DEPARTMENT FOR HEALTH
Sport, Health and Exercise Science

Load Monitoring Workshop

UNIVERSITY OF BATH

RS BATH RUGBYSCIENCE

#RSN live17

RSNLive17

Presented by Dr. Sean Williams & Dr. Dan Weaving

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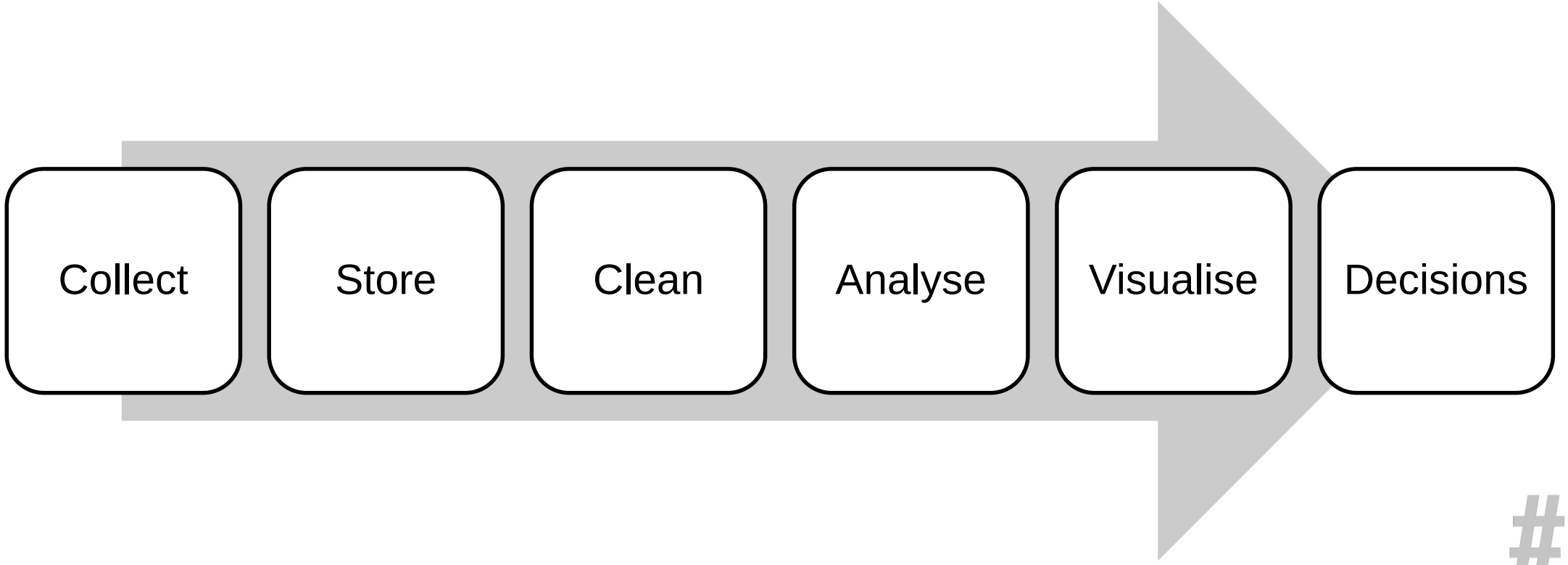
Workshop Plan

- Why monitor training loads?
- Making sense of complex data – Dr Dan Weaving



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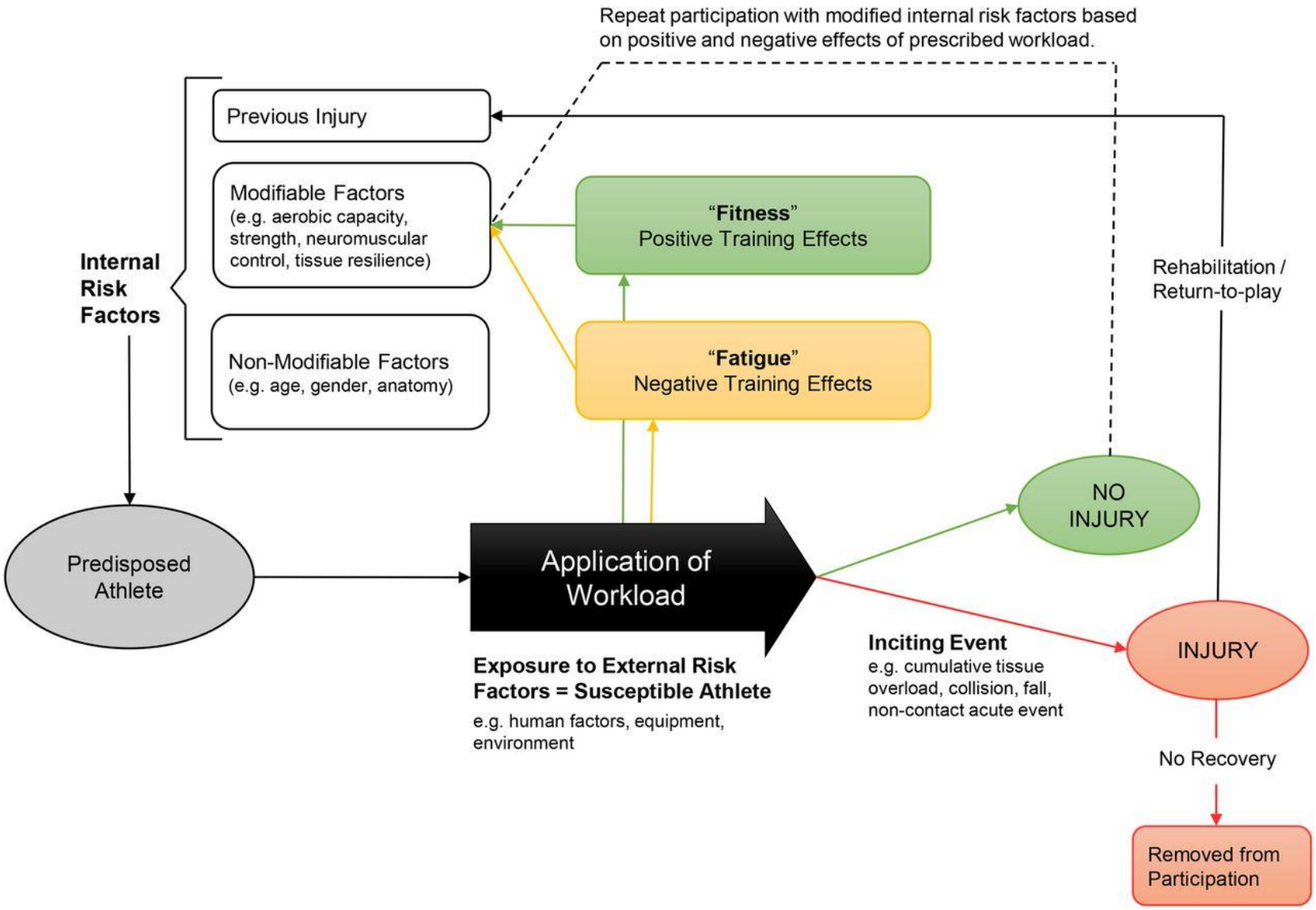
Theoretical basis for monitoring loads



Windt, J., & Gabbett, T. J. (2016). How do training and competition workloads relate to injury? The workload—injury aetiology model. *British Journal of Sports Medicine*, bjsports-2016.

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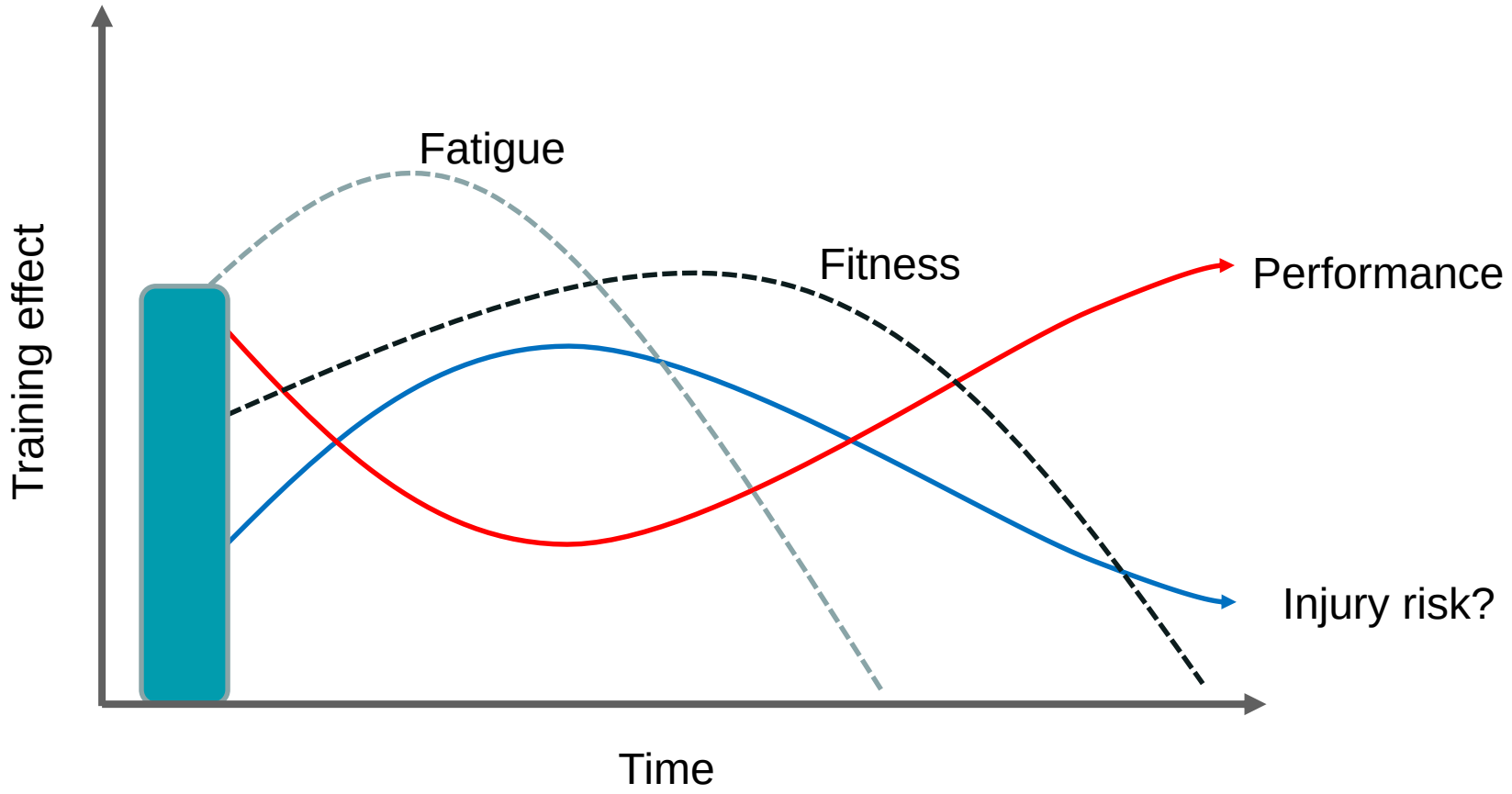
Theoretical Basis for Monitoring



Banister, E., Calvert, T., Savage, M. & Bach, T. (1975) A systems model of training for athletic performance. *Aust J Sports Med, 7*, 57-61.

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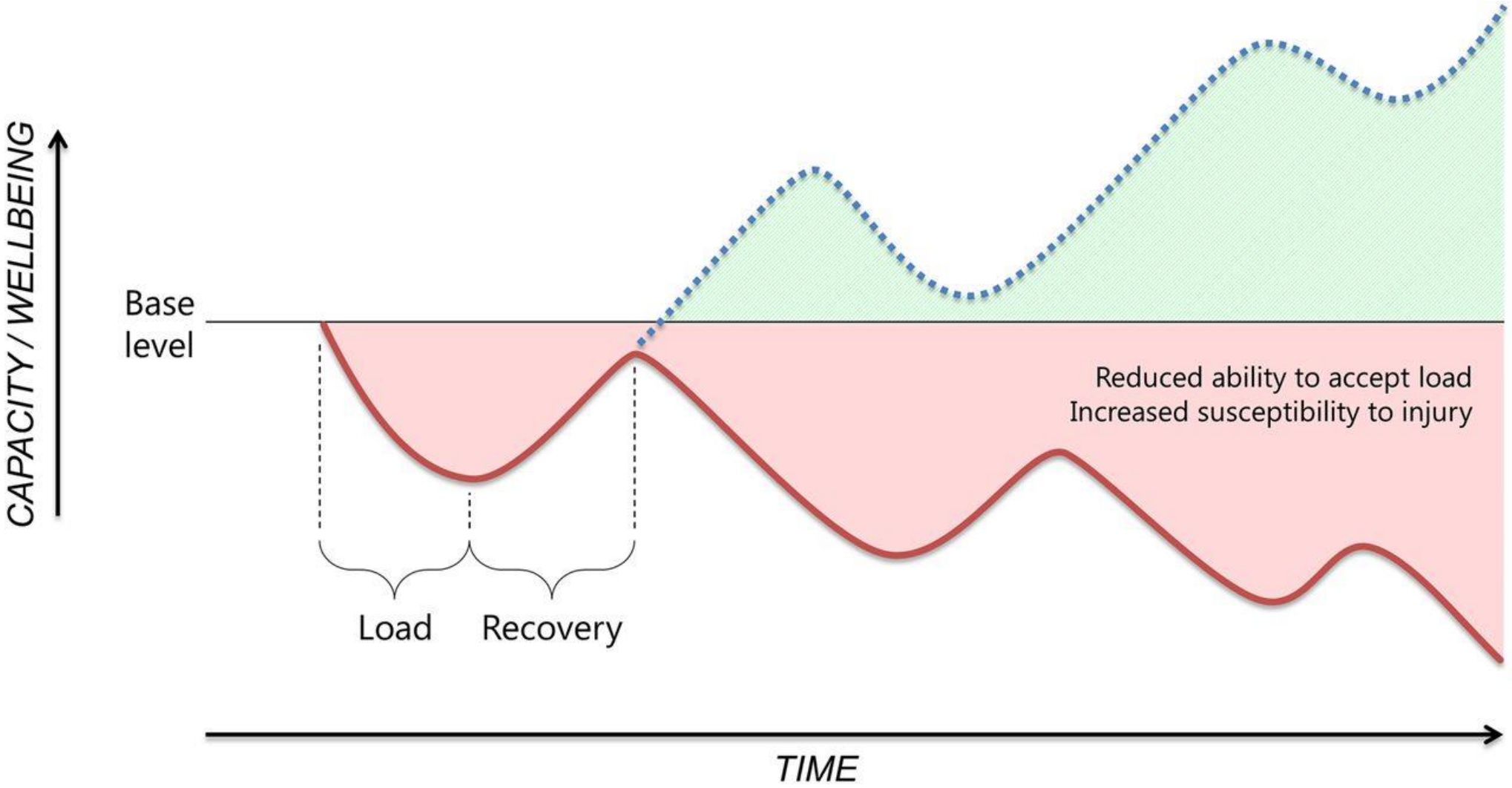

Soligard, T., Schwellnus, M., Alonso, J. M., Bahr, R., Clarsen, B., Dijkstra, H. P., ... & Van Rensburg, C. J. (2016). How much is too much? International Olympic Committee consensus statement on load in sport and risk of injury. *British Journal of Sports Medicine*, *50*(17), 1030-1041.

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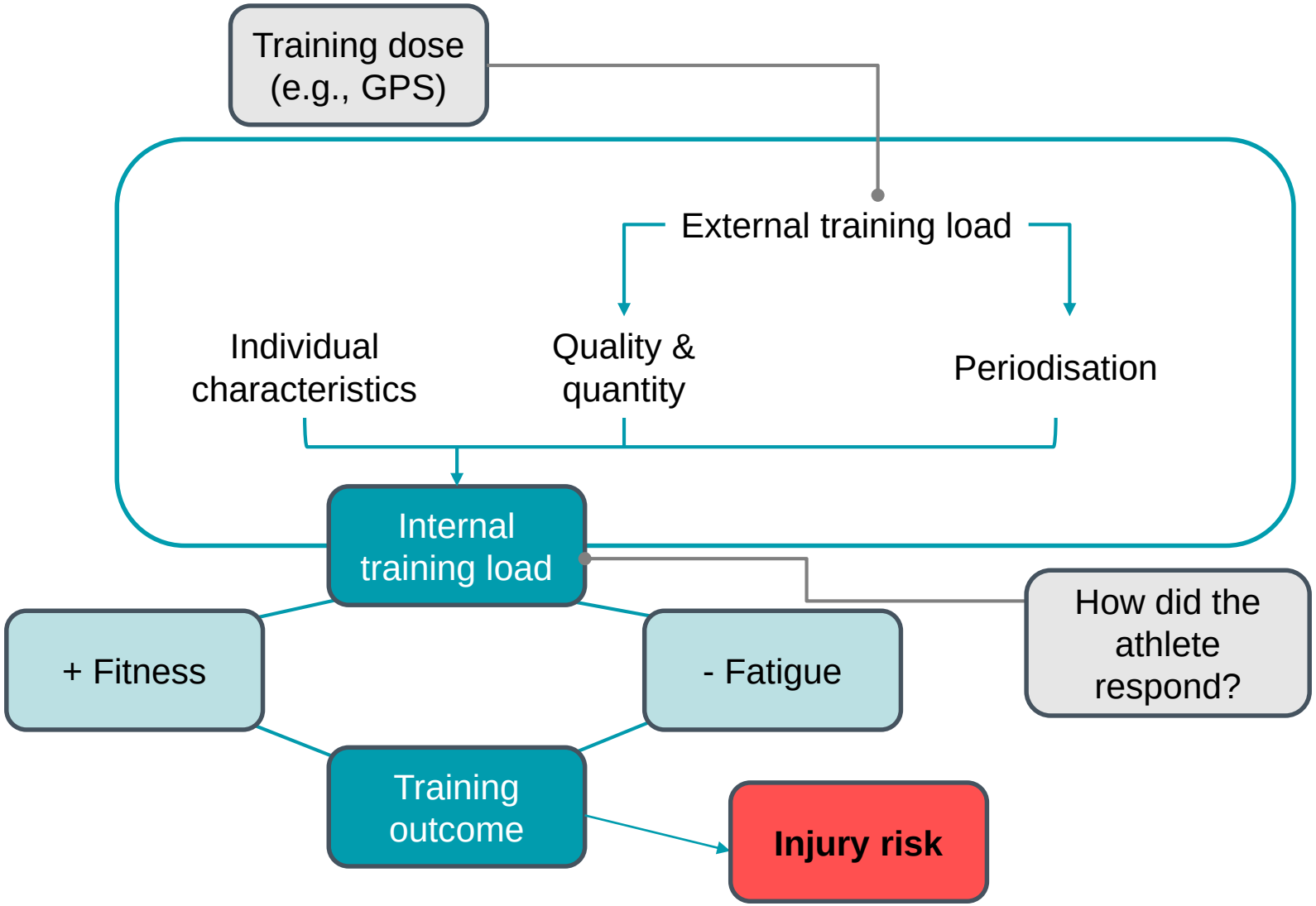

Impellizzeri, F. M., Rampinini, E. & Marcora, S. M. (2005) Physiological assessment of aerobic training in soccer. *Journal of Sports Sciences, 23*, 583-592.

