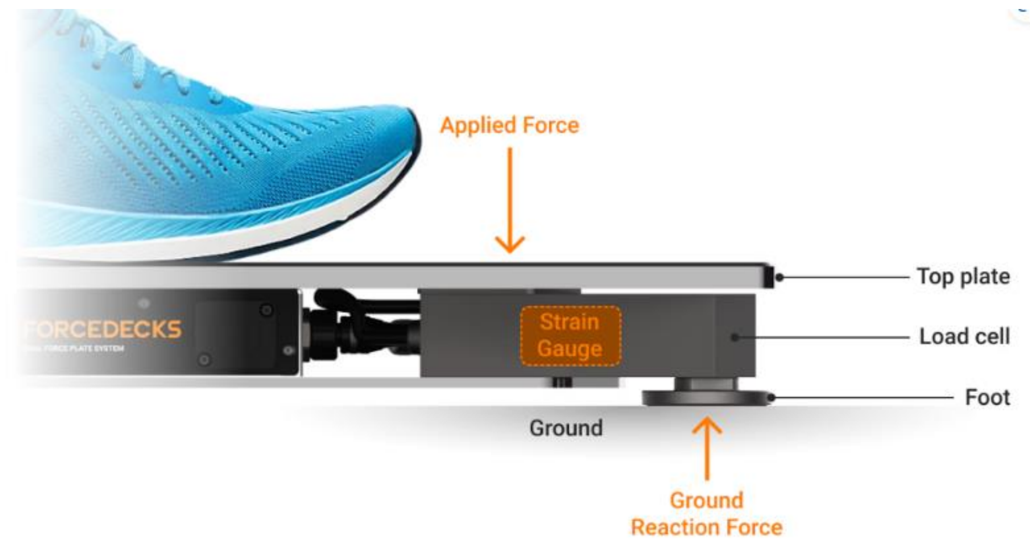
Force platforms, profiling and detection of changes in calculations

We have already mentioned force platforms as a technology used for data recording in the context of the Sport Scientist. We have used sample data in multiple examples to perform analyses and some of the specific protocols and variables have also been described. In this course, we will delve into the specifications of this technology, its range of test possibilities it offers and its day-to-day applications aimed at decision-making, seeking to improve players' performance.

Force platforms, unlike jump platforms, are equipped with sensors. These sensors measure the ground reaction forces (GRF) of the subject who is jumping or performing different actions on top of them. These sensors are also called load cells (Lamkin-Kennard; Popovic, 2019). Therefore, this device not only allows us to measure the time that the subject is not in contact with the platform (as in the case of traditional jump platforms) but also, based on the force signal retrieved by the sensors and the subject's weight, we will be able to calculate derived parameters that have to do with different properties of the test execution (speed, displacement, acceleration, power, etc.).

Figure 1: Force Platforms



Source: Clubb, 2023. https://bit.ly/3WKd5RA

In addition, it is fairly common for current technologies to have two devices connected to each other, and, in most test protocols, each of the legs is placed in one of the devices, enabling calculations of asymmetries and detection of differences in force production during the different protocols.

This technology has experienced greater portability in recent years. At the beginning of its implementation, the tests had to be carried out in laboratory conditions since the platform had to be located in a specific and fixed place so that the sensors did not get decalibrated and the measurements were valid. Although nowadays these strict conditions are no longer so, there are a number of considerations to take into account when using this technology in order to guarantee its correct results. They will be described below,

- The place where we carry out the tests must be a firm and level surface.
- We must calibrate the device before each test session. The software allows for this option before recording any data.
- We must make sure that we correctly measure the weight of the player who is going to perform the test (in tests where the player is placed completely on top of the platforms). Most of the variables or results presented by the software use the player's weight on their calculations.

Although they are not related to the sensitivity of the tool, we must remember that to guarantee the quality of the data in any type of test we perform, we must establish a correct protocol and guarantee sufficiently standard conditions before recording data. These parameters ought to be repeated consistently if we assess the player on multiple occasions.

Test Options

In the same way as with any other technology used in sports performance, when using force platforms, it will be our objectives as Sport Scientists that will influence our decision to select the test(s) which provide us with the necessary information to help answer our guiding questions.

Depending on our training methodology and the environment in which we work, we will select one array of tests or another to evaluate specific qualities.

