Striving for Excellence Summit

Strength training in football
From performance to prevention and rehabilitation

Parc des Princes, Paris
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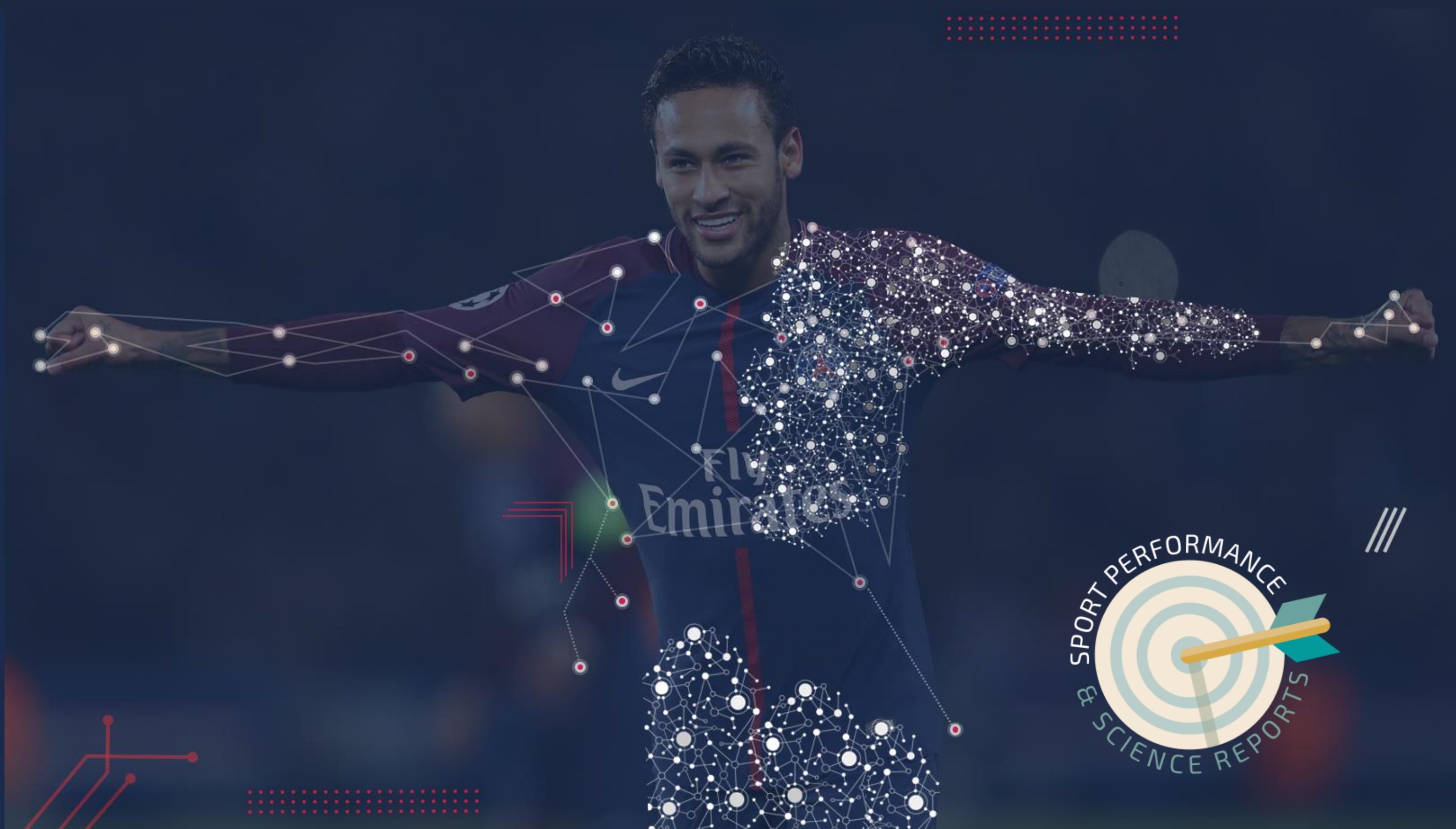
2018 Proceedings



Strength training in football - from performance to prevention and rehabilitation

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For the first edition of the Paris Saint Germain "Striving for excellence summit" that was held on the 14th of May 2018, we chose to focus our attention on of the most impactful physical capacity, strength [1]. In fact, only a few physical qualities such as speed and strength can transform and light up the game. Strength is a key physical attribute that is necessary to allow speed, acceleration and technique to shine through [1]. Strength is also part of the overall health of a player, making them more robust and resistant to injury [2]. However, while the importance of strength is not to be doubted, what is the best way, in practice, to improve it? Are all forms of force application capacity relevant for our practice? Shall we all lift weights as traditionally in the gym, or are there any other approaches that may be more time-efficient with regard to performance and injury risk? Can strength be developed and monitored on the pitch? Are there specific training strategies for players following an injury? Are there any specific diets and supplements that can increase strength gains? If you are a practitioners working with players, there is no doubt that you have already asked yourself all these questions. But do we all agree on the responses? Are there any consensus on those? Do 'best practices' exist at all levels? The response is very likely "NO". In fact, when it comes to delivering successful programs to top level athletes [3, 4], the training puzzle is usually more complex than initially meets the eye [5]. There are often as many appropriate practices or training approaches that there are practitioners, players or clubs, since every context tends to be unique [6]. Also, my personal experience in various contexts has told me that the beliefs of yesterday are unlikely to remain certitudes tomorrow (Figure 1).

The journey one takes for gaining confidence and certitude in the applied (football) world can be described by the Dunning-Kruger effect [7] (Figure 1). As the figure shows, we are generally full of the confidence that we know everything needed to succeed as a practitioner when exiting university. "I just graduated, so I know". Good high-performance university courses often allow students to gain not only excellent knowledge in a specific discipline, but sometimes (for the best courses) some practical skills necessary to work in the field (e.g., teaching some strength exercise movements or how to use GPS and sport-specific technology). However, with time and experience, people often realize that things learned on the page can seldom be applied as they are meant to be. With time, more questions arise… and confidence level decreases! "Should we really program strength like that?" With experience, we learn that the real world of elite athletes is far more complex than we could ever fathom from the outside [5]. When experience merges with humility [8] and open-mindedness [9], we begin to recognize that there are countless ways "to skin the cat" [10], and that endless roads lead to Rome [11, 12]. One of the better approach for personal development, to (re)gain certitude and in turn, improve our practices, very likely lies in our ability to listen, learn from others, accept constructive criticism [9] and develop a wide range of knowledge and skills, so that the right actions and behaviours can be implemented (often on the fly) within each specific context [13]. Confronting others' idea, respecting others' opinion and making the difference between scientific debate vs. personal battle is the best start to becoming a life-long leaner [9]. I believe that every conference should be viewed in this perspective.

