
Wearable Tech:
Where can it take us?
NOVEMBER 2017
Jono Neville
AUT SPORTS PERFORMANCE
RESEARCH INSTITUTE NEW ZEALAND
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INNOVATION

Sports Technology Research Centre

- 1 of 9 core research groups within SPRINZ
- Engineering / Sports Science mix

Our Purpose to support the other SPRINZ research streams by providing knowledge and assistance on all things technology in sport.

AUT Millennium Campus

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Introduce self (Jono Neville) Background in Engineering and IT with transition to Sport Tech PhD

The Sports Technology Research Centre

- Sits within SPRINZ
- Combination of Engineering / Sports Science
- Purpose to support other research streams by providing knowledge and assistance on technology in all sports science research

Core technology:
Low cost inertial measurement and GPS Unit
    Cricket bowling workload and intensity tracking
Isometric force measurement using wireless load cells
    Isometric midthigh pull
Effects of wearable resistance on sprint kinematics and kinetics
    Team went to Japan measuring 50m sprints
        Force plate, IMU, motion capture, radar, image / video
Development of a lightweight expandable material force mat.

Goal of this workshop

Identify current technology in primarily a S&C space

Will look at some tangential technology

Will be limited due to the sheer quantity of new products

It's a workshop! So please I encourage you to raise questions, discuss and chip in

Overview

- Background
- Gold Standard Tech
- Introduction to Wearables
- Examples from research
- Gym wearables
- Sport specific wearables
- Possible future developments

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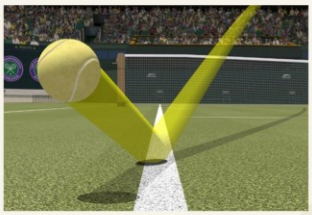
Background

What is the purpose of technology

Assisting in in athlete:

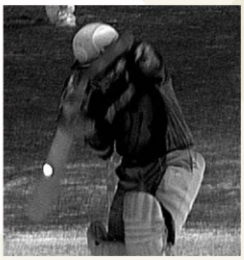
- Monitoring
- Injury prevention
- Injury recovery



Tennis Hawk-eye system in practice

Less known / thought-about applications

- Sport Fairness / umpiring or referring
  - Cricket - Video umpire / Snick-o-meter / hotspot camera / stumps camera
  - Tennis - Hawke eye
- Spectator engagement
  - Access to athlete / team information
  - Access to performance data
  - Apps
  - Broadcasting revenue



Cricket hotspot camera detecting ball-bat impact point.

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Benefits

- Elite
- Sub-elite
- Public / social

Risks

- Drowning in data

Solutions

- Smarter sensors
- Automation and data mining
- Communication / understanding

Adapting technology from the research environment will have ideally already answered the question of what we are trying to answer.
The approach will change from a research environment to practical environment.

Best practice Measurements

- Motion capture systems
- Force plates
- Video analysis
- Linear position transducers (LPT)

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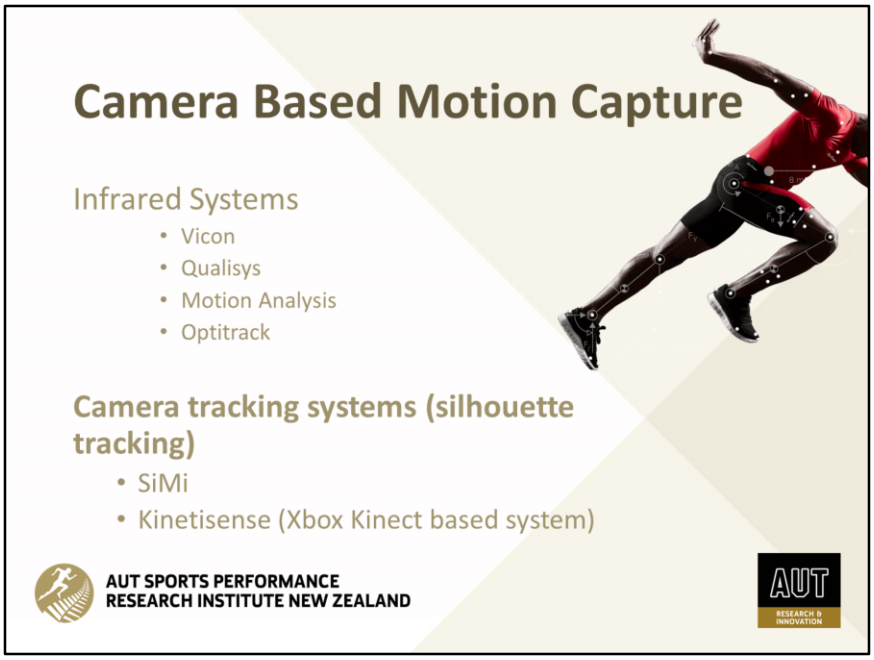


