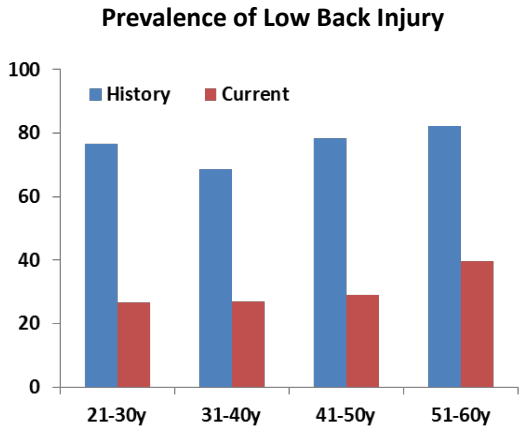
Human Dynamics Laboratory

UNIVERSITY of DENVER

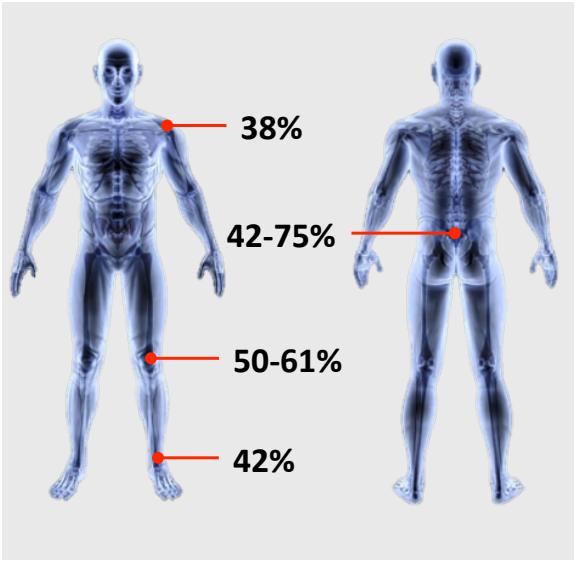
DENVER

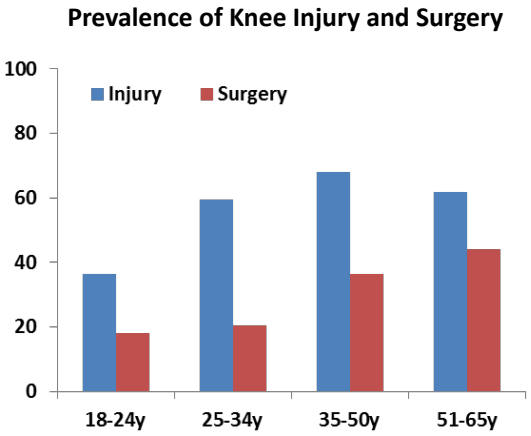
Injury prevalence: Snow sports instructors

Low back, knee commonly injured and symptomatic



Peacock et al., J Orthop Sports Phys Ther, 2005





Decker and Torry, Med Sci Sport Exerc, 2015

Decker and Torry, Med Sci Sport Exerc, 2015
Roberts, BioMed Res Int,. 2013
Peacock et al., J Orthop Sports Phys Ther, 2005

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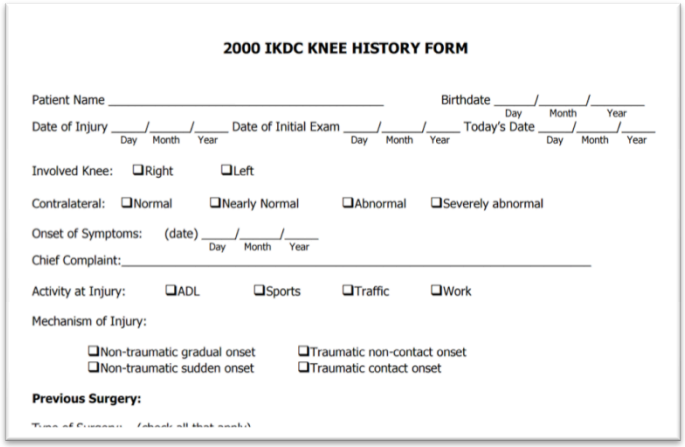
International Knee Documentation Committee (IKDC)

High level of knee function required for ski employment longevity



2000 IKDC KNEE HISTORY FORM

Patient Name _____ Birthdate ____/____/____ (Day Month Year)

Date of Injury ____/____/____ (Day Month Year) Date of Initial Exam ____/____/____ (Day Month Year) Today's Date ____/____/____ (Day Month Year)

Involved Knee: ❑Right ❑Left

Contralateral: ❑Normal ❑Nearly Normal ❑Abnormal ❑Severely abnormal

Onset of Symptoms: (date) ____/____/____ (Day Month Year)

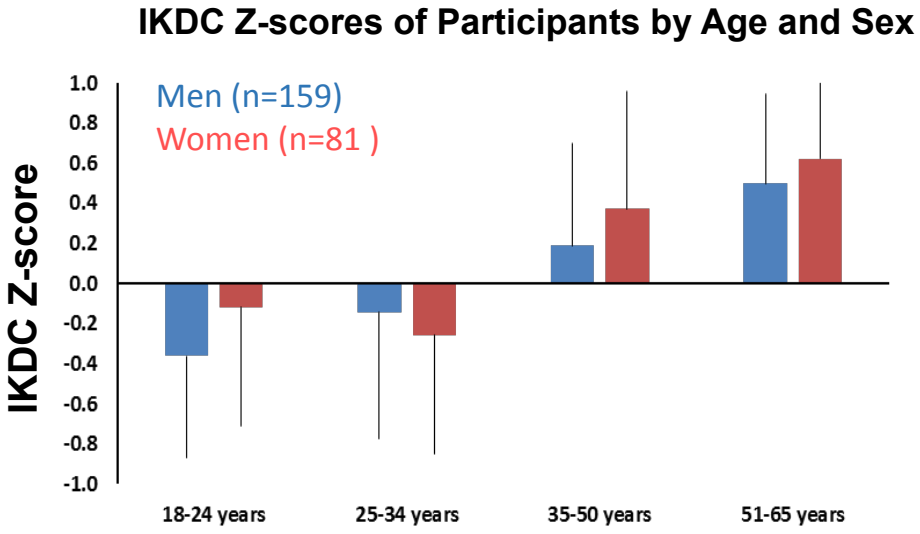
Chief Complaint:_____

Activity at Injury: ❑ADL ❑Sports ❑Traffic ❑Work

Mechanism of Injury:

❑Non-traumatic gradual onset ❑Traumatic non-contact onset
❑Non-traumatic sudden onset ❑Traumatic contact onset

Previous Surgery:



Decker and Torry, Med Sci Sport Exerc, 2015

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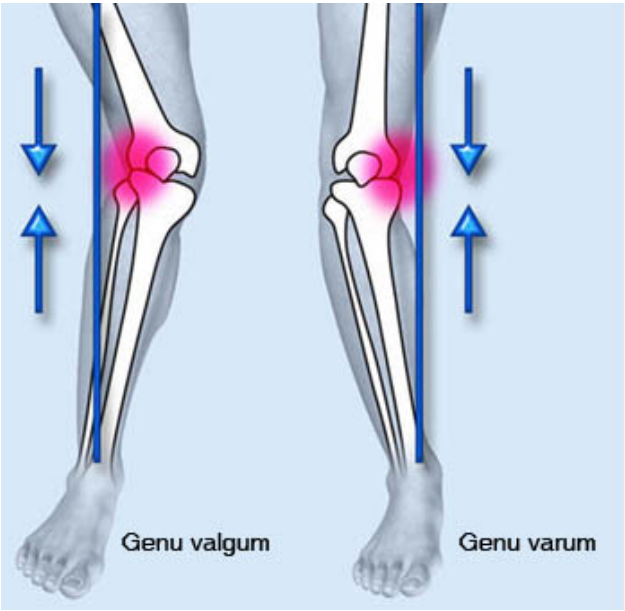
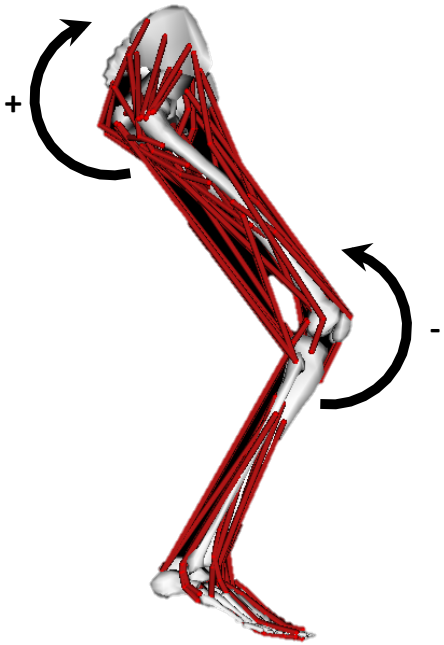
Opedix: Knee-Tec Tights





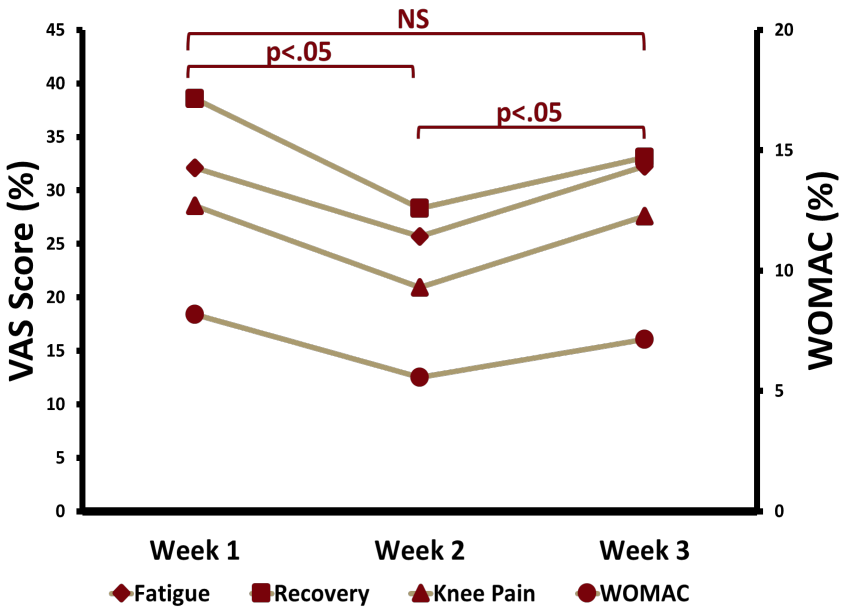
Immediate Effects of Opedix KNEE-Tec Tights