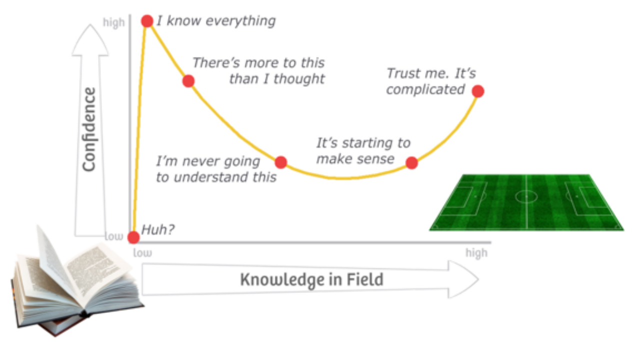

Fig. 1. The Dunning-Kruger effect. Adapted from http://agilecoffee.com/toolkit/dunning-kruger/

For this first edition of the Paris Saint Germain "Striving for excellence summit", because we believe that learning and building one's opinion requires critical thinking and getting out of the box [9], we decided to invite people from different backgrounds with sometimes diverging (but very likely complementary) views and approaches when it comes to training strength. We brought together some of the best international experts in this sector, including globally-renowned researchers, strength and conditioning coaches and physiotherapists. In order of appearance in the program, we listened to Jean Benoit Morin (Nice University, France), Alberto Mendez-Villanueva (Qatar Football Association), Julio Tous (Chelsea, UK), Ben Simpson and Mathieu Lacome (Sport Science, PSG, France), Anthony Shield (Queensland University, Australia), Jurdan Mendigutxia (Spain - Zentrum Rehab & Perf), Jérôme Andral (Physio, PSG, France) and Marina Fabre (Nutritionist, PSG, France). All presentations were very well received, and it was impossible to leave those amazing contributions for our guest's memories only. The present manuscript offers a unique summary of the presentations of that day, enlivened by the always excellent infographics prepared by Yann Le Meur [14]. Please take time to read and reflect on your own practices and researches, and let's all keep moving forward.

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Strength for jump and sprint performance in football: what the force?

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What force, at what velocity? What does "a strong player" actually mean? It depends on the velocity of motion considered. Laws of dynamics dictate that the external net force applied to a mass induces a proportional acceleration in the direction of the force vector. Thus, in sport tasks such as jumping or running acceleration, it is pretty intuitive to think that the more force is applied onto the ground, the more velocity (and performance) will be generated. Stronger, faster, better. However, our "motor" is the skeletal muscle, and muscle physiology dictates that there is an inverse relationship between the velocity of contraction of a muscle and its force output capability. So the complexity of ballistic exercises such as jumping and sprinting is that the force-velocity-power (FVP) spectrum (or profile), must be established to know exactly the force capability of the athlete in various velocity conditions. For instance, an athlete may be "strong", i.e. producing high amounts of force at low velocity (typically under high resistance in jumping or sprinting) but much "weaker" at higher velocity, or vice versa. An elite sprinter who is still able to produce net force and accelerate while running at 8-10 m/s or more should be considered as "strong", but in his case, in a high-velocity context.

The "force" output of a player in the context of lower limb exercises such as jumping or sprinting can in theory be assessed at various levels, from micro- to macroscopic: single muscle cell/fibers to macroscopic, in-game muscle force output. While the first context might be irrelevant or too microscopic for overall football performance, the second one is currently impossible (despite recent breakthrough results (1). So, we are left with two types of approaches, that bring clearly different information: single joint measurements (e.g. isokinetic testing) and jump- or linear sprint-specific force-velocity-power profiling.

"Profiling" players allows to identify, and then track during the training, development, rehabilitation process, the entire "big picture" spectrum of muscular capabilities (from maximal force to maximal velocity) in the specific context of jumping and sprinting. In squat jump or countermovement jump, the maximal power output and linear FV profile may be accurately established from jump height (2), body mass and push-off distance and used to compute the individual optimal profile (3), i.e. the theoretical FV profile or slope that, for a given maximal power capability, would maximize jump height. This key information may be used to better tailor training programs to the specific needs of each athlete, with more effectiveness compared to a standard "one-size-fits-all" approach (4), or more specifically monitor the return-to-performance process, based on accurate specific pre-injury data.

During sprint acceleration, this linear FV profile may now be accurately established on the basis of split times or velocity-time inputs (5), while it was only hitherto accessible with heavy laboratory devices (force plates or instrumented treadmill). The key sprint FV outputs (maximal theoretical force, velocity and power, and mechanical effectiveness of ground force application) may help better characterize athletes' capabilities and design more individualized and effective training interventions (3).

Recently, experimental data demonstrated that hamstring muscles activity and strength was related to sprint maximal horizontal force output (6) and that this sprint-specific force capability was impaired in the context of previous or even future sprint-related hamstring injuries (7,8). These preliminary data open a new track for research into a "win-win" strategy putting hamstring function during sprinting at the center of a performance-prevention continuum (9).

Practical Applications

- Only a comprehensive exploration of the entire force-velocity-power spectrum of players (in jumping and sprinting) can provide the complete macroscopic picture of the individual mechanical underpinnings of their physical performance.
- In turn, this may help performance and medical practitioners better individualize the training and rehabilitation interventions, and adapt them to the specific strengths/weaknesses of each player.
- This approach (now possible with simple field tests and smartphone/tablets apps) may also be implemented regularly as a dynamic monitoring tool to also adapt to the players' individual adaptation kinetics, in performance and injury management scenarios.

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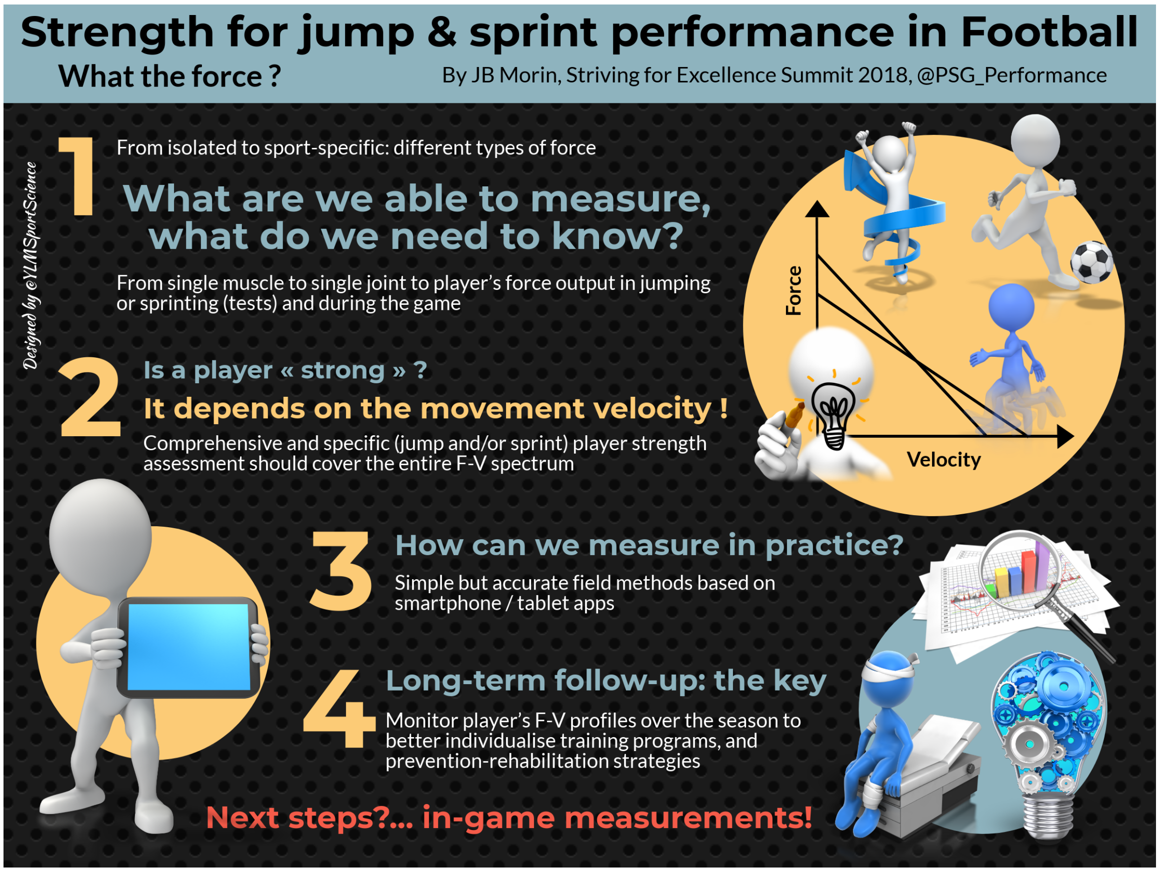
Teamwork
Multifactorial
Sprint
Creatine
Protein
Isokinetic
Individualized
Movements and muscles
Tactical periodization
Load management
In-game measurements
Invisible monitoring
Time-efficient strategies
Specificity
FV profile
Transfer
Designed by @YLMSportScience