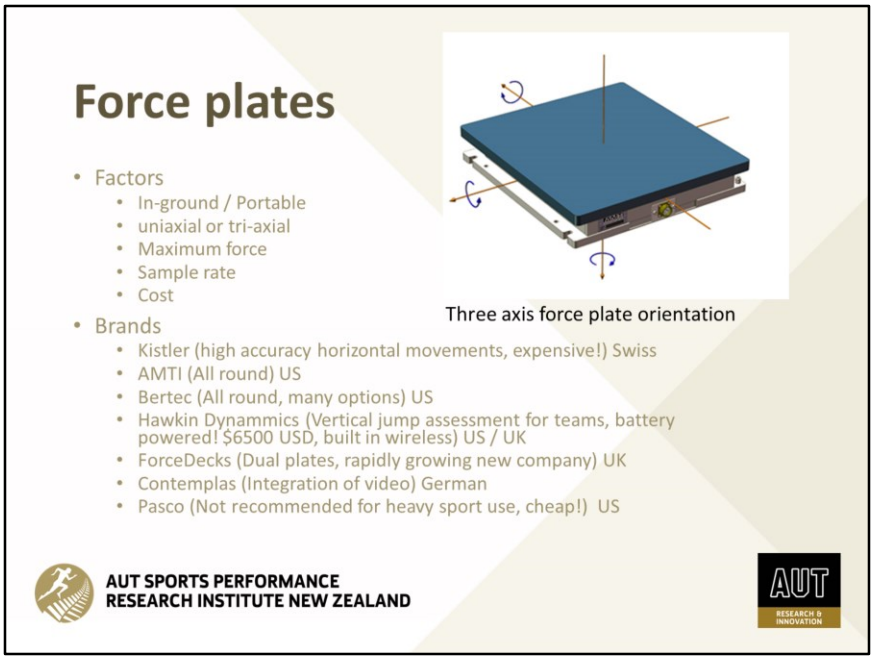
Optimal fitting of silhouettes with 3D-model allows extraction of 3D joint positions and joint angles.
Significant differences between the SiMi and marker tracking, especially during rotations.

SiMi Validity

[1] Becker, L. and Russ, P., 2015. Evaluation of joint angle accuracy using markerless silhouette based tracking and hybrid tracking against traditional marker tracking. *Poster für Masterarbeit bei Simi Reality Motion Systems GmbH und der Otto-von-Guericke-Universität Magdeburg*.

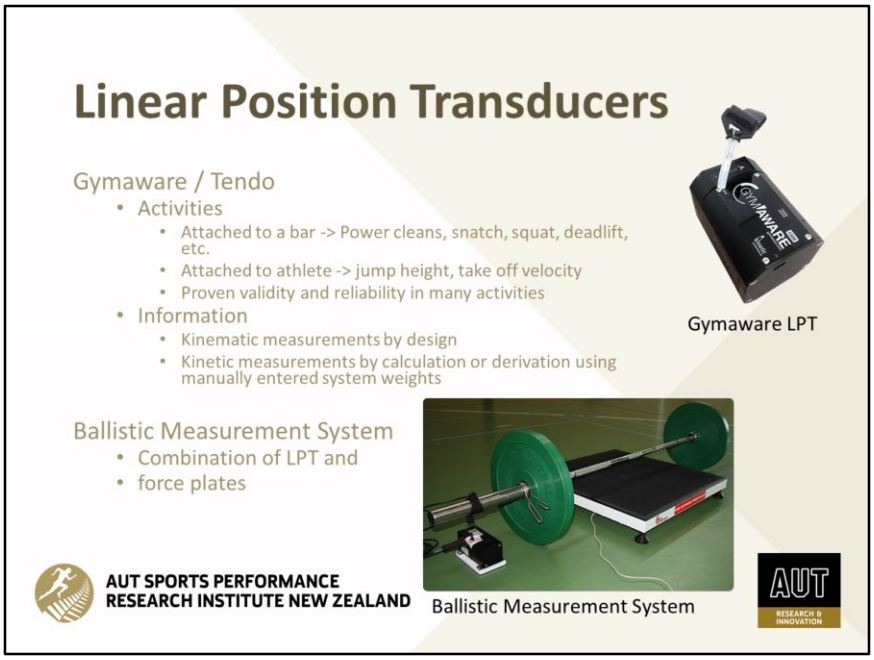
[2] Frühschütz, H., Becker, L., Russ, P. and Spitzenpfeil, P., 2017. EVALUATION OF SILHOUETTE-BASED MARKERLESS TRACKING FOR KINEMATICS IN SPORT. *ISBS Proceedings Archive*, *35*(1), p.231.