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Making sense of complex data

UNIVERSITY OF BATH

Dr Dan Weaving

Post-Doc Research Fellow at Leeds Beckett and

1st team Sport Scientist with Leeds Rhinos

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@danweaving

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Making Sense of Complex Data

Dr Dan Weaving

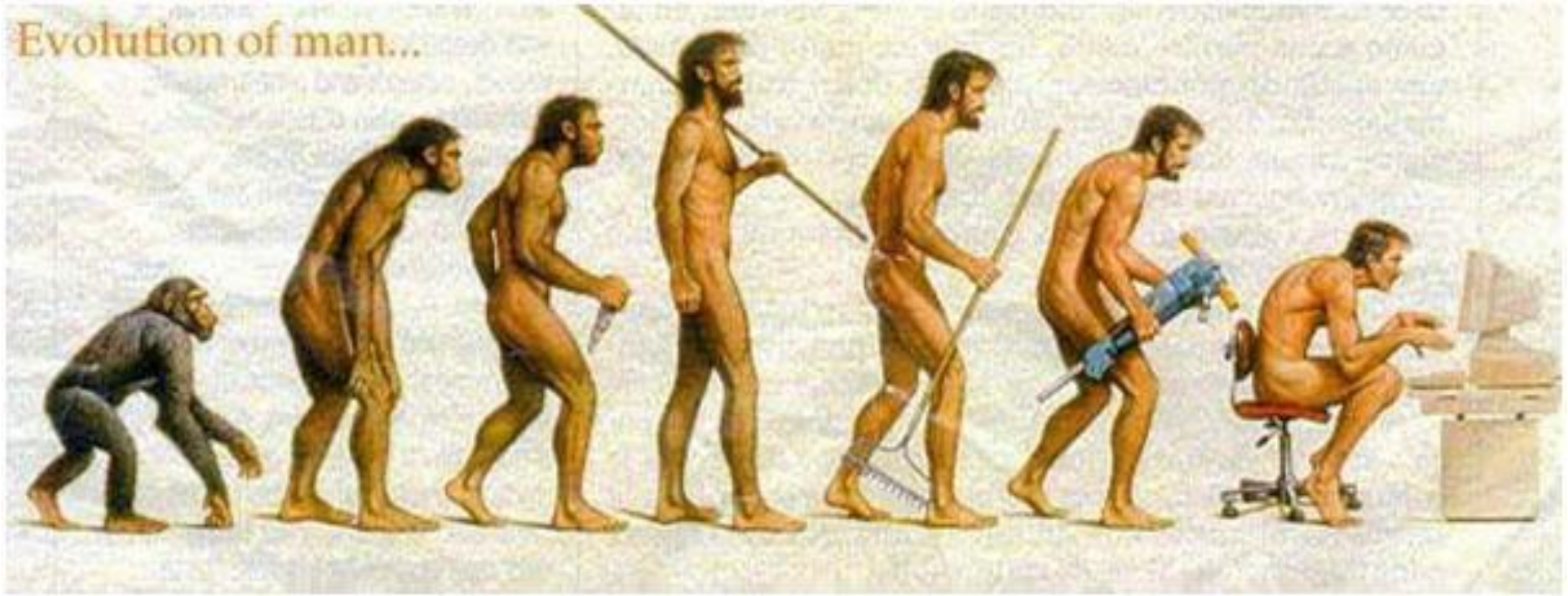
Post-Doctoral Research Fellow

Leeds Rhinos 1st Team Sports Scientist

Overview

- The Information Age: placing the applied sports scientist in the context of a data-driven society
- Considering the journey data takes from collection to presentation/decision making and some of the potential pitfalls along the way
- Working fast and slow with the multiple data sources we collect

Welcome. To the Information Age.



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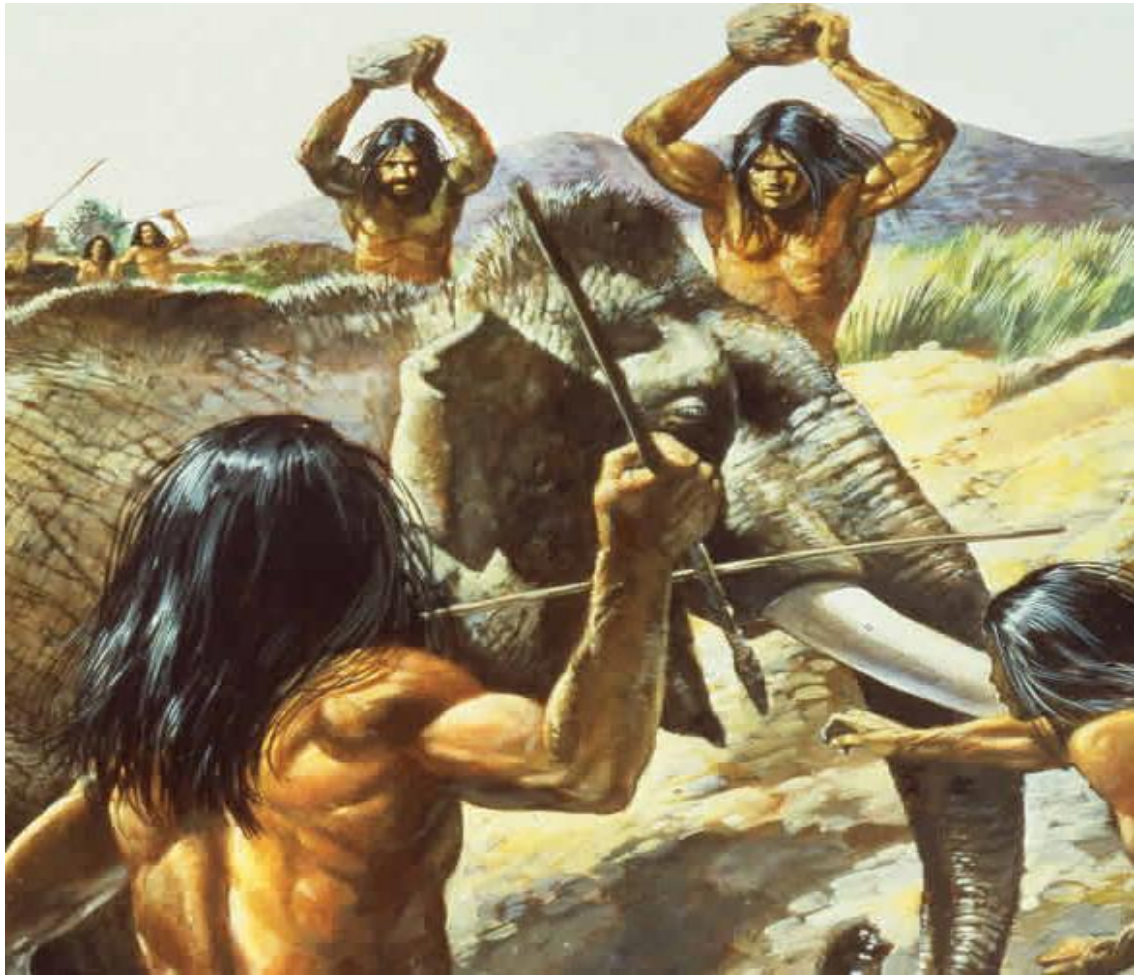
Building tools to ensure it's not too long before our next meal arrives



Using data to ensure our next meal is delivered just before GoT starts

https://www.theguardian.com/business/2017/jun/27/ocados-self-drive-vehicle-makes-deliveries-in-first-uk-trials

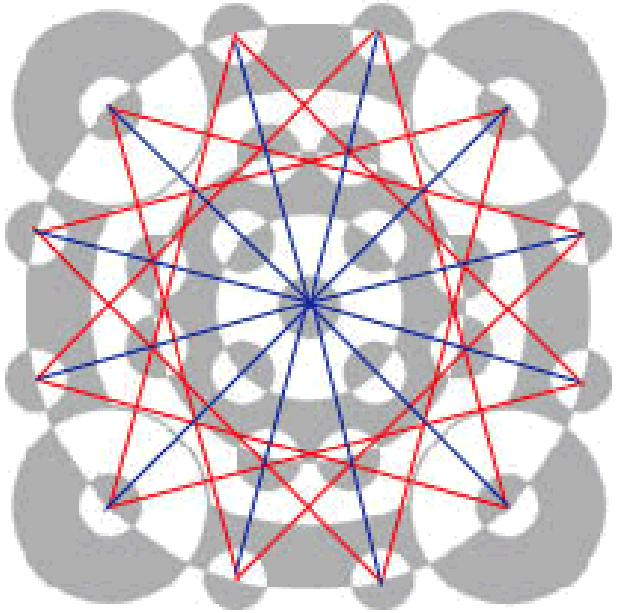
Talent Identification

Injury Prevention

Training Management

Playing performance

Are broad areas/systems that both coaches and sports scientists consider important to understand and quantify



Yet are <u>multifactorial</u> and <u>interrelated</u>

We are surrounded by data and it has never been easier to collect……

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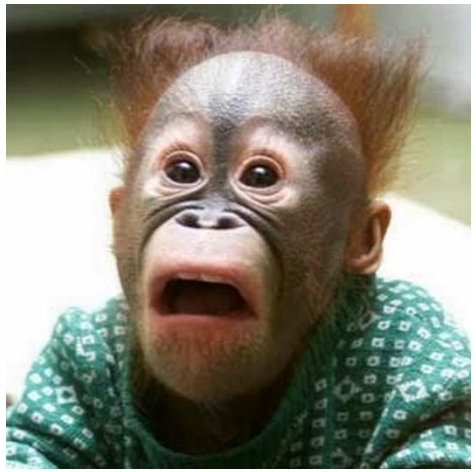
Estimated Volume of Global Internet traffic

1,000,000,000,000,000,000,000,000 bytes

or

152 million years of high-definition video (based on a two-hour, 1.5GB film).



http://www.telegraph.co.uk/technology/2016/02/04/worlds-internet-traffic-to-surpass-one-zettabyte-in-2016/

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But in practice, we need to consider the **volume, velocity** and **variety** of the data we collect

Alongside the validity and reliability of the data, of course!

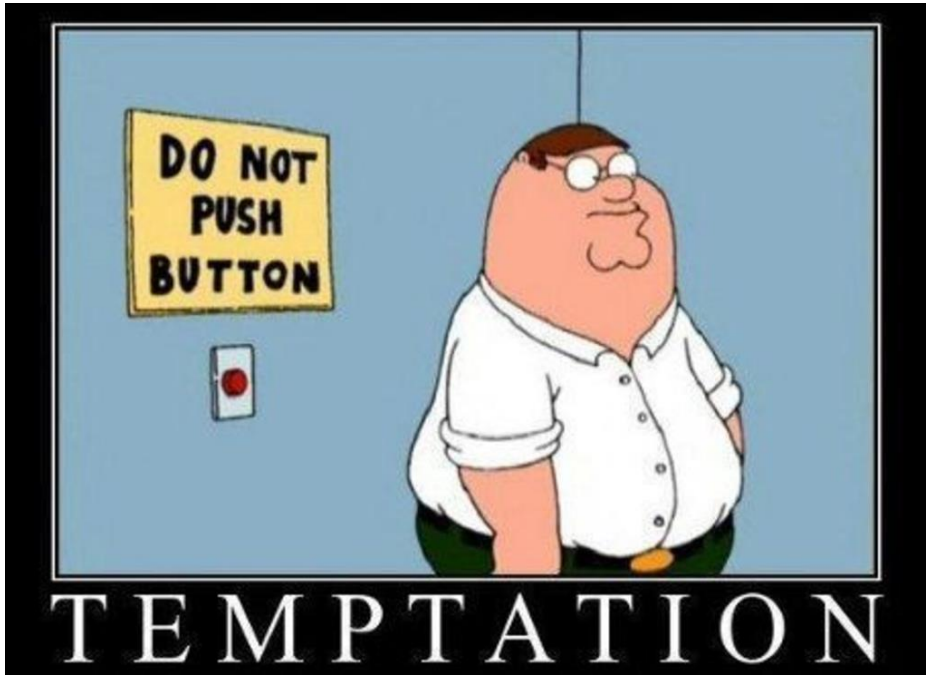
Zikopoulos (2012): IBM Understanding Big Data

10 Hz GPS = 10 times a second for 80 minute training or match multiplied by 25 players **(volume)** and occurring 5 times a week **(velocity)** =

6,000,000 data points a week

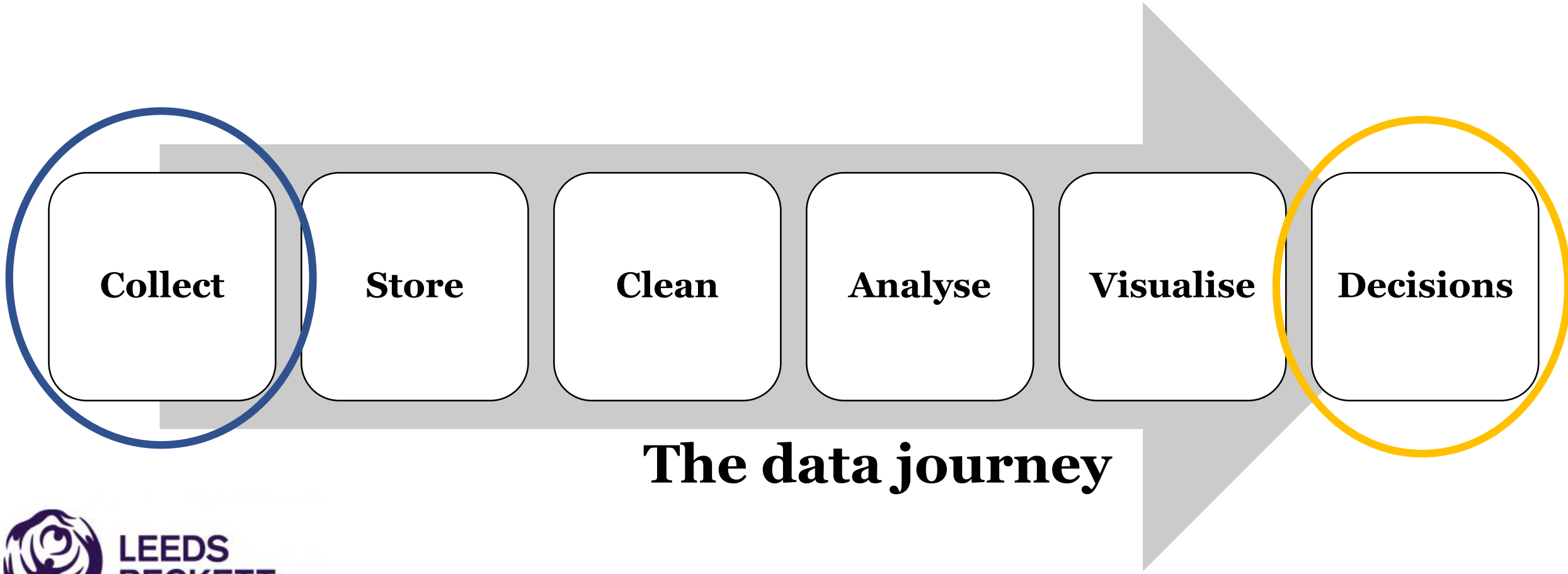
+ hydration, questionnaires, injury, fitness, training load and technical-tactical statistics **(variety)**….