An example is the case study described by Schuster, Bove, and Little (2020) in a basketball team. In the article they describe how they use a wide variety of tests using force platforms. They have used countermovement Jumps (CMJ) to assess the physical qualities associated with performance in jump and unipodal jumps to provide specific information on one laterality or another. They also used these tests to compile reference values in case of injury. Squat Jumps (SJ) were used to isolate the concentric part of the movement and provide information on possible inefficiencies in force production when compared to movements that include the eccentric part. They also used Drop Jump (DJ) and repeated jump tests as they are similar to specific actions of the sport and, therefore, provide information on jump phases that are decisive for performance. Finally, they used landing tests, another sport-specific action, which allowed them to collect information on stability and balance.

Although in most cases tests on force platforms are related to lower body assessments, there are specific tests to assess upper body strength and its relationship with specific movements in sport (Ashworth et al., 2018).

This tool can not only be used to assess performance or progress during the return to competition process, but it can also be a control or guide tool during the training process, i.e. it can be used to measure that the prescribed training is being carried out at the appropriate intensity. In the same way that we could use encoders for strength training, if we use a training methodology based on isometric contractions, force platforms can provide us with instant feedback on the player's performance during each of the exercises proposed. Natera (2024) provides a large amount of practical information to use this tool during the testing and training processes.

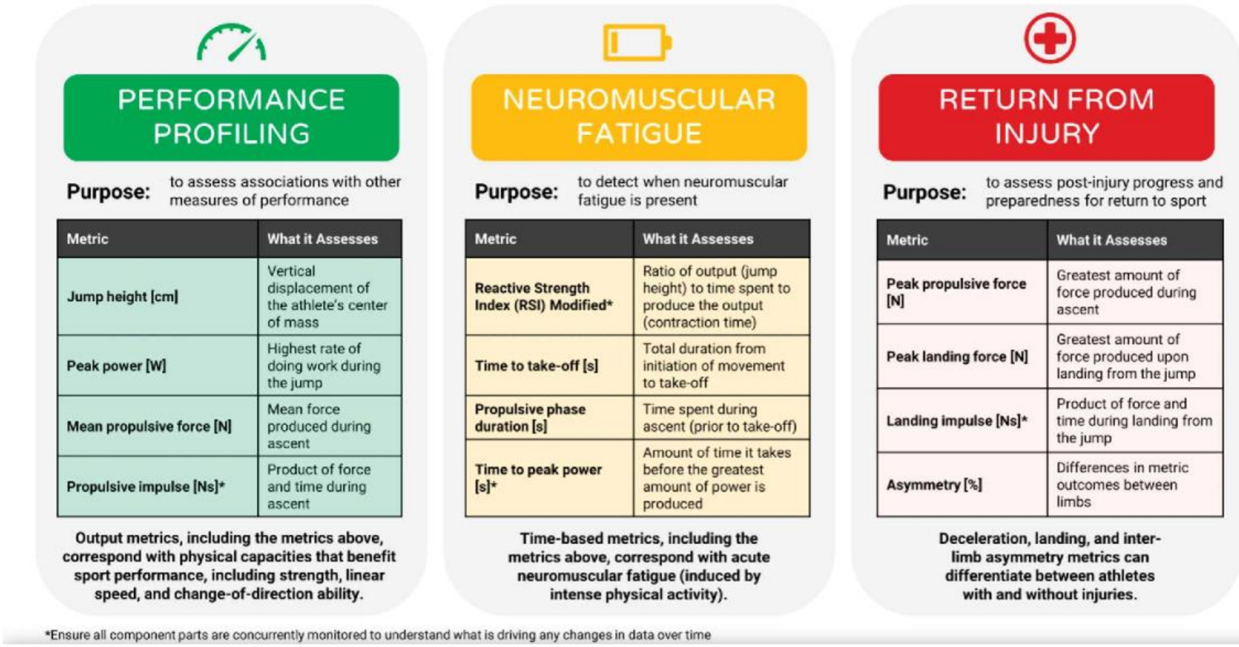
In the same way that we have established a series of considerations to use the tool, the general requirements before administering each test should also be highlighted to ensure the highest possible quality and reliability of the results. The time it takes athletes to get familiar with the tests has to be considered, which can vary depending on the complexity of the action and the athlete's experience. The time it takes to administer the test will determine the feasibility of its implementation as well as the frequency of its registration throughout the season. Finally, it is useful to perform tests that provide different or complementary information - using multiple tests that provide similar information will not provide us with an efficient data recording protocol, will not provide more context to make decisions and may cause greater rejection to the performance of tests by the players with whom we work.