Lack of peer reviewed publications on Kinetisense



Force plates
Common Use
- Vertical forceplates
  - Jump assessment (squat, counter movement, drop, single leg)
  - Isometric vertical strength tests
- 3D forceplates
  - Gait
  - Change of Direction

Practical applications of force plates
- Gym settings
  - Racks / Free weights
  - Cable weights



LPT Validity to Video coded data

[1] Drinkwater, E.J., Galna, B., McKenna, M.J., Hunt, P.H. and Pyne, D.B., 2007. Validation of an optical encoder during free weight resistance movements and analysis of bench press sticking point power during fatigue. *Journal of Strength and Conditioning Research*, *21*(2), p.510.

LPT Reliability

[2] Cormack SJ, Newton, R.U., McGuigian, M.R. and Doyle, T.L.A. Reliability of Measures Obtained During Single Repeated Countermovement Jumps. International Journal of Sports Physiology and Performance. 2008;3(131-144).

[3] Taylor K-L, Cronin, J., Gill, N.D., Chapman, D.W. and Sheppard, J. Source of variability in iso-inertial jump assessments. International Journal of Sports Physiology and Performance. 2010;5:546-58.

[4] Hori N, and Andrews, W.A. Reliability of Velocity, Force and Power Obtained from the GymAware Optical Encoder During Countermovement Jump With and Without External Load. Journal of Australian Strength and Conditioning. 2009;17(1):12-7.

[5] Cronin JB, Hing, R.D. and McNair, P.J. Reliability and Validity of a Linear Position Transducer for Measuring Jump Performance. Journal of Strength and Conditioning Research. 2004;18(3):590-3.

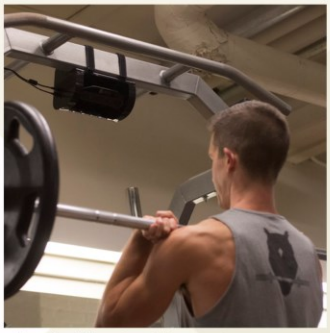
Video Analysis systems

Video collection systems

- Perch – 3D motion tracking for kinetic and kinematic assessment
- Similar systems set up in gyms such as the Queensland academy of sport.
- Un-obtrusive, once set up, easy to run / manage, reasonably priced.

Video analysis systems

- Dartfish (commonly used and well supported, a bit pricey $240 USD/year)
- Kinovea (rapidly growing, open source!)



Perch video tracking system

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Perch is looking for strength and conditioning coaches, gyms, and athletes to demo our product. (still in beta trials) no publications on accuracy yet.

Wearable Technology
(for sport)

- What is wearable technology
- Common (and not so common) sensors
- Gym specific wearables
- Sport specific wearables
- Trends in future wearable technology

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What makes up wearable tech

- Computer system
- Communications
- Sensors

Limitations

- Processing speed
- Software
- Size / shape / weight
- Impact on sport

Considerations

Design:

- Hardware is important (Speed, power)
- Software is important (OS, Apps)
- Interfaces are important (How do we use it?)
- Implementation is important (Meets needs of user?)