Strength for jump & sprint performance in Football
What the force ?
By JB Morin, Striving for Excellence Summit 2018, @PSG_Performance
1
From isolated to sport-specific: different types of force
What are we able to measure, what do we need to know?
From single muscle to single joint to player's force output in jumping or sprinting (tests) and during the game
2
Is a player « strong » ?
It depends on the movement velocity !
Comprehensive and specific (jump and/or sprint) player strength assessment should cover the entire F-V spectrum
Force
Velocity
3
How can we measure in practice?
Simple but accurate field methods based on smartphone / tablet apps
4
Long-term follow-up: the key
Monitor player's F-V profiles over the season to better individualise training programs, and prevention-rehabilitation strategies
Next steps?... in-game measurements!
Designed by @YLMSportScience

Strength training & player development: road to the World Cup 2022

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A well-developed capacity of the neuromuscular system to control and drive football movements is highly desirable to successfully compete against better-ranked opponents. The ability of the neuromuscular system to functionally control movements, for instance, enables football players to generate and co-ordinate complex, whole-body movements in order to effectively solve game-related tasks and to avoid joint and muscle damage. Thus, it is believed that football performance can be enhanced and injury risk reduced by appropriate and systematic exercise interventions targeting neuromuscular factors. The long-term methodological framework being implemented by the Qatar National Team leading to the World Cup 2022 is presented.

Defining training targets:

1. Increase neuromuscular resources to face game-related (performance & injury) situations (1).
2. Those neuromuscular adaptations should allow the player to exercise at relative lower intensities (2).
3. Ideally, by achieving to the above players should: remain injury free & increase task-dependent (football) fatigue resistance.

Framing training interventions:

1. Training in specificity (specificity being considered the most important training principle) (1). To exemplify this principle: being strong does not warrant at all being adapted to play football.
2. Overload principle (with the game demands as a reference). If the desired overload is not achieved through football training (being those exercises the more "specific"), complementary interventions are suggested (both in the field & gym).

Evaluation & amending training interventions:

1. Football exercises are assessed in relation to the degree of specificity (resemblance to the game model) and magnitude of overload.
2. Gym-based interventions are organized around players needs in relation to individual weakness and can typically be grouped in 6 families:
   (a) Activation & prehab
   (b) Core & lumbo-pelvic stability
   (c) Structural & eccentric
   (d) Maximal tension
   (e) Explosive (power)
   (f) Integrated & complex drills

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Strength Training in Elite Football: An alternative approach

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We place strength at the highest hierarchical range of physical abilities since it generates the main human faculty to interact with its environment: movement. As a consequence, endurance is understood as those resources that help to maintain prolonged strength efforts over time, while speed is a direct outcome of rapid force application to generate fast movements. To better comprehend this approach, we enrich the spectrum with two catalyzers such as the "repeated power ability" (RPA) (1,2) or the "maximal power endurance" (MPE) (3). RPA is the ability to perform several blocks of sets of maximal power training with incomplete recovery between sets. On the other hand, MPE entails the challenge of maintaining a high target power-output (>90% Pmax) during a set with the load that maximizes the power output and complete recovery between sets.

Rather than just increasing or maintaining power output under controlled/stable conditions, in elite football the final aims of a strength training program should be to optimize performance (how players effectively move on the pitch and maintain high intensity efforts over the match/season) while reducing the injury rate (considered as restraining the number of days out of training/competition). Unfortunately, limited time is available to include comprehensive training sessions given the highly congested calendar and as a matter of fact few top teams regularly (weekly) include mandatory group sessions into their in-season microcycles. This reality challenged us to search for more time-efficient training strategies in order to maintain or even create those adaptations needed to tailor those aims

The complexity of football movements and hence the strength application relies on a noisy and stumbled dynamic. Most of the actions are performed in an unbalanced/unpredictable environment that lead players to adopt transgressive behaviors such as the need to *anticipate* (feed-forward mechanisms and co-contractions) (4) or generate new movement strategies. Specifically, the nature of most football actions is *unilateral, variable* and '*multidirectional* (5): players kick, pass, press, cut or jump while mainly using one limb over the three space dimensions. Rather than repeating these moves in a cyclic fashion they *alternate* them without a pre-fixed route or pacing strategy resulting in an *ad-hoc duration.* A number of *perturbations* (6), *unknown* (7) or *unexpected* (4) *events* coming from the opponents or team-mates usually constraint their pre-planned movement strategies. Thus, a sudden brake in form of *eccentric overload* (8) is often required to reorganize the plan or fake the defender. At the end of the road, movement *efficiency* and *efficacy* (9) in a given playing situation is much more relevant than for example the extent of power output during the propulsive phase of that movement.

Far from neglecting the conventional approach to strength training mainly based on muscles, our aim is to evolve it into a more comprehensive approach. This alternative proposal incorporates the conventional one, which does not occur in the opposite order. Movement functionality should be the epicenter when the player competes at an optimum level while focus on "muscles" is a necessary backup when deficits/injuries appear. However, the real challenge is to introduce a systematic/mandatory weekly in-season session.

Practical Applications

- Since playing football alone is not a comprehensive training stimulus to maintain neuromuscular performance and avoid injuries during a particularly long season, elite football players are in need of a strength training program including a number of non-conventional training variables able to shape how football actions evolve in a stochastic real-game situation.
- We may call this as movement/action configuration elements which include (in contrast with conventional approaches): unilateral (bilateral), variable (constant), multidirectional (vertical), alternation (monotonous reps), ad-hoc duration (fixed), perturbations (stable), unknown (known), unexpected (pre-planned), eccentric overload (concentric emphasis), efficiency/efficacy (velocity/power output).
- In order to spur permanent adaptations during the season the cited elements should be progressively incorporated into each movement family and direction (eg, lunges, step-ups, diagonal chops, side-steps, crossover, shuffling, drop, or jab-step maneuvers) with the ball addition as key element to increase movement variability and adaptability (10).
- A weekly strength training session should be at least included along the season. If this is not possible because of a congested fixture period we may design micro-sessions (10-15 minutes) to introduce them as a high-quality activation before technical-tactical sessions to replace empty and non-effective warm-ups.
- Compensatory exercises (i.e. dynamic rotational –core- stability and vibratory training) should be added on a daily basis to attenuate the aggressive loads players are exposed to.