For this module, we will only describe the data analysis processes related to the CMJ test, as it is one of the most widespread tests in the field of physical performance assessment (Bishop et al., 2023).

In addition, the large number of variables it provides allows us to use each of them to make decisions about different areas related to physical performance.

In this figure by Bishop et al. (2023), each of the metrics is classified taking into account their particularities and objectives.

Figure 2: Classifying metrics based on their objective



PERFORMANCE PROFILING

Purpose: to assess associations with other measures of performance

Metric	What it Assesses
Jump height [cm]	Vertical displacement of the athlete's center of mass
Peak power [W]	Highest rate of doing work during the jump
Mean propulsive force [N]	Mean force produced during ascent
Propulsive impulse [Ns]*	Product of force and time during ascent

Output metrics, including the metrics above, correspond with physical capacities that benefit sport performance, including strength, linear speed, and change-of-direction ability.

NEUROMUSCULAR FATIGUE

Purpose: to detect when neuromuscular fatigue is present

Metric	What it Assesses
Reactive Strength Index (RSI) Modified*	Ratio of output (jump height) to time spent to produce the output (contraction time)
Time to take-off [s]	Total duration from initiation of movement to take-off
Propulsive phase duration [s]	Time spent during ascent (prior to take-off)
Time to peak power [s]*	Amount of time it takes before the greatest amount of power is produced

Time-based metrics, including the metrics above, correspond with acute neuromuscular fatigue (induced by intense physical activity).

RETURN FROM INJURY

Purpose: to assess post-injury progress and preparedness for return to sport

Metric	What it Assesses
Peak propulsive force [N]	Greatest amount of force produced during ascent
Peak landing force [N]	Greatest amount of force produced upon landing from the jump
Landing impulse [Ns]*	Product of force and time during landing from the jump
Asymmetry [%]	Differences in metric outcomes between limbs

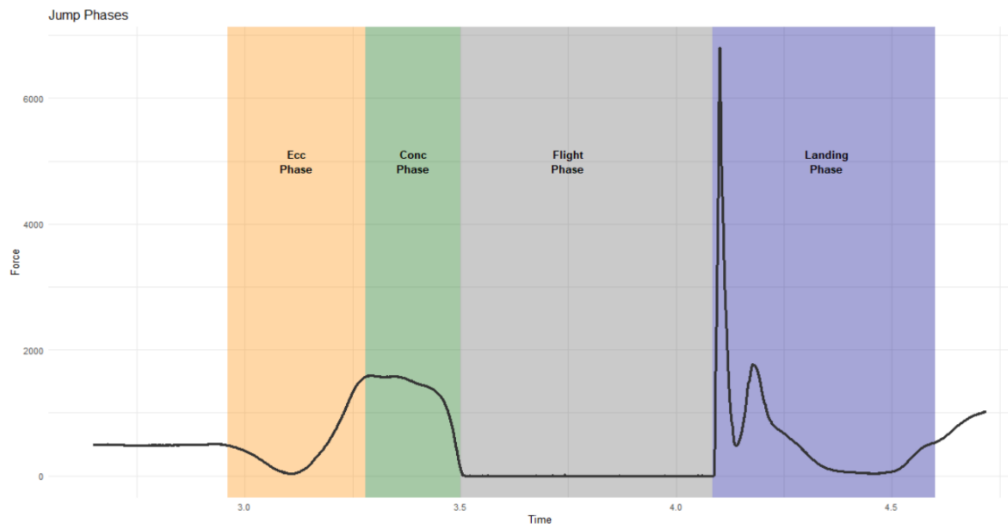
Deceleration, landing, and inter-limb asymmetry metrics can differentiate between athletes with and without injuries.

*Ensure all component parts are concurrently monitored to understand what is driving any changes in data over time

Source: Bishop et al., 2023, p.6.

