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INTERNSHIP REPORT

PERFORMANCE ASSESSMENT AND PLAYER'S MONITORING IN SOCCER: METHODS APPLIED IN A HIGH-PERFORMANCE DEPARTMENT

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Keywords: Soccer; Monitoring; Return-to-Play; Performance

This work is based on Order (Science) from Chaos (Practice)

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ABSTRACT

The relentless search for the best performance (physical, technical, tactical and psychological) in the field, force coaches, athletes and other surrounding departments to interact in a harmonious way. The aim is to adjust and direct the training through periodic and continuous evaluations that will facilitate decision making. This internship report belongs to the master course in Sports Training from the Superior School of Sports and Leisure, with the objective of obtaining a Master's degree. Taking into account the chosen specialization (soccer), this internship was carried out in the high-performance department (DAR) assigned to “B” team of Vitória Sport Clube, in Guimarães.

The objectives of this internship were to: (i) support the DAR in the periodic and continuous assessments; (ii) support the return-to-play process of injured athletes; (iii) propose the creation of a periodic and continuous assessment process, from the U13 to “A” team; (iv) propose the creation of the club’s research laboratory, and (v) to produce and publish two scientific papers related with periodic and continuous assessments. All the objectives initially proposed were fully accomplished. In fact, my expectations regarding both the master course and this internship were completely exceeded.

Two scientific papers were published. The paper 1 aimed to assess changes in physical fitness of amateur soccer players after a pre-season training period. Results revealed a lack of significant positive changes after the assessed period. The paper 2 aimed to test the relationship of volume and weekly training intensities with match-running demands of professional male soccer players. Results revealed that weekly training volume and intensity of high-intensity demands had moderate relationships with match high-intensity demands.

For all the above-mentioned, this internship drew a robust profile in me in order to combine science with practice, and to transmit this path to all stakeholders involved in this process of “order-versus-disorder” soccer context.

Keywords: Soccer; Monitoring; Return-to-Play; Performance

RESUMO

A busca incessante pela melhor performance (física, técnica, tática e psicológica) em campo, obriga os treinadores, atletas e restantes departamentos envolverem a interagirem de forma harmoniosa. Procura-se ajustar e direcionar o treino através de avaliações periódicas e contínuas que facilitarão a tomada de decisão. O presente relatório de estágio surge na continuidade do mestrado em Treino Desportivo da Escola Superior de Desporto e Lazer, com o objetivo de obtenção do grau de Mestre. Tendo em conta a especialização escolhida (futebol), o estágio foi realizado no departamento de alto rendimento (DAR) afeto à equipa B do Vitória Sport Clube, em Guimarães.

Os objetivos deste estágio foram: (i) apoiar o DAR nas avaliações periódicas e contínuas; (ii) apoiar o processo de retorno à competição de atletas lesionados; (iii) propor a criação de um processo de avaliação periódica e contínua, desde a dos Sub13 até à equipa “A”; (iv) propor a criação do laboratório de investigação do clube, e (v) produzir e publicar dois artigos científicos relacionados com avaliações periódicas e contínuas. Os objetivos i propostos foram integralmente cumpridos. As minhas expectativas em relação ao mestrado e ao estágio foram totalmente superadas.

Dois artigos científicos foram publicados. O artigo 1 teve como objetivo avaliar as alterações na aptidão física de atletas amadores de futebol após a pré-época. Os resultados revelaram ausência de mudanças significativas após o período avaliado. O artigo 2 teve como objetivo testar a relação do volume e da intensidade de treino semanal com as demandas de corrida de jogadores profissionais de futebol. Os resultados revelaram que o volume e a intensidade das demandas de alta intensidade de treino semanal tiveram relações moderadas com as demandas de alta intensidade em jogo.

Este estágio traçou em mim um perfil robusto no sentido de aliar a ciência à prática, e transmitir este caminho aos intervenientes neste processo de ordem versus desordem, que é o treino de futebol.