<u>29%</u> reduction in quadriceps fatigue

<u>30%</u> improvement in quadriceps fatigue recovery

<u>26%</u> Reduction in knee pain

<u>19%</u> improvement in knee function



Decker, Proceedings of the Rocky Mountain ASB, 2013

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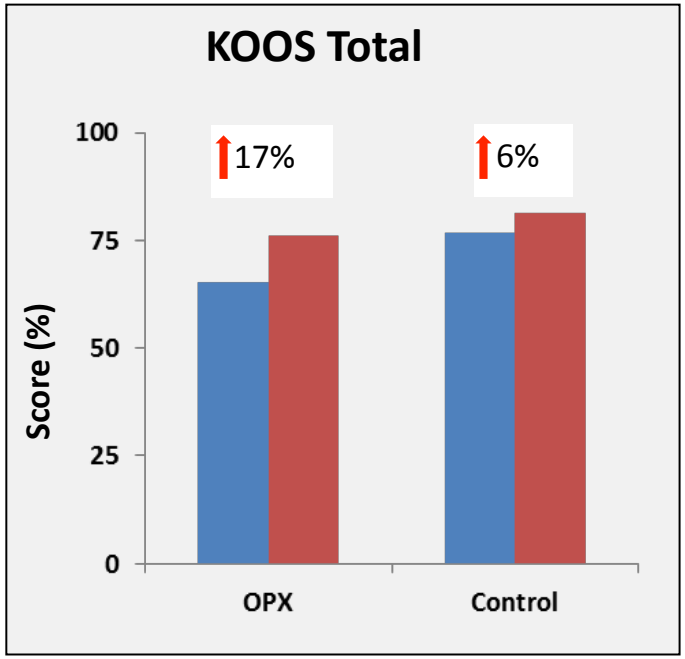
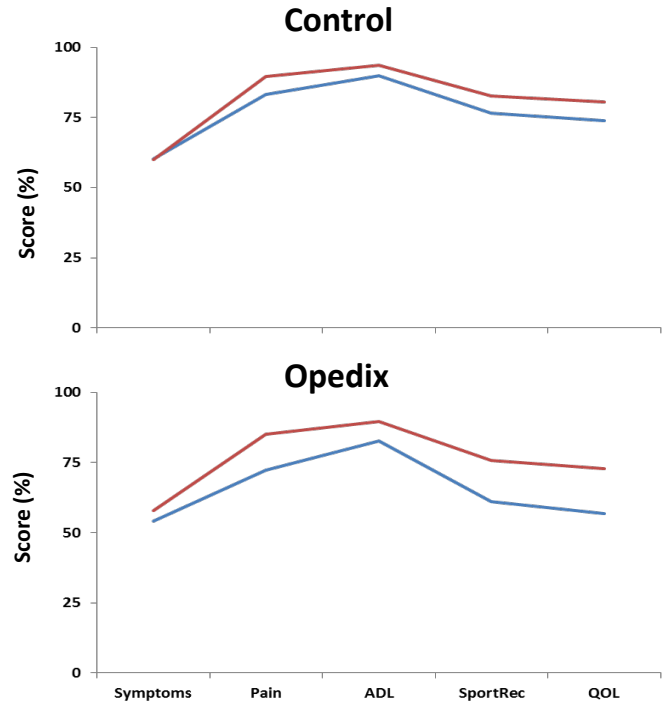
Long-Term Effects of Opedix KNEE-Tec Tights



Start of Season
End of Season



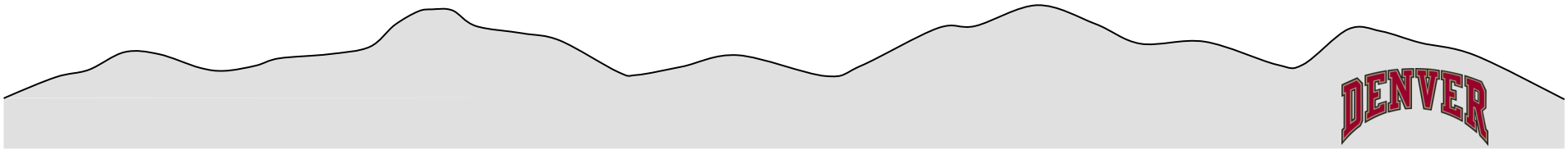
Knee Injury Risk Reduction

59% reduction in the ***Relative Risk*** of a knee injury with Opedix

One knee injury reduced for every 34 people skiing with Opedix

	Intervention Program	Knee Injury Rate (%)		Risk Reduction (%)			
		Intervention	Opedix	ARR	RRR	*p<.05	NNT
Vail, Oates et al., 1999	None (Knee Inj)	8.7	2.0	6.7	77.1	*	15
Vail, Oates et al., 1999	None (Healthy)	4.1	2.0	2.1	51.6		47
Sterret et al., 2006	Knee Brace (Knee Inj)	3.9	2.0	1.9	48.6		53
Sterret et al., 2006	None (Knee Inj)	9.1	2.0	7.1	77.9	*	14
Total		4.9	2.0	2.9	59.2	*	34

ARR, absolute risk reduction; RRR, relative risk reduction; NNT, number needed to treat

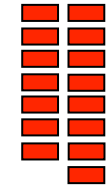


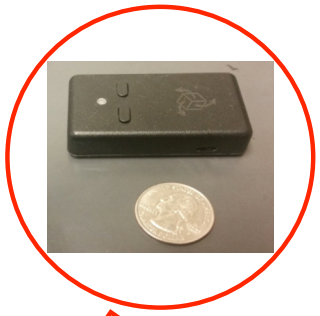
Alpine Ski Biomechanics

Michael Decker, PhD
Kevin Shelburne, PhD
Bradley Davidson, PhD

Craig Simons, PhD Student
Daniel Kim

John Seifert, PhD
William Sterett, MD





Wireless IMU (x15)

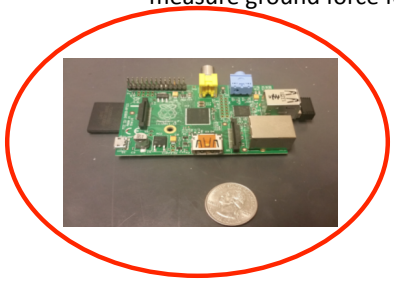
→ Data from all IMU sensors are combined to obtain segment kinematics

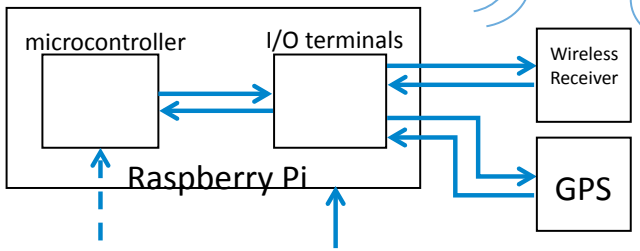
IMU

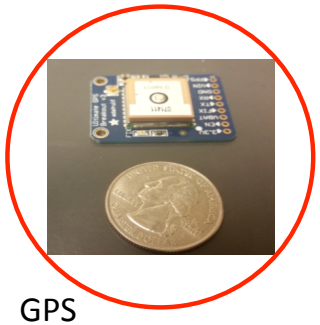
Pressure Insoles

→ Ultra thin load cells placed under each foot to measure ground force for joint kinetics

Wireless data transfer







Raspberry Pi

→ A credit card sized computer that provides computational power and storage capacity for controlling system operation

Custom computer programs are executed by the microcontroller to control sensors and coordinate data acquisition and storage

External Power (Battery)

GPS

→ Provides localization data for determining global position and trajectory of the athlete

Participants

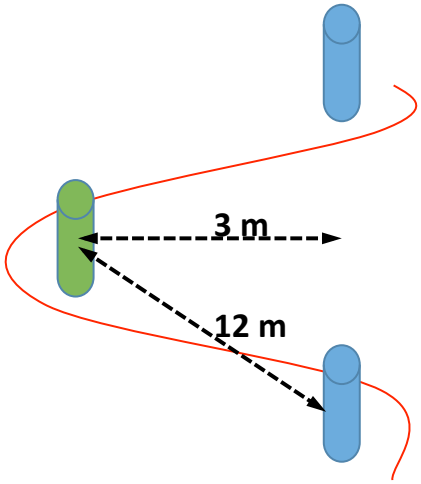
4 Males; 5 females

Age: 21.8 ± 2.7 y

FIS Slalom ranking: 24.0 ± 16.3
range (10-58)

Participant's personal FIS regulation equipment

Slalom Course Setup



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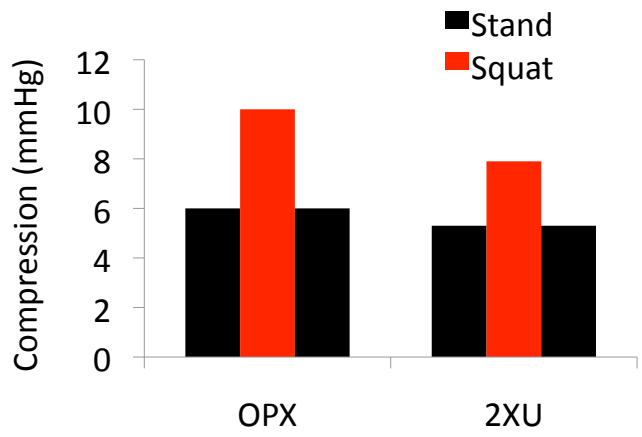
Conditions