This classification is made based on the knowledge of the information each of the metrics provides. It should be noted that the signal obtained from the platforms (raw data) is a continuous signal. The calculations made on the basis of that signal will produce the metrics, which show "how" the jump was made. This aspect is related to each of the objectives proposed in the research. It may be relevant to know the calculations from which to arrive at each of the metrics, but it is essential to know the information they provide if we want to use them for decision-making in each of the groups shown.

Figure 3: Jump phases



Source: Author's own production.

Change detection

During the course we have described different analysis methods to visualize trends over time in the different test results. In this section, we will look into detecting significant changes in the results of multiple tests. We will highlight the change detection processes and in the video material you will find their implementation using RStudio.

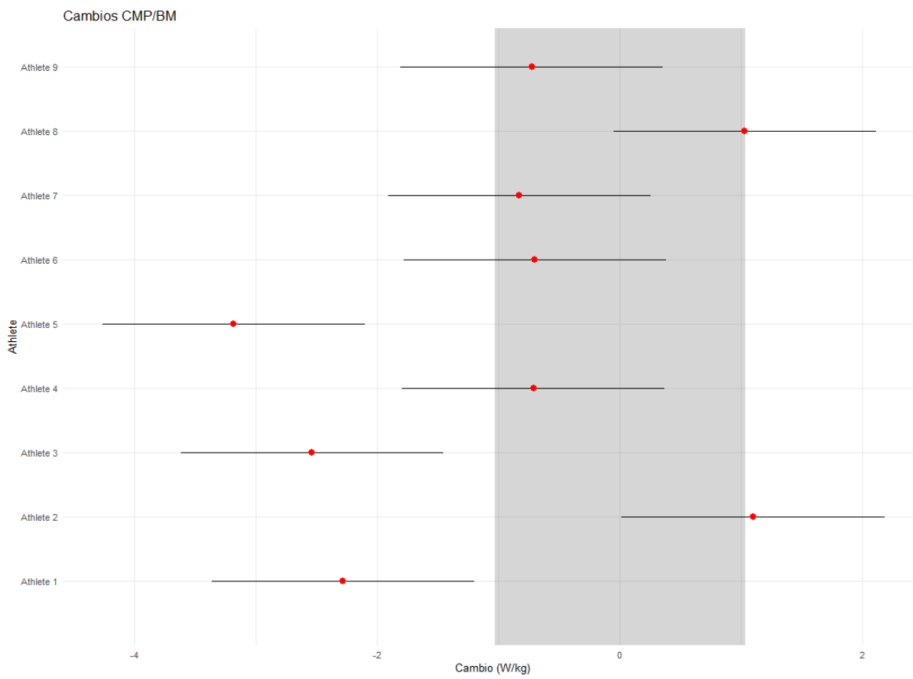
In Sports Science, Magnitude Based Inferences (MBI) approaches are commonly used to determine changes instead of using statistical analyses that are based on the null hypothesis approach (Buchheit, 2017). This approach, instead of determining whether there have been changes by "yes or no", allows the probabilities of that change being real or significant in a quantitative way.

As we have mentioned on multiple occasions during the course, players present a certain degree of variability in the results of the tests they perform; this variability is given by the instrument's error margin and also by small daily fluctuations in the player's state or fatigue. Therefore, if we only assess whether there has been a change in the result of one test, we do not have enough information to verify that this change has been significant. To determine whether there has been a significant change in performance, we need to calculate the "Smallest Worthwhile Change". It will be the threshold from which we can consider whether the change we have observed is real.

To calculate this threshold, we consider the population and the type of sport, but as a general rule, the SWC should be established as 0.2 multiplied by the standard deviation among subjects for each test (Hopkins, 2004). This is based on the fact that it would be a significant enough change if the player moves within the scores distribution of the group they are in.

However, that is not all there is to consider; as we have mentioned before, each of the tests has some intrinsic variability; therefore, we have to consider and quantify that variability before determining the magnitude of the change. To do this, we can use the variation coefficient (VC) between tests for each player in repeated measures such as a jump. If that VC is greater than the SWC, we can use the VC as a measure to determine that change.

Figure 4: CMP/BM changes



Source: Author's own production.

With this information, we have the steps to take to apply these considerations to our results and determine what functions we will need to analyse and visualize the data in a timely manner, using RStudio.

Raw data

Once again, these tools raw data from which the metrics arise make available to us; in some contexts we may not have the specific data analysis software and it may be necessary to perform the calculations from scratch using RStudio.