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Strength training & player development
Road to the World Cup 2022
By A. Mendez-Villanueva, Striving for Excellence Summit 2018, @PSG_Performance
1 Research-based = evidence-based? Defining strength training principles and practice
EVIDENCE
2 Strength training in football: focus on high-intensity actions as they are typically linked with decisive performance episodes and injury situations
3 Force production and reduction scenarios typically happen in situations of compromised joint stability and/or fatigue
4 Force production and reduction scenarios not easily reproducible outside football
5 Focus on game-specific strength in the field to ensure specificity and transfer
6 Complementary strength training outside the field should mainly focus on high-intensity, unilateral actions with augmented eccentric demands in addition to the inclusion of extreme ROMs
Designed by @YLMSportScience

Strength training in Football
An alternative approach
By J. Tous, Striving for Excellence Summit 2018, @PSG_Performance
The reality of elite football
Soccer movements: highly dynamic & stochastic
Limited time is available for strength training and conditioning sessions
Inventing time-efficient training strategies
Locomotive-specific actions + Injury prevention + Affordances that may induce emergent behaviors for generating optimal movement synergies
Multidirectional movements
Efficacy & Efficiency
Eccentric overload
Dynamic instability
Unilateral exercises
Variability
Movement alternance
Adjustable duration
Clusters
Unexpected events
Designed by @YLMSportScience
Practical example
with evidence-based results
A)
B)
Versapulley
C)
D)
Flywheel
E)
Vibration
H)
25 min high-intensity session
Reference: Tous et al. IJSPP 2016

Monitoring strength on & off the field.

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Why force monitoring is important in football?

Football is a high-intensity intermittent game where players are sometimes required to cover up to 1500m above 19.8 km.h-1. But when it comes to pressing an opponent, finding free space or accelerating to score a goal, accelerations and decelerations are key. During these events, greater force is applied to the ground, greater velocity is generated (1); in current modern football, strength is then essential. Practitioners spend time on and off the field trying to develop this quality and in turn, it's obvious that valid and reliable monitoring methods are paramount.

During the first part of this talk, we discussed the importance of monitoring strength on the field, proposed some metrics to achieve this and presented a couple of case studies. The second part focussed on why monitoring strength and power off the field matters and explains various methods.

Monitoring strength on the field

In football, the majority of training is completed outside; monitoring actions that require strength production is thus mandatory. Player tracking – is one of the most important components of load monitoring in team sports (2) – offers some possibilities to do so. We use mechanical work - an overall measure of velocity changes and is computed using >2 m.s^{-2} accelerations, decelerations and changes of direction events (3) – as an estimate of tight work and the overall force production during training. Another metric commonly used is force load: computed using GPS-embedded accelerometer data, force load is the product of the mass with the sum of vertical accelerations (4). This metric can be useful to analyse foot strikes, especially where displacement is limited.

Which small-sided games overload or unload the 'strength' component of the game? Which specific positional roles are overloaded for specific small-sided games? Used in combination with good analytics (i.e., peak game demands), force-related metrics can help in the planning of training and aid practitioners to propose adequate training for a given context. Force load, used during a standardised drill such as box-to-box runs, is useful to monitor neuromuscular fatigue following various training sessions or training cycles (5).

Monitoring strength off the field

Off field training to develop strength in football can be complex, especially during congested periods where players are required to play every 3-4 days. Training load monitoring presents as an important component during these periods to fully optimise training content in relation to fitness and fatigue. While traditional pen-and-paper methods are easy (i.e., count weight) limitations exists: inability to measure movement velocity or power output. Current methods using linear position transducers or accelerometers offer this possibility. Over the past several years, velocity-based training (VBT) has come to the forefront as an innovative way to determine load for strength training. Using velocity of the bar for a given weight can help adjust load based on potential fatigue or performance improvement. We presented a case study proving that, even starting players and during congested periods, using low volume of training based on VBT allowed for strength and power improvements during the season.

Practical Applications

- Strength is a key determinant of performance in football, especially for elite players.
- Monitoring 'strength' on the field can be done using GPS and accelerometer data, during a standardised drill, and used to estimate neuromuscular fatigue.
- Velocity-based training is an innovative tool to monitor strength and power off field and allows for immediate feedback to players during training.

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Hamstring strengthening strategies.

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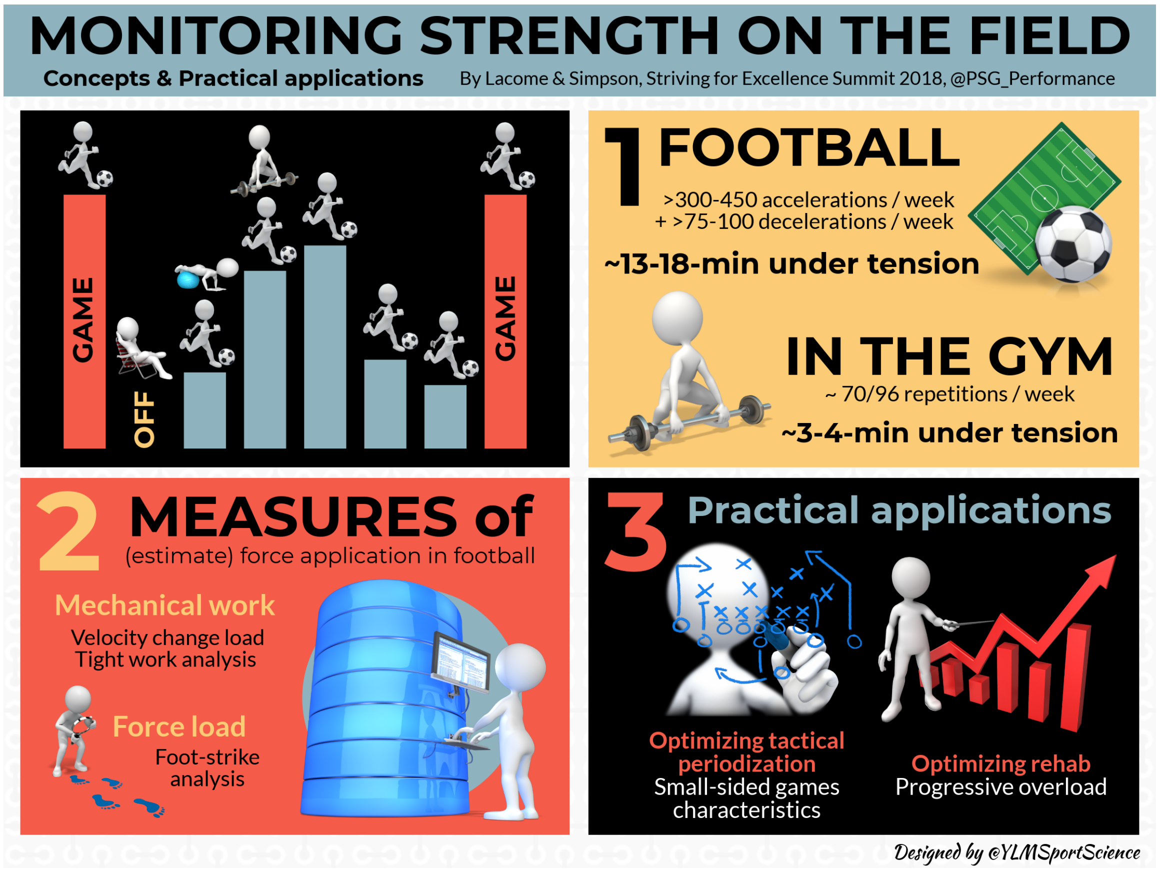
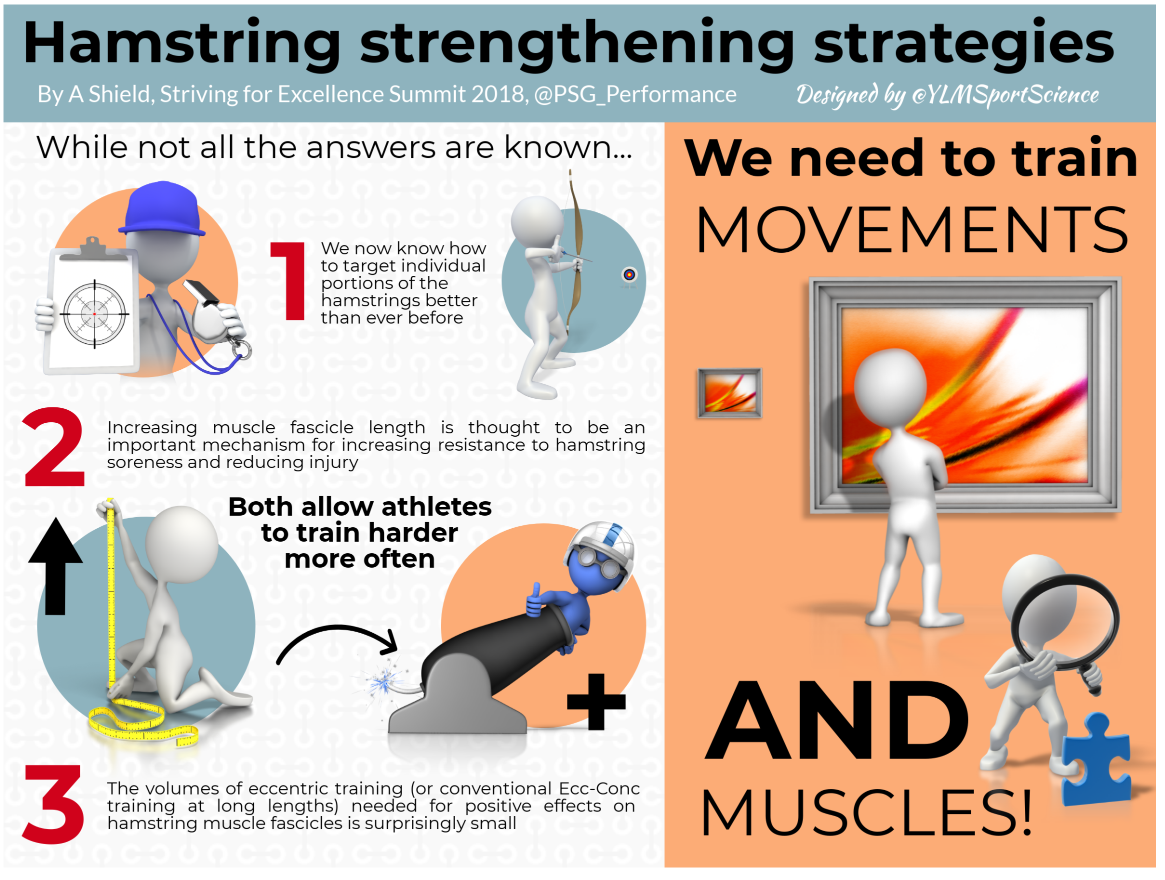
Practical Applications