Application:

- Size
- Weight
- Design
- Battery life

Just a few of the smart watch options

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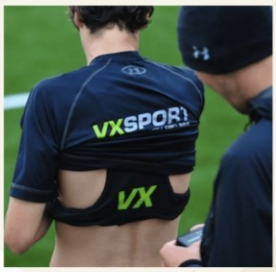
Global Positioning Systems

GPS for team sports

- Catapult / GPSports
- VXSport
- StatSport
- Axysis
- SPT



VX Sport GPS unit and vest

- New GPS Developments
  - Standard GPS -> no base station (2-3m) (satellite timing)
  - Differential GPS -> base station assisted GPS used in car racing (50cm) (satellite timing)
  - Real Time Kinetic (RTK) GPS -> also base station assisted, (1-2cm) (signal wavelength calculations)

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Different systems range from 1->25 Hz

The Data

- Position
- Displacement
- Speed
- Acceleration

Algorithms to calculation

- Bouts of acceleration
- Velocity intensity thresholds
- synchronize with video

GPS for personal or individual activities

- Garmin / Tomtom / Polar / Apple
- Smart phone apps
- Samsung Gear2

Heart Rate Sensors

Samsung Gear Icon X

- Measurement Location
  - Chest strap -> gold standard, most inconvenient to use.
  - Wrist -> smart watch.
  - Inner ear -> smart headphones.
- Brands
  - Polar – many options
  - Garmin – many options
  - Wahoo - chest sensor
  - Samsung Gear Icon X – in-ear wireless activity and heart rate

Light pulse oximetry

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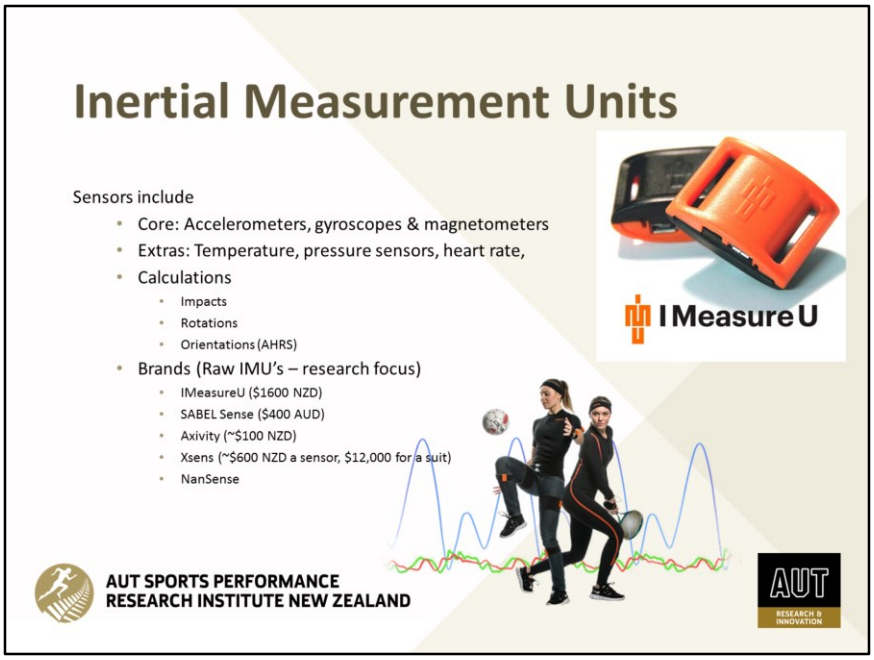
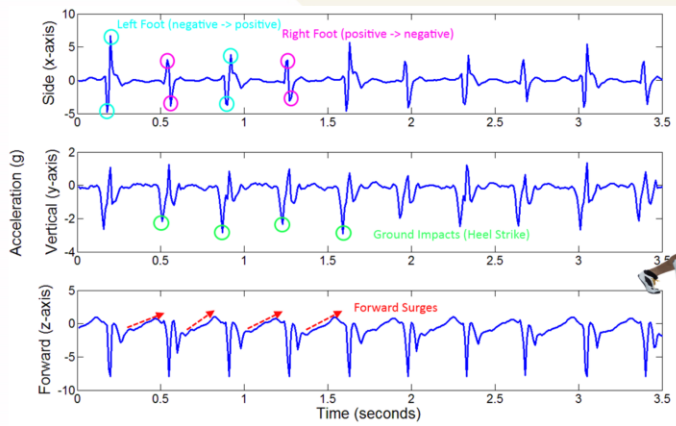


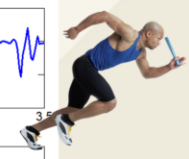
XSense Accuracy

[1] Xsense has shown good flexion / extension measurements but decreased accuracy in the other two axes.