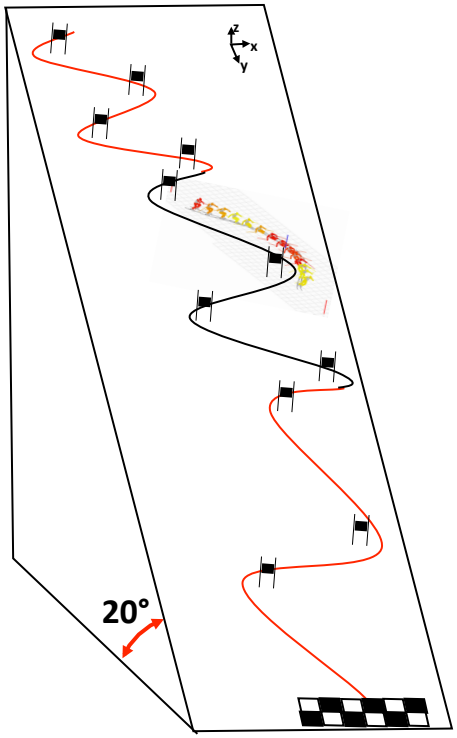
Standard Compression ¾ Length

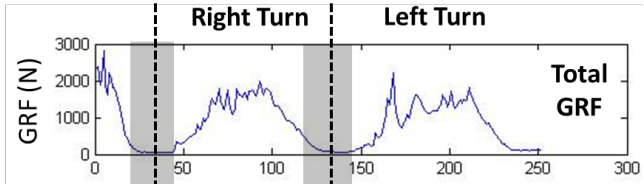
Directional Compression ¾ Length

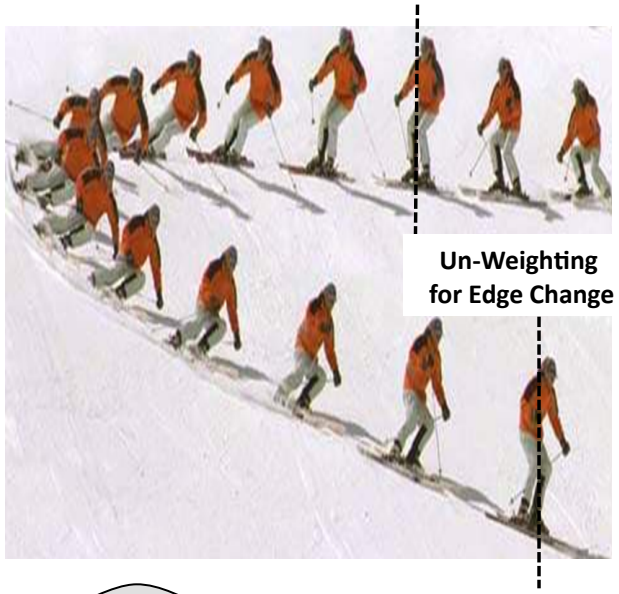


*Stiffness: OPX, 20; 2XU, 16

Analysis: 18 Turns (9 right, 9 left)







Nakazato et al., J Sports Sci Med, 2011

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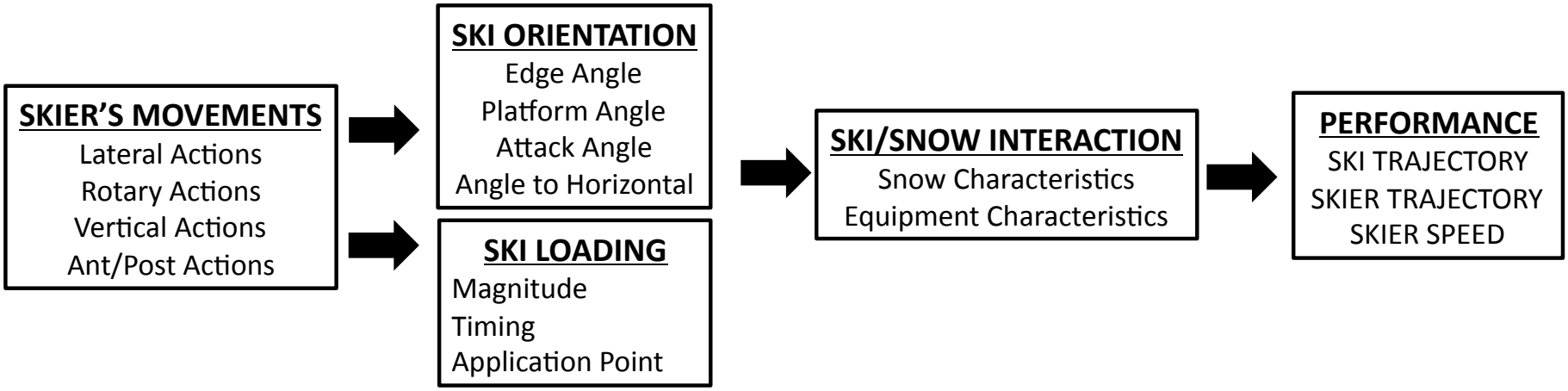
Conceptual Model of Alpine Ski Turning Technique



Adapted from Reid, 2010

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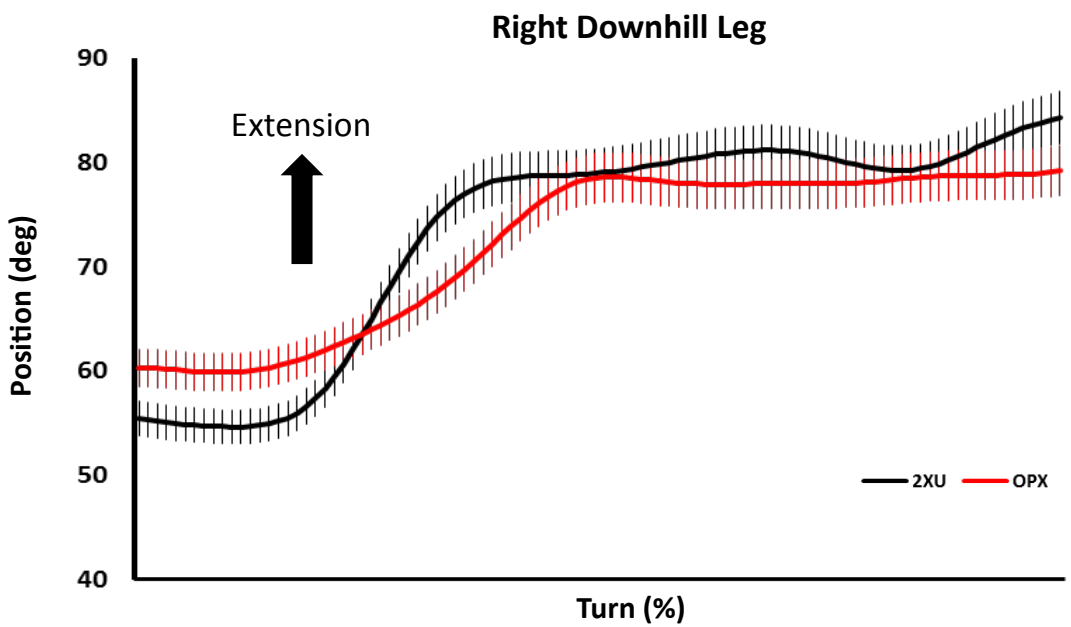
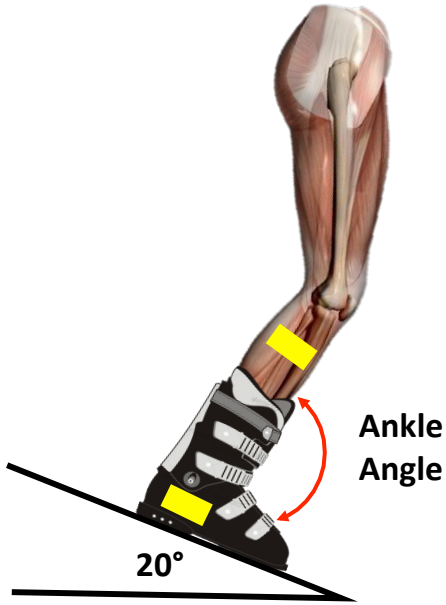
Skier's Movements: Ankle Angle

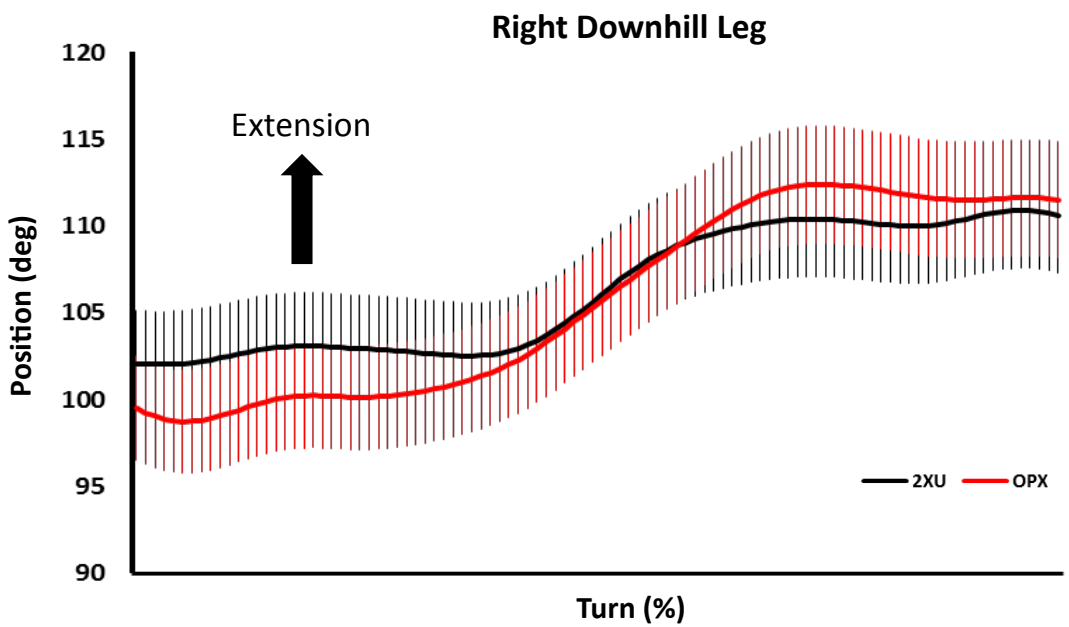
OPX: Minimum ankle position 7% less flexed