- There are many opinions about hamstrings that exist despite the absence of evidence. It is important to consider whether there is evidence for each of our beliefs.
- The suggestion that the hamstring problem "Is more complicated than just strength and fascicle length" is axiomatic.
- It is impossible to construct a conditioning program for footballers entirely on the basis of the limited scientific evidence. We also need to consider conventional practices and the first principles of exercise science.
- It is axiomatic that athletes need to run fast and in fatigued states in training. Whether running technique (eg. lumbopelvic movements) has a role in injury causation is not well evidenced based at the moment.
- Resistance training exercises can preferentially target individual hamstrings and this has been shown with surface EMG studies, functional MRI studies and, most convincingly, in a training study.
  - Due to a lack of comparison trials we don't know which exercises are most effective. Only the Nordic hamstring exercise (NHE) has convincing evidence as an injury preventer although others may be equally or more effective.
  - Some alternative exercises may be less effective but more readily accepted by coaches and athletes and these may, in the future, help to prevent more hamstring injuries by virtue of better adoption.
- Knee flexor exercises such as the Nordic hamstring and the leg curl preferentially target the semitendinosus (ST) and, to a smaller extent, the biceps femoris short head (BFSH). Despite not selectively targeting the long head of biceps femoris (BFLH), the NHE and eccentric leg curls have been shown to effectively lengthen that muscle's fascicles. Fascicle lengthening may be one mechanism for injury prevention, although more work is needed to prove this. Preferentially strengthening the ST may help to protect the often injured BFLH.
- Hip extensor exercise in a 45 degree Roman chair activates the two-joint hamstrings relatively evenly with little involvement of the BFSH. Hip extension is significantly more effective than the NHE when it comes to stimulating BFLH hypertrophy. The hip extension also lengthens biceps femoris fascicles, at least in recreationally trained men.
- Biomechanical modelling supports the belief that trunk and other posterior chain muscles protect the BFLH from excessive strain during sprint gait.
- Eccentric knee flexor training has a positive effect on fascicle lengths while two studies suggest that concentric training has a negative effect. The razor curl (a pseudo-isometric exercise for hamstrings) has recently been reported to have no effect on fascicle lengths.
  - The evidence suggests the need for some emphasis on eccentric exercises for the hamstrings.
  - The suggestion that isometric exercise may be more effective than eccentric training for hamstring injury prevention is not evidence-based. Hopefully we will see some research in the near future.


MONITORING STRENGTH ON THE FIELD
Concepts & Practical applications
By Lacome & Simpson, Striving for Excellence Summit 2018, @PSG_Performance
GAME
OFF
GAME
1 FOOTBALL
>300-450 accelerations / week
+ >75-100 decelerations / week
~13-18-min under tension
IN THE GYM
~ 70/96 repetitions / week
~3-4-min under tension
2 MEASURES of
(estimate) force application in football
Mechanical work
Velocity change load
Tight work analysis
Force load
Foot-strike
analysis
3 Practical applications
Optimizing tactical
periodization
Small-sided games
characteristics
Optimizing rehab
Progressive overload
Designed by @YLMSportScience


Hamstring strengthening strategies
By A Shield, Striving for Excellence Summit 2018, @PSG_Performance
Designed by @YLMSportScience
While not all the answers are known...
1 We now know how to target individual portions of the hamstrings better than ever before
2 Increasing muscle fascicle length is thought to be an important mechanism for increasing resistance to hamstring soreness and reducing injury
Both allow athletes to train harder more often
+
3 The volumes of eccentric training (or conventional Ecc-Conc training at long lengths) needed for positive effects on hamstring muscle fascicles is surprisingly small
We need to train
MOVEMENTS
AND
MUSCLES!

Rehabilitation of hamstring injuries in elite professional football

Jurdan Mendiguchia [1]

[1]ZENTRUM rehab and performance

Striving for Excellence | Paris SG | 2018

If we take a historical perspective on the management of hamstring muscle strains it seems that the foundations for our current management strategies have not changed substantially since mid-century (1). In general the rehab processes were divided into 3 phases according to biology of muscle injury and repair and progress from a protective phase (control of inflammatory process) to a stage where the fundamental focus is the knee flexors strength development (normally isometric-concentric-eccentric progression) to finally PERFORM sports specific movement and sprinting activities (2). Attending to the criteria used in the scientific literature to advance from one phase to another, the rehabilitation proposals were based on subjective clinical assessments and performance tests as RTP criteria and if something was quantified then isolated knee flexor torque (2). Another element that draws our attention is the lack of periodization and limited attention to aspects such as number of repetitions and sets, intensity as well as the disposition of the contents on the different workouts. Based on this reality... *What is our proposal?*

When we face the art of designing the rehabilitation process of an elite player we consider 3 fundamental aspects:

1. Injury mechanism (deconstruction) and its related risk factors
2. Performance of the player in order to a successful return to sport
3. Biology of muscle injury and repair.