Zhang, J.T., Novak, A.C., Brouwer, B. and Li, Q., 2013. Concurrent validation of Xsens MVN measurement of lower limb joint angular kinematics. *Physiological measurement*, *34*(8), p.N63.

Accelerometers (example)





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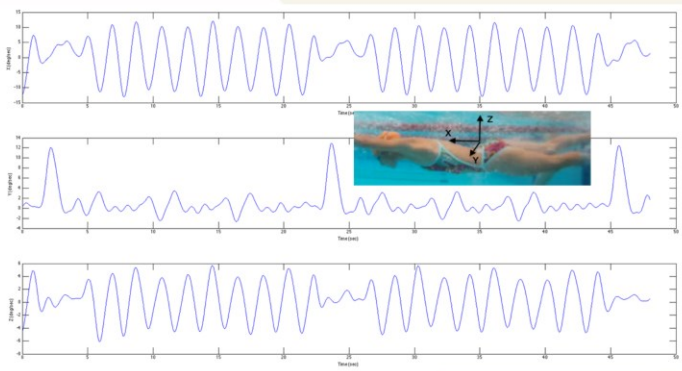
Gyroscope (example)



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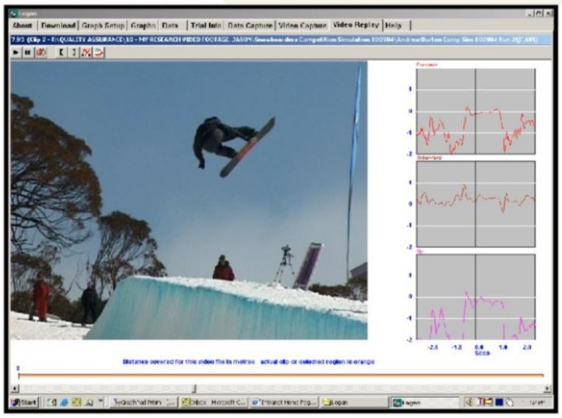
If you can measure it, you can improve it!

Outside the box applications:



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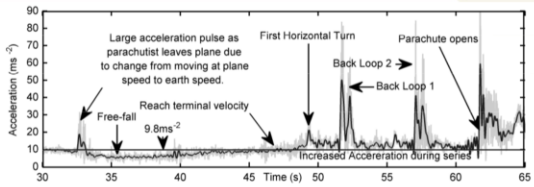

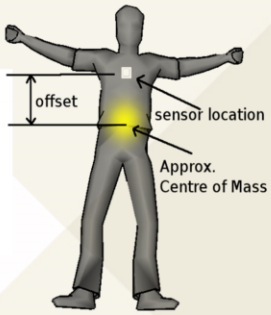

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If you can measure it, you can improve it!

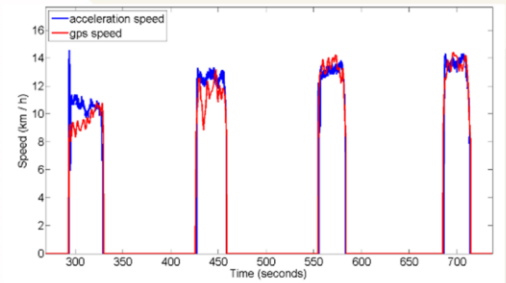
Outside the box applications:

Method

- Sample an athlete running at a range of speeds
- Model athlete running speed with step frequency
- Use model on continuous running data to estimate running speed

Benefits

- Light weight
- Small form factor
- Low power
- No external dependencies



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Application Specific Wearables

- Gym wearables
- Sport specific wearables

Huge range of research projects on IMU in specific sport / gym activities.
A few of these (if in enough demand) make their way into the commercial space.

Beast, full imu, design for athletes and coaches, max 50Hz
Beast Valid for low intensity squats but not high intensity or bench press against LPT

No known validation papers on Moov

Cricket is a brand new product that allows for electro-muscle measurement and has won several early business awards and featured on TED ideas worth sharing blog.

Beast

[2] Bergenblad, J., 2017. Validation study of a portable accelerometer to measure muscular power output: Correlation between the Beast Sensor and the linear encoder MuscleLab.

Push Validity to Motion Capture

[1] Sato, K., Beckham, G.K., Carroll, K., Bazyler, C. and Sha, Z., 2015. Validity of wireless device measuring velocity of resistance exercises. *Journal of Trainology*, *4*(1), pp.15-18.

