Taken Too Far? What the Locomotor Profile Does Well, Less Well, and Least Well in Football (Soccer)

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Headline

Why players in the same squad respond differently

Players from the same football (soccer) squad do not respond to, tolerate, or benefit from the same training in the same way. The same dose produces different internal and adaptive responses, so a one-size-fits-all group programme reliably leaves some players well stimulated and others under- or over-stimulated (Mann et al., 2014; Buchheit et al., 2021b; Sandford et al., 2021). Some cope well with higher volumes and longer aerobic work, while others thrive on short, explosive efforts but struggle once sessions get longer or denser. This is not about current conditioning or effort, but about real, measurable differences in what players are physically made of.

Part of this variation is anchored in muscle and its fiber types. Type II (fast-twitch) fibers are glycolytic and powerful, but fatigue quickly. In contrast, type I (slow-twitch) fibers are oxidative, energy-efficient, and fatigue-resistant (Schiaffino & Reggiani, 2011). The proportion of each fiber type in a muscle, i.e. fiber type composition, varies considerably between individuals, is largely genetically determined and changes little with training (Komi et al., 1977; Simoneau & Bouchard, 1995; Ingalls, 2004). On average, high-level football players have a fairly balanced muscle fiber type composition, as might be expected given the mixed demands of the sport. However, within a single squad, fiber type composition can vary markedly between players, with differences of up to 43.6 percentage points and clear heterogeneity even within one playing position (Jacobs et al., 1982; Bangsbo et al., 1993; Mohr et al., 2016; Lievens et al., 2022; Hopwood et al., 2023). The spread of this characteristic, which influences training responses, is one of the reasons why one programme cannot suit everyone, and why profiling earns its place.

The usual way to make sense of this in the field is the locomotor profile: where a player sits on an endurance-speed continuum, defined by maximal aerobic speed (MAS) and maximal sprinting speed (MSS), with the anaerobic speed reserve (ASR) as the gap between them (Bundle et al., 2003; Sandford et al., 2021). Above MAS, what matters most is not intensity as a percentage of MAS, but the proportion of the ASR being used (Blondel et al., 2001; Bundle et al., 2003; Sandford et al., 2021). Simple, field-based and familiar, the locomotor profile is the foundation this paper builds on.

But it can only take us so far, for two reasons. Practically, MAS and MSS are often not measured as the model assumes, so the profile we work with is an approximation. Conceptually, even a perfect locomotor profile tells us how fast a player is, not what their muscle is made of. The proposition of this paper is, therefore, that player profiling works best as two complementary layers. The locomotor profile is a tool for acute prescription, guiding how running and high-intensity interval training (HIIT) are pitched (Buchheit & Laursen, 2013a, 2013b; Sandford et al., 2021). An estimate of muscle fiber type composition is a tool for load management: recovery, overload tolerance and injury risk mitigation (Lievens et al., 2020; Bellinger et al., 2020; Lievens et al., 2022; Van de Casteele et al., 2026). The two are related but not interchangeable.

Box 1. Taken too far? The present first author included

One thing is worth stating clearly before going further. The locomotor profile has been taken further than the evidence currently supports, and the present first author has walked that road himself. He has built on the locomotor profile since the seminal work of Bundle et al. (2003), and it has shaped most of what followed on the 30-15IFT, from its use to individualise interval training (Buchheit, 2008) to ASR-based HIIT programming (Buchheit & Laursen, 2013a, 2013b; Sandford et al., 2021). More than two decades of applied work therefore rest, at least in part, on the locomotor profile, yet its link with muscle fiber type composition has never been tested directly. The framework was not built to carry that weight. Sandford et al. (2021), the paper that popularised it, insisted that the absolute MSS and MAS values must always be read alongside the reserve, and presented the profile as one input into training decisions, not as a verdict on the muscle. In practice, both caveats were largely lost along the way: the ASR has often been read as a proxy for fiber type without any direct validation, and the profile used to choose not only how hard players run but also what training they receive, in courses and practitioner articles alike (e.g., Buchheit, 2025; Colomer, 2025, 2026). As with any idea that spreads at scale, part of this drift lies in how it was used rather than in what was proposed. The reason the field went down that route is pragmatism rather than carelessness, since MAS and MSS are cheap, familiar and often already collected. Much of what follows is therefore as much a correction as an extension, and the limitations are set out in full at the end.

Aim

This paper offers practitioners a usable, honest framework for profiling players when ideal measurements are not available, and shows how that framework extends beyond running speed into the muscle underneath. The reference standard for determining fiber type composition is the evaluation of a muscle biopsy (Bergström, 1975), which remains invasive and unrealistic for routine use in a squad (Lievens, 2021; Van de Casteele et al., 2026). Everything that follows is therefore about estimation, not measurement, of the muscle.

Two things must be kept apart from the start, and we keep them apart throughout. The evidence that muscle typology matters for how much load a player can absorb is strong, and rests on longitudinal overload and injury data (Bellinger et al., 2020; Lievens et al., 2022). The evidence that a club can accurately estimate typology with the tests at its disposal is weak. A good reason to care about the muscle is not the same thing as a good way to measure it, and readers should not let the strength of the first claim carry the second.

In this paper, we first set out the three purposes a test can serve and then discuss each one in turn: bucketing the player, prescribing from the bucket, and managing load from an estimate of muscle typology. We also address the typical working conditions in applied practice, where MAS and MSS are not measured as intended, and we rank the substitutes based on what they still support. Our guiding principle is not to chase perfect fiber typing or a flawless profile, but rather to help practitioners select the least burdensome combination of tests that provides sufficient information for their context. Profiling for practice, not for perfection.

What a set of tests lets you do: three purposes

Before any test is chosen, it helps to separate three purposes a test can serve, because they do not survive equally well once the ideal measurement is unavailable.

- **Bucketing** means sorting players into endurance, hybrid, speed and skilled groups. It is the coarsest judgment and the most resilient one.
- **Prescription** means turning test results into a session, and it works at two levels (Sandford et al., 2021). The first is intensity, setting the speed as a percentage of the ASR or the corresponding percentage of the 30-15 Intermittent Fitness Test end-test velocity (V_{IFT}), which needs a genuine aerobic anchor and a genuine speed anchor. The second is content, choosing which training model a profile follows across a season and which format it receives on the day, what we called the macro and micro levels of individualisation (Sandford et al., 2021). Both are used as prescription in practice, but they do not rest on the same evidence, and we treat them separately.
- **Load management** means anticipating and managing recovery, overload tolerance and injury risk. This is the purpose of an estimate of muscle typology, and it becomes possible only as the tests we use start sampling the muscle itself rather than locomotor output.

The three follow a logical order. The bucket comes first and guides content. Intensity does not depend on the bucket at all: it comes straight from each player's own anchors (MAS and MSS, or V_{IFT}). Load management follows from the typology estimate. Much of the confusion in applied practice comes from treating a test that can bucket a player as if it could also prescribe for them. Keeping the three purposes distinct is what lets us be flexible without pretending every test does everything. The rest of this paper takes them one at a time.

A word on where these three meet. Prescription and load management are not separate activities in a weekly plan, and they constantly inform each other: the session prescribed determines the recovery a player needs, and the recovery a player needs limits the session that can be prescribed. The two layers are not a claim that these decisions are independent. They are a claim about which test informs which decision. The locomotor profile sets the dose inside a session, because it is expressed in the same currency as the session itself. The typology estimate sets the spacing, the density and the monitoring around those sessions, because it speaks to how much a player can absorb and how quickly they return. The two meet at the microcycle, which is where the practitioner has to hold both at once.

Bucketing the player: the locomotor profile

The best place to start is the simplest: position players by their MAS and MSS (Figure 1). Together, these two anchors place a player on the endurance-speed continuum and separate the broad profiles in a squad (Buchheit & Laursen, 2013a, 2013b; Sandford et al., 2021). One word on labels. MAS is a maximal aerobic power measure, the lowest velocity at which VO_2max is reached (Billat & Koralsztein, 1996), whereas endurance performance depends at least as much on the fraction of that power a player can sustain. We keep the familiar term "endurance" because it is what practitioners use, but it should be read as shorthand for the metabolic side of the profile.



Fig. 1. The locomotor profile on two axes. Players are positioned by relative MAS (vertical) and MSS (horizontal), producing four broad profiles: endurance, hybrid, speed, and "skilled".

Figure 1 shows how players are categorised into four profiles based on their relative values for MAS (vertical axis) and MSS (horizontal axis). High MAS with lower MSS is the endurance player; high values in both is the hybrid, the most complete profile; high MSS with lower MAS is the speed player, built for explosive actions. Lower values in both give the profile we half-jokingly call "skilled". These players are not especially fast or enduring, but often still excellent due to their technique, tactical intelligence, positioning and/or decision-making.

Figure 2 stacks MAS and MSS in a single vertical profile that summarises the overall locomotor profile (Bundle et al., 2003), making each component's contribution and the size of the reserve easy to read. Speed players show a large reserve

on high MSS and lower MAS; endurance players a smaller reserve and more aerobic contribution; hybrids high values in both; skilled players lower values in both, though they are not necessarily worse football players. With only MAS and MSS you can already sort a squad into four broad profiles. The framework is written in speed units because football (soccer) is locomotion-based. However, it translates directly to power-based sports such as cycling or rowing, where MAS becomes maximal aerobic power, MSS becomes maximal peak power, and the reserve becomes the anaerobic power reserve (Buchheit & Laursen, 2013a, 2013b; Sandford et al., 2021).

The MSS/MAS ratio, and why it should never travel alone

The next step is often to summarise the balance as the MSS/MAS ratio (the speed reserve ratio). Higher values indicate speed and lower values indicate endurance. In applied football practice, 1.9 or above is taken to suggest speed, 1.8 to below 1.9 hybrid, and below 1.8 endurance (adapted from Sandford et al., 2021; Colomer, 2025; Buchheit, 2025). These cut-offs are working benchmarks rather than validated thresholds, but they are quick to compute and handy for grouping. They also assume MAS from a continuous incremental run and MSS from a true maximal sprint. A field test that overestimates MAS by 1.6 km/h (Thron et al., 2022) moves a player with an MSS of 33 km/h and a MAS of 16 km/h from 2.06 to 1.88, from speed to hybrid. And on those terms most elite players sit above 1.9: the positional means of Manzi et al. (2025) give ratios from 1.94 (midfielders) to 2.14 (forwards), so a squad bucketed on the ratio alone would be steered almost entirely toward the speed profile.