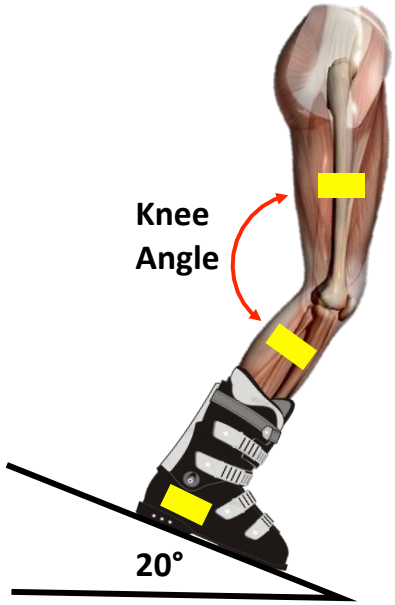




Skier's Movements: Knee Angle

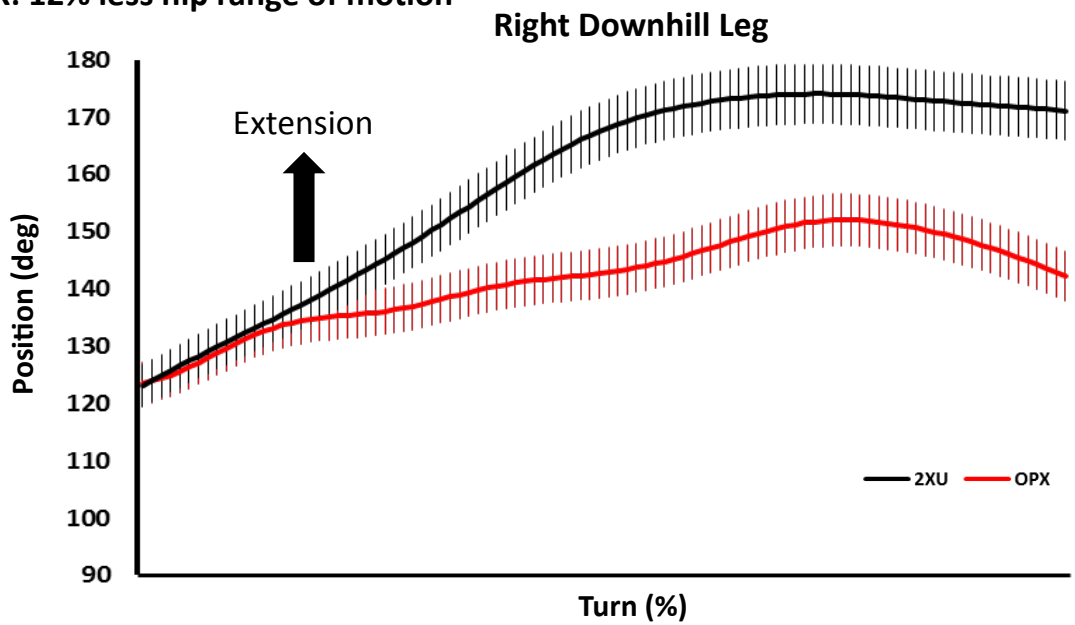
No statistical differences

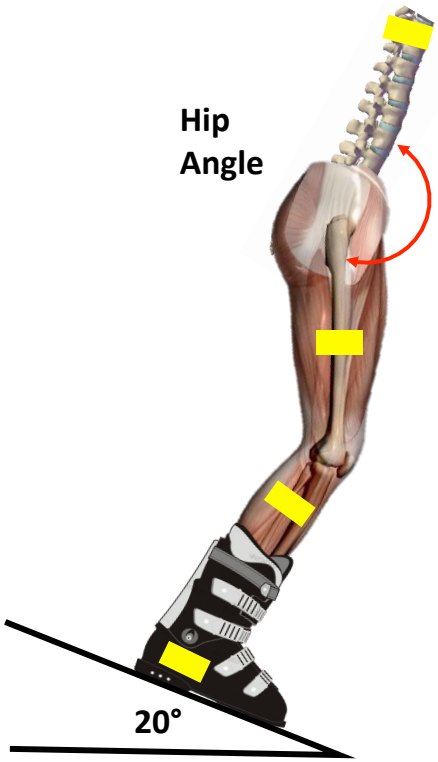




Skier's Movements: Hip Angle

OPX: Maximum hip position 5% more flexed
OPX: Average hip position 3% more flexed
OPX: 12% less hip range of motion