For the purpose of this abstract we will use injuries derived in high speed running as an example. In this case all the rehab will revolve around sprinting, a key parameter in football both from a performance and injury point of view. 1) Due to the complex and unique sprinting movement (leg interaction, elastic energy transfer, reflexes, kinematics, kinetics, intensity) we will escape from the medical understanding of the human body as an entity assembled from many pieces and that conceives any system as the sum of its isolated parts (3). In contrast, we will try to analyze and evaluate the interaction of the different risk factors in relation to their influence on the sprint and the football player that we have in front (3). Finally, the **key** will be to recognize the origin of the alteration of the affected factor, instead of only focusing on correcting the consequence and not the underlying source(s). As an **example**, a problem of flexibility in the sprint on a subject could be caused by: shortening of the hip flexors, neural issue, pelvic tilt or the structural properties of the hamstrings. If we are not able to find the source of this deficit, we can hardly solve the origin of the problem and we could even make it worse (3). Consequently, screening and subsequent intervention will always be aimed at evaluating and modifying those factors that influence the sprint NOT to improve an isolated test. 2) We cannot forget that in addition to **REPAIRING** the player we must **PREPARE** (performance) him to return in the best possible physical conditions. To do so, we must recognize the impact of the injury on the locomotive profile of our player, as well as to the demands he is exposed during the matches (4), both being fundamental aspects in the design and periodization of the rehabilitation process (5). Due that in football, high-speed running actions such as sprints are common in many match-winning actions (6) and that recently, experimental data showed that hamstrings muscle activity and strength (7) were related to sprint maximal horizontal force output (8) and that this sprint-specific force capability was impaired in previous or even future sprint-related hamstring injuries (9). The assessment of the sprint mechanics (10) during return to play seems essential both from a performance and specificity perspective in contrast to a more conventional and not performance-injury related single joint torque assessment approach 2. 3) Last but not least, we will respect and try to improve in parallel the biology of the muscle injury and repair since analyzing the data of the literature seems to have its weight in relation to the high index of early re-injuries just after return to play (11).

In summary, analysis, control and intervention over the injury mechanism and its contextualized risk factors, performance and the biology of tissue repair will allow to attack the multifactorial character of this type of injury in an individualized way (type of mechanism and player) and therefore guide the player in the fastest, specific and safest way until his return to play.

Practical Applications

- Injury mechanism (deconstruction) as a central pillar from which the rehabilitation process is designed
- Prepare (performance) and repair (healing) the player in parallel to the correction of his specific and contextualized risk factors and locomotor profile
- Adapts the screening, rehab program and return to play assessments around the injury mechanism and specific characteristics of the player to be treated

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The use of isokinetic devices for rehabilitation

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Muscular strain is the first reason time is lost by a player in an elite football club, and has the highest injury burden. Injury recurrence, close to 16% for hamstring injury (1), is the worst case that every staff and player would like to avoid. So, challenges are multiple for medical and performance staff: optimize performance while reducing injury incidence, minimize time lost due to an injury when occurred, and avoid recurrence. Thereby practitioners should use objective tools and data, isokinetics can be utilised during both the prevention and rehabilitation phases.

Hamstring prevention and isokinetic

One of the multiple means in the field of prevention is the analysis of risk factors. Previous injury has been shown as an important risk factor compared to a non-injured population (risk ratio (RR) 3.57) (2), as injury imbalance and weakness. A preseason isokinetic test can provide objective data on muscle strength, which is the first step of imbalance analysis. More than the disbalance between left and right, the hamstring to quadriceps ratio (H/Q ratio) and strength to bodyweight (N.m.kg) are the factors most associated with hamstring strain injury. When the H/Q ratio is under 50.5% at 60°/s in concentric, or eccentric hamstring strength to bodyweight at 30°/s is under 2.4, the RR is respectively 3.14 and 5.59 (2). Concerning the mixed ratio (eccentric hamstring at 30°/s to concentric quadriceps at 240°/s) (3), threshold is fixed at 1.2.

In the same spirit of analysis and comparison between healthy and injured populations, angle of peak torque (PT angle) is an essential parameter to consider. The length tension relationship is modified due to the injury. PT angle occurs in a shorter stretching position, yet the majority of lesions occur in maximum elongation positions when the passive tension is large (4,5). Ideally the PT angle must be in the last 15 degrees of extension for hamstring injury (6) and should be a target during rehabilitation.

Hamstring rehabilitation and isokinetic

Passive stretching is the first eccentric stress on a muscle, so eccentric isokinetic work can start as soon as passive stretching is pain free. The recovery of force will be guided and objectified by repeated work (5 sets of 5 reps) of 30 to 80% of the known maximum eccentric force, at slow speed (10 to 30°/s) to promote the healing process. This, added to the effects of eccentric training, among others the increase of sarcomeres in series, the modification of the passive tension, the lengthening of muscular fascicles (7), will contribute to the displacement of the PT angle towards an optimal position (8). Work intensity, defined as the percentage of the maximum eccentric force, will change from session to session depending on the tolerance of the lesion and the patient's ability to perform all the repetitions at the required intensity. Gradually, the recovery of force will allow the functional recovery. The objective data input makes it possible to codify the different steps. Thus, jogging will be done when the patient is able to repeat work at 60% of his maximum in eccentric. In the same spirit, sprinting will commence once 80% is achieved (9,10). It must be noted that isokinetic work remains an analytical effort that guides functional recovery.

It is not because one is able to do it analytically that it will work out well. But if we are not able to do it analytically, then it will go wrong functionally!