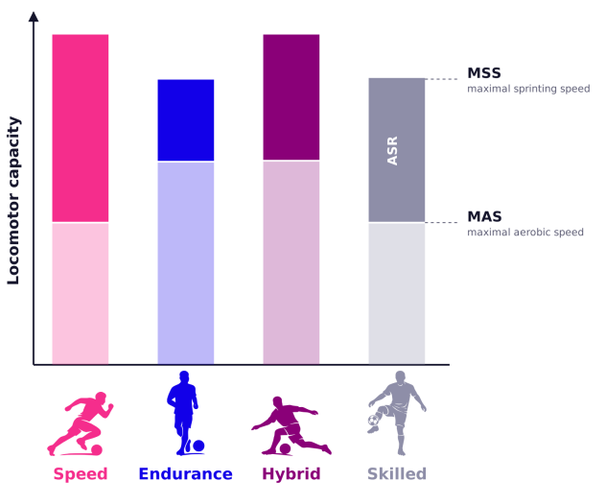


Fig. 2. The locomotor profile as stacked components. MAS and MSS are shown within a single vertical profile so the relative contribution of each and the size of the ASR (darker color) are visible across the four profiles.

The ratio also carries a trap, and the ASR literature is explicit about it: a ratio says nothing about the absolute capacities beneath it (Sandford et al., 2021). A player can look like a speed profile because his MAS is poor relative to a modest MSS, not because he is fast. Two players can share an ASR of 17 km/h, one with MSS 37 and MAS 20 km/h, the other with MSS 33 and MAS 16 km/h, yet the first has clearly greater capacity (Manzi et al., 2025). The ratio hides that. So treat it as a classification aid, never a standalone label, and always read it next to the absolute values that produced it. The same caution applies to absolute ASR, as a low MAS in an aerobically untrained athlete can inflate the ASR as easily as a genuinely high top speed (Sandford et al., 2021; Thron et al., 2026).

Where players actually sit

It helps to know the normative landscape. Positional data from elite football (Serie A; Italian first division) give role-specific references: full-backs and midfielders record the highest MAS (approximately 16.8 to 16.9 km/h), while center-backs and forwards sit lower (approximately 15.5 to 15.6 km/h); full-backs reach the highest MSS (approximately 33.9 km/h) and center-backs the lowest (approximately 32.4 km/h); and midfielders carry the smallest ASR of the outfield roles (Manzi et al., 2025). Judging a player against those references rather than a squad average is especially useful for youth players (i.e., benchmarking) or those returning from injury (i.e., readiness to compete).

Team-based or normative? A bucket that can carry a content prescription

Reference values matter, because there are two ways to place a player in a bucket and they do not always agree. The team-based version ranks players against their own teammates, so a squad splits into endurance, hybrid, speed and skilled players whatever its absolute level. The normative version compares each player's MAS and MSS against role- and level-specific reference values (Manzi et al., 2025). Both are useful, but only the latter should guide the choice of session content.

The problem with the team-based version is that the boundaries between high and low MAS or MSS move with the squad rather than with the individual players. A group with a uniformly modest top speed will still produce speed-profile players, who may then be steered toward short explosive work and long recoveries they may not warrant, while in a genuinely fast squad a player with an excellent MSS can be labelled endurance. The boundaries can also move while the player stands still: a transfer window or a new intake can reclassify someone who has not changed physically. The working rule is therefore to bucket on normative values wherever reference data exist, and never to let a team-based label override what the normative numbers say. Figure 8 shows what this looks like on a real professional squad.

The limit of this first layer lies elsewhere. Two players with the same locomotor profile may cope with load completely differently (Sandford et al., 2021). Understanding that point means looking past how fast a player is, which is the subject of the second layer, set out after prescription and imperfect testing have been dealt with.

Prescribing from the anchors and the bucket

The two levels of prescription are usually presented as one, but they do not rest on the same evidence. The first level, HIIT intensity prescription, has a solid scientific basis. The second level, which concerns the content of HIIT and conditioning sessions, has been shaped by decades of sports practitioners' experience, but there is little direct scientific evidence to support it yet.

Level 1: individualising the HIIT intensity

The logic follows from the ASR construct. Because what matters above MAS is the proportion of the reserve used, players with a large reserve (speed profiles) reach a given speed at a lower fraction of their ASR and tolerate high-speed work differently from those with a small reserve (Blondel et al., 2001;

Bundle et al., 2003; Buchheit et al., 2012a; Sandford et al., 2021; Thron et al., 2025). Prescribing HIIT intensity as a percentage of the ASR rather than of MAS makes this concrete, and reduces inter-individual variability in acute internal responses compared with MAS-based prescription (Buchheit, 2008; Buchheit et al., 2012a, 2021b; Thron et al., 2025). This is the strongest and best-supported application of the locomotor profile, and the one part of profiling we would keep whatever happens to the rest, because it does not depend on the profile-to-training mapping being correct. Because it uses each player's own MAS and MSS, intensity individualisation is also unaffected by how, or against whom, the player was bucketed.

The same holds when the aerobic anchor is based on the 30-15 Intermittent Fitness Test (30-15IFT), which matters because most clubs are more likely to perform a 30-15IFT than to measure a true MAS. Its end-test velocity (V_{IFT}) is not MAS, but it relates to the locomotor profile in a principled way: V_{IFT} is reached at a velocity corresponding to roughly 25% of the ASR above MAS (Buchheit & Mendez-Villanueva, 2013), a roughly constant fraction of the reserve rather than an arbitrary point (Figure 3). The link also runs the other way: V_{IFT} follows from the locomotor profile itself, since MAS and MSS together predict V_{IFT}, and energetic modelling of four contrasting profiles showed that, for a similar MAS, a larger reserve from a faster MSS allows a higher V_{IFT} (Buchheit et al., 2021a). Because that relationship is broadly stable, prescribing at a percentage of V_{IFT} and prescribing at the corresponding percentage of the reserve are, on average, the same operation, placing players of different profiles at a comparable standardised intensity (Figure 4). Note however that the 25% figure is a group mean rather than a constant. In the source data V_{IFT} averaged 119% of the velocity reached in an incremental field test, but individual values ranged from about 104% to about 130% (Buchheit & Mendez-Villanueva, 2013). The slice of the reserve that V_{IFT} represents is therefore wider in some players than in others, so a fixed percentage of V_{IFT} places players at a similar, but not identical, fraction of their own reserve. That residual variation is part of the price of using V_{IFT} instead of a measured MAS and MSS. A club already running the 30-15IFT is therefore already prescribing this way, and prescribing from V_{IFT} gives less variable acute heart-rate responses than MAS-only based prescription (Buchheit, 2008), since V_{IFT} already carries some anaerobic and neuromuscular information. The cost of ignoring the profile altogether is easy to show. When four modelled player profiles performed the same fixed box-to-box HIIT session, all running the same distance together, the fittest and fastest profile finished with about 65% of its W′ (the work capacity available above critical power) left, and the less fit and slower profile with about 27%. Individualising the run distance to 100% of V_{IFT} brought all four profiles to about 40% (Figure 5; Buchheit et al., 2021b). A fixed distance, in other words, hands each profile a different session.

The support runs past the acute response. Over a training block, individualising interval intensity to either the ASR or V_{IFT} rather than to MAS alone has been reported to produce more uniform physiological adaptation across a squad (Wang & Ye, 2024), and these ASR-based prescriptions are now being detailed for each profile across long intervals, short intervals and repeated sprints (Buchheit, 2025; Colomer, 2026). For run-based HIIT, free spreadsheets now turn either the locomotor profile or V_{IFT} into individual running distances, including the extra cost of each change of direction in shuttle formats (Buchheit et al., 2026; available at `https://30-15ift.com/downloads/`). One limit keeps even this in proportion: the calculation is only as good as the MAS and MSS behind it, which are rarely measured as intended, and which is part of why the 30-15IFT route is attractive.

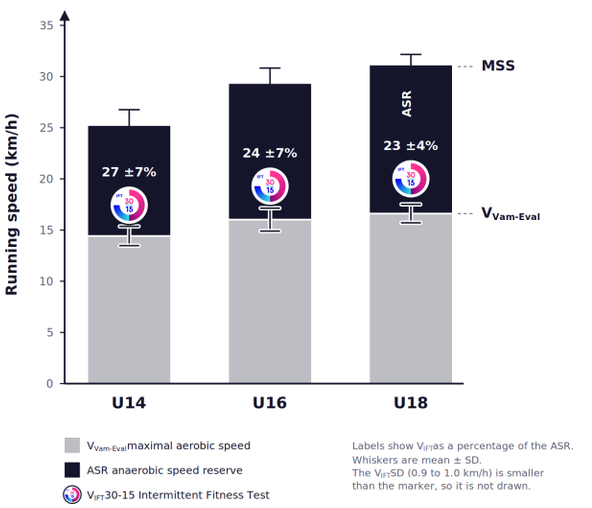


Fig. 3. The 30-15IFT end-test velocity (V_{IFT}) in relation to the locomotor profile. V_{IFT} is reached at a velocity corresponding to roughly 25% of the ASR above MAS, so it reflects both the aerobic base and part of the reserve. Source: concept per Buchheit & Mendez-Villanueva (2013).

Box 2. Intensity: the no-brainer

Of everything the locomotor profile is used for, setting HIIT intensity is the best supported. Prescribing from the ASR, or from V_{IFT}, reduces inter-individual variability in acute responses compared with MAS-based prescription (Buchheit, 2008; Buchheit et al., 2012a, 2021b; Thron et al., 2025), and has been reported to produce more uniform adaptation over a training block (Wang & Ye, 2024). It uses each player's own MAS and MSS, so it does not depend on how, or against whom, the player was bucketed, nor on the profile-to-training mapping being correct. Whatever the rest of this paper questions, this part stays: individualising intensity from the locomotor profile is the default, not an option.