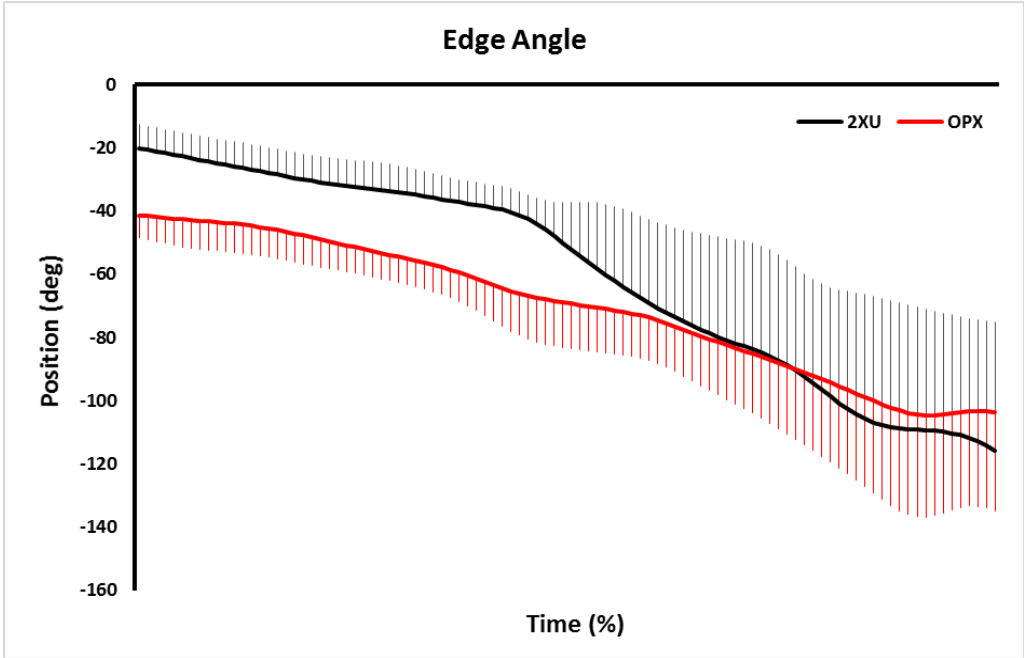


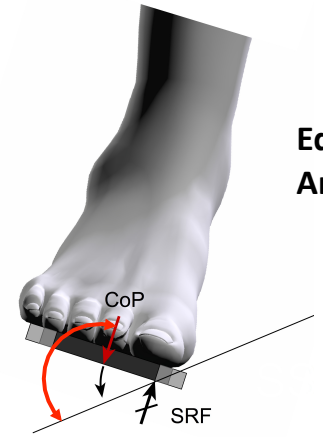


Edge Angle

OPX: Average edge angle 18% more inclined

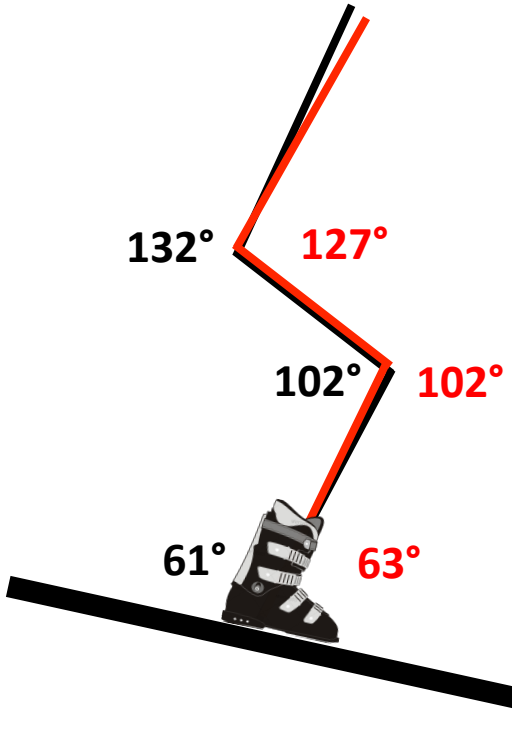
Medial Inclination





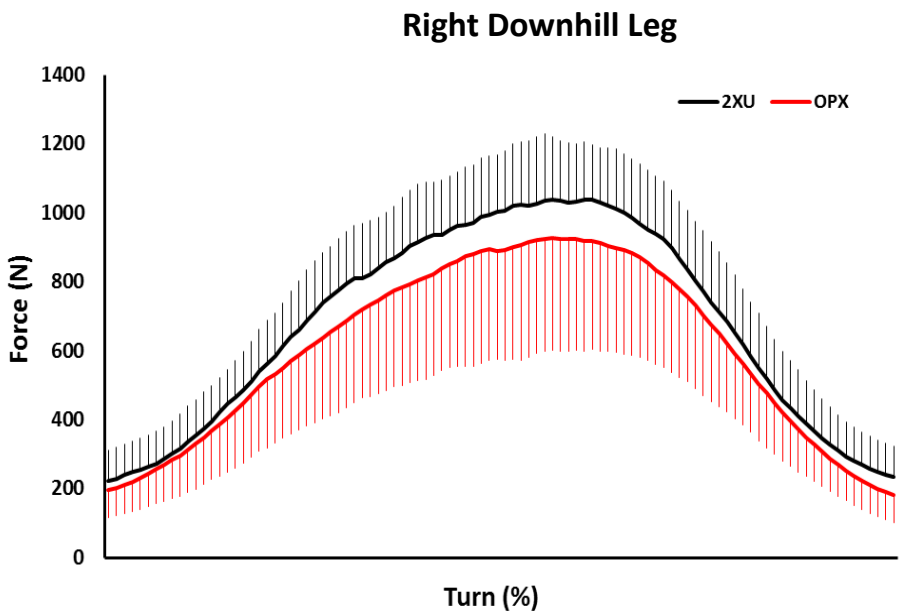
Edge Angle

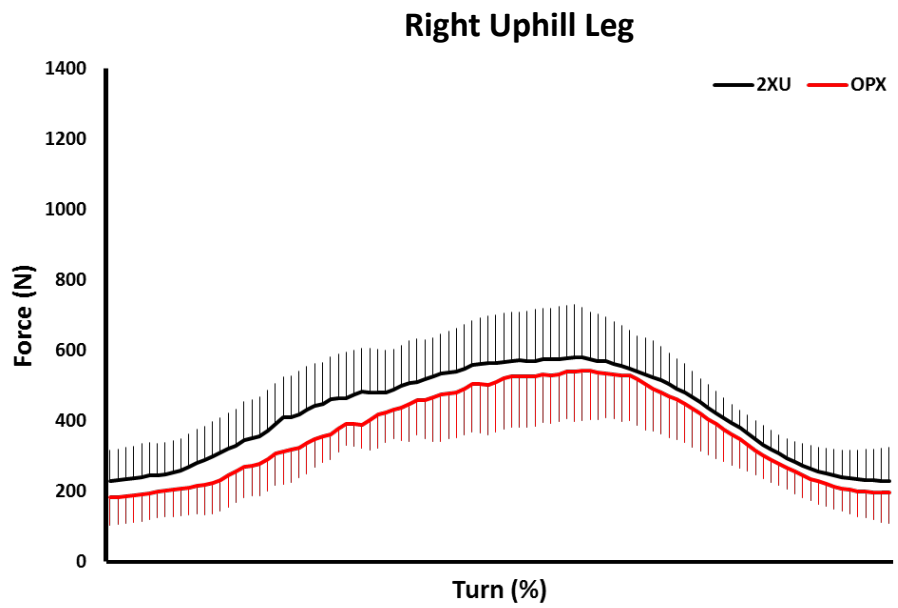
Skier's Movements: Average Position



Ski Loading: Normal Force

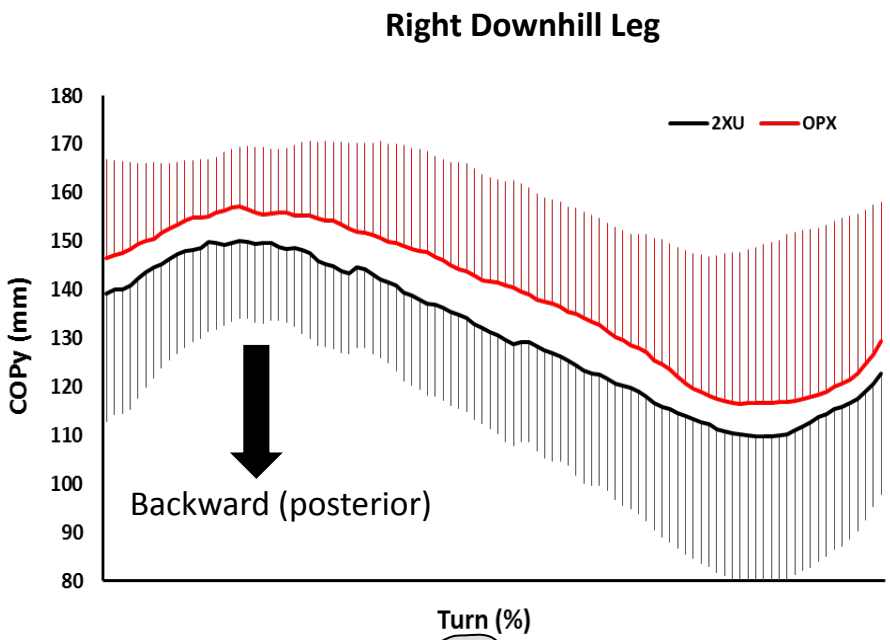
OPX: Peak force 9% lower

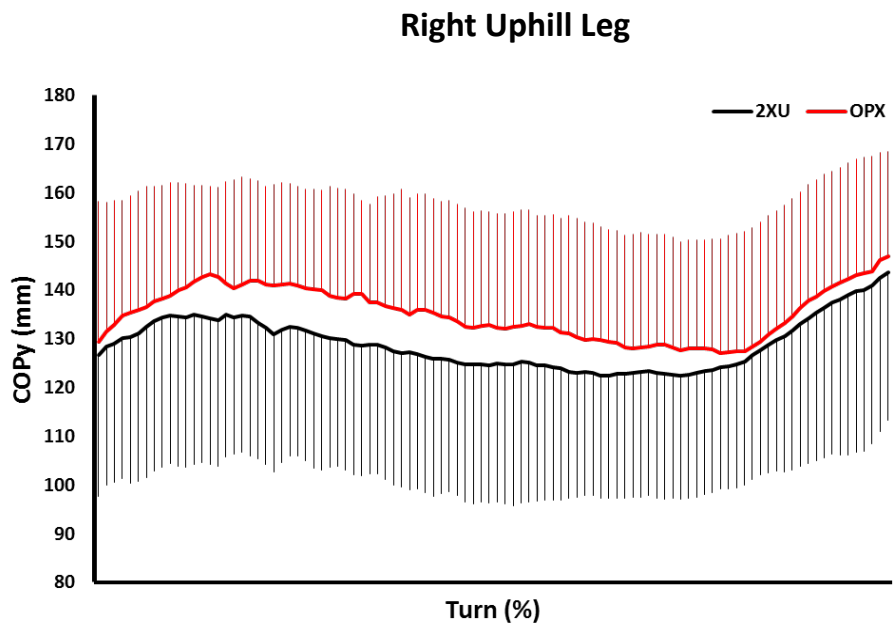




Ski Loading: Anterior-Posterior Center of Pressure

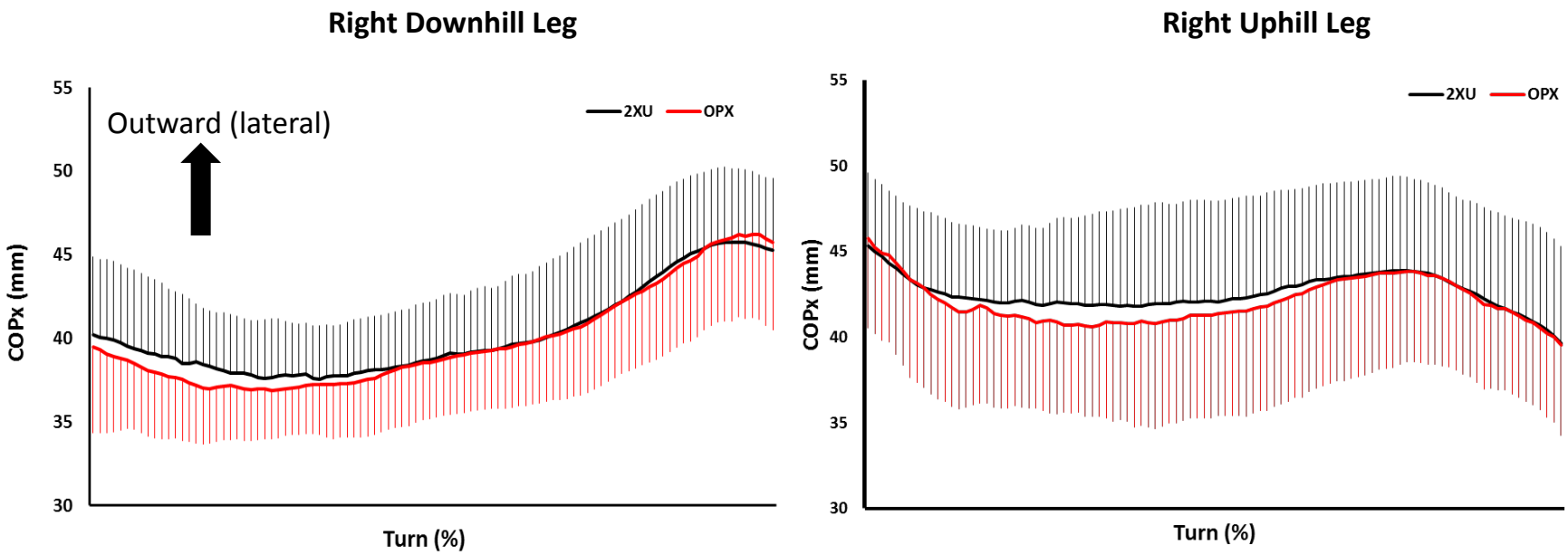
OPX: Center of Pressure 3% anterior



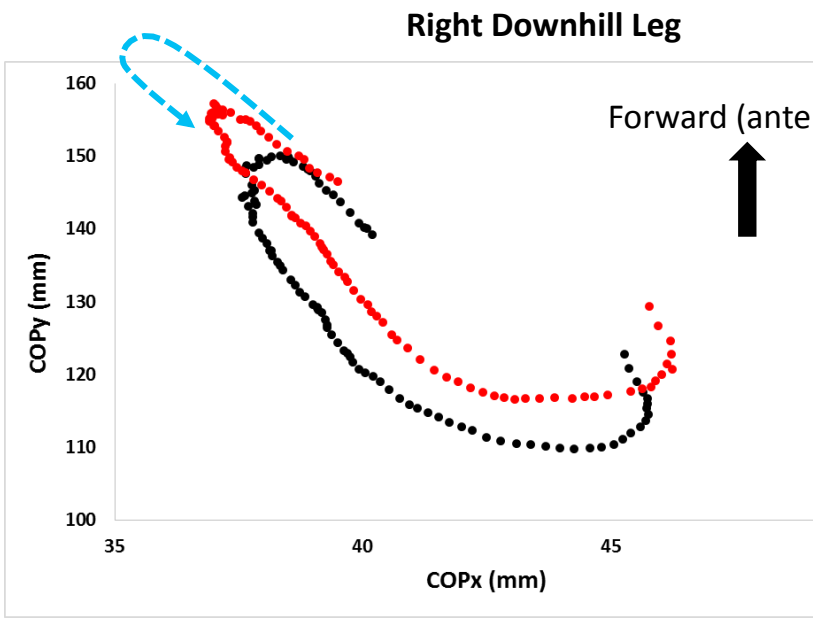


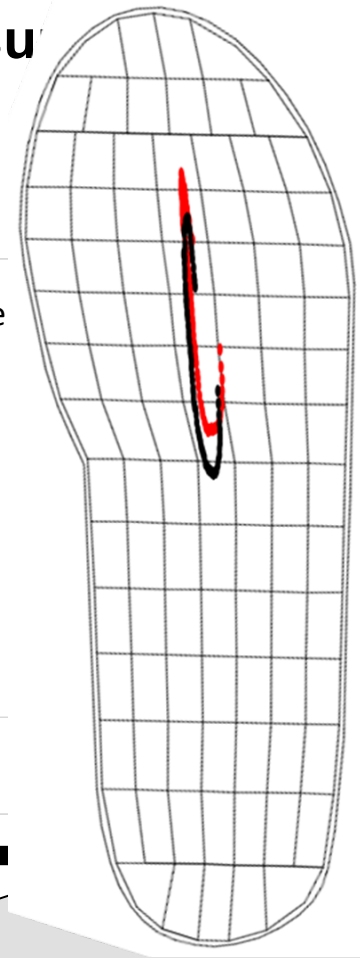