This leaves us with multiple sources of data, each with their own volume, velocity and variety



However, before we collect more data……

We need to consider the steps that our data takes from collection to presentation to impact on practice



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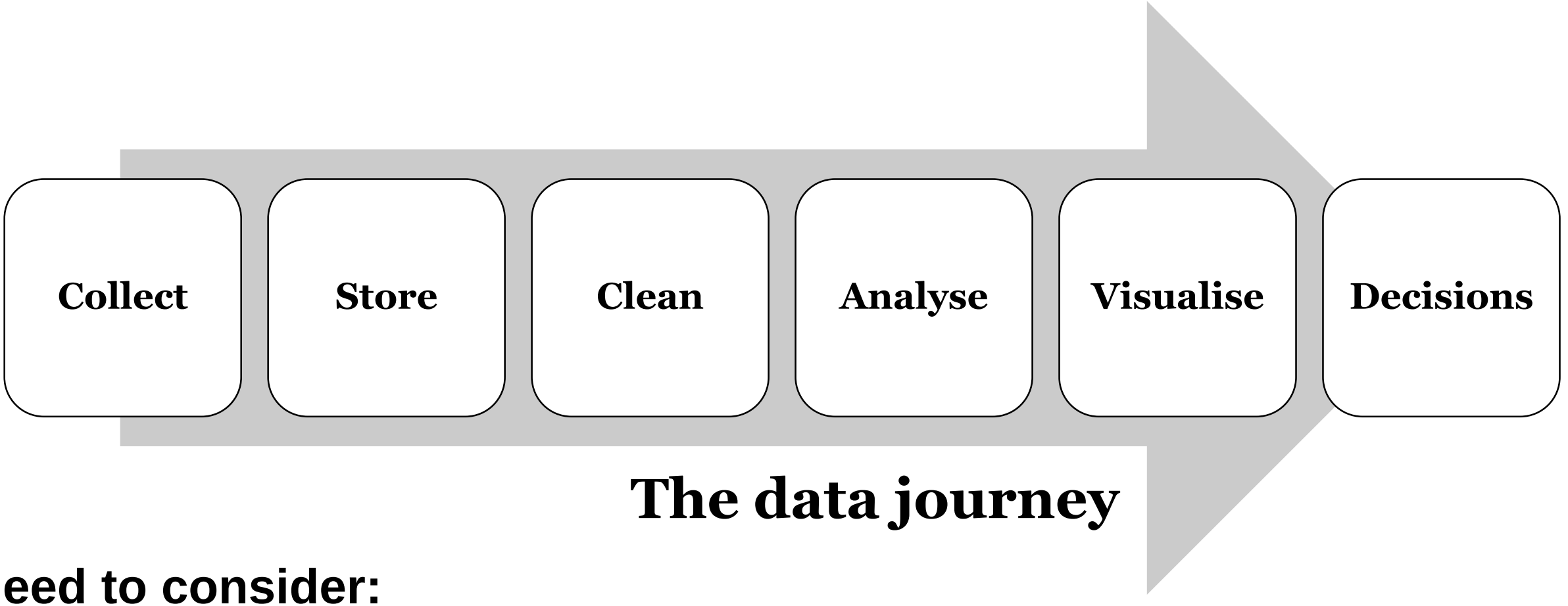


The data journey

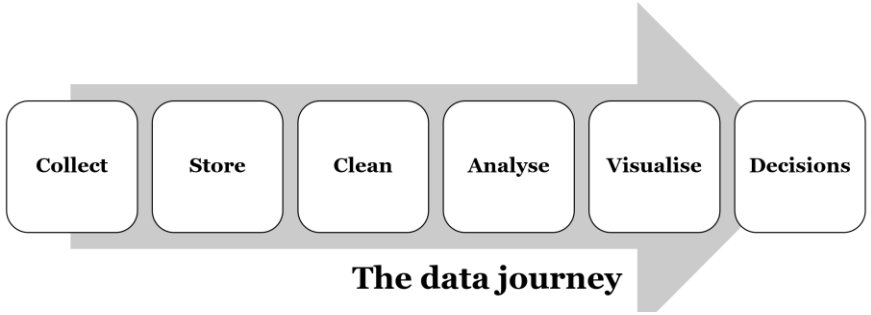
Need to consider:

1.) is there too much data collected too quickly to store accessibly?
2.) to then clean so that the data is correct?
3.) to then analyse so our interpretations are valid?
4.) to then visualise appropriately to coaches so that they can actually make sense of the data to impact on practice?

Time is the enemy

Coaches need to receive robust data quickly, in the correct format to increase the use of data to aid their decisions

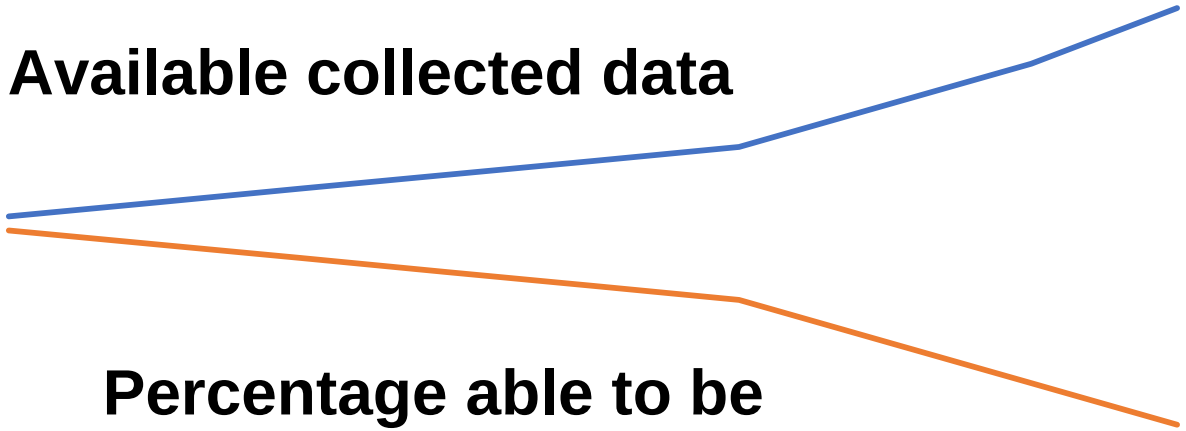
Applied Sports Scientists are often caught between a rock and a hard place



\+

Often single sports scientist, lack of financial investment/time to develop IT infrastructure to cope with increasing amount of collected data

Available collected data



Percentage able to be processed, analysed, visualised and presented in time

Blind spot: unprocessed data could be important or rubbish but we don't know because its floating around on our computer!

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Falling down data rabbit holes

Miss things that we could identify from the data

or

Possibly worse… we may think things are happening with the data that actually aren't!

If we repeatedly struggle to provide the correct inferences from the data at the right time in the best format…….

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Coaches may lose confidence in data so therefore don't use to make decisions or eventually don't collect at all

or

Improve infrastructure to pass through the 6 stages QUICKLY or adjust data collection accordingly!

Time is the enemy: working ‘fast’ and working ‘slow’ with the data that we collect

Working Fast (decisions with coaches)

Real-time, often conversation based, feedback: “We’re running 25% ‘harder’ in this drill than we have done in any 10-minute period during a game across the season”

“It would be beneficial to modify his exposure today, we’ll put him in a risky position if he covers similar to his teammates”

Working Slow (increasing rigour of feedback and recommendations)

Customised *R* algorithm to find highest, duration-specific speeds covered during matches

Longitudinal load-injury analyses

Int J Sports Physiol Perform. 2016 Jan;11(1):1-2. doi: 10.1123/IJSPP.2015-0781.

Working Fast and Working Slow: The Benefits of Embedding Research in High Performance Sport.

Coutts AJ[1].

Approaches to working ‘fast’

- Don’t focus too much on the day-to-day reporting (i.e. building ‘shiny’ daily reports): often leads us to only completing the day-to-day!
  - Often, it is the longer-term analyses and data that impact on practice the most
- Get the coaches to understand that you actually need to focus on working work ‘slow’ in the first instance
  - Data infrastructure (building spreadsheets/databases, configuring AMS, building data collection process etc)
  - Understanding which data is important for which context

= scientist having more confidence in the data and its inferences into practice

= speeds up the day-to-day and often leads to increasing chances of ‘daily’ reporting being conversational based and in real-time

Working Slow

Collect many variables, report a few!

But, which ones?

Int J Sports Physiol Perform. 2014 Sep;9(5):741. doi: 10.1123/IJSPP.2014-0353.

In the age of technology, Occam's razor still applies.

Coutts AJ[1].

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Collect many variables, report a few!

But, which ones?

By its evidence of validity and reliability

Is there redundancy in some of the data that we collect as a whole?

Int J Sports Physiol Perform. 2014 Sep;9(5):741. doi: 10.1123/IJSPP.2014-0353.

In the age of technology, Occam's razor still applies.

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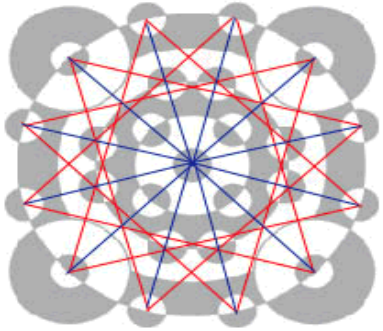

Adopting a systematic process to reduce data by understanding the similarity and uniqueness of the multiple measures we collect

Collect → **Store** → **Clean** → **Analyse** → **Visualise** → **Present to Coaches**

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GREENE KING CHAMPIONSHIP IPA

Using a data reduction technique* for each individual in a squad, do 4 common training load measures provide similar or distinct information during field-based skills training in professional rugby union players across a whole season?

PlayerLoad™ Session-RPE Total-Distance Ind HSD (>61% of V_{MAX})

Weaving et al. (2017). Same story or unique novel? Within-participant principal component analysis of training load measures during professional rugby union skills training. *Under Review*.

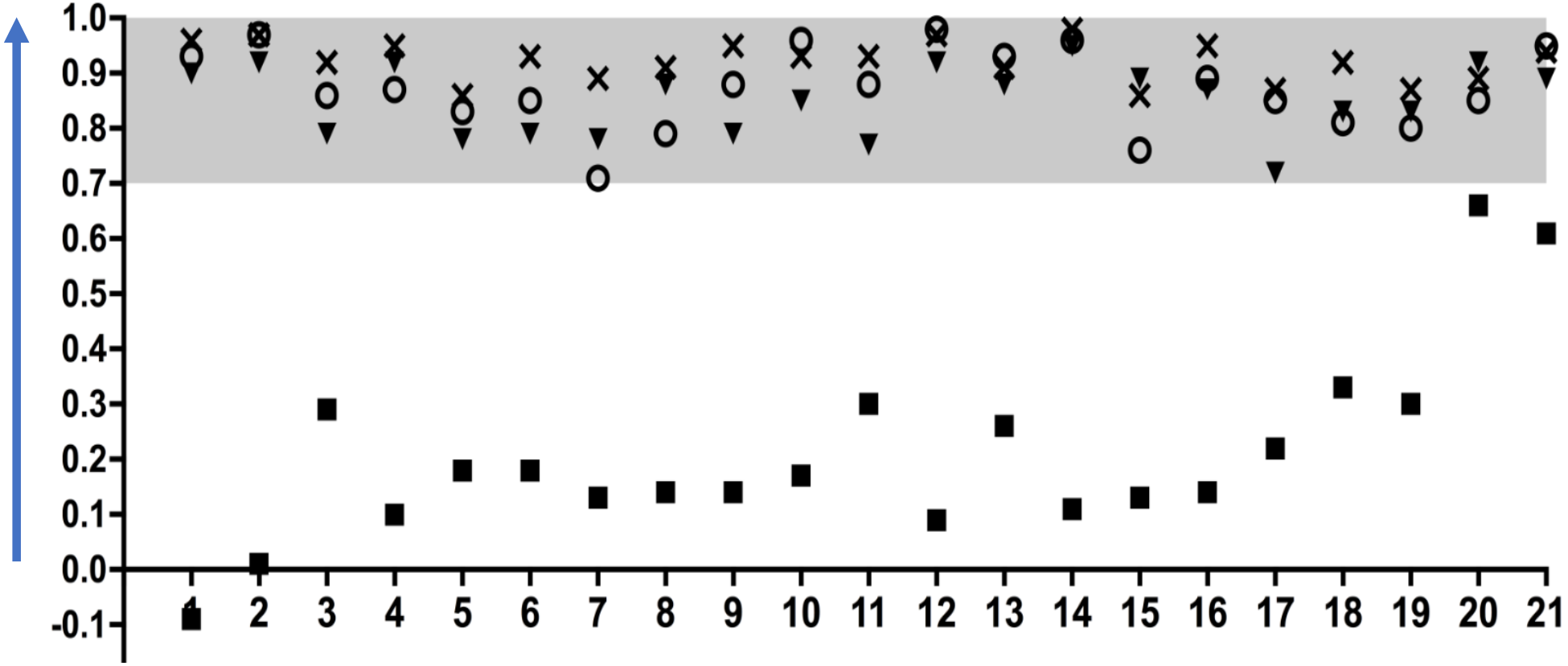
*Principal Component Analysis

For each individual, 3 of the 4 TL methods provide similar information and can be reduced to 1, yet still explain up to 70% (55 to 70%) of the variance provide by the 4 measures

Weaving et al. (2017). Same story or unique novel? Within-participant principal component analysis of training load measures during professional rugby union skills training. *Under Review*.

From that 55-70%, which measures provide the most information yet tell us the same thing?

Stronger relationship with the 55-70%



○ sRPE ▼ PlayerLoad × Total Distance ■ HSD

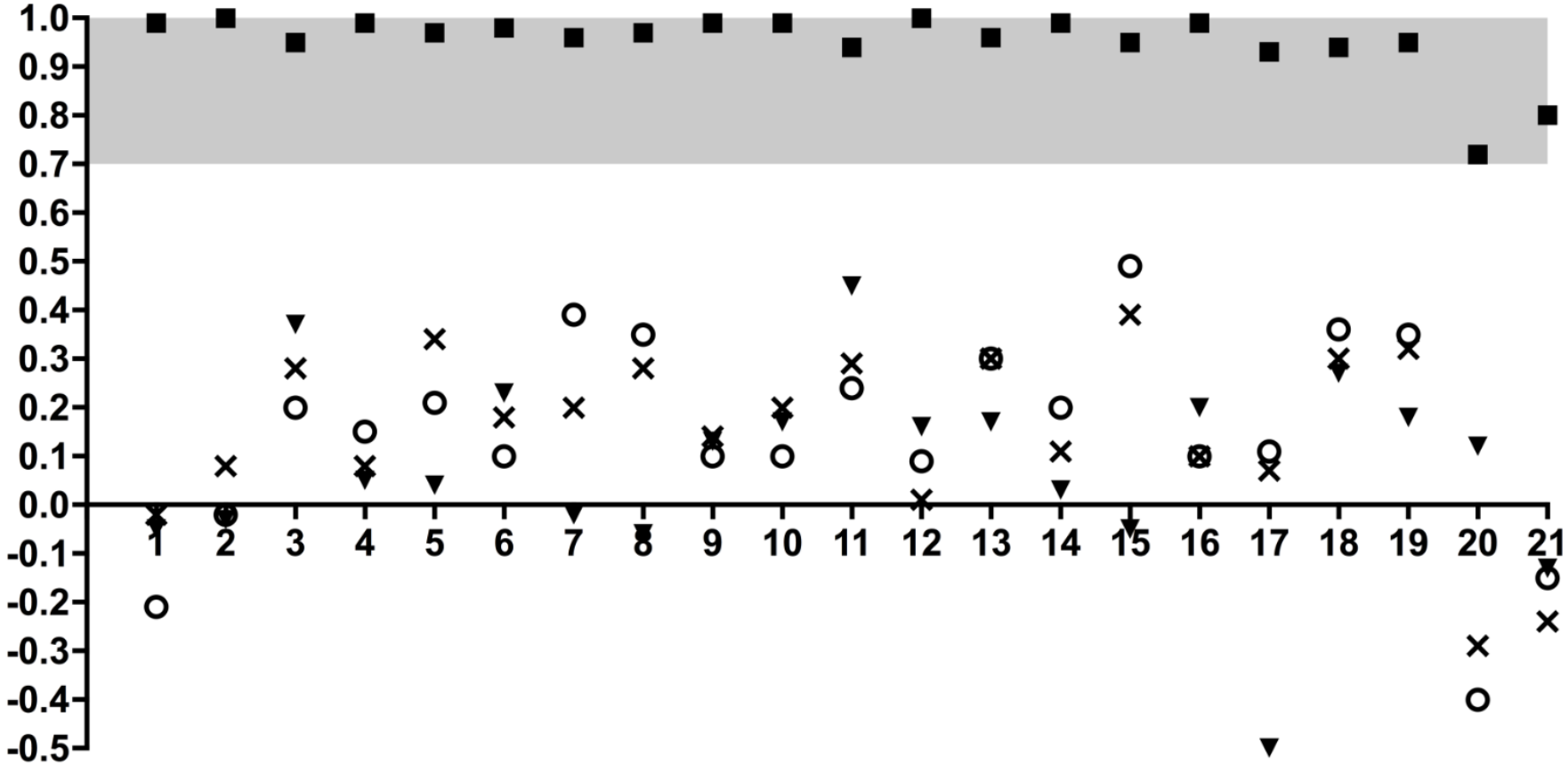
But what about the unaccounted 30-40%?

Weaving et al. (2017). Same story or unique novel? Within-participant principal component analysis of training load measures during professional rugby union skills training. *Under Review*.