Level 2: individualising the content

Applied frameworks then extend that logic from intensity to session content: endurance profiles tolerate continuous and longer-interval work and higher volume, while speed profiles are steered toward shorter intervals and repeated sprints with fuller recovery, on the reasoning that forcing a speed profile through high-volume continuous work risks maladaptation or overreaching (Sandford et al., 2021; Colomer, 2025; Buchheit, 2025). Hybrids tolerate the widest range; lower-capacity players need the most conservative, progressive exposure.

That extension is an inference drawn from the intensity logic, not a finding in its own right, and Sandford et al. (2021) say as much themselves, noting that HIIT formats have never actually been tailored to the locomotor profile. That is not

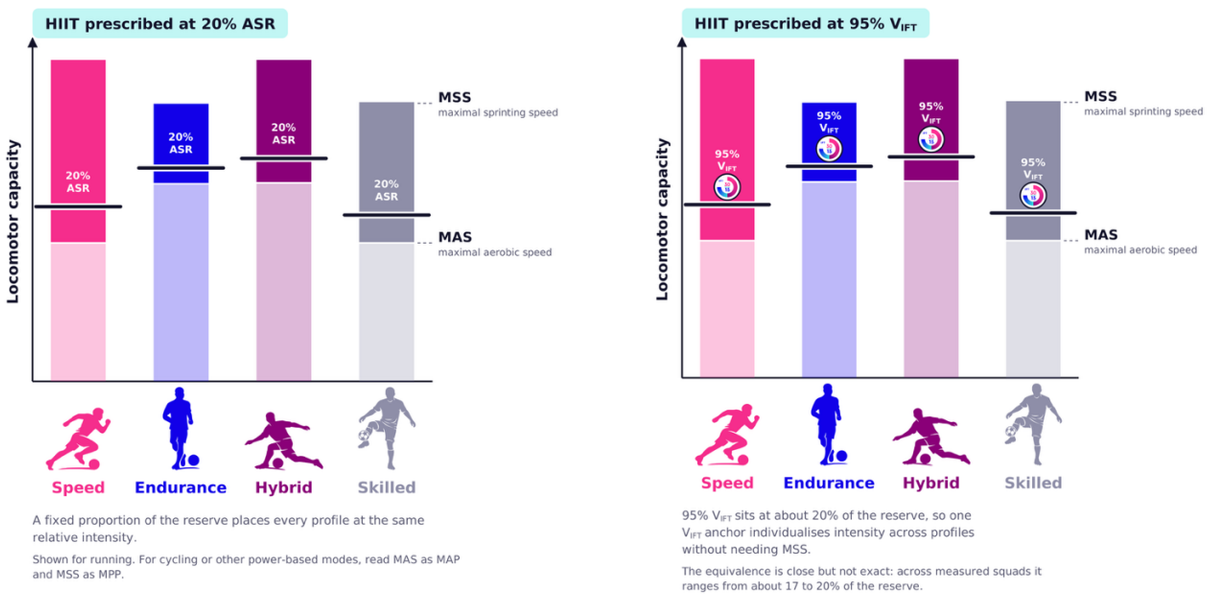


Fig. 4. **Standardising HIIT intensity using either ASR or the 30-15IFT. Because V_{IFT} sits at a roughly constant fraction of the anaerobic speed reserve, prescribing at a percentage of the reserve above MAS (a, left) and at the corresponding percentage of V_{IFT} (b, right) place all profiles at a similar standardised intensity (e.g., 20% and 95%). The two conventions are broadly interchangeable and both normalise the stimulus across profiles (Buchheit et al., 2021a).**

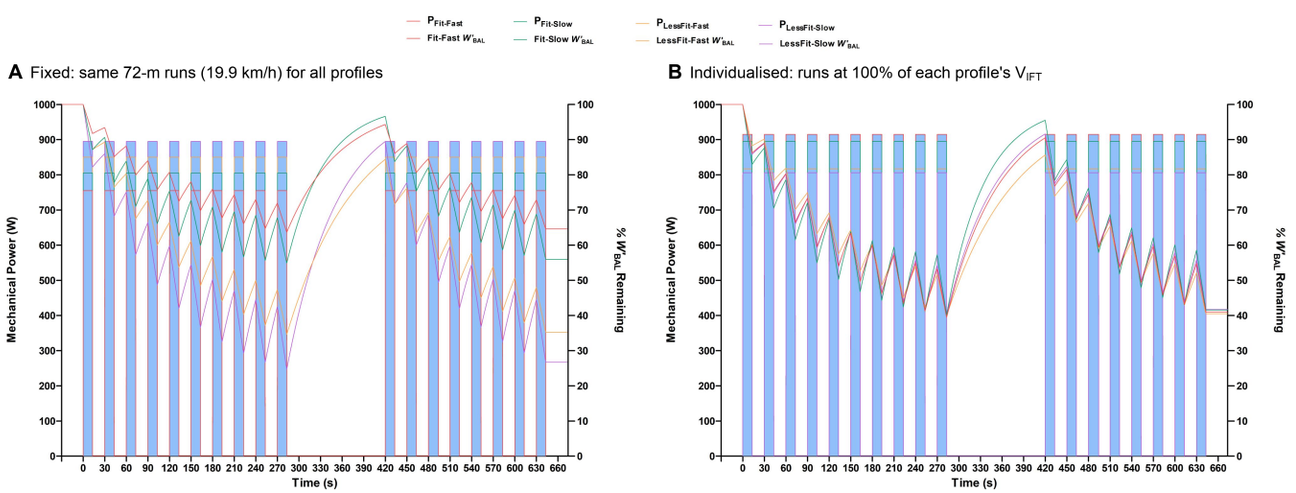


Fig. 5. **One box-to-box does not fit all. Modelled box-to-box HIIT (13-s runs with 17-s recovery; series 1, 10 repetitions; series 2, 8 repetitions; 2 min between series) for four athlete profiles (Fit-Fast, Fit-Slow, LessFit-Fast, LessFit-Slow). Bars show the external mechanical power output (P) of each run; lines show the balance of remaining W' (W'_{BAL}, %): W' is expended when P is above critical power (CP) and reconstituted when P is below it. (A) Fixed HIIT: every profile runs the same 72 m in 13 s (19.9 km/h). Body mass and stature change the mechanical power each profile produces, and a higher CP (aerobic fitness) speeds W' recovery between series, so responses spread widely: about 65% of W' left for the fittest and fastest profile, about 27% for the less fit and slower one. (B) Individualised HIIT at 100% V_{IFT}, with speed converted into mechanical power using an over-ground running energetics model: all four profiles finish with about 40% of W'. Adapted from Buchheit et al. (2021b).**

the same as calling it arbitrary. The mapping codifies what the first author and many colleagues have converged on across squads and seasons, and in applied sport science that kind of accumulated practice is usually where a prescription begins rather than where it ends. It carries real weight. It is simply a different kind of evidence from a controlled comparison, and the honest course is to label it as such.

It helps to use a common language for the sessions them-

selves. The HIIT-science framework organises interval sessions by which biological systems the session is meant to tax (Buchheit & Laursen, 2013a, 2013b; Sandford et al., 2021; Buchheit, 2025). Six targets run from purely metabolic to purely neuromuscular: Types 1 and 2 load the aerobic system, with Type 2 adding a neuromuscular component; Types 3 and 4 recruit the anaerobic system alongside it, with Type 4 again adding neuromuscular load; Type 5 pushes peripheral and anaerobic strain with a strong neuromuscular component, as in sprint interval training; and Type 6 is essentially neuromuscular. Long intervals (60 s and above) and short intervals (under 60 s) cover the more metabolic types, repeated-sprint and sprint interval training sit toward the anaerobic and peripheral end, and speed or speed-strength work occupies the neuromuscular end.

Table 1 brings together what is currently assumed for each profile, organised around a simple strategic idea: two of the four profiles are nudged toward the desired, hybrid profile from opposite sides. Endurance-dominant players add speed, strength and power, developed when fresh so the quality is real and not blunted by fatigue. Speed-dominant players build metabolic fitness in short intense efforts with long recovery, microdosed across the week rather than delivered in large blocks. Players with a fast muscle typology lose more power within an all-out bout and, more importantly, accumulate fatigue across repeated bouts and recover more slowly (Lievens et al., 2020). Longer efforts and shorter recoveries are therefore likely to widen the gap with slow-typology players, although this has not been tested beyond 30-s bouts. That rationale is a cross-layer inference. It holds where a speed bucket also carries a fast muscle typology, which, as the later sections show, is not guaranteed. Hybrids are maintained; skilled or lower-capacity players are built up gradually.

What the chronic evidence says

Two studies provide evidence relevant to the tidy rows set out in Table 1, albeit in different ways. The first does not challenge which session a given profile should receive, but shows that the same session does not buy the same return across profiles, and that the tool used to monitor it must also respect the profile. The second speaks directly to mapping the HIIT content to the player profile.

Profile shapes the dose-response between load and adaptation. Across an 11-week in-season block in a Gaelic football squad, an extra 10 minutes per week above 80% of maximal heart rate was associated with roughly 3% V_{IFT} improvement in endurance profiles, around 2.5% in hybrids and around 2% in speed profiles (Malone & Buchheit, 2025). Endurance profiles showed a slower initial response but the steepest slope, while speed profiles improved earlier then met diminishing returns. One finding there speaks directly to using the right load marker: heart-rate load behaved as a valid index of metabolic stress for endurance profiles, whose adaptations could be more centrally driven, but underestimated demand in speed and hybrid profiles, whose response may be more peripheral and who need neuromuscular and peripheral markers such as muscle oxygenation alongside it. Not only the dose but the monitoring tool may need to respect the profile (Malone & Buchheit, 2025).

To our knowledge, only one study so far has examined chronic adaptations to different training types across locomotor profiles based on MAS and MSS, and its findings complicate the simple prescriptions outlined in Table 1 (Thron et al., 2026). In trained runners completing six weeks of either long-interval HIIT or sprint interval training, speed-type athletes gained more in MAS and lactate-threshold speeds than endurance types regardless of the training, while endurance types gained more in sprinting speed and VO_2max with sprint interval training. The mapping from profile to optimal training type is not the simple "speed profile equals short intense work" that applied frameworks often assume. This should be weighed carefully rather than taken as overturning the framework, because the reasons reinforce the argument made here. The cohort consisted of trained distance runners, so its speed-type athletes were the faster-sprinting members of an endurance population, not genuine speed profiles in the team-sport sense, and profiles were defined by position within the sample's own distribution rather than by absolute MAS and MSS, the exact trap described earlier (see section "Team-based or normative?").