Ski Loading: Medial-Lateral Center of Pressure

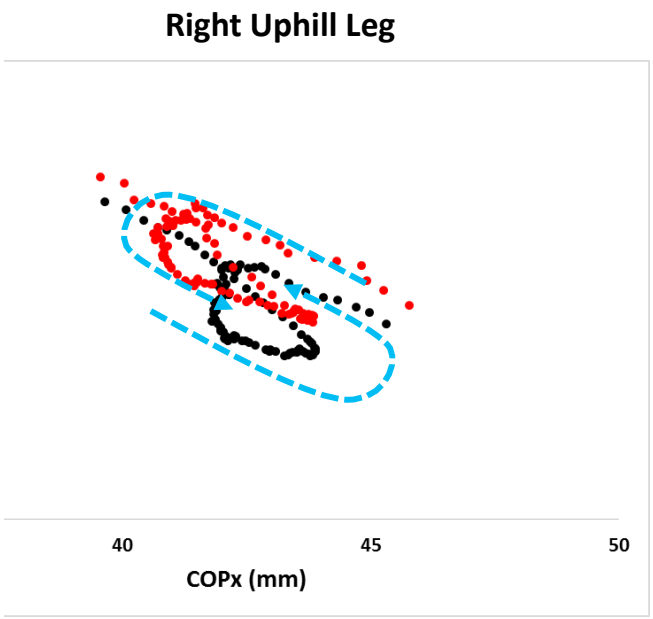
OPX: Center of Pressure 9% medial



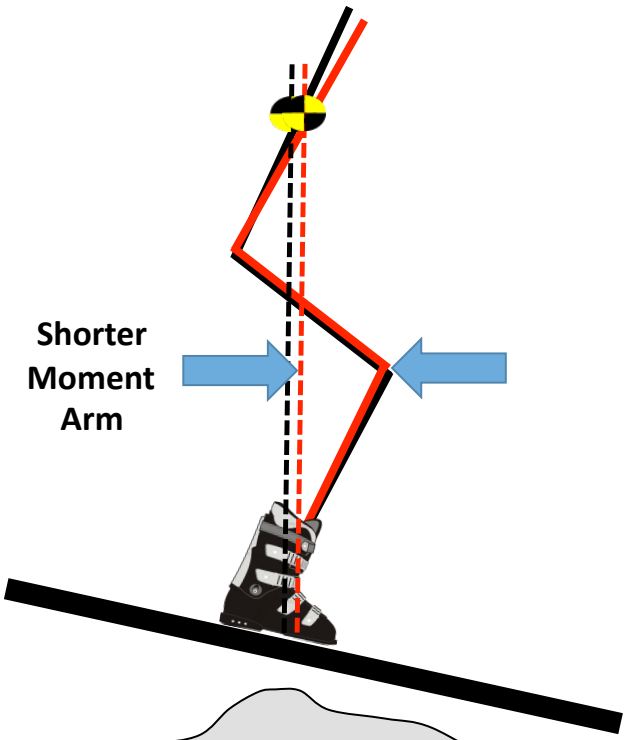
Ski Loading: Center of Pressu

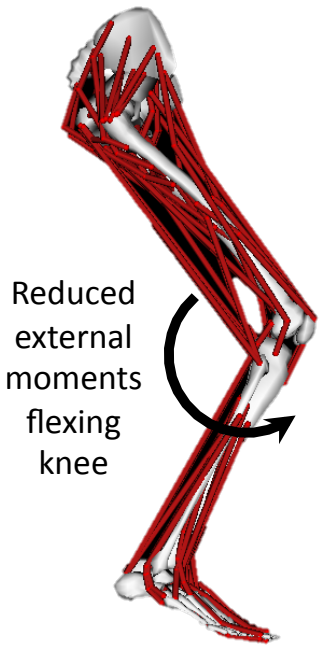






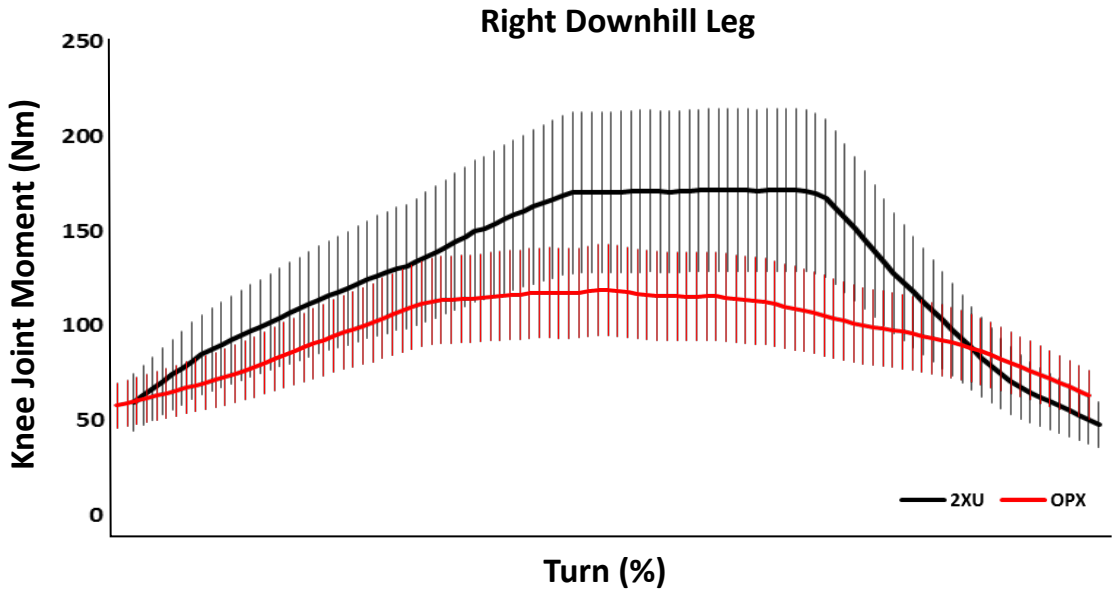
Skier's Movements and Ski Loading

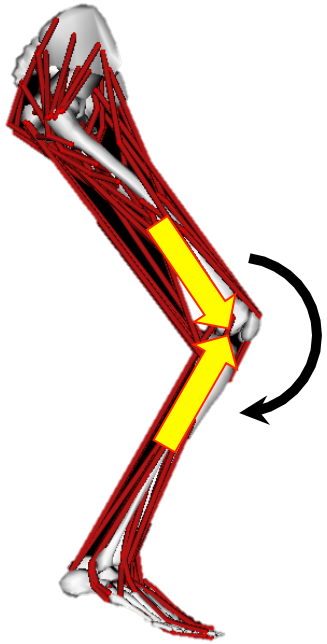




Knee Torque

OPX: Peak Knee Torque 16% Lower





Reduced internal moments extending knee

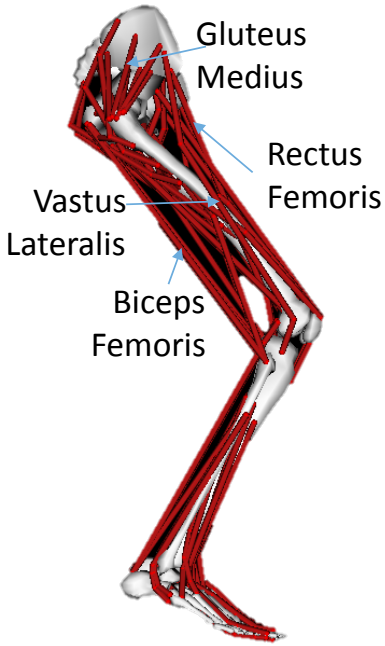
May explain 26% reduction in knee pain

Muscle Activation

OPX: Gluteus Medius (GM) 26% lower
OPX: Rectus Femoris (RF) 17% lower
OPX: Vastus Lateralis (VL) 17% lower
OPX: Biceps Femoris (BF) 4% higher