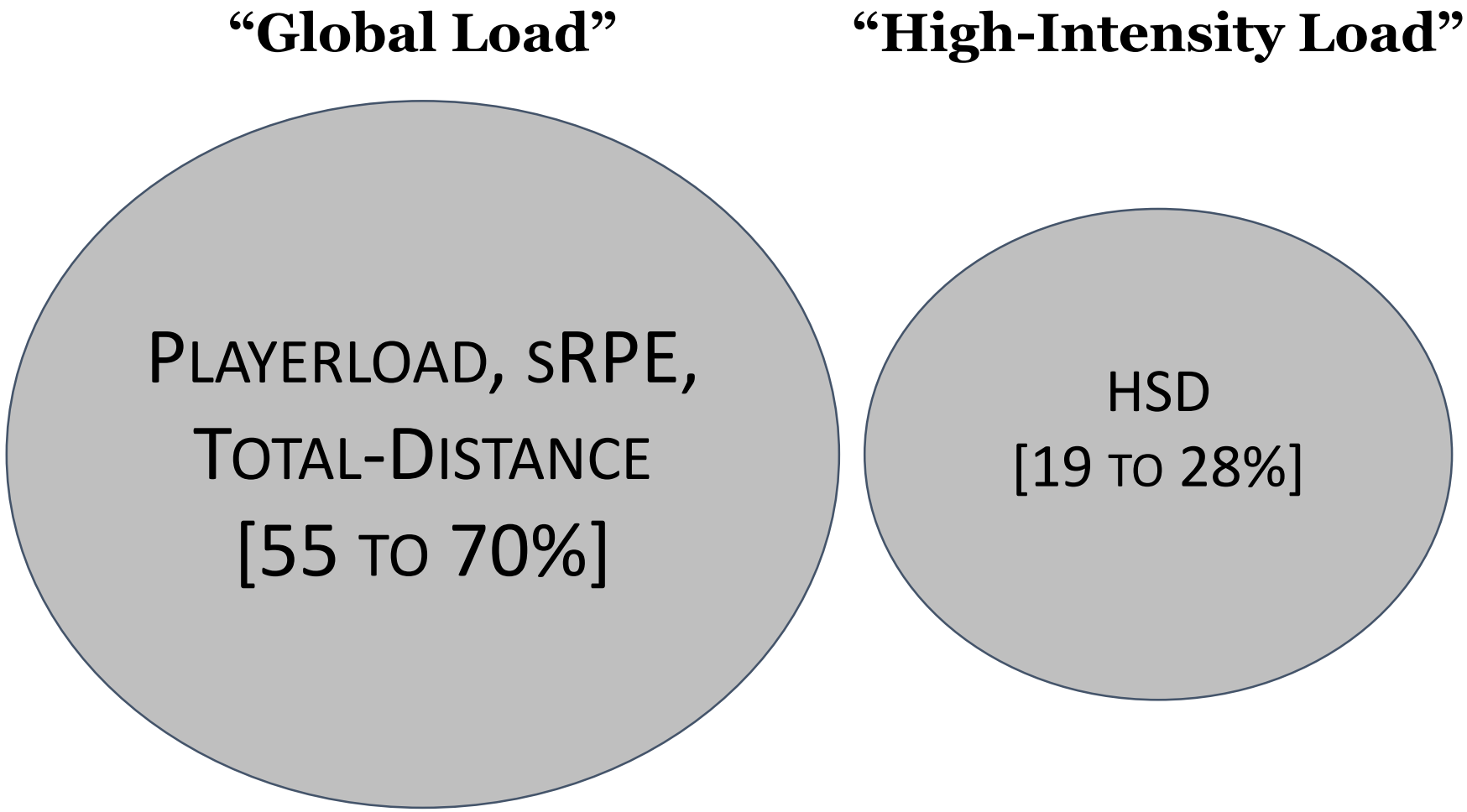
From the analysis criteria

one measure isn't enough…. HSD provides additional info (15 to 28%)

Stronger relationship with the additional 15-28%

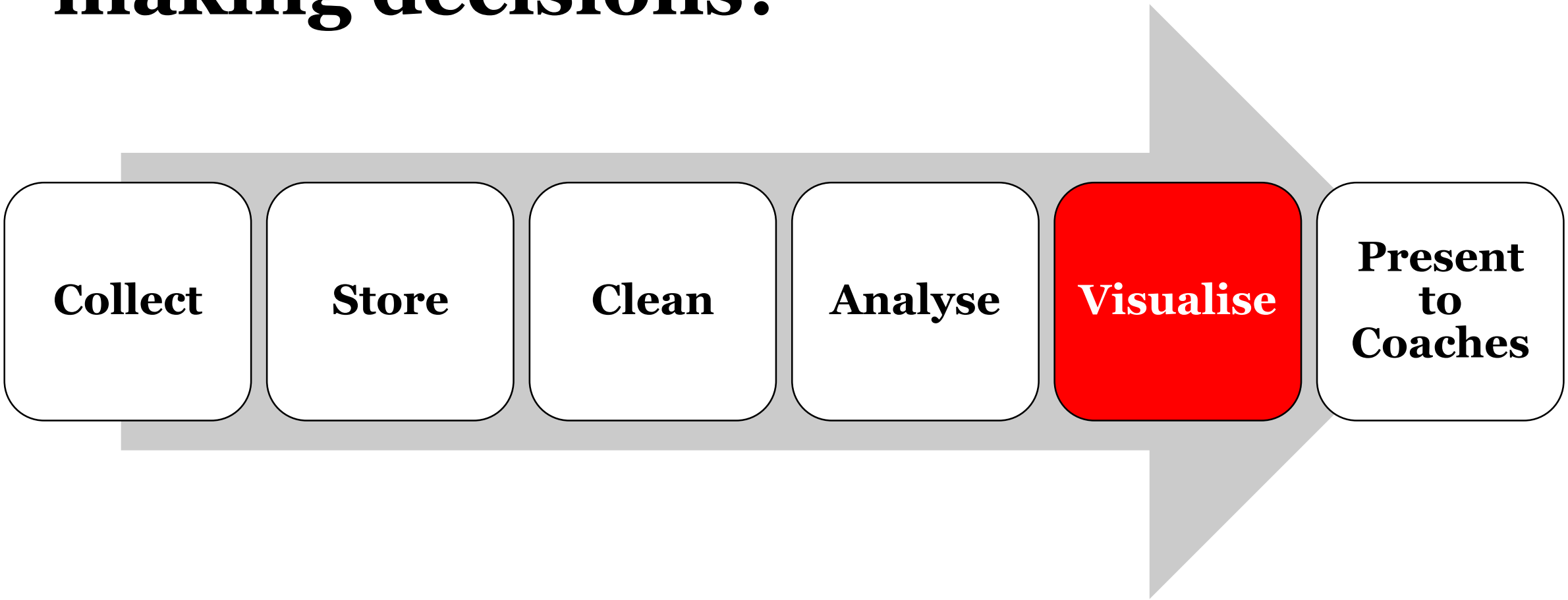


○ sRPE ▼ PlayerLoad × Total Distance ■ HSD

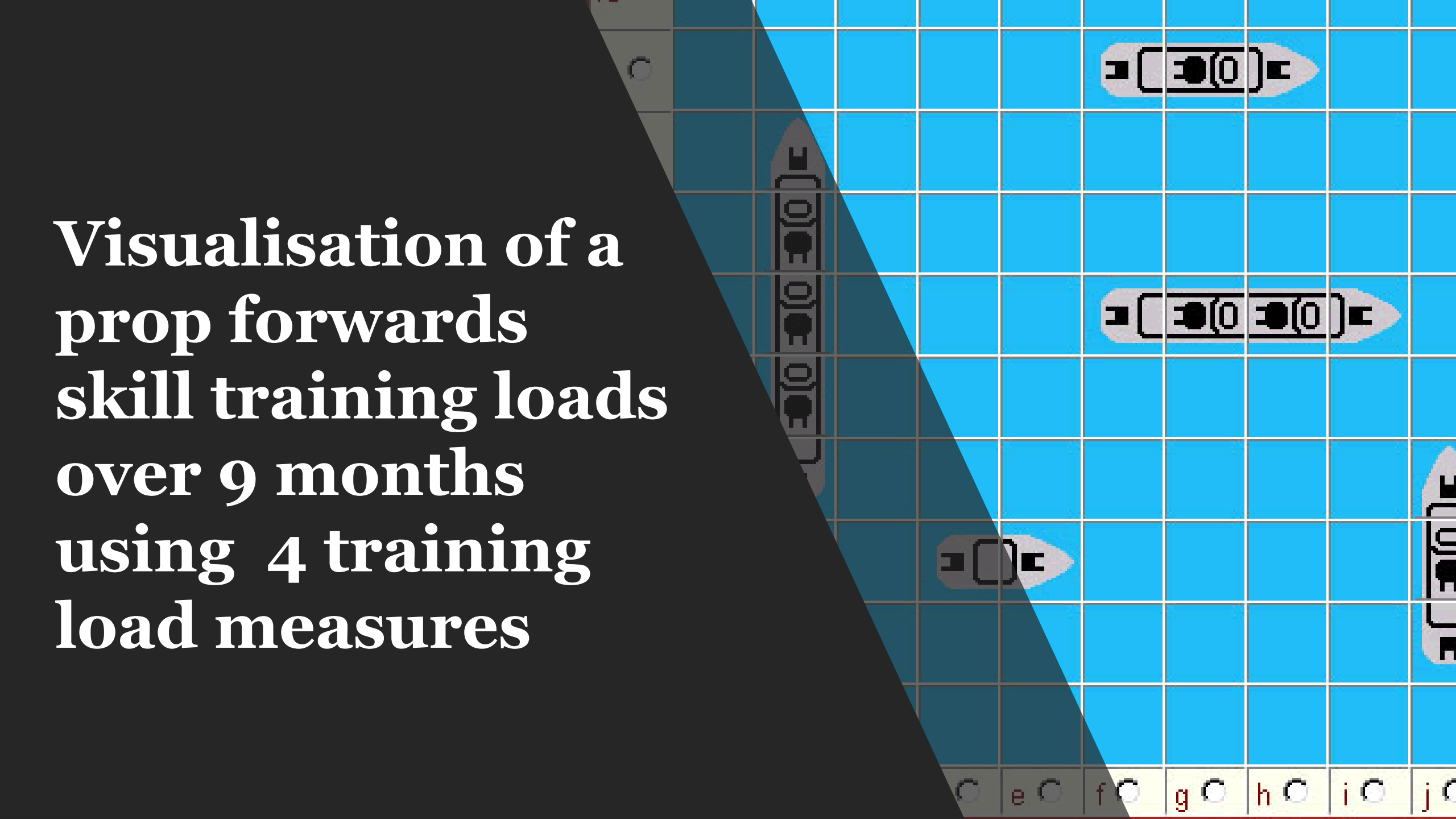


Weaving et al. (2017). Same story or unique novel? Within-participant principal component analysis of training load measures during professional rugby union skills training. *Under Review*.

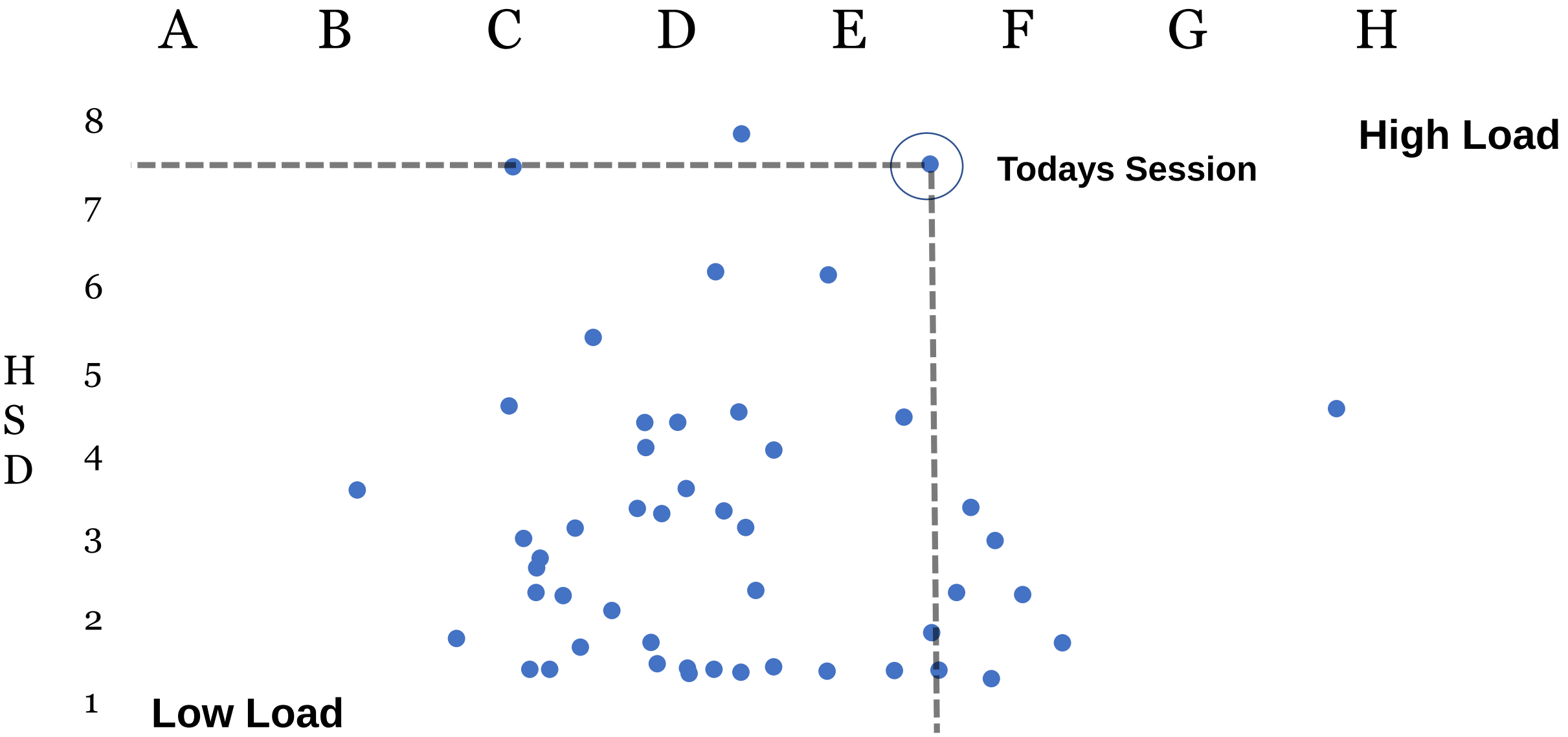
How can these approaches also be used to aid data visualisation to assist making decisions?



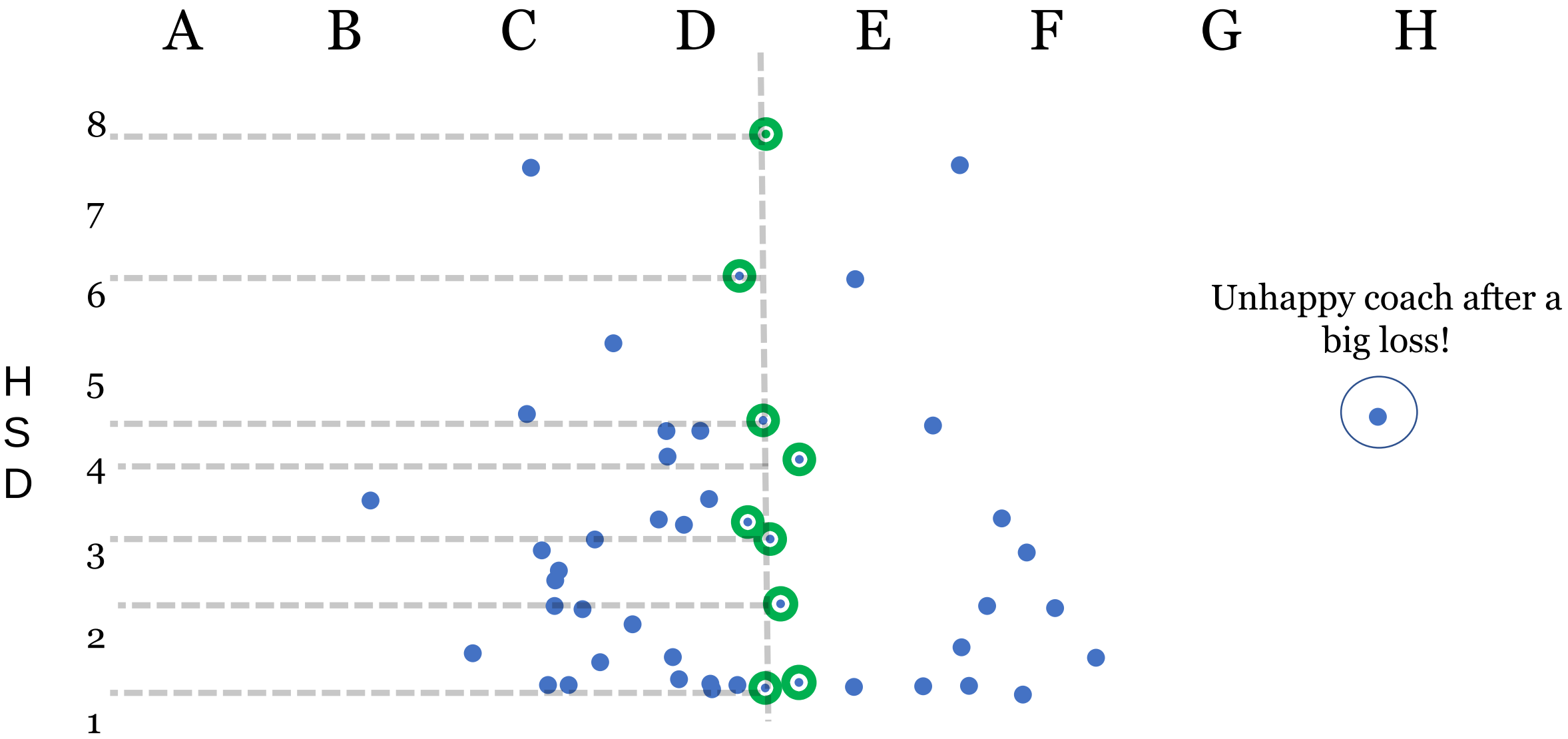
Visualisation of a prop forwards skill training loads over 9 months using 4 training load measures



PlayerLoad, sRPE, Total Distance- ‘Global’ Load



PlayerLoad, sRPE, Total Distance- ‘Global’ Load



Similar global load, vastly different HSD, different fatigue responses?