The direction of the gains is also easier to read as novelty than as suitability. Endurance types improved their sprinting speed with sprint interval training more plausibly because they had the most room to improve and the least prior exposure to that stimulus, not because their muscle was better suited to it (Haugen et al., 2019). The same logic runs the other way: speed types gained most in MAS, probably because they started from a lower aerobic base, in line with the general finding that aerobic adaptations, VO_2max included, are largely set by the initial level (Mølmen et al., 2025). What the study more likely shows is that athletes adapt where they are furthest from their ceiling and least accustomed to the stimulus, which is a training-history effect rather than a profile effect, and it is exactly what a six-week study in a homogeneous cohort would be expected to produce.

Two things follow. None of this touches intensity individualisation, which does not depend on the profile-to-training mapping being right, since a percentage of the reserve remains a percentage of the reserve whatever session it is used in. Profile-based choices of session content are a different matter: they remain reasonable starting points, but they are hypotheses about optimal adaptation rather than established prescriptions, and we would now hold them more loosely than we have done in the past.

Table 1 is therefore best used as a first draft of a plan, checked against how each individual player actually responds. This is where an in-house monitoring system earns its cost, because the dose-response check only works if load and response are measured consistently on the same players over time, with tools matched to the domain being stressed (Buchheit & Hader, 2025; Hader & Buchheit, 2026).

When MAS and MSS are not measured as intended

The locomotor profile is the right place to start, but rarely the place we can actually stand. On the aerobic side, the problem often starts before any test is chosen: many squads run no formal metabolic assessment at all. Where testing does happen, the rule is simple. MAS, as defined above (di Prampero, 1986; Billat & Koralsztein, 1996), is obtained from a continuous, linear, incremental run. Anything that is not that run, whatever its other merits, is measuring something else. On the sprint side, the issue is usually absence rather than substitution: maximal sprint testing is often not part of a club's culture, and MSS is inferred from GPS peaks across matches and training (Kyprianou et al., 2022). Those values may be the only option, but they are not a controlled maximal sprint, so the sprint anchor is often incomplete or biased low (Buchheit et al., 2012b). In most real settings, then, the locomotor profile is built from approximations (Thron et al., 2024). That is the normal working condition, not a failure.

Table 1. What is currently assumed. The locomotor-profile framework as it is applied today, organised by training intent. The organising idea is that endurance- and speed-dominant players are both nudged toward the hybrid profile from opposite sides, endurance by adding neuromuscular quality when fresh, speed by building metabolic fitness in microdoses that respect its tendency to fatigue. Profiles are labelled by underlying quality (metabolic fitness and neuromuscular output), since bucketing does not depend on MSS/MAS alone. The conditioning column covers metabolic conditioning only. The speed, strength and power side of each training intent is built in the gym and through sprint and speed-strength work, not through HIIT, which is why the HIIT types listed for the endurance-dominant profile are the low-neuromuscular ones. HIIT types follow Buchheit & Laursen (2013a, 2013b): Types 1-2 target the aerobic system (Type 2 adds neuromuscular load), Types 3-4 add the anaerobic system (Type 4 adds neuromuscular load), Type 5 is peripheral/anaerobic with strong neuromuscular load (SIT), and Type 6 is neuromuscular (speed-strength). A practical starting framework from the ASR literature and applied practice (Buchheit, 2025; Sandford et al., 2021; Colomer, 2025, 2026), not settled prescription; read against the Thron and Malone caveats in the text.

Player profile	Training intent (goal)	Priorities & cautions	Conditioning approach & HIIT types
Endurance-dominant *(higher metabolic fitness, lower neuromuscular output)*	Move toward hybrid by adding speed, strength and power.	The added quality only counts if it is developed while fresh, so it is not blunted by fatigue. Watch out for high-density repeated-sprint work or maximal efforts done when already tired.	Longer intervals or continuous work for the aerobic load, kept low in neuromuscular demand. HIIT Types 1 and 3.
Speed-dominant / explosive *(higher neuromuscular output, lower metabolic fitness)*	Also move toward hybrid, but by building metabolic fitness while maintaining maximal sprint speed.	This profile accumulates fatigue across repeated intense bouts and recovers slowly (Lievens et al., 2020), and longer intervals are likely to make this worse, so the metabolic work has to be introduced gently rather than in large blocks.	Short, intense efforts (roughly under 15 s) with long recovery, microdosed across the week. HIIT Type 2 for individual conditioning; Type 4 only when game-based or tactical.
Hybrid *(high metabolic fitness and neuromuscular output)*	Maintain the complete profile; this is the target the others move toward.	These players cope with the full range of stimuli, so the choice is driven by the sport, position and team tactics rather than by any contraindication.	Rotate HIIT types across the microcycle. All types usable; Types 2 and 4 integrate most easily into sport-specific work.
Skilled / lower capacity *(lower metabolic fitness and neuromuscular output)*	Build both qualities gradually and safely.	This profile tolerates dense loading least, so exposure is raised slowly with careful sequencing.	Conservative dosing with progressive overload. HIIT Types 1 and 2.

Box 3. Interval types by profile: practice-based, not yet tested
Every row here comes from experience and physiological logic, not from controlled trials. The priorities were built by practitioners running these sessions with these players across squads and seasons, and reasoning from what each profile should tolerate. That is a real basis for a decision, and it is where most good prescriptions begin. But it is not a test, and we should stop presenting it as one.
The test is the same for every row: does the prescribed approach produce better adaptation and better load tolerance, in that profile specifically, than the approach it replaces? For the endurance-dominant row, that means showing that long intervals buy more performance and fewer soft-tissue problems than an equal dose of repeated sprints. None of these comparisons has been run.
Until they are, use the table as a starting hypothesis and check it on the player in front of you. Individualising the intensity does not depend on any of this being right.

The vertical (aerobic) axis: three tiers

Methods that quantify the aerobic axis fall into three tiers (Figure 6), and it pays to be honest about which tier a test belongs to and which purpose that tier still supports. The first tier is true MAS, from continuous incremental running (ideally with gas analysis, since the incremental Université de Montréal track test overestimated gas-derived MAS by about 1.6 km/h in football players; Buchheit & Laursen, 2013a; Thron et al., 2022). This is the ideal anchor and keeps the full model intact: ratios are interpretable, the ASR can prescribe HIIT as intended, and the player is cleanly bucketed on the aerobic axis (Sandford et al., 2021).

The second tier entails tests that estimate MAS while measuring essentially the same construct, such as a 6-minute run or a 2-km time trial. These tests are less precise, mainly because of pacing and because time to exhaustion at MAS varies widely between athletes with the same MAS (Billat et al., 1994), but they are genuine attempts to capture the velocity tied to maximal aerobic capacity. Finally, an alternative approach to maximal MAS testing is to estimate it from a submaximal lactate ramp test, using a regression model based on the running velocity associated with a blood lactate concentration



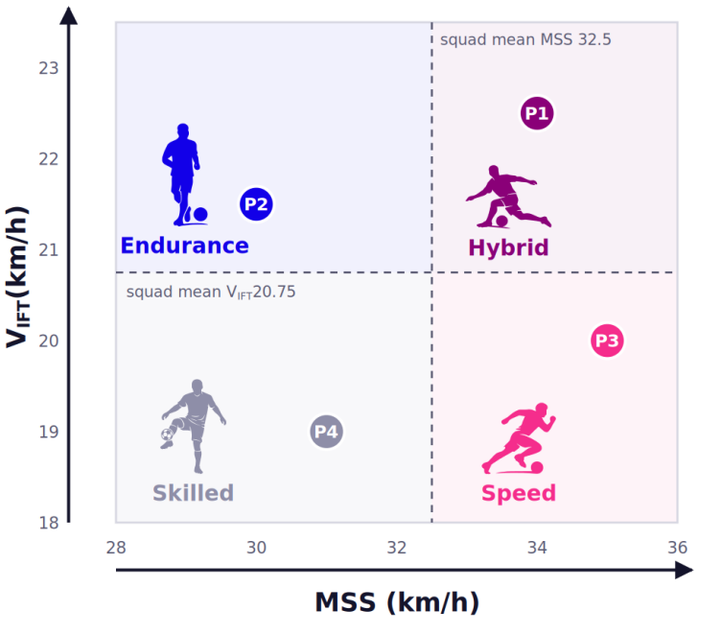
Fig. 6. **Bucketing a player on both axes using alternative tests, for use when the standard locomotor tests are unavailable and, on the horizontal axis, when more definition is wanted than a sprint alone can give, since sprint time is influenced by technique as well as physical capacity. The vertical (aerobic) axis can be read with the 30-15IFT, Yo-Yo or Bronco, and the horizontal (neuromuscular) axis with a countermovement jump (CMJ), a 6-s cycling peak power, or isometric mid-thigh pull (IMTP). Using one test from each axis places a player in an endurance, speed, hybrid or skilled bucket even when true MAS and MSS are unavailable; the horizontal tests also carry information about fiber-type composition, with the limitations set out in the sections that follow.**

of 4 mmol/L, age, and HR response at 12 km/h (Thron et al., under review). All of these measures stay on the vertical axis, still support prescription with more noise, and bucket players well (Buchheit & Laursen, 2013a).

The third tier consists of tests that do not estimate MAS but still carry useful aerobic-related signal, such as the Yo-Yo tests (Bangsbo et al., 2008) and the Bronco (Weakley et al., 2026), which reflect a blend of aerobic power, change-of-direction ability, recovery and anaerobic contribution. Here the purposes come apart: because these are not a velocity at VO_2max, the ASR can no longer be defined and prescription as a percentage of the reserve is lost, but the test still places a player on the aerobic axis, so it still buckets. Dropping to a Yo-Yo or Bronco costs you prescription, not bucketing. The 30-15IFT is the exception among the non-MAS tests, because its consistent link to the reserve keeps prescription intact, as set out above (Buchheit et al., 2021a).