Being able to deal with the raw data signal and to perform complementary analyses eliminates any limitations that the specific software of the tool may present. We need to know how to perform the relevant calculations and the steps to follow in RStudio to achieve the desired result. In previous courses, and especially in the module on the analysis of raw data, we have seen a figure regarding the force-velocity curve calculated from the raw data from a CMJ jump. This analysis allows us to provide information on player fatigue (Gathercole et al., 2015) based on the identification of changes in force production throughout the time series.

All variable calculations are based on the raw data of the force signal. Acceleration comes from the knowledge of force and mass over time - with this information we can get velocity. Finally, with the signal of force and speed we can get power. From these signals, we can get the derived metrics or "features". When "x" conditions are met, we will determine that it is one phase of the jump or another and after identifying these phases we can calculate metrics that may be important for our context, such as the peak in the concentric phase, the "rate of force development" or the "concentric peak power".

McHugh et al. (2020), propose to use the force signal during jumps to determine if there is a more efficient profile of force production during movement. As we can see in the figure below, they classified players according to the characteristics of force production which allowed them to determine which players in which group are capable of producing greater results, indicating possible characteristics that benefit that output. This is yet another example of how to use raw data to provide quantitative and qualitative information about jump execution, which has a positive impact on player performance.

Figure 5: GRF jump profiles for different types of observed jumps

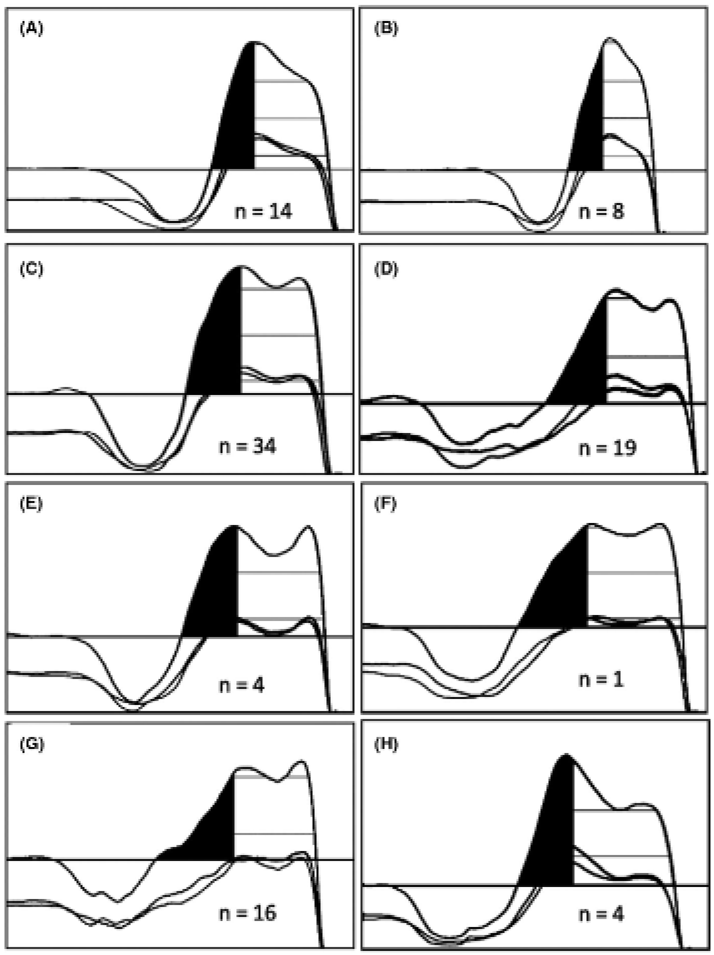


FIGURE 2 GRF jump profiles for different types of jumps observed. A, unimodal, peak force at low position (n = 14). B, unimodal, peak force after low position (n = 8). C, bimodal, first peak greater than second peak, peak force at low position (n = 34). D, bimodal, first peak greater than second peak, peak force after low position (n = 19). E, bimodal, first and second peak equal, first peak at low position (n = 4). F, bimodal, first and second peak equal, first peak after low position (n = 1). G, bimodal, second peak greater than first peak, peak force after low position (n = 16). H, bimodal, first peak greater than second peak, peak force before low point (n = 4)

Source: McHugh et al., 2021, p. 142.

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