(Oxendale et al., 2015; Thorpe et al., 2017)

Recommendations to make sense of complex datasets

- There is a need to collect multiple measures to understand the complex world of sport. With this, challenges arise.

- Before collecting additional data consider whether you have an appropriate infrastructure in place to get the data through its journey from collection to presentation.

- Acknowledge that whilst multiple measures are needed, the interrelationships between longitudinal data means the challenge is to find out which ones provide similar or distinct information for each of the areas (injury, fatigue, training load etc) that you are trying to understand

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Thanks for listening

 @danweaving

**Volume of Internet Traffic = One Septillion bytes*

The Data Journey

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① COLLECT

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Collect

I WANT TO MONITOR MY ATHLETE BUT WHERE DO I START?

The athlete monitoring cycle: a practical guide to interpreting and applying training monitoring data

Tim J Gabbett,[1,2] George P Nassis,[3] Eric Oetter,[4] Johan Pretorius,[5] Nick Johnston,[6] Daniel Medina,[7] Gil Rodas,[7] Tom Myslinski,[8] Dan Howells,[9] Adam Beard,[10] Allan Ryan[11]

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Collect

I WANT TO MONITOR MY ATHLETE BUT WHERE DO I START?

https://progressiveathleticperformance.com/2016/04/06/how-to-create-a-free-athlete-wellness-workload-monitoring-tool-using-google-docs-and-microsoft-excel/

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Collect

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The Data Journey

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② STORE

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Storing Your Data (Research Perspective)

When considering your data storage approach, you should consider the following:

- Is the storage reliable or is there a risk that the data may be lost?
- How much storage will I need and will this vary during the project?
- Can I access my data storage from the different places that I work?
- Are my data secure and how do I ensure that they can only be accessed by authorised people?

Working with sensitive data:

http://www.bath.ac.uk/research/data/working-with-data/sensitive-data/

"While external services such as Dropbox, Google Drive and OneDrive are convenient, they do not comply fully with the University's data policies…"

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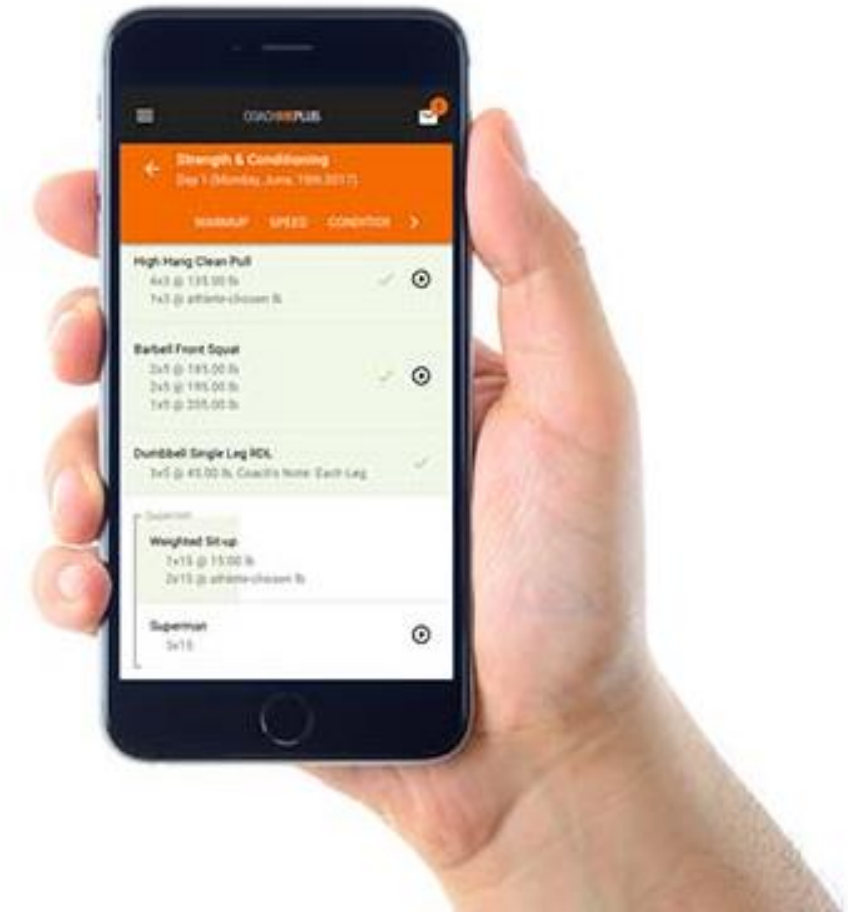
Buyers Guide…

https://simplifaster.com/articles/buyers-guide-athlete-management-system-software/

- Kitman Labs
- AthleteMonitoring
- SMARTABASE
- Metrifit
- AMP
- BridgeAthletic
- CoachMePlus
- TeamBuildr
- TrainHeroic
- EDGE10…



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The Data Journey

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③ CLEAN

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DEPARTMENT FOR HEALTH
Sport, Health and Exercise Science

Training Load Workshop "Clean"

Presented by Stephen West

UNIVERSITY OF BATH

RS BATH RUGBYSCIENCE

Rugby Science Network Conference
SEPTEMBER 2017

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The landscape

REVIEW ARTICLE

Monitoring Training Load to Understand Fatigue in Athletes

Shona L. Halson

"Monitoring Systems should be intuitive, provide efficient data analysis and interpretation, and enable efficient reporting of simple, yet scientifically valid feedback"

A New Approach to Monitoring Exercise Training

CARL FOSTER, JESSICA A. FLORHAUG, JODI FRANKLIN, LORI GOTTSCHALL, LAURI A. HROVATIN, SUZANNE PARKER, PAMELA DOLESHAL, AND CHRISTOPHER DODGE

Rating of Perceived Exertion (RPE)
0- Rest
1- Very, Very Easy
2- Easy
3- Moderate
4- Somewhat Hard
5- Hard
6-
7- Very Hard
8-
9-
10- Maximal

→ Session Length: Minutes → Session RPE: RPE score x time

PREMIERSHIP RUGBY

Applications of the Session Rating of Perceived Exertion System in Professional Rugby Union

Tom Comyns, PhD[1] and Eamonn P. Flanagan, PhD, CSCS[2]
[1]Irish Institute of Sport, National Sports Campus, Co. Dublin, Ireland; and [2]Irish Rugby Football Union, Dublin, Ireland

QUANTIFICATION OF TRAINING LOAD IN CANADIAN FOOTBALL: APPLICATION OF SESSION-RPE IN COLLISION-BASED TEAM SPORTS

NICK CLARKE,[1] JONATHAN P. FARTHING,[1] STEPHEN R. NORRIS,[2,3] BART E. ARNOLD,[1] AND JOEL L. LANOVAZ[1]
[1]College of Kinesiology, University of Saskatchewan, Saskatoon, Canada; [2]University of Calgary Calgary, Canada; and [3]Mount Royal College, Calgary, Canada

J Strength Cond Res. 2004 Nov;18(4):796-802.

Quantitation of resistance training using the session rating of perceived exertion method.

Sweet TW[1], Foster C, McGuigan MR, Brice G.

J Sci Med Sport. 2009 Jan;12(1):79-84. Epub 2008 Feb 20.

Heart rate and blood lactate correlates of perceived exertion during small-sided soccer games.

Coutts AJ[1], Rampinini E, Marcora SM, Castagna C, Impellizzeri FM.

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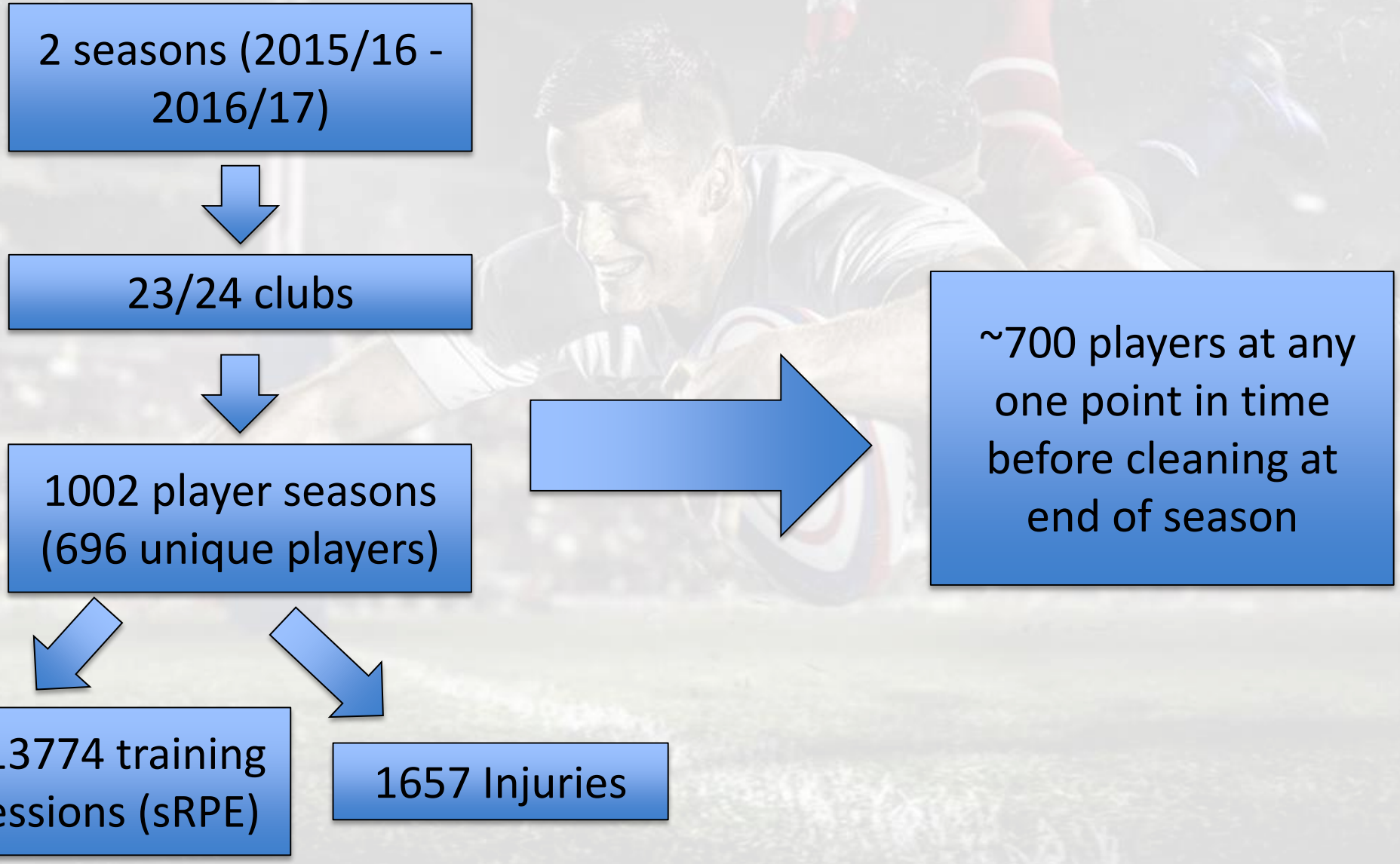
The landscape



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Process

<table>
<tr><th colspan="3">Process</th><th>Result</th></tr>
<tr><td colspan="3">Recorded on one spreadsheet; Easy to format</td><td rowspan="15">Extract and copy to club database

Name

Date

Load (sRPE)</td></tr>
<tr><td>Separate spreadsheet for each week</td><td>Each session, separate tab</td><td>Index function to sum load each day</td></tr>
<tr><td>Weeks split into tabs</td><td>Extract each session</td><td>Index function to sum load each day</td></tr>
<tr><td colspan="3">Recorded on one spreadsheet; Easy to format</td></tr>
<tr><td>Different spreadsheet every week</td><td>Each tab represents a day</td><td>Index function to sum load each day</td></tr>
<tr><td>Insert formula to recalculate to minutes</td><td colspan="2">Insert formula to calculate load</td></tr>
<tr><td colspan="3">Use our template</td></tr>
<tr><td colspan="3">Use our template</td></tr>
<tr><td>Field session s/s and gym session s/s</td><td>Insert formula to calculate load</td><td>Extract each player, each session separately and index to sum load</td></tr>
<tr><td colspan="3">Use our template</td></tr>
<tr><td colspan="3">Use our template</td></tr>
<tr><td colspan="2">One large spreadsheet, sessions need to be summed</td><td>Takes time to insert formula</td></tr>
</table>

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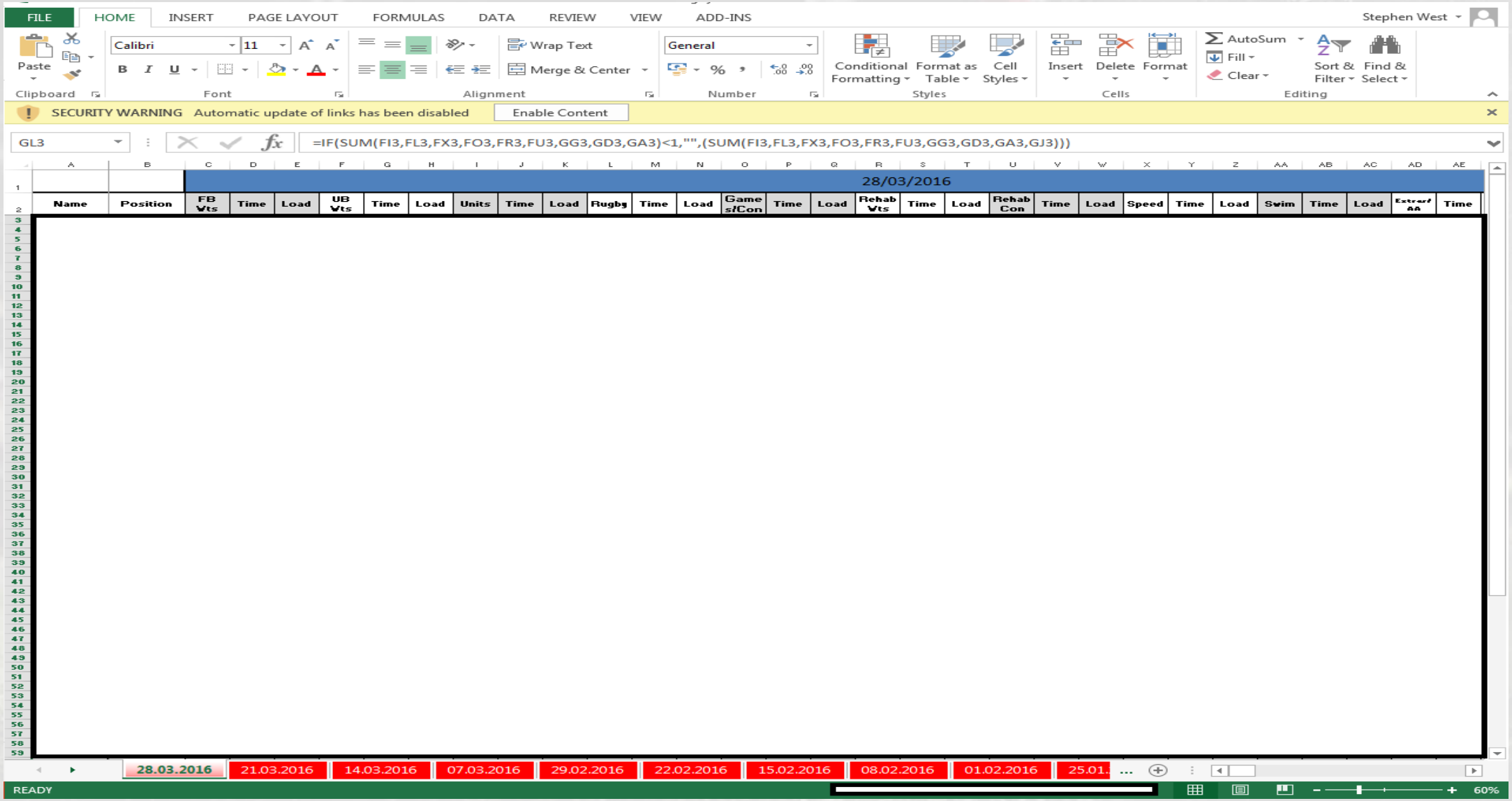
Example template