What the 30-15IFT cannot do on its own, any more than MAS alone, is complete the bucket. Hybrids, with a strong aerobic base and large reserve, post the highest end-test speeds; lower-capacity skilled players the lowest. The catch is the middle: endurance and speed players can land on simi-

lar, moderate V_{IFT} scores for opposite reasons, the endurance player from a strong aerobic base with a small reserve, the speed player from a large reserve on a weaker aerobic base. So the 30-15IFT reads the aerobic axis well but it compresses the distance between endurance and speed players rather than resolving it, because that separation lives on the other axis. The two profiles rarely land on an identical V_{IFT}, since V_{IFT} tracks aerobic capacity more closely than speed, but the gap narrows enough that a mid-range score on its own does not say which side of the axis a player belongs to (Figure 7).



Player	V_{IFT} km/h	MSS km/h	Profile
P1	22.5	34	Hybrid
P2	21.5	30	Endurance
P3	20	35	Speed
P4	19	31	Skilled

V_{IFT}= final running speed of the 30-15 Intermittent Fitness Test

Quadrants split at the squad mean. With these four players every profile falls in its own quadrant.

Fig. 7. Why the 30-15IFT alone does not resolve endurance from speed profiles. Endurance and speed players can reach similar V_{IFT} scores for opposite reasons, so a mid-range score is ambiguous and one added speed- or power-related marker is needed to separate them. Adapted from Buchheit (2025).

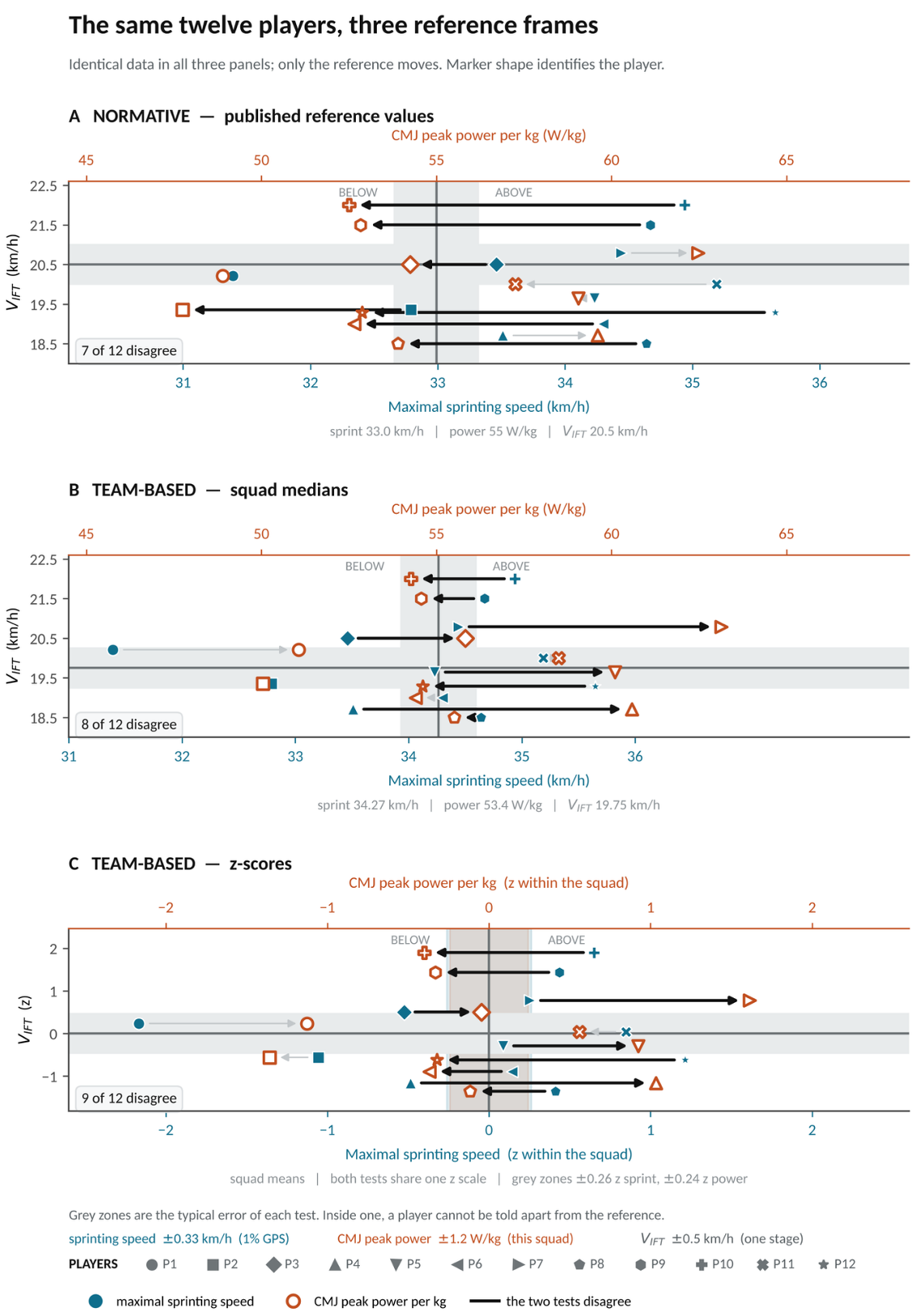
The horizontal axis: quantifying speed and explosiveness

The vertical axis places a player by aerobic capacity; the horizontal axis places them by speed and explosiveness, and a full bucket needs both. The ideal horizontal anchor is MSS, which serves both purposes: it defines the ASR, so it prescribes, and it positions the player, so it buckets. Where MSS is missing, the same tiered logic applies. A countermovement jump (CMJ), a 6-s cycling peak power, or an isometric mid-thigh pull (IMTP, with its rate-of-force-development measure) cannot define the ASR, so they do not prescribe, but a player who jumps high, pulls hard and develops force quickly sits toward the speed end. The bucket gets completed (Figure 6); the prescription does not (Buchheit, 2025).

These are not simply weaker copies of a sprint, and there is an older version of the problem on the African savannah. When African wild dogs approach a herd of Thomson's gazelles, the gazelles do not simply run. They stot, bouncing on stiff legs with all four feet leaving the ground at once, in full view of the predator. The dogs then select the individuals that stot least. Gazelles that were chased and escaped had stotted more, and for longer, than those that were caught, and gazelles in poor condition in the dry season stotted less and at lower rates (FitzGibbon & Fanshawe, 1988). The jump is an honest signal of the ability to run, and the predator reads it that way because it cannot be faked. The applied data agree: in a large multi-sport sample (n = 1352), horizontal jump distance and maximal-speed sprint time could be used essentially interchangeably to stratify athletes once grouped appropriately (Kleeberger et al., 2024). In a broad population, most athletes will therefore not move much when the horizontal test changes.

The interesting case is the minority who do move, and agreement appears weakest in the fastest athletes, who are also the players for whom muscle typology-informed load management may carry the highest stakes. Inside a single professional squad the spread is narrower than in a large multi-sport sample, so disagreement becomes correspondingly more common (Figure 8). The reason is that sprinting is a technical skill as much as a physical capacity: the ability to apply force horizontally to the ground explains a large share of sprint performance independently of how much force an athlete can produce (Morin et al., 2011). A predator that needed to predict running ability evolved to read the jump rather than watch a sprint, and for the same reason we reach for one. A jump, a 6-s cycling peak power or an IMTP strips much of that technique away, so what the two tests do not share is exactly the part technique contributes.

What that costs depends on which purpose the axis is serving. For prescription it is largely moot, because the locomotor profile stays in one currency: MAS, MSS and ASR are all speeds, so the test that positions the player is the test that



Twelve outfield players from one professional squad; goalkeepers excluded. Reference lines in A: sprinting speed 33.0 km/h (Manzi et al. 2025, N = 195); CMJ peak power 55 W/kg (VALD ForceDecks football median, 2020-21); V_{IFT} 20.5 km/h (30-15ift.com benchmarks). Points are nudged vertically where players share a V_{IFT}.

Fig. 8. The same twelve players, three different reference frames. Twelve Ligue 1 professional outfield players with a 30-15IFT result, a GPS-derived maximal sprinting speed (STATSports Apex) and a countermovement jump measured on force plates (VALD ForceDecks). The vertical axis is fixed throughout. On the horizontal axis each player carries two markers, one for sprinting speed (filled, lower scale) and one for CMJ peak power per kilogram (open, upper scale), joined by an arrow; a black arrow means the two tests place the player on opposite sides of the reference. Marker shape identifies the player, so any individual can be followed across panels. The data are identical in all three panels; only the reference moves. (A) Normative professional benchmarks: 33.0 km/h for sprinting speed, pooled across the four position groups of Manzi et al. (2025); 55 W/kg for CMJ peak power, the median of approximately 17 000 ForceDecks tests in English and European football during the 2020-21 season (VALD Performance, 2021); 20.5 km/h for V_{IFT}, the professional football median of the 30-15IFT benchmark database (Buchheit et al., 2021a). (B) The same design referenced to this squad's own medians, expressed in real units. (C) The same design in within-squad z-scores. Grey zones are typical error, not percentile bands: ±0.33 km/h for sprinting speed (1% for GPS peak speed), ±1.2 W/kg for CMJ peak power, and ±0.5 km/h for V_{IFT} (one test stage). A player inside a grey zone cannot be distinguished from the reference. In A and B the two horizontal scales are aligned on their own typical error so the zone is the same width on both; in C the widths are free and come out nearly identical (0.26 versus 0.24 z). Sprinting speed is the mean of the three highest GPS session peaks; CMJ values are the mean of each player's valid sessions. Goalkeepers are excluded. This is a working example drawn from routine club testing rather than a controlled study. The two horizontal tests disagree for 7 of 12 players in A, 8 of 12 in B and 9 of 12 in C. Table 2 summarises which of the three purposes each test on each axis still serves, including the typology column that the next section introduces.

sets the dose. Here the technical component is a feature rather than a flaw, because a player sprints with their own mechanics in a match, so expressed top speed is exactly what we want to anchor running loads to. For bucketing the currency changes, and two tests can place the same player on opposite sides of the same reference without either being wrong. Figure 6 shows the two-axis bucketing in practice.