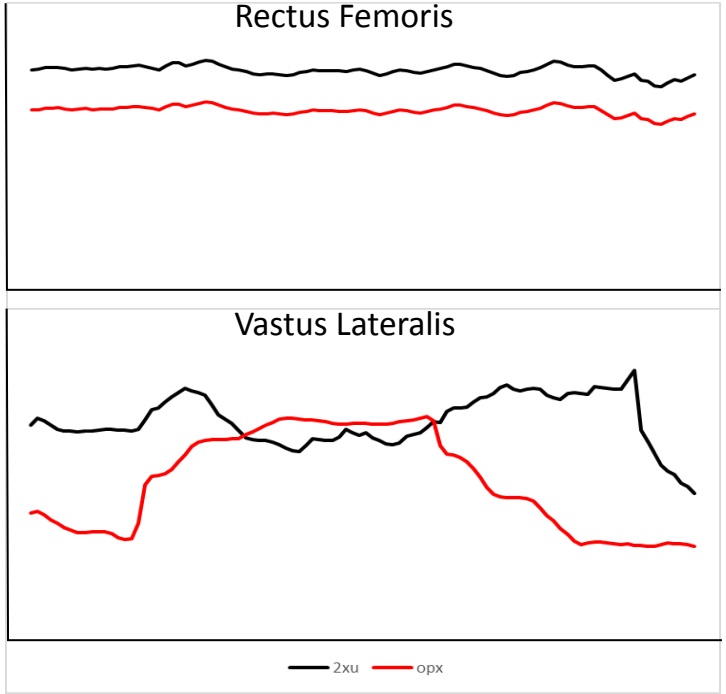
Quadriceps Muscles

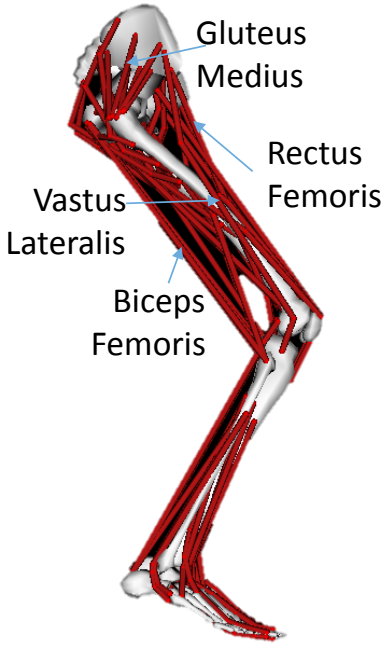
	GM	RF	VL	BF
OPX	**2.741 (1.852)**	**2.998 (1.980)**	**2.420 (1.498)**	3.648 (2.398)
2XU	3.713 (2.645)	3.618 (2.715)	2.913 (2.144)	3.494 (2.339)



Muscle Activation

OPX: Vastus Lateralis and Rectus Femoris 17% Lower

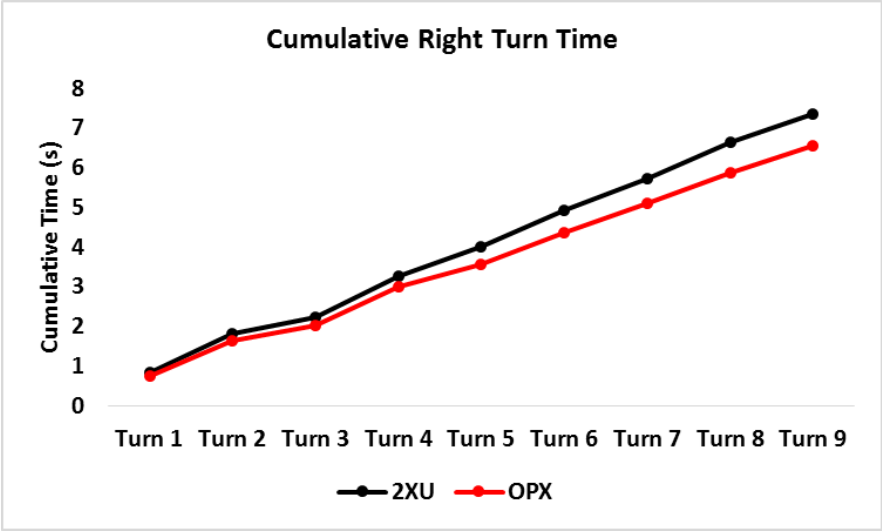


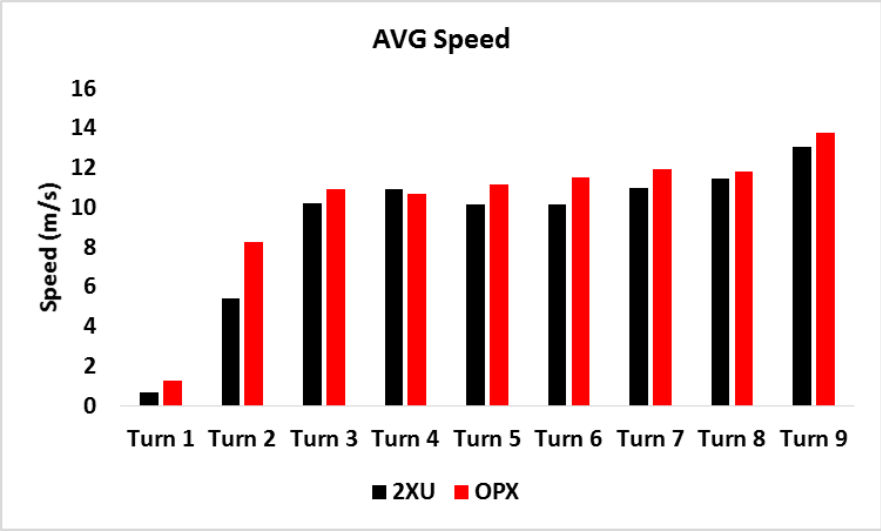


May explain 29% reduction in quadriceps fatigue

Performance

OPX: Average speed 10% higher (0.44 s faster)





Summary

Support leg alignment and promote hip extensor muscles

↓

Shift weight forward and toward inside edge

↓

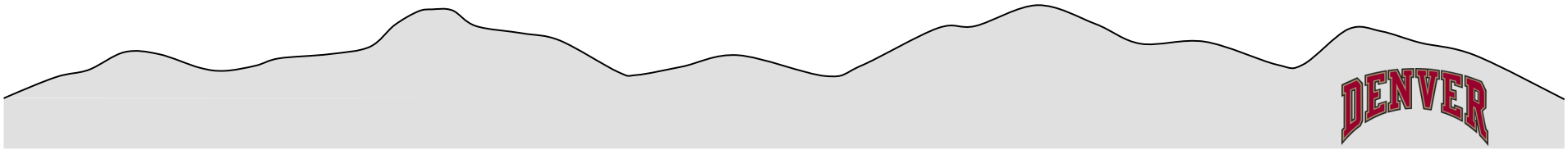
Earlier and greater carving during turn

↓

Requires less force and knee torque

↓

Lower quadriceps fatigue and knee pain



Knee-Spine Syndrome in Snow Sports Instructors

Poor lumbar spine Kinetic Health may be caused by poor knee Kinetic Health

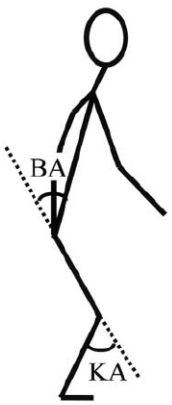
Knee injury leads to degenerative changes and pain

↓

Degenerative changes cause limitations in knee mobility

↓

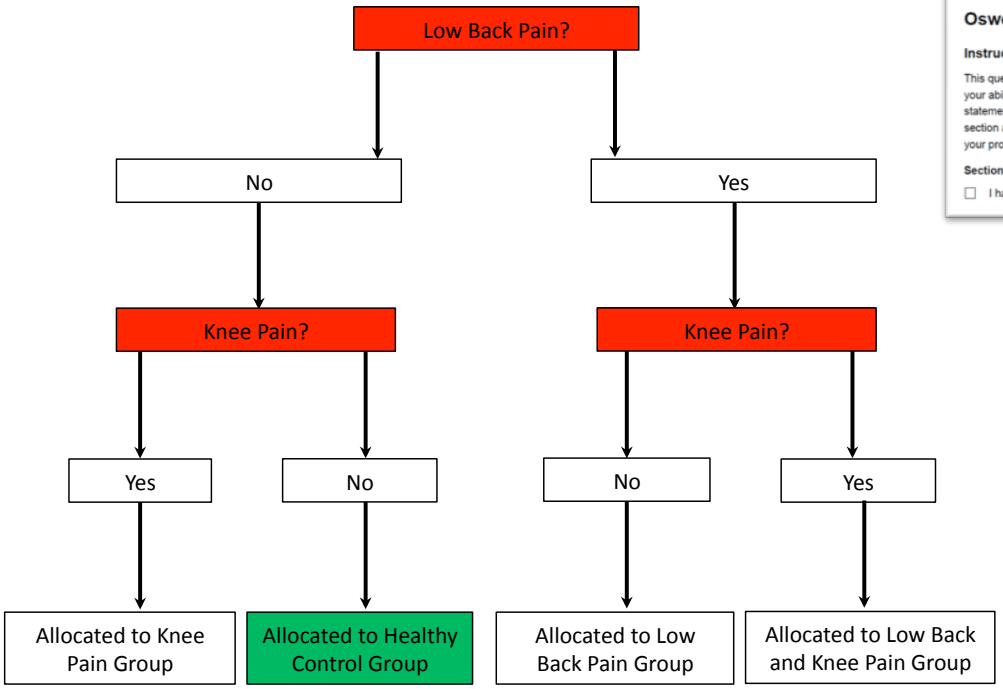
Limitations in knee mobility are related to a flattening of lower back and pain

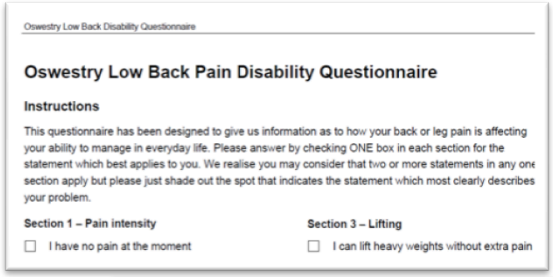


Bergstrom et al. Knee Surg Sports Traumatol Arthrosc, 2004
Murata et al., J Bone Jt Surg, 2003

DENVER

Kinetic Health Assessment





Oswestry Low Back Disability Questionnaire

Oswestry Low Back Pain Disability Questionnaire

Instructions

This questionnaire has been designed to give us information as to how your back or leg pain is affecting your ability to manage in everyday life. Please answer by checking ONE box in each section for the statement which best applies to you. We realise you may consider that two or more statements in any one section apply but please just shade out the spot that indicates the statement which most clearly describes your problem.