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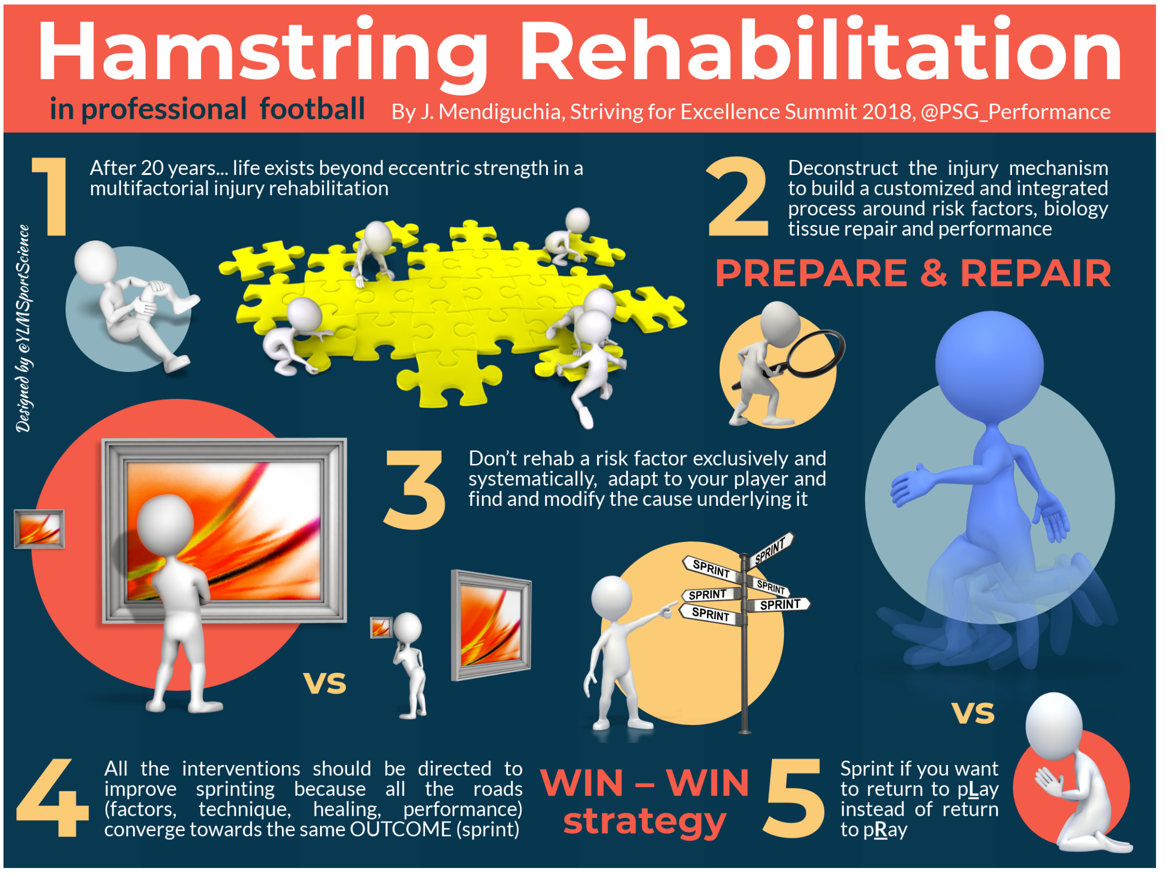
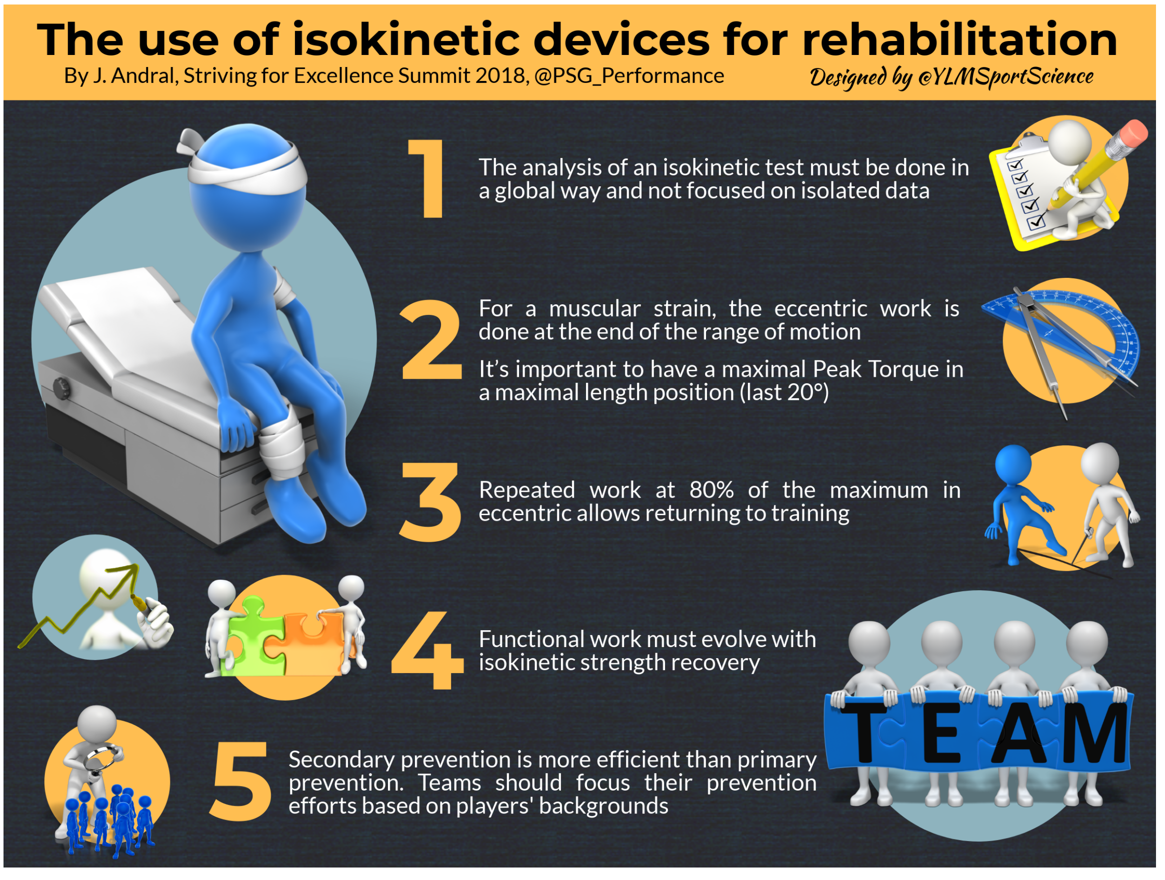

Hamstring Rehabilitation
in professional football
By J. Mendiguchia, Striving for Excellence Summit 2018, @PSG_Performance
Designed by @YLMSportScience
1
After 20 years... life exists beyond eccentric strength in a multifactorial injury rehabilitation
2
Deconstruct the injury mechanism to build a customized and integrated process around risk factors, biology tissue repair and performance
PREPARE & REPAIR
3
Don't rehab a risk factor exclusively and systematically, adapt to your player and find and modify the cause underlying it
VS
SPRINT
VS
4
All the interventions should be directed to improve sprinting because all the roads (factors, technique, healing, performance) converge towards the same OUTCOME (sprint)
WIN – WIN strategy
5
Sprint if you want to return to pLay instead of return to pRay


The use of isokinetic devices for rehabilitation
By J. Andral, Striving for Excellence Summit 2018, @PSG_Performance
Designed by @YLMSportScience
1
The analysis of an isokinetic test must be done in a global way and not focused on isolated data
2
For a muscular strain, the eccentric work is done at the end of the range of motion
It's important to have a maximal Peak Torque in a maximal length position (last 20°)
3
Repeated work at 80% of the maximum in eccentric allows returning to training
4
Functional work must evolve with isokinetic strength recovery
5
Secondary prevention is more efficient than primary prevention. Teams should focus their prevention efforts based on players' backgrounds
TEAM

Nutritional supplementation and strength adaptations

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Resistance training plays an important part in the training programs of athletes, with the aim being generally to improve strength and power. Nutritional strategies alongside exercise can maximize the muscle responses to resistance training. Protein and creatine are the most effective nutritional supplements currently available to athletes to increase lean body mass and high-intensity exercise capacity (1).

On the one hand, the scientific literature provides a large body of evidence suggesting that protein supplementation can improve muscle adaptation to resistance training (2). Quality, quantity and timing of protein intake have particularly engaged the attention of scientific studies. These three factors should be considered to get an optimal increase of muscle protein synthesis after exercise and throughout the day. The protein quality is determined by three main factors: the content of essential amino acid (8-10g) and leucine (3g), the digestibility and rapid absorption of the protein (3). The optimal quantity of protein to ingest just after exercise should be ≈0.24g per kg body weight (4), and between 1.8 to 2.5g per kg body weight per day during a limited period of resistance training program (3). In regards to optimal timing of protein intake, the scientific studies highlight 1) the importance of protein intake immediately after exercise (4), 2) the importance of protein intake every 3 hours during the day (5), and 3) the potential interest for protein intake before bedtime (6).