A worked example: the same twelve players, three reference frames

Figure 8 applies the principle set out in Figure 6 to a single professional squad. Twelve outfield professional players from a Ligue 1 club (French first division) held all three measures. Referenced against normative professional benchmarks (panel A), the two candidate horizontal tests placed 7 of the 12 players on opposite sides of the reference. Referencing the same players against their own squad instead (panels B and C) did not change this conclusion, 8 and 9 of 12 respectively, but it did change many of the individual verdicts. Player P3 illustrates the point most directly: with a maximal sprinting speed of 33.5 km/h he sits above the professional reference yet below the median of his own squad, and would be labelled fast or slow depending only on which comparison was chosen.

The asymmetry of this squad is informative in itself. Its median sprinting speed (34.3 km/h) sits roughly 0.8 standard deviations above the professional reference (Manzi et al., 2025), while its median CMJ peak power (53.4 W/kg) sits slightly below (VALD Performance, 2021), so most arrows in panel A point leftward: players who are clearly fast on the grass are unremarkable on the force plate. Two implications follow. First, the choice of second axis is not a matter of convenience; a locomotor ceiling and a neuromuscular ceiling rank the same squad differently, and neither substitutes for the other. Second, any bucketing exercise should carry its measurement error explicitly. Several players here sit within one typical error of the reference on at least one axis, and for those a categorical label is not supportable from a single test.

From the horizontal axis to the muscle underneath

These neuromuscular tests are not only locomotor stand-ins. They sample properties of the muscle itself, including power and contractility, and so they may carry information about fiber type composition that MAS and MSS do not (Schiaffino & Reggiani, 2011; Van de Casteele et al., 2026). The technical component of sprinting now becomes a disadvantage: what is a feature for prescription is contamination for reading the muscle, and a jump, a 6-s cycling peak power or an IMTP gets closer to the underlying tissue precisely because technique has less influence on the score. Less, however, is not none. These tests still require coordination and motivation. Only measures taken at rest, such as muscle carnosine or electrically evoked muscle contractility, remove the skill component entirely, which is part of the reason why some researchers and clubs use these tests despite them being the least practical (Van de Casteele et al., 2026). This is where bucketing and typology begin to overlap without becoming the same thing. A bucket, even a normative one, classifies locomotor output, and output depends on training history, mechanics and body size as well as on the muscle; typology is a property of the tissue. A player who is genuinely fast in absolute terms need not be type II dominant. One guard travels with this: agreement or disagreement between a player's own sprint and jump says something about sprint-jump concordance and nothing about their fiber type, because we hold no biopsy on those players. The link from these tests to the muscle rests entirely on the validation literature (Hopwood et al., 2023; Van de Casteele et al., 2026).

Managing load: muscle typology as a second layer

Muscle fiber type composition is not equally consequential for every player, which is why this second reading is worth the trouble at all: its payoff is not prescription but load management. Get the dose wrong for a slow-twitch-dominant player and the result is usually mild: they simply do not improve much, especially in speed and power. Get it wrong for a fast-twitch-dominant player and the cost can be steeper, and the three outcomes below are ones the locomotor profile does not predict but muscle typology does.

The first is recovery from intense exercise. When individuals with fast versus slow muscle typology performed repeated all-out Wingates, the fast-typology group showed both a larger power drop (around 61% versus around 41%) and much slower recovery: maximal voluntary contraction torque returned to baseline in the slow-typology group within about 20 minutes, while the fast-typology group had still not recovered five hours later, the end of the measurement window (Lievens et al., 2020). These stark differences occurred despite both groups having performed the same total amount of work across the Wingates. The same session can leave one player ready within the hour and another impaired for the rest of the day, and across a week, especially with double sessions, that under-recovery can accumulate.

The second is tolerance to overload. When highly trained middle-distance runners completed a block of rising volume then a taper, those who became functionally overreached had a faster estimated typology than those who merely acutely

fatigued, and typology correlated with both the performance drop across the overload block and the supercompensation after the taper (Bellinger et al., 2020). Athletes with a faster muscle typology were more likely to tip from productive overload into overreaching under the same relative load increase.

The third, and most directly team-sport relevant, is muscle injury. In a prospective cohort of 165 professional footballers across three seasons, fast-typology players carried a 5.3-fold higher risk of an index hamstring strain than slow-typology players, holding independently in each of the two first division leagues studied (Lievens et al., 2022). Only about 15% of the total number of players were categorised as having a fast muscle typology, yet they carried a substantially elevated risk. Since hamstring injuries occur disproportionately late in matches, fatigue is one of the plausible mechanisms, though the study did not test it. Together the three point the same way, and two of them are longitudinal with performance and injury as outcomes, which is more than the locomotor side of the framework can currently offer.

The first layer (locomotor profiles) is not a proxy for this second layer. It is tempting to assume a fast, speed-profile player must have a type II-dominant musculature, and there is mechanistic reason to expect some association (Schiaffino & Reggiani, 2011; Hopwood et al., 2023). But the two constructs move on different timescales: a locomotor profile can shift within weeks as MAS rises with training, whereas fiber type is largely genetic and changes little within such a timeframe (Komi et al., 1977; Simoneau & Bouchard, 1995; Ingalls, 2004). A construct that changes in a fortnight cannot be a close proxy for one that essentially does not. The team-sport evidence supports association without identity: a greater proportion of type II fibers has been linked to faster 10- and 30-m sprint times in youth footballers, but these associations rest on few studies and are not deterministic (Metaxas et al., 2019; Hopwood et al., 2023). So the practical adjustments here follow from the typology estimate, not from the locomotor bucket: fast-typology players warrant more recovery between intense sessions, more careful sequencing of dense loads and closer monitoring during overload phases.

Estimating typology without a biopsy

Because a biopsy is not an option in a squad, practitioners turn to non-invasive alternatives, often without clear evidence for which ones work (Lievens et al., 2024; Van de Casteele et al., 2026). Those wanting the underlying biology in one place will find the doctoral work behind much of this literature an outstanding starting point (Lievens, 2021).

In a study built specifically to compare non-invasive methods against a strong criterion of muscle fiber type composition, 40 recreationally-to-competitively trained participants (20 men, 20 women, from various sports) completed a broad battery of metabolic, power, contractility and endurance tests. These tests were validated against fiber type composition from two biopsies each in the vastus lateralis and gastrocnemius medialis, averaging more than 5000 fibers per participant (Van de Casteele et al., 2026). The criterion was the relative area of type II fibers averaged across both muscles, ranging from 21 to 60%.

The finding has two parts. First, no single test sufficed. The strongest single predictor was blood lactate three minutes after a cycling Wingate test (r = 0.67), explaining around 45% of the variance. Field measures were weaker: 10- to 30-m sprint times correlated moderately (r = -0.37 to -0.39) and squat jump height slightly more (r = 0.43). Second, combining tests from different physiological dimensions clearly improved the estimate. The best model (sex, post-Wingate blood lactate, isokinetic knee-extension torque at 300°/s relative to lean mass of the upper leg, muscle carnosine and singlet contraction time), spanning metabolism, power and contractility, explained 68% of the variance (adjusted $R^2 = 0.63$) and was robust under leave-one-out cross-validation ($R^2 = 0.58$). Fiber types differ across several dimensions, and this study demonstrated that tests sampling different dimensions carry complementary rather than redundant information. Both post-Wingate blood lactate and muscle carnosine sit within the metabolic dimension, yet both were retained: the former captures a dynamic glycolytic response to an all-out effort, while the latter measures the resting concentration of a H^+-buffer. A test earns its place when it samples a fiber-type-specific characteristic the others do not, whether that is a different dimension or a different facet of the same one.

Two features temper expectations. First, this strong model relies on measures unrealistic for most professional clubs, since measuring muscle carnosine requires proton magnetic resonance spectroscopy and singlet contraction time requires peripheral electrical stimulation. The full 68% is, therefore, research-grade and not yet achievable in the field. Second, and more sobering, the low-burden field tests explain far less on their own. Sprint and jump each explain about 7 to 8% of the variance in fiber type composition when the median correlation across a preliminary literature review is used (Van de Casteele, 2025), and about 15 to 18% in the multi-biopsy experimental study (Van de Casteele et al., 2026). The two figures differ because they come from different evidence bases, the lower from pooling many small studies, the higher from the single study with the strongest criterion. Either way, no field-only combination has been shown to approach the research-grade model, and an honest framework says so rather than implying a jump and a sprint reveal a player's muscle. Why these correlations are so low, and whether the tests alone are to blame, is set out in Box 4.

The trade-off ladder, and what each test is really telling you

The question is therefore not "which one test is best?" but "what is the best next test to add, given what I have and what I can run?" The perceived burden of these tests was surveyed in a large sample of practitioners. They rated sprint and jump tests as easy to administer; isokinetic dynamometry, VO_2peak and Wingate-based measures as moderately difficult; and muscle carnosine and electrical-stimulation contractility as difficult, needing specialist equipment and expertise (Lievens et al., 2024; Van de Casteele, 2025) (Figure 9).