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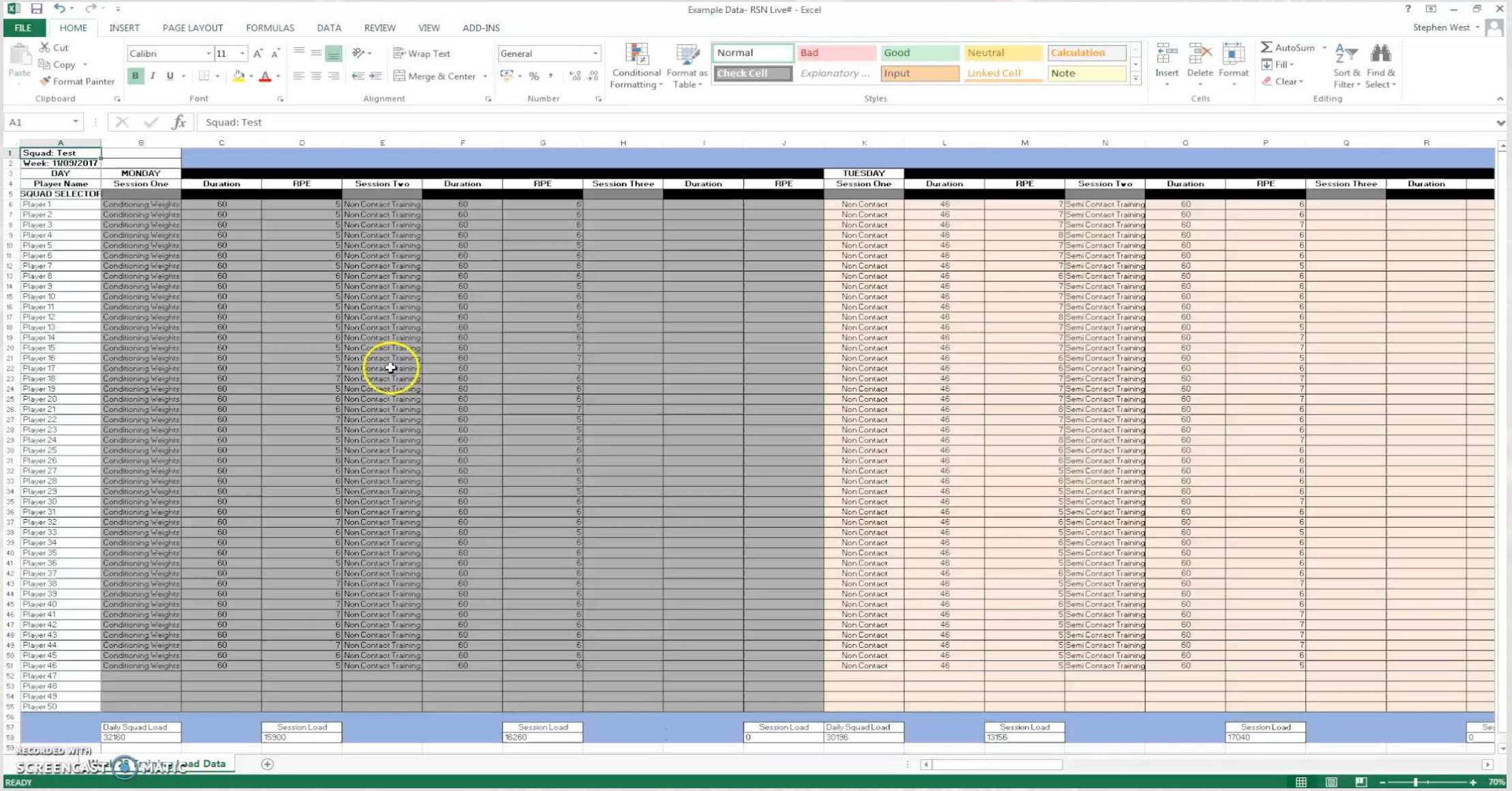
Our template



Rugby Science Network Conference
SEPTEMBER 2017
@westy160991
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Ideal world

- This is the section of your monitoring process where you will spend the **majority of your time**
- Where possible, collect the data in a **standardised** template
  - **Names** always the same
  - **Dates** in correct format
- Before starting, play around with **different formats** to find what works best for your needs
- There is usually a quicker way of doing things
  - Find the **shortcuts** (VLookUps, Macros, Index)
- Take note of the **formatting** you complete, especially with Macros
- **Save** regularly!

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The Data Journey

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④ ANALYSE

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Analyse

Data representation

- Coding injury
- Level of analysis (day, week)
- Number of features
- Correlation of the features

Data/Metrics Engineering

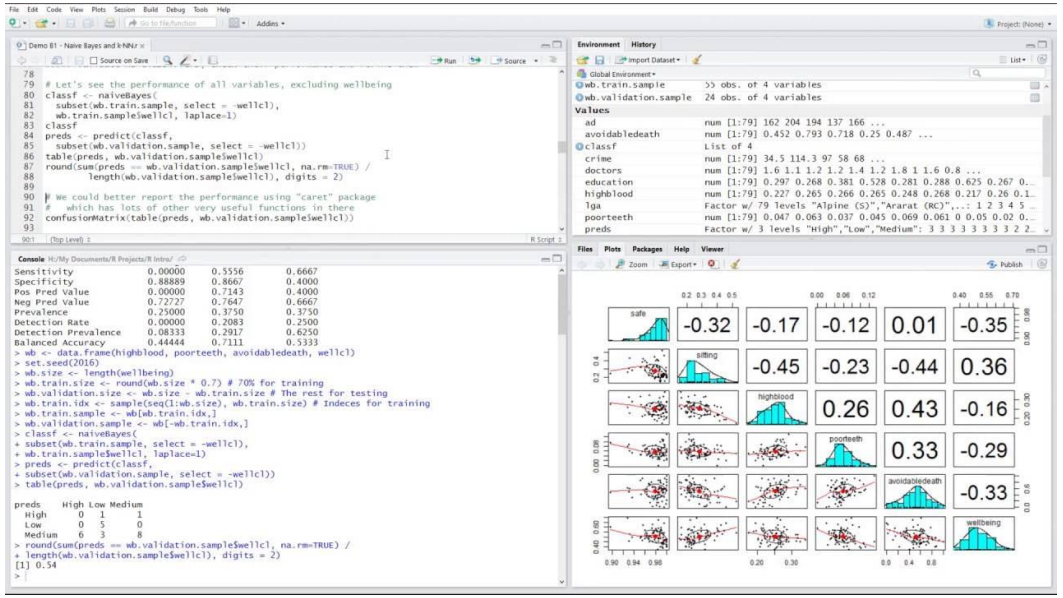
- Rolling Sum/Mean/SD
- Z-scores
- Exponential/Rolling
- Time Lag
- Confounders/Mediators (previous injury, readiness metrics…)

Data Analysis

- Linear v non-linear models
- Continuous v categorical
- Random effects

Predictive Performance

- AUC
- Sensitivity/Specificity



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Weighted v Rolling Averages

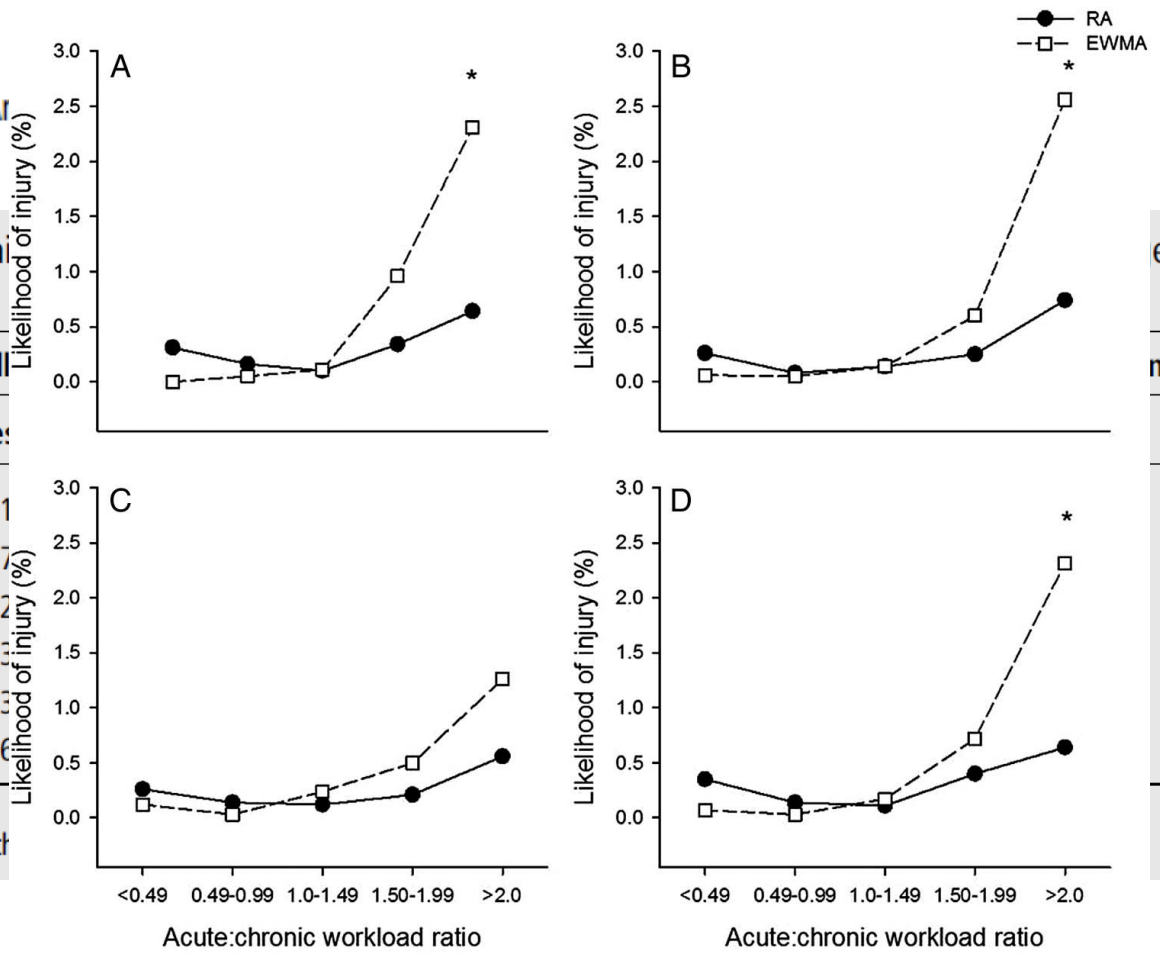
Calculating acute:chronic workload ratios using exponentially weighted moving averages provides a more sensitive indicator of injury likelihood than rolling averages

Nicholas B Murray,[1] Tim J Gabbett,[2] Ar

Table 1 Variance (R^2) in injury explai… ratio (ACWR) models

Workload variable	Roll… Pres…
Total distance (m)	0.21
Low-speed distance (m)	0.47
Moderate-speed distance (m)	0.32
High-speed distance (m)	0.13
Very high-speed distance (m)	0.23
Player load (au)	0.46

Data are variance (R^2) with 95% CIs.
*Denotes significantly different ($p<0.05$) from th…



…es acute:chronic workload …moving averages ACWR model

In-season
0.78 (0.54 to 1.00)*
0.75 (0.48 to 1.00)*
0.77 (0.52 to 1.00)*
0.67 (0.33 to 1.00)
0.66 (0.31 to 1.00)
0.72 (0.43 to 1.00)*

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Weighted v Rolling Averages

Worksheet for calculating EWMA and rolling averages:

RSNLive17_EWMA-worksheet

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Number of Features

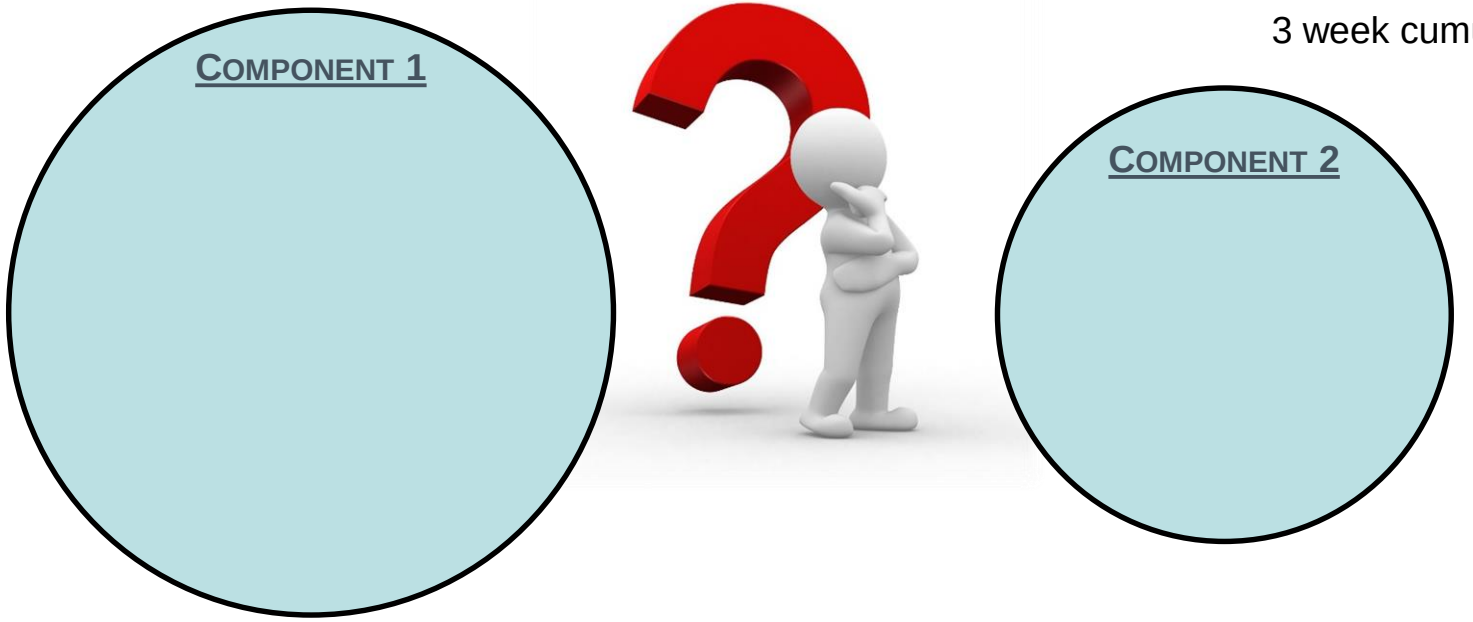
1 week cumulative

Daily load

Monotony

2 week cumulative

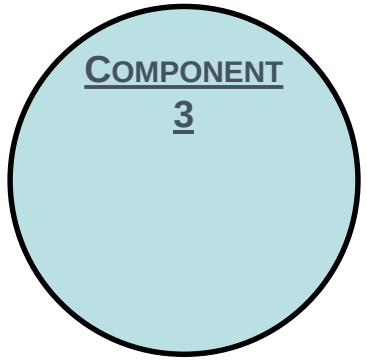
3 week cumulative



Strain

Week-to-week change

4 week cumulative



Weighted-moving average

Acute:chronic workload

Williams et al. (2016). Monitoring What Matters: A Systematic Process for Selecting Training Load Measures. *IJSPP*, 1-20.