Section 1 – Pain intensity

☐ I have no pain at the moment

Section 3 – Lifting

☐ I can lift heavy weights without extra pain

KOOS KNEE SURVEY

Today's date: ____/____/____ Date of birth: ____/____/____

Name: _____

INSTRUCTIONS: This survey asks for your view about your knee. This information will help us keep track of how you feel about your knee and how well you are able to perform your usual activities.
Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.

Symptoms

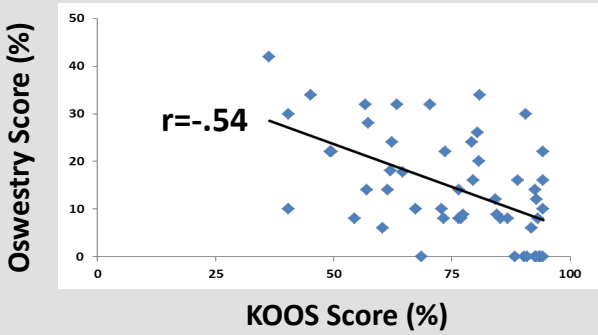
Oswestry Low Back Pain Disability Questionnaire

Low Back Pain (LBP) Prevalent in Professional Skiers	
History of LBP	78%
LBP within past year	64%
LBP within past week	54%

Oswestry LBP Disability Score	
Minimum Disability	63%
Moderate Disability	35%
Severe Disability	2%

LBP and Knee Pain (KP) during Skiing	
History of LBP and KP	40%
History of KP	75%
History of LBP	51%

LBP Disability Related to Knee Function



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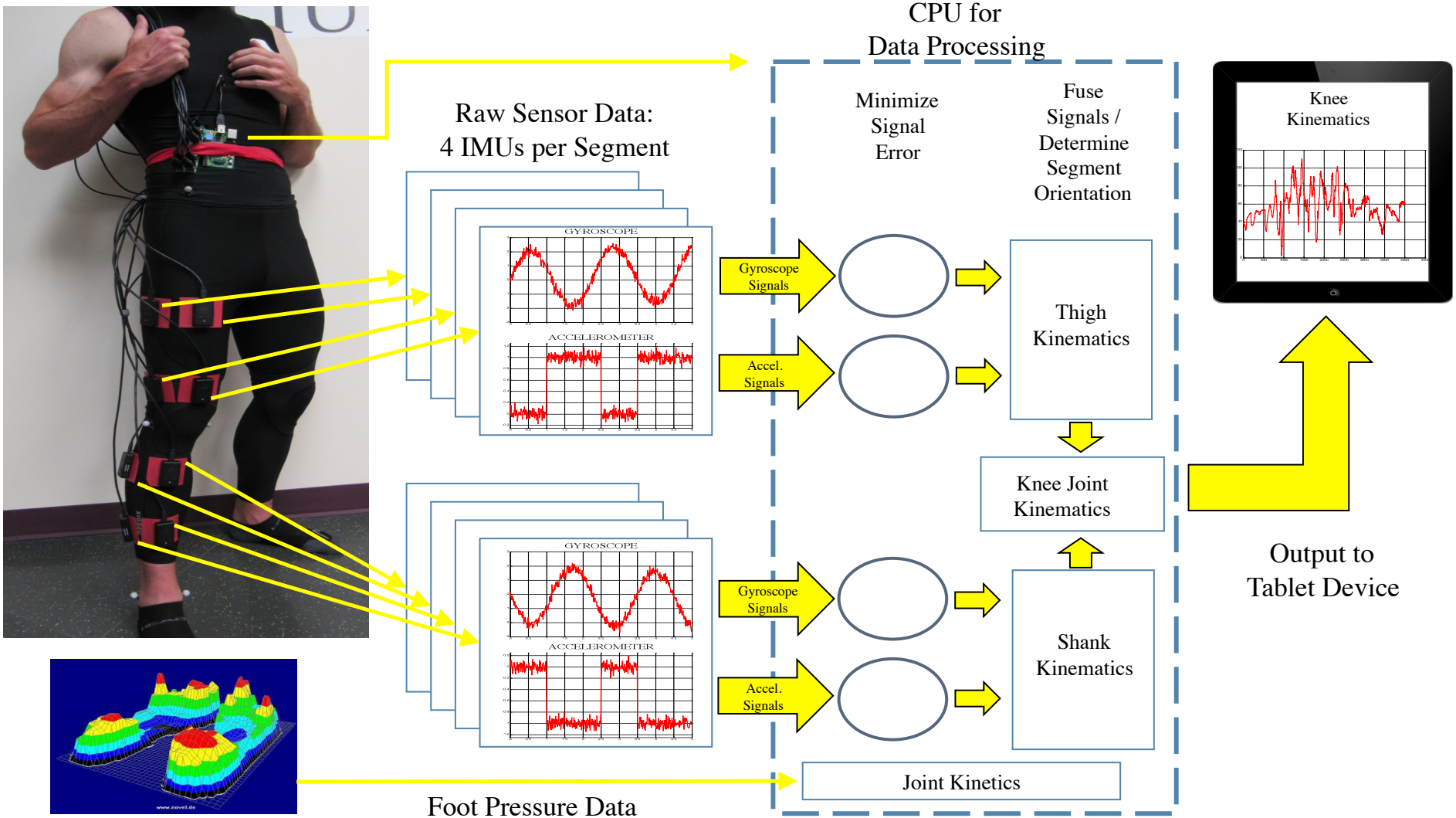
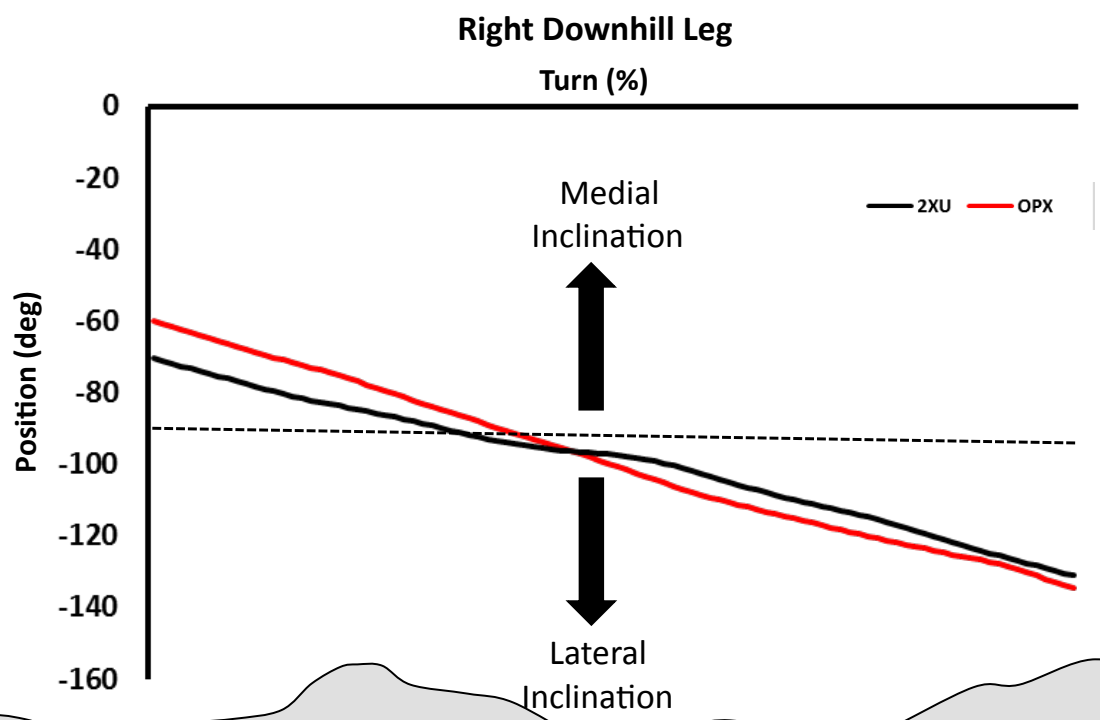
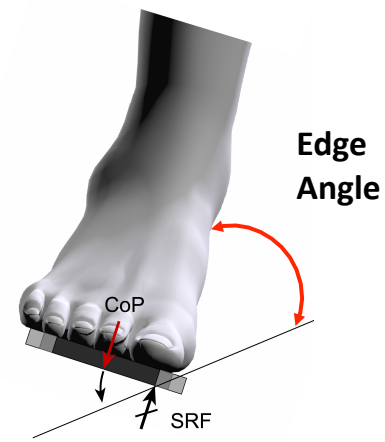

CPU for
Data Processing
Raw Sensor Data:
4 IMUs per Segment
GYROSCOPE
ACCELEROMETER
Gyroscope Signals
Accel. Signals
Minimize Signal Error
Fuse Signals / Determine Segment Orientation
Thigh Kinematics
Knee Joint Kinematics
Shank Kinematics
Joint Kinetics
Knee Kinematics
Output to Tablet Device
Foot Pressure Data

Ski Orientation: Edge Angle

OPX: Average edge angle 14% more inclined