At the lowest rung sit sprint and jump, easy to run but individually explaining little. Adding a short sprint to an existing MSS is unlikely to add much, because both sit on the same sprint axis. In the multi-biopsy study, 10- to 30-m sprint times from a standing start were only moderately related to fiber type (r = -0.37 to -0.39; Van de Casteele et al., 2026), and the top speed reached during the 30-m sprint, the closest available measure of MSS, was no better (r = 0.35; unpublished data from the same study). That top speed approximates MSS, but over 30 m from a standing start it may underestimate it in the fastest players. A second test only earns its place when it samples a muscle fiber type property that the first does not. The next rung is where that pays off: post-Wingate blood lactate is the strongest single predictor while remaining realistic in many settings, and for a practitioner investing one step of extra burden it is often the highest-value single upgrade. Two caveats. The Wingate is performed on a cycle ergometer, so it is not a running field test. And none of the power-derived metrics (e.g., fatigue index, peak power) were retained in the best multivariable model, so it is the lactate measurement that justifies the extra burden (Van de Casteele

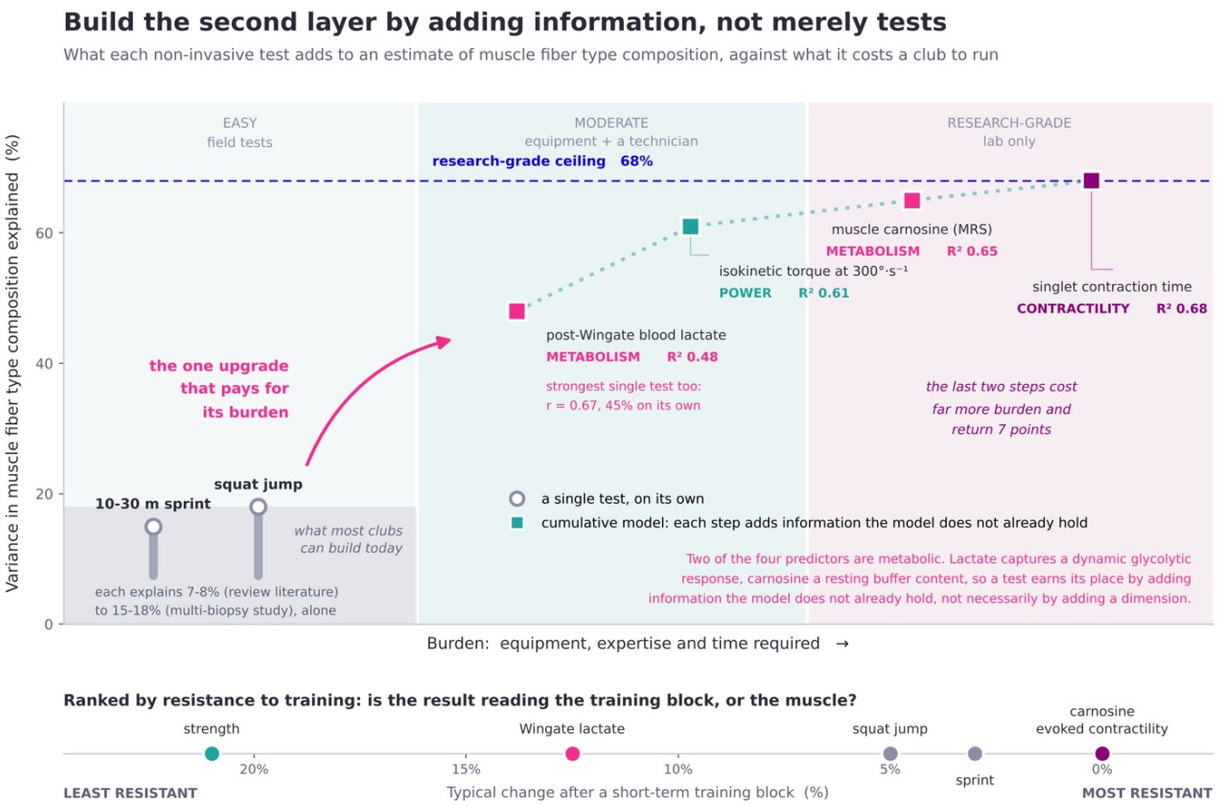


Fig. 9. Build the second layer by adding information, not merely tests. What each non-invasive test adds to an estimate of muscle fiber type composition, against what it costs a club to run. Upper panel: open circles are single tests read on their own, with the bar spanning the literature review median (7 to 8%) and the multi-biopsy experimental study (15 to 18%). Filled squares are the stepwise multivariable model of Van de Casteele et al. (2026), in which each step adds a predictor that captures something the model does not already hold, starting from a base model of intercept and sex: post-Wingate blood lactate (metabolism) reaches R^2 0.48, relative isokinetic knee-extension torque at 300°/s (power) 0.61, muscle carnosine by magnetic resonance spectroscopy (metabolism) 0.65, and singlet contraction time by electrical stimulation 0.68 (contractility), giving a final adjusted R^2 of 0.63 and a leave-one-out cross-validated R^2 of 0.58. Singlet contraction time was retained but was not a significant predictor ($p = 0.080$). Post-Wingate lactate is also the strongest single predictor ($r = 0.67$, 45% of the variance alone), which is why it is the highest-value single upgrade for most clubs. Burden categories follow the practitioner survey reported in Van de Casteele (2025); horizontal position is ordinal and not a measured scale. Lower panel: the same tests ordered by how much each moves with a short-term training block, from least to most resistant. Values are gains after short-term training blocks, from meta-analyses where available and from single training studies for the Wingate. The more resistant a measure is, the more a single result can be read as a property of the player rather than of their recent training.

et al., 2026). Higher still is isokinetic torque at high angular velocity, then carnosine spectroscopy and electrically-evoked contractility, which push the estimate toward its ceiling but are unrealistic for routine use. Plotted as ease of use against explained variance, the shape is the main point (Van de Casteele, 2025): cheap field tests plateau low, one well-chosen metabolic test more than doubles explained variance, and, in field settings, the final climb costs far more burden than it returns.

A third property changes how a result should be read: whether it reflects something relatively fixed about the muscle or something that moves with training status (Figure 9). Carnosine and evoked contractility behave like trait markers, measured at rest and largely unaffected by short-term training (Kendrick et al., 2008, 2009; Baguet et al., 2011; Jenkins et al., 2016). This stability makes them attractive indicators of underlying muscle characteristics, despite being among the least practical measures to obtain. Strength-related measures are the most training-sensitive, with meta-analytic gains in dynamic strength of around 21% after 3 to 16 weeks of resistance training (Davies et al., 2017). Wingate-derived measures also shift with recent training: four weeks of sprint interval training raised Wingate peak power by about 10% and post-Wingate blood lactate by about 15% (Bayati et al., 2011), and six weeks of sprint training increased post-Wingate peak blood lactate even though Wingate power did not change (Jacobs

Table 2. The two axes and what each test lets you do. Tests are grouped by the axis they inform, vertical (aerobic) and horizontal (neuromuscular), and rated on three purposes: Bucketing (sorting players into endurance/hybrid/speed/skilled), Prescription (setting HIIT intensity as %ASR, or the corresponding $\%V_{IFT}$), and Typology / load-management (estimating fiber type for recovery, overload and injury). Dots read ●●● strong, ●●○ moderate/partial, ●○○ weak, ○○○ none. Prescription needs a true anchor and is lost once we drop to a Yo-Yo, Bronco or a jump; bucketing is the resilient middle; typology switches on only as the tests begin sampling the muscle, on the horizontal axis, and rises as burden rises. A full bucket needs one test from each axis. Signal and burden figures from Van de Casteele (2025) and Van de Casteele et al. (2026).

Test / anchor	Bucketing	Prescription	Typology / load-management	What it adds (signal)	Practicality (burden)
VERTICAL / AEROBIC AXIS: places a player by aerobic capacity					
True MAS (incremental run with gas)	●●●	●●●	○○○	Defines the ASR with MSS; full prescription. Not a typology estimate.	Moderate (protocol + effort control)
MAS estimates (6-min run, 2-km TT)	●●●	●●○	○○○	Same construct as MAS with more noise; still supports prescription.	Low (field test)
30-15IFT (V_{IFT})	●●○	●●●	○○○	Built to prescribe: V_{IFT} sits at ~25% of ASR above MAS, a roughly constant fraction of the reserve. Buckets the aerobic axis; needs a neuromuscular marker to complete the bucket.	Low (field test)
Yo-Yo / Bronco	●●○	○○○	○○○	Not a velocity at VO_2max, so ASR and prescription are lost; still buckets the aerobic axis.	Low (field test)
HORIZONTAL / NEUROMUSCULAR AXIS: places a player by speed and explosiveness (and starts sampling the muscle)					
MSS (maximal sprinting speed)	●●●	●●●	●○○	Defines the ASR with MAS; full prescription. Also the one locomotor anchor tested against biopsy: top speed in maximal 30 m sprint (r = 0.35; unpublished data), 12% of variance.	Low-moderate (needs a true max sprint)
Jump / Cycling peak power /IMTP (RFD)	●●○	○○○	●●○	Cannot define the ASR, so no prescription; completes the bucket and is a recognised proxy of explosiveness / fast-twitch dominance (squat jump height r = 0.43, ~18% of variance).	Low (easy field tests)
Wingate + post-exercise blood lactate	●●○	○○○	●●●	Strongest single typology predictor (r = 0.67; ~45% of variance), about two and a half times the best field test; sharpens the bucket.	Moderate (cycle ergometer + a lactate measure)
Isokinetic torque (high velocity)	●●○	○○○	●●●	Genuine power-dimension signal, strongest at the highest velocities (part of the 68% model).	Moderate-high (dynamometer + expertise)
Muscle carnosine (MRS) / evoked contractility (e-stim)	●○○	○○○	●●●	Reflects the muscle rather than locomotor output, so it carries only weak information about where a player sits on the neuromuscular axis (r = 0.23 to 0.36 between muscle carnosine z-score and CMJ height and r = -0.22 with 10 m sprint time, the latter for gastrocnemius carnosine only, in professional footballers; Van de Casteele et al., 2024a). Pushes the typology estimate toward its ceiling; does not prescribe.	High (research-grade: spectroscopy / e-stim)

et al., 1987), so those results reflect both typology and current state (Van de Casteele, 2025). One correction to a common assumption belongs here: sprint and jump are often filed as highly trainable, but short-term training typically improves squat jump by only around 5% (Markovic, 2007) and sprint by around 3% (Rumpf et al., 2016), placing them among the more training-resistant options. A jump or sprint result can therefore reasonably be read as saying something about the player rather than about their recent training week, even though its predictive value for fiber type stays modest at best.