Gym Specific Wearables

Atlas

- Garmin Vivosmart ($200 NZD)
- Atlas – machine learning, strength training ($200 NZD)
- Jabra elite sport – headphones with heartrate ($400 NZD)
- Moxy Muscle Oxygen Tracker (different approach, using muscle oxygenation via light pulse oximetry, more research focused)($1300 USD)
- Skulpt – Body fat percentage measurement – hold the device on specific muscle locations to measure body composition. ($100 USDz)

Garmin Vivosmart

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X2 Biosystems –massive acceleration and angular acceleration over-estimates due to sensor – skin coupling

A review by Patton, and a systematic review by O'Connor have shown these systems to have limited utility due to error rates, designs, and low specificity in predicting concussive injury.

Validity of X2 Biosystems concussion monitoring

[1] Siegmund, G.P., Guskiewicz, K.M., Marshall, S.W., DeMarco, A.L. and Bonin, S.J., 2016. Laboratory validation of two wearable sensor systems for measuring head impact severity in football players. *Annals of biomedical engineering*, *44*(4), pp.1257-1274.
[2] Wu, L.C., Nangia, V., Bui, K., Hammoor, B., Kurt, M., Hernandez, F., Kuo, C. and Camarillo, D.B., 2016. In vivo evaluation of wearable head impact sensors. *Annals of biomedical engineering*, *44*(4), pp.1234-1245.

A review of a wide range of concussion measuring wearable sensors.

[3] Patton, D.A., 2016. A review of instrumented equipment to investigate head impacts in sport. *Applied bionics and biomechanics*, *2016*.

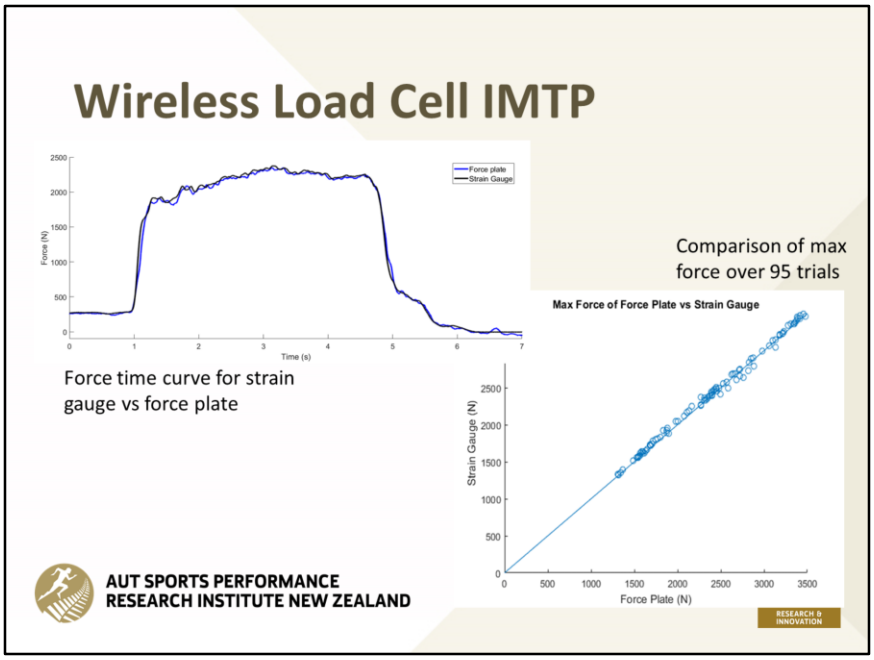
[4] O'Connor, K.L., Rowson, S., Duma, S.M. and Broglio, S.P., 2017. Head-Impact–Measurement Devices: A Systematic Review. *Journal of athletic training*, *52*(3), pp.206-227.

Tennis Babolat POP Validity

[5] Kos, M., Ženko, J., Vlaj, D. and Kramberger, I., 2016, May. Tennis stroke detection and classification using miniature wearable IMU device. In *Systems, Signals and Image Processing (IWSSIP), 2016 International Conference on* (pp. 1-4). IEEE.


Wearable
Technology
Trends

Superflex is a compression exoskeleton suite designed by SRI International
Potential for eccentric load training in the field, during dynamic activities, game simulations
Adapts to movement patterns with the potential to target specific lower limb and back movements



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