On the other hand, creatine supplementation can increase intra-muscular creatine concentration. The increase of phosphocreatine content can enhance the capacity for repeated bouts of high-intensity exercise with brief recovery intervals which would otherwise provide inadequate recovery for phosphocreatine stores. This can allow athletes to improve exercise performance and/or training adaptations (1). The recommended protocol of use consists in a loading phase with ≈20-25g per day (0.3g per kg of body weight) for 5-7 days, or 3-5g per day for 28 days. The following maintenance phase consists of a 3 to 5g of creatine monohydrate ingestion (7). During the loading phase, some studies have reported a small increase in body weight from 1 to 2kg, which results mostly from water retention (1). This potential effect on body composition must be taken into consideration, mostly for sports with weight classes. By respecting the recommended intake protocol, the actual scientific literature does not point out any side effects on health (1).

In summary, supplement use by athletes is a wide-spread practice and potentially useful for sports performance. To optimize muscle adaptations from resistance training, protein and creatine are the most effective. However, the supplement must have a certified label for quality, purity and safety of their composition. Their use must be well controlled and associated with a well-balanced diet to get the potential optimal positive effect on performance and limit the risk of adverse effects.

Practical applications for protein and creatine supplementation during resistance training program:

Protein supplementation after exercise:

- **What?** Animal based protein (milk, whey, eggs) or vegetal based protein (soya)
- **When?** Rapidly after exercise, within the first 30-45minuts after
- **How much?** 0.24g/kg body weight

Creatine supplementation:

- **What?** Creatine monohydrate
- **When?** To be ingested with carbohydrate and protein for better absorption, before and/or after exercise
- **How much?**
  - Loading phase: 20-25g (0.3g per kg of body weight) in split doses (4x5g/day) for 5-7 days or 3-5g/day for 28 days
  - Maintenance phase: 3-5g/day

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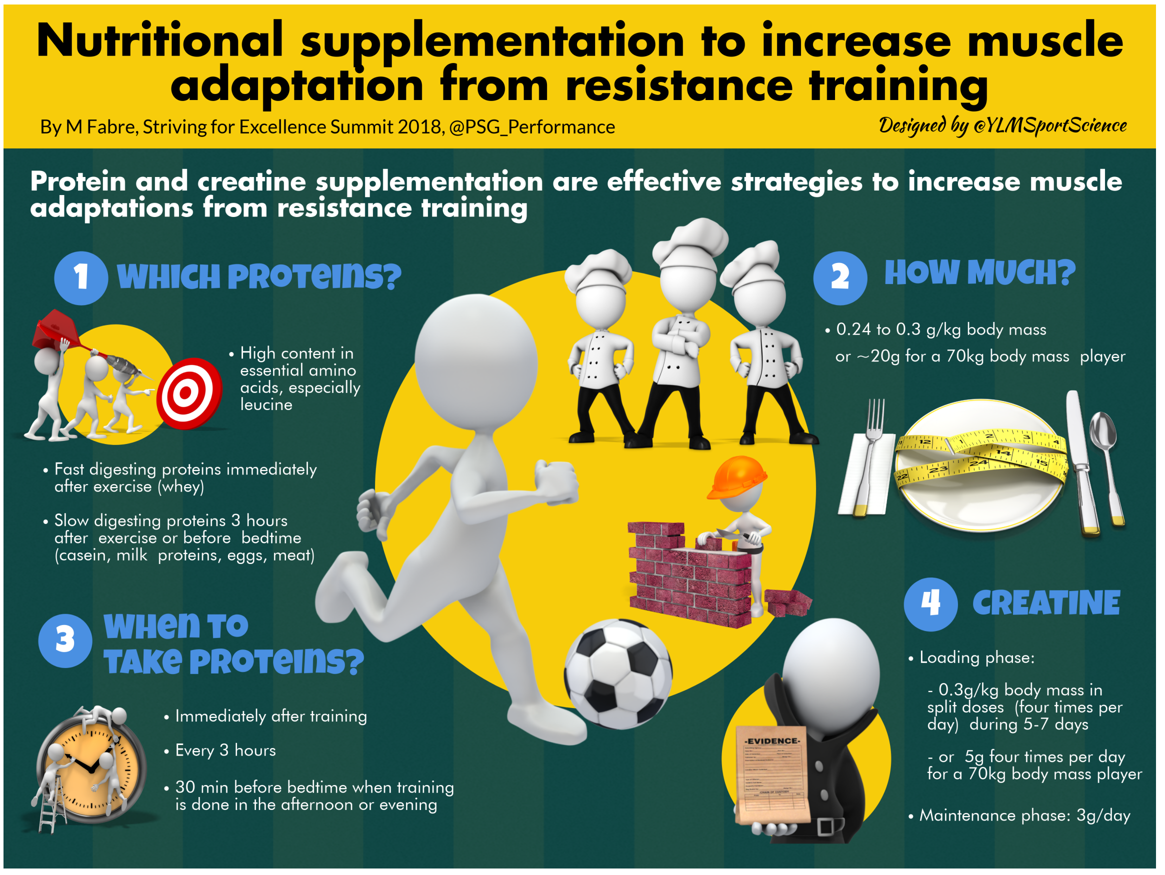

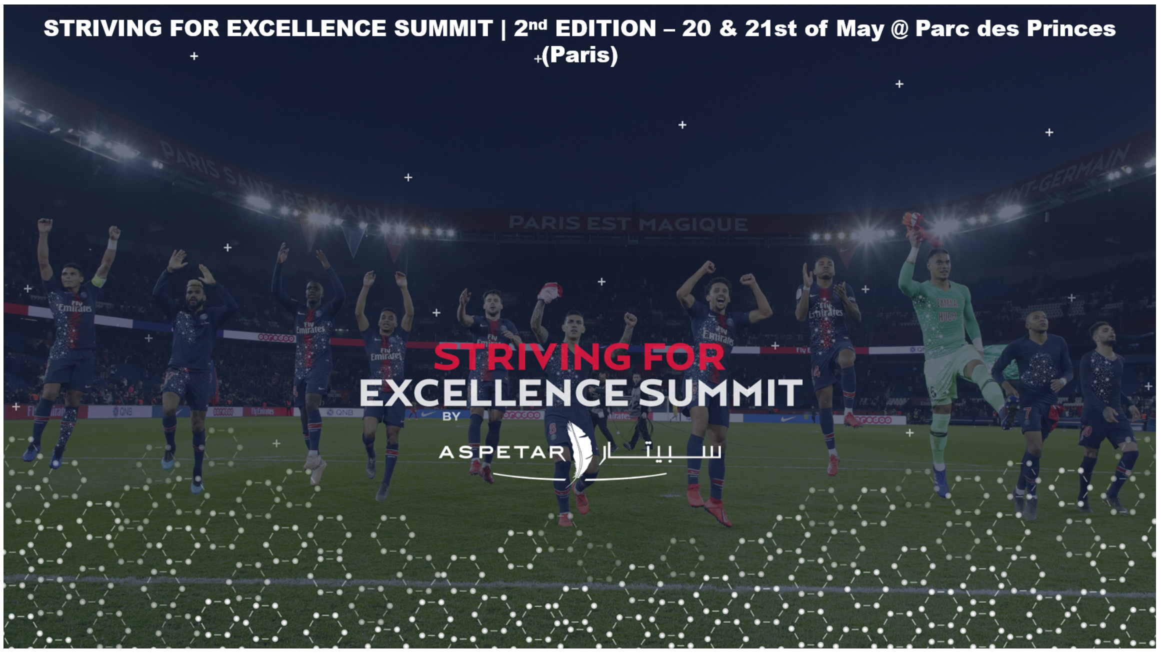

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