What each test still lets you do

Table 2 summarises the two axes and the three purposes together. For broad screening the low-burden tools suffice. For

Box 4. Why do sprint and jump tests track fiber type so poorly?
The modest correlations above could easily be interpreted as a verdict on the tests alone. However, for a correct interpretation, it is important to consider the following factors.
Who was tested. Correlations shrink when the values of the variables of interest are narrowly distributed within a sample and grow when the sample includes the extremes. As the range in muscle fiber type composition and 30-m sprint and jump performance was relatively wide among the participants of the multi-biopsy study, a narrow spread cannot explain the modest correlations. Wide ranges of fiber type composition have also been observed and can be expected in professional football squads (Van de Casteele et al., 2024a). Paradoxically, in a group of 10 well-trained high and long jumpers, a strong relationship between the percentage of fast-twitch fibers and power production during 15 s of continuous jumping (r = 0.86) was observed (Bosco et al., 1983). So why does this study find a strong relationship despite the group being more homogeneous? Aside from the different jump performance metric, it may be that other trainable factors determining jump performance have become very similar over years of training, leaving a more decisive role for muscle fiber type composition within this sample. This brings us to the next factor to consider.
Which other factors drive sprint and jump performance. Sprinting depends heavily on the skill of applying force horizontally to the ground (Morin et al., 2011). In power-trained men, sprint performance was related to estimated thigh muscle size alone, while jump performance was related to lean mass, fascicle length and type II fiber size (Methenitis et al., 2016). The more skillful a test, the weaker its link with the muscle appears to be. An example of this can be found in a study where muscle typology was estimated using ^{1}H-MRS-based muscle carnosine in 147 professional football players: CMJ height without arm swing correlated significantly with muscle typology (r = 0.23 to 0.36), CMJ with arm swing did not (r = 0.14 to 0.19), and 10-m sprint time was only related to gastrocnemius typology (r = -0.22) (Van de Casteele et al., 2024a). The arm swing adds coordination, and part of the signal is likely lost in it. Sprinting requires the most coordination of the field tests, jumps require less, and measures taken at rest require none.
Which muscle fiber type composition reference is used. Although biopsy-based measurements are considered the gold standard for determining muscle fiber type composition, they are not perfect. A single biopsy typically samples only a few hundred fibers, whereas large skeletal muscles such as the vastus lateralis contain hundreds of thousands (Lexell et al., 1988). The large variation in fiber type composition with repeated biopsies in the same muscle therefore indicates that one biopsy sample is not representative of the whole muscle (Horwath et al., 2021; Van de Casteele et al., 2024b). Sampling more than 5000 fibers from two muscles per participant, as was done in the multi-biopsy study, is still imperfect, but it is arguably the most rigorous measurement possible in living humans from an ethical standpoint and the fairest reference to compare field tests to. Yet, the sprint and jump could only explain 15–18% of the variance. In this study, the vastus lateralis and gastrocnemius medialis were carefully chosen for the biopsies, as they are important muscles for producing movements in field-based team sports. However, jumping and sprinting involve many more muscles, most of which are never sampled. It should also be noted that some of the evidence from team sports, including the 147 players mentioned above, has relied on muscle carnosine measured by ^{1}H-MRS rather than a biopsy. Carnosine in itself is an estimate; against a multi-biopsy criterion its correlation with fiber type was only moderate (r = 0.44 to 0.49; Van de Casteele et al., 2026), whereas earlier studies found stronger relationships (r = 0.71 to 0.73; Baguet et al., 2011; Van Vossel et al., 2023). Comparing a field test with carnosine is therefore comparing a proxy with a proxy.
What this changes, and what it does not. Due to the methodological intricacies explained in this box, the true link between a player's explosive output and his muscle could be stronger than the field correlations suggest. However, the practical message stays the same. Tests that carry technique, which are typically used in football clubs, create the conditions that weaken the correlations with muscle fiber type composition in research. Simply put: a fast sprint still tells us the player is fast, not necessarily that his muscles are fast-twitch. This is why the second layer needs at least one test that samples the muscle more directly, such as post-Wingate blood lactate.

better identification of the fast/speed players most likely to struggle with dense loading, a moderate-burden metabolic or power measure is usually the most valuable step. One caution travels with the bucketing column. Equal ratings mean each test can complete a bucket, not that two tests will place the same player in the same one: on a professional squad, sprinting speed and CMJ peak power disagreed for 7 of 12 players (Figure 8). A bucket should therefore always name the test it was built from.

Practical applications

- **Taken too far? In places, yes.** For intensity, no: setting HIIT intensity from each player's own MAS and MSS, or from V_{IFT}, remains the best-supported use of the locomotor profile and should stay the default. For bucketing, partly: buckets hold up, but only against normative references and when they name the test they were built from. For content, yes: matching session types to profiles rests on practice-based evidence and should be held as a hypothesis, not a rule. For the muscle, clearly yes: the reserve has been read as a window on fiber type without ever being tested against it, and a fast sprint tells us a player is fast, not necessarily that his muscles are fast-twitch. Keep the profile for what it does well, and add a second layer when load management is the question.
- **Run the three purposes in order.** Bucket the player first, set intensity from the player's own anchors, choose content from the bucket, and manage load from the typology estimate. Ask of any test not "is it good?" but "which of the three purposes does it serve?"
- **Individualise intensity with confidence; individualise content with less.** Setting intensity as a percentage of the ASR, or the corresponding percentage of V_{IFT}, is the best-supported level and should be the default whenever a genuine aerobic and speed anchor exist. Choosing which session a player receives is physiologically reasoned and backed by years of applied practice, but not yet demonstrated in research. Use it as a hypothesis to check on the player, not a rule to apply. Free spreadsheets do the arithmetic for run-based HIIT, shuttles included, from either anchor (Buchheit et al., 2026).
- **Never read the MSS/MAS ratio without its absolute values.** The same applies to the buckets: a team-based bucket is fine for organising a session, but the choice

of session content should follow a normative one, read against role- and level-specific reference values, because team-based boundaries move with the squad rather than with the player.

- **Name the test your bucket was built from.** Maximal sprinting speed and CMJ peak power placed 7 of 12 professional players on opposite sides of the same reference (Figure 8). Prescription survives this because every anchor on that axis is a speed, so the test that places the player also sets the dose. Bucketing does not, because sprinting is partly the skill of applying force horizontally to the ground (Morin et al., 2011) while a jump, a 6-s cycling peak power or an IMTP strips much of that technique away. This matters for content prescription: if session content is chosen from the bucket, a bucket built from a different test can send the same player to a different session.
- **Know which tier your aerobic test belongs to:** true MAS, a MAS-like estimate (6-minute run, 2-km time trial), or a non-MAS test. Among the non-MAS options the 30-15IFT stands apart, because its consistent link to the reserve keeps prescription intact, whereas the Yo-Yo and Bronco support bucketing only. Like all aerobic tests, it needs one added speed- or power-related marker to separate endurance from speed profiles in the middle.
- **Build the second layer deliberately.** No single non-invasive test estimates typology well, and a test earns its place only when it samples a fiber type-specific characteristic not already covered, so a second sprint-type measure adds little over MSS. Post-Wingate blood lactate is the strongest single option and, for most clubs, the highest-value moderate-burden upgrade, though it remains rare in team-sport practice today.
- **The fast and explosive player is where the second layer pays.** A faster muscle typology is associated with slower recovery, lower overload tolerance and substantially higher hamstring injury risk. The practical adjustments are more recovery between intense sessions, careful sequencing of dense loads, and closer monitoring during overload phases.
- **Match the monitoring tool to the profile.** Heart-rate load is a valid metabolic-stress marker for endurance profiles but underestimates demand in speed and hybrid profiles, who likely need additional neuromuscular and peripheral monitoring (Malone & Buchheit, 2025). An in-house monitoring system is what makes the dose-response check possible on your own players (Buchheit & Hader, 2025; Hader & Buchheit, 2026).

Limitations

- **The locomotor profile is largely untested against muscle fiber type composition.** Of its components, only MSS has been examined in relation to biopsy-determined fiber type, showing a moderate correlation ($r = 0.35$; unpublished data from Van de Casteele et al., 2026), similar to the strength of the correlations observed for 10 to 30 m sprint times (Van de Casteele et al., 2026). To the best of our knowledge, MAS as a running velocity has never been reported in relation to fiber type. However, whole-body peak oxygen uptake has, and was not significantly related in the one multi-biopsy study (Van de Casteele et al., 2026), though it was relatively strongly associated in earlier studies pooled in a literature review (Van de Casteele, 2025). The ASR, the MSS/MAS ratio, V_{IFT} and the buckets built from them have never been tested against muscle fiber type composition at all (Van de Casteele et al., 2026). Read the whole framework as exploratory in the research sense rather than the practical one.
- **Field estimation of typology has a real ceiling.** Sprint and jump each explain only about 7 to 18% of the variance in fiber type, depending on the evidence base. The research-grade ceiling of around 68% requires proton magnetic resonance spectroscopy and peripheral electrical stimulation. A club-feasible battery is an estimate, not a measurement. Part of that ceiling likely comes from the samples, the technique the tests carry and the criteria used, rather than from the tests alone (Box 4), but those are the conditions a club works under.
- **The load-management evidence is not in team-sport athletes, except for injury.** The recovery study used recreational athletes and the overreaching study used highly-trained middle-distance runners, and all three estimated typology by measuring muscle carnosine using spectroscopy rather than field tests. The chain from a field-estimated profile to these outcomes is an inference, not a demonstrated pathway.
- **The validation study on the non-invasive estimation of muscle fiber type composition was not specific to team-sport athletes.** The study involved recreationally-to-competitively trained individuals from a variety of sports, with the aim of finding estimators that apply universally to a diverse active population.
- **The content rows in Table 1 are working hypotheses.** They distill what practitioners who have run these sessions with these players for years have converged on, which is worth considerably more than nothing, but it is not a trial. Recommendations of this kind, ours included, have run ahead of both the dose-response evidence and the precision of the field tests used to sort players.
- **Figure 8 is a working example, not a study.** Twelve outfield players from one Ligue 1 squad, using routine club testing rather than a controlled protocol. It illustrates a principle; it does not establish a prevalence.
- **Only one chronic-adaptation study exists across locomotor profiles**, it was conducted in trained distance runners, and it defined profiles relative to the sample rather than against absolute values (Thron et al., 2026). Players in the Gaelic football dose-response study were likewise grouped by a modified speed reserve ratio without absolute MAS and MSS, so those findings are profile-associated tendencies rather than exact thresholds (Malone & Buchheit, 2025).

Use of generative AI

The authors used Claude (Anthropic) to propose language and consistency edits, to help write the code for all Figures, to check cited statements and bibliographic details against the source articles, and to standardise the reference list. All suggestions were reviewed, edited or rejected by the authors, who take full responsibility for the content. No data were generated by AI, and the squad data in Figure 8 come from routine club testing.

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