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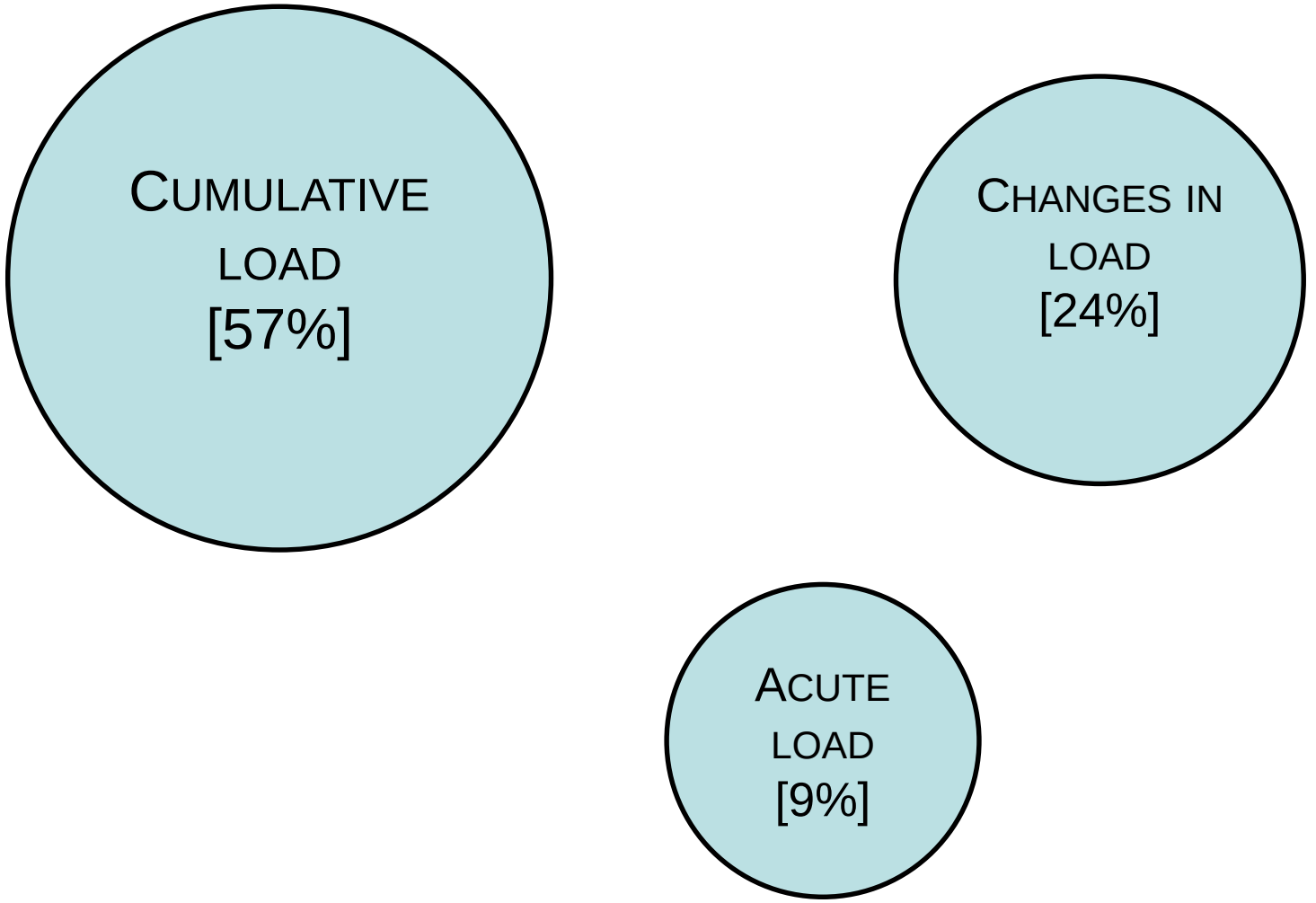
Number of Features



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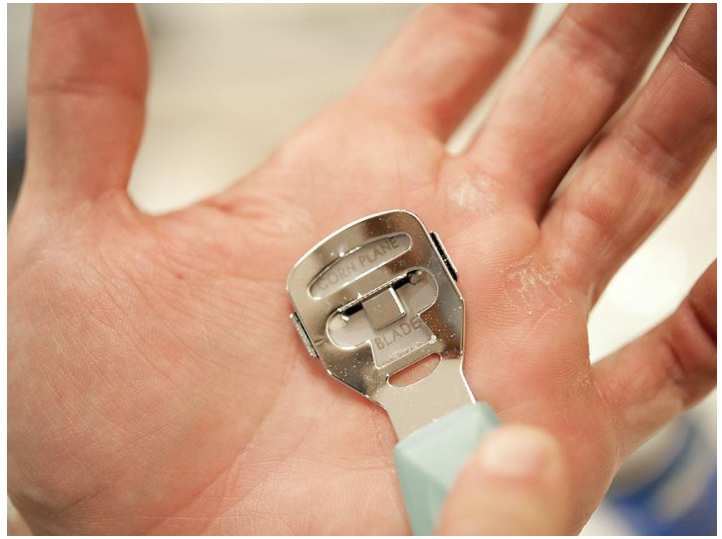
Number of Features

Training load is the difference between a blister and a callous. Too much too soon and you get pain and injury, but little and often and you get a resilient tissue.

Kris Borthwick

SCIENCE for SPORT

- Cumulative load
- Changes in load
  - Acute load



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Number of Features

Demonstrates PCAs use as a systematic process for determining which variables provide similar or distinct information

A lot of variables provide similar information **yet,** this also shows you will omit a lot of unique information if a single representation of load is adopted (i.e. using just cumulative load or acute load or A:C ratio)

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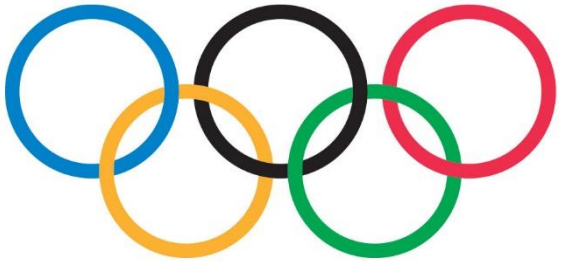
Number of Features



"the sport and non-sport burden *(single or multiple physiological, psychological or mechanical stressors)* as a stimulus that is applied to a human biological system….."

International Olympic Committee Consensus Statement on Load in Sport

Soligard et al. (2016): BJSM

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Number of Features

Given the definition highlighted in previous slide, is using a single method of quantifying training load (i.e. sRPE) enough across all types of training (skills, speed, SSG) prescribed?

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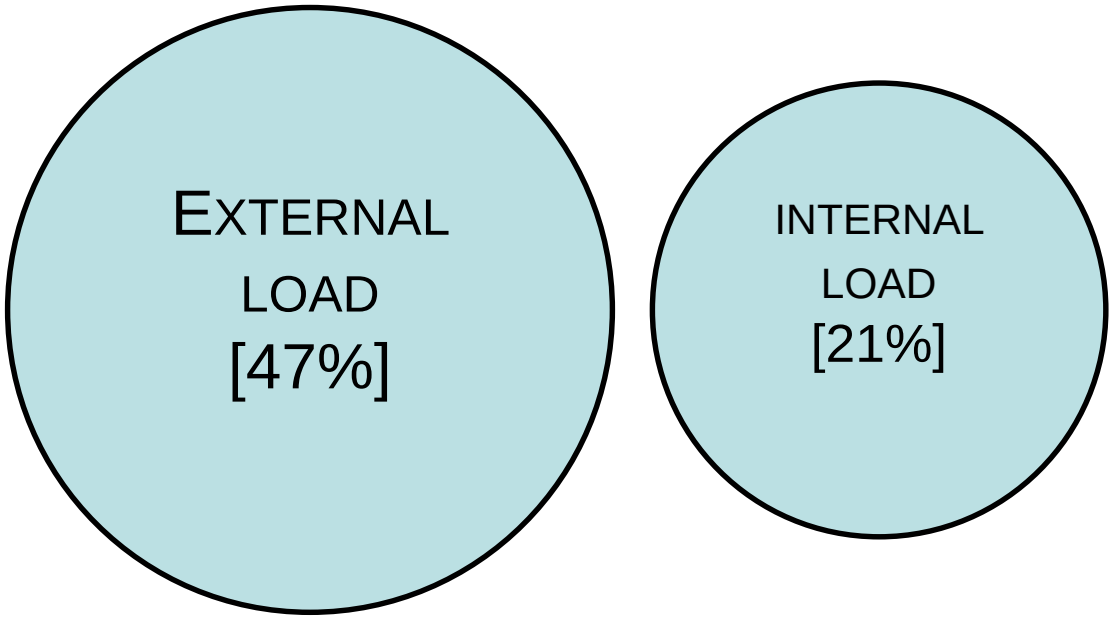
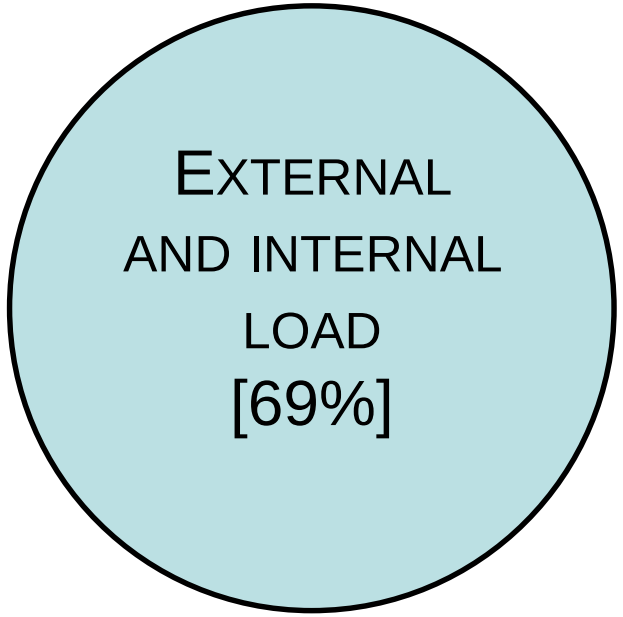
Number of Features: Influence of training mode

Skills training



Small-Sided-Games



iTRIMP BodyLoad Impacts High-Speed-Distance
(> 15 k·hr^{-1})

Weaving et al. (2014). Combining internal- and external-training-load-measures in professional rugby league. *IJSPP*.

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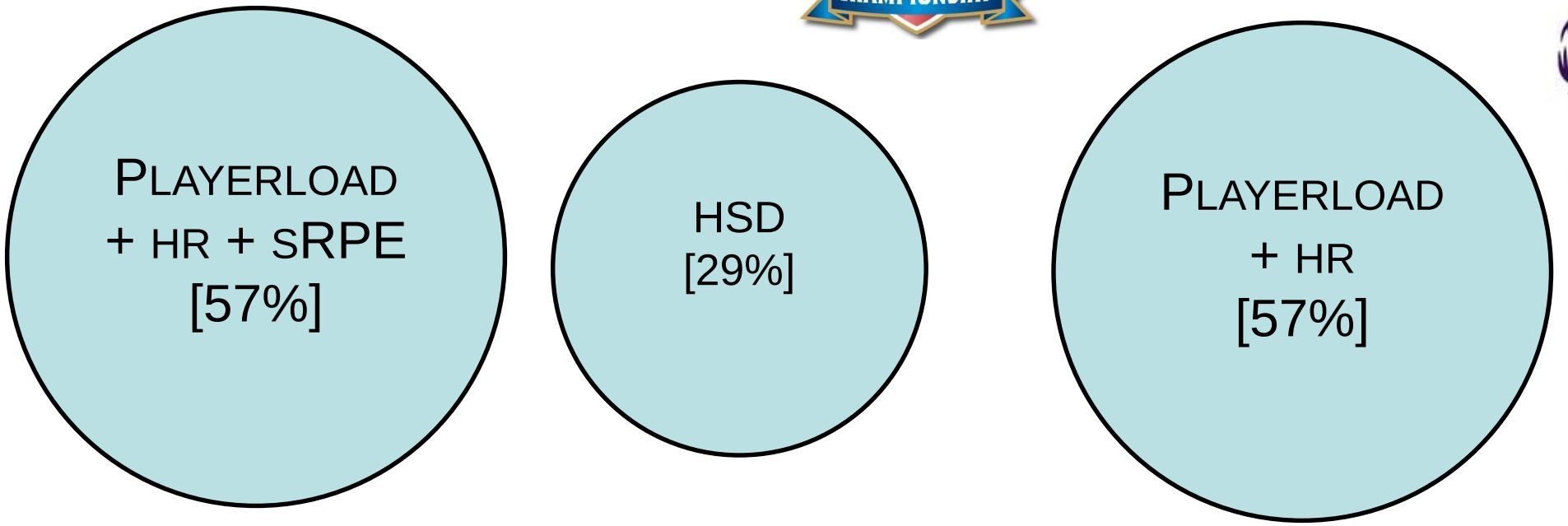
Number of Features: Influence of training mode

Conditioning

Skills



Heart-rate-exertion

PlayerLoad

sRPE

Individualised High-Speed-Distance
(> v30-15$_{IFT}$)

Weaving et al. (2017). Multiple measures are needed to quantify training loads in professional rugby league. *IJSPP*.

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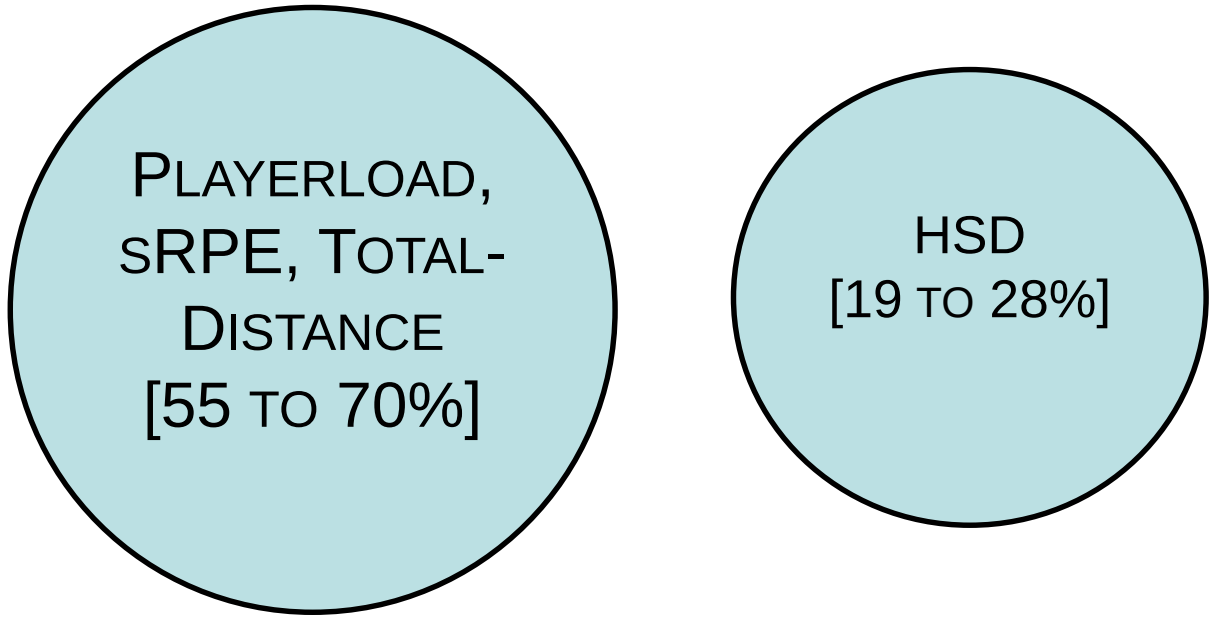
Number of Features: Influence of training mode

Rugby Union Skills Training

Within-individual relationships



Weaving et al. (2017). Same story or unique novel? Within-participant principal component analysis of training load measures during professional rugby union skills training. *Under Review*.

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Modelling TL: Summary

- Training mode is a substantial moderator of training load relationships (Weaving et al. 2014; 2017a; 2017b). Supported by meta-analysis (McLaren et al., 2017 [under review]).
- Therefore, different combinations of load measures likely needed to provide best representation of the ‘stress’ of training/competition.
- Multiple data engineering of training load measures (i.e. cumulative load, acute load, changes in load) needed as they provide differing contributions of information that relate to injury risk (Williams et al., 2016).
- There is also a need to account for additional moderating/mediating effects (i.e. previous injury, fatigue measures).

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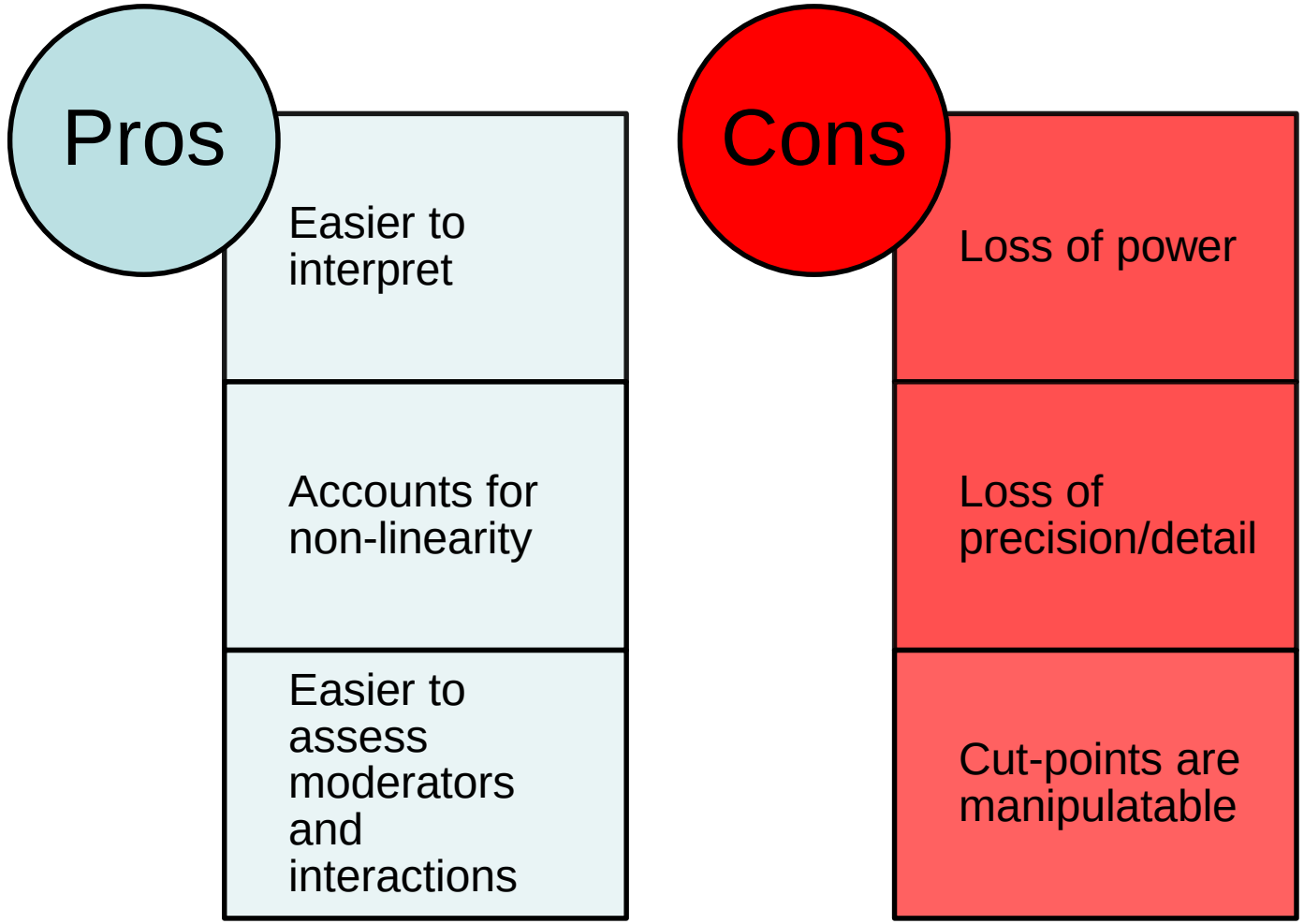
Coding For Time-Lag

RSNLive17_analysing-time-lags

Continuous v Categorical

Splitting continuous data into categories (tertiles/quartiles/quintiles etc. etc.)



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The Data Journey

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⑤ VISUALISE

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Visualise

Excel workbook:

RSNLive17_load-monitoring-worksheet

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The Data Journey

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⑥ DECISIONS

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Applications of load monitoring: Performance

Placing the data into the contextual decision making of coaches

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Applications of load monitoring: Performance

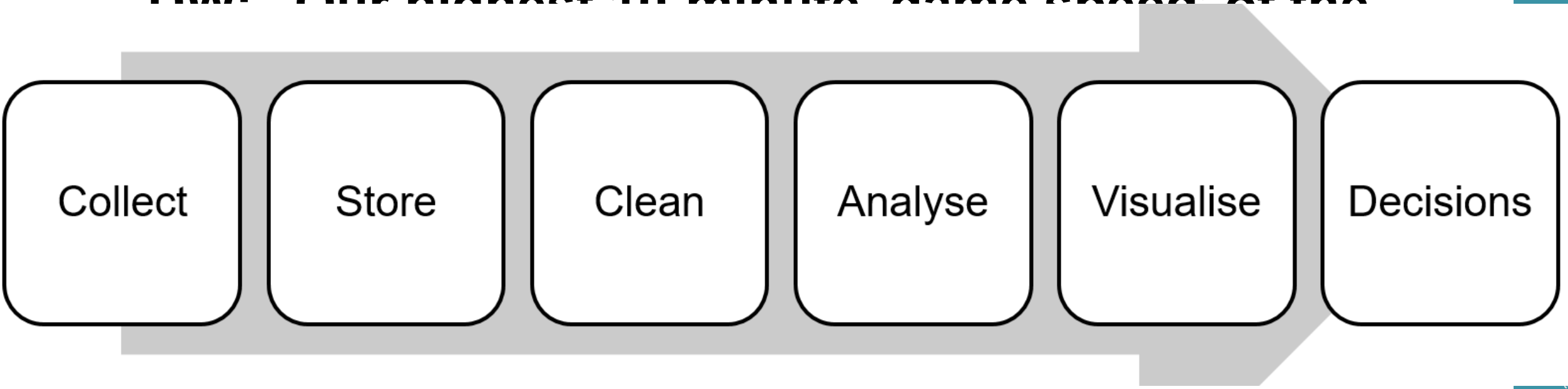
Coach: “this game will be a war of attrition… therefore we need to deal with the ball being in play for considerable length of time coupled with frantic periods of play”

Coach: “We need to develop our running legs in the build up to this game”

Applications of load monitoring: Performance

"We need running legs"

DW: "Our highest 10-minute 'game speed' of the



and this came in the 1st 10-minutes against team x"

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Applications of load monitoring: Performance

1.) Export time coded (e.g. half/involvement) match files

2.) 10-minute rolling average of 'raw' instantaneous speed (e.g. average speed 00:00:00 to 00:10:00; 00:00:01 to 10:00:01 etc)

3.) Customised algorithm using *zoo* package to find the peak 10-min m·min^{-1} and the time in match this occurred

Int J Sports Physiol Perform. 2015 Sep;10(6):725-31. doi: 10.1123/ijspp.2015-0092. Epub 2015 May 26.

Establishing Duration-Specific Running Intensities From Match-Play Analysis in Rugby League.

Delaney JA[1], Scott TJ, Thornton HR, Bennett KJ, Gay D, Duthie GM, Dascombe BJ.

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Applications of load monitoring: Performance

Coach Engagement/Outcomes

4. Look back at the video of the match where the peak 'running' period of the season occurred: can we replicate and/or exceed these demands in training?

- **Ball in play for ~9 minutes**
- **3 line breaks, 0 points scored/conceded**

5. Led to development of weekly "Tempo Cycles" integrated into skills training.

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Applications of load monitoring: Performance

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Real-time Feedback

OpenField

6. Real-time GPS data

7. Feedback speed to coaches every minute in reference to peak

8. Simulated 'line breaks' to manipulate speeds

J Strength Cond Res. 2017 Jul 8. doi: 10.1519/JSC.0000000000002127. [Epub ahead of print]

The validity of real-time data generated by a wearable microtechnology device.

Weaving D[1], Whitehead S, Till K, Jones B.

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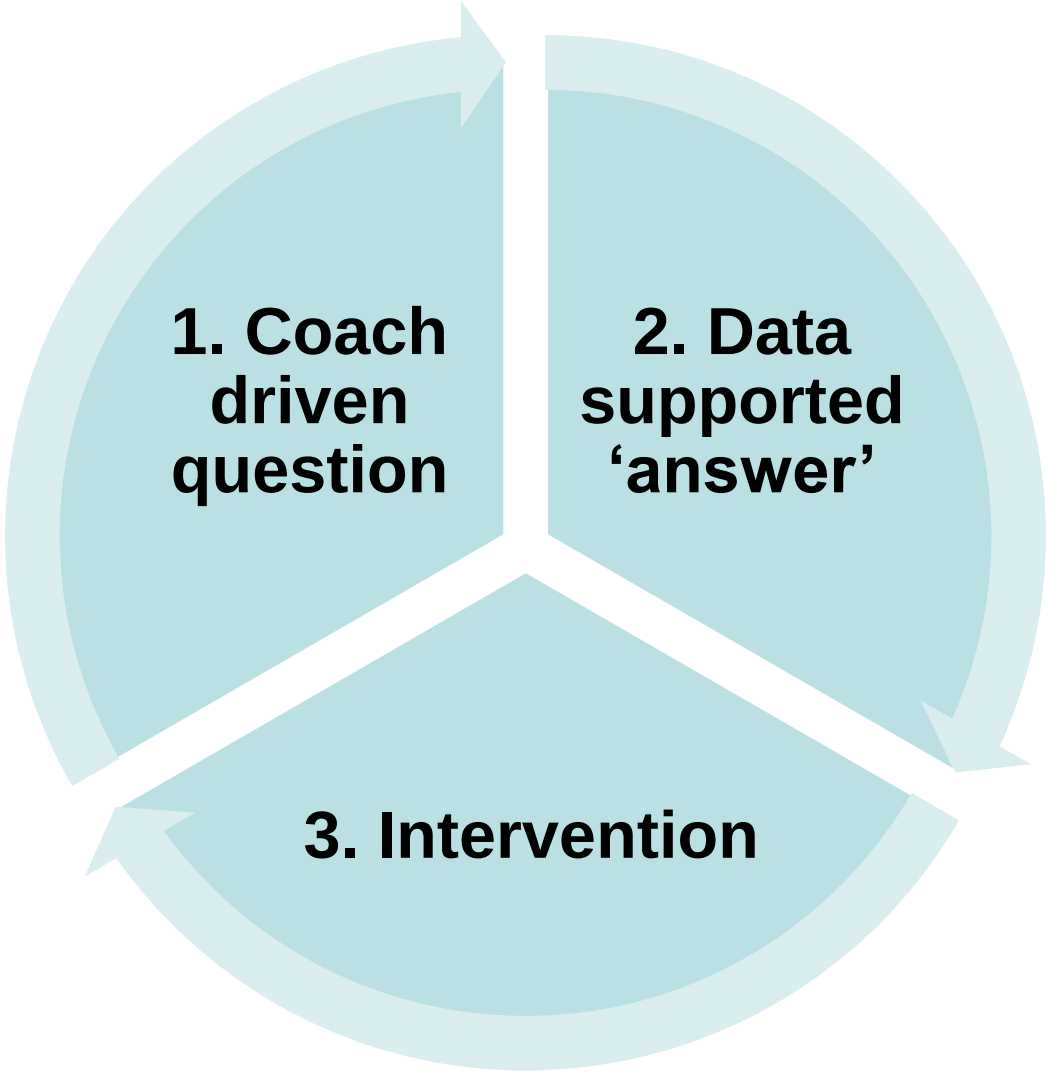
Applications of load monitoring: Performance



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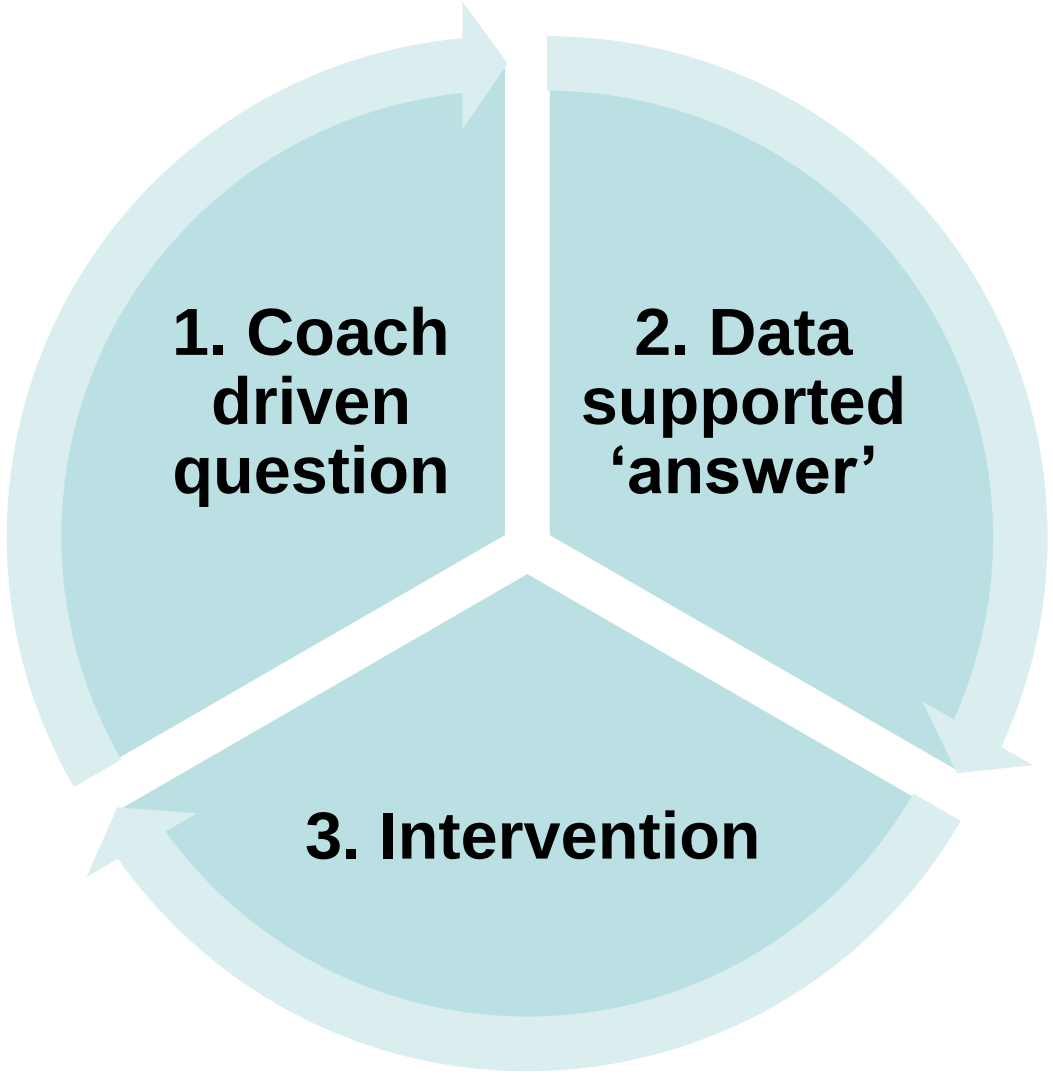
Applications of load monitoring: Performance



Allows coach-researcher dialogue to evolve

"We need running legs"

To now:

How do I know my outside backs are getting the same high-speed-running they do in this peak period?

How do I know my 'middles' are getting the same collisions?

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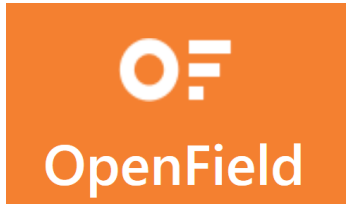
Applications of load monitoring: Performance

2.) 10-minute rolling average of 'raw' instantaneous speed (e.g. average speed 00:00:00 to 00:10:00; 00:00:01 to 10:00:01 etc)

3.) Customised algorithm to find the peak 10-min m·min^{-1} and the time in match this occurred



4.) Code time of peak 10-minute back into Openfield to determine high-speed-running/sprinting/collision events that occurred during peak 10-minute

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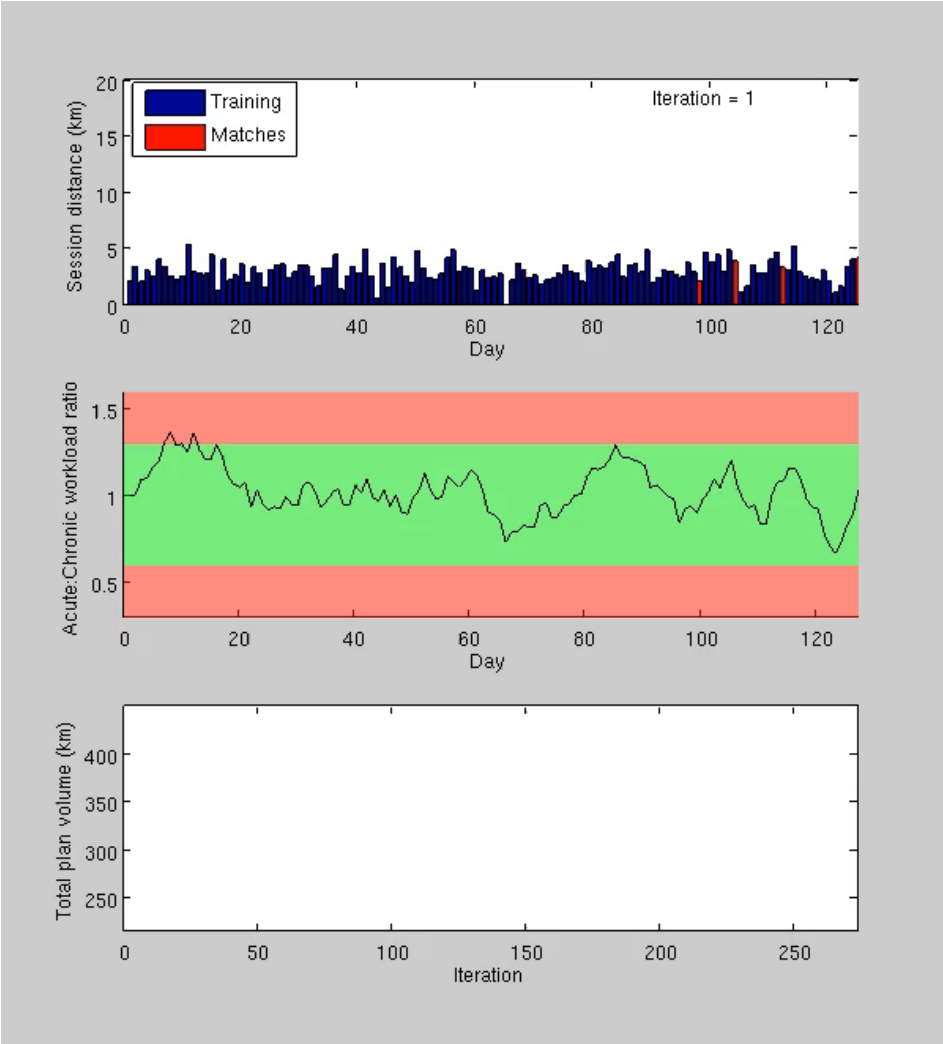
Decisions

- Load optimiser workbook
- Load planner workbook



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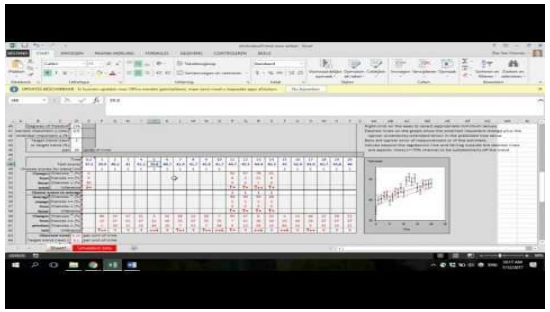
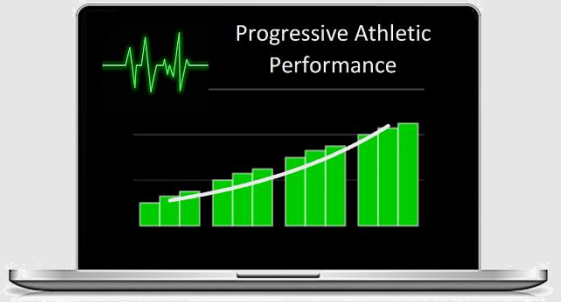
Additional Resources

[A Spreadsheet for Monitoring an Individual's Changes and Trend]



[https://progressiveathleticperformance.com/]



ExcelTricksforSports (YouTube Channel)

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