Palavras-Chave: Futebol; Monitorização; Retorno-à-Competição; Performance

LIST OF ABBREVIATIONS

ACWR: acute:chronic workload ratio
ALs: acute loads
A.U.: arbitrary units
CMJ: countermovement jump
COD: change-of-direction
CLs: chronic loads
DJ: drop jump
ES: effect size
EWMA: exponentially weighted moving averages
GPS: global positioning systems
HSR: high-speed running
IMU: inertial sensor units
IMTP: isometric mid-thigh pull
MEMS: microelectromechanical systems
MD: match day
MRI: magnetic resonance imaging
1RM: one-repetition maximum
RA: rolling averages
RTP: return-to-play
RTR: return to running
StARRT: strategic assessment of risk and risk tolerance
SJ: squat jump
SSC: stretch-shortening cycle
SSCGs: small-sided and conditioned games
sRPE: session-rate of perceived exertion
TD: total distances
TLs: training loads
TM: training monotony
TS: training strain
YYIR1/2: yo-yo intermittent recovery test level 1 and 2

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CHAPTER 1

INTRODUCTION

1 THEORETICAL FRAMEWORK

1.1 SOCCER OVERVIEW

The path of soccer in the sports science community has been dictated by a profound characterization, in which it has been demonstrated its intermittent nature (Bangsbo et al., 2006). The natural evolution of this sport has led to increased technical and tactical performance determinants, competitiveness and physically demanding matches, as well as congested fixtures (Aquino et al., 2017; Dellal et al., 2015; Djaoui et al., 2014).

Considering the open system nature of team sports and their unpredictable complex interactions, in soccer, inter- and intra-team tactical behaviors are expected to influence both decision making and the final outcome of a match (Beebe et al., 2012; Gréhaigne et al., 1997). As these interactions of order versus disorder characteristics are part of training and match complexity, it is also expected that players follow a comprehensive and logical pattern of play (Gréhaigne et al., 2011). Furthermore, this open system of interactions is organized into other system dimensions, that englobe: **1) Methodological** (principles of play) and **2) Structural** (formations) sub-systems (Castelo, 2004).

These sub-systems are manipulated by the game model chosen by coaches, and may influence the contraction and expansion of effective play-space (Gréhaigne et al., 2011), as well as the positional centroid dependencies on field (Gonçalves et al., 2014). From this dyadic complex system perspective, it is expected that soccer players have to deal with great unpredictable tactical behaviors that are mainly associated with the moments and principles of play (Sampaio & Maçãs, 2012). Coaches' strategies and game model ideologies may impact different training and match physical demands of players, depending on their positions (Paul et al., 2015). Also, different team structural formations may induce different physical demands on soccer players (Bradley et al., 2011).

1.2 SOCCER PHYSICAL DEMANDS

Regarding training and match activity, soccer teams can cover approximately up to 7.000 m per training session, up to 13.000 m per official match and up to 40.000 m per week of total distances (Bangsbo et al., 2006; Clemente et al., 2019; Malone et al., 2015). Weekly running distances can reach approximately 7.000 m and up to 2.000 m for high-

speed running (HSR) distances, while sprints (>25 km/h) can reach 400 m per training session and match (Oliveira et al., 2019). Also, it is expected high intensity accelerations (metabolic loads) and decelerations (mechanical loads) during soccer training and matches, which are related with greater levels of fatigue (Akenhead et al., 2013; di Prampero et al., 2015; Harper et al., 2019a).

Table 1 present the approximate, but not exact mean values, of the running demands of a soccer match, depending on each playing position, based on the literature (Bradley et al., 2009; Metaxas, 2018; Miñano-Espin et al., 2017; Tierney et al., 2016; Wehbe et al., 2014).

Table 1 Typical mean running demands of a soccer match by position

	ED	CD	MF	W	FW
TD (m)	11000	10000	11000	12000	10000
RUN (m)	2200	1500	2000	2400	1500
HSR (m)	870	490	670	940	680
SPRINT (m)	290	150	190	300	260
MaxSpeed (m.s⁻¹)	9	8	8	9	9
High ACC (n)	30	20	20	40	20
High DEC (n)	60	35	40	60	40

ED: external defender; CD: central defender; MF: midfielder; W: winger; FW: forward; TD: total distance; RUN: running; HSR: high speed running; Max. Speed: maximum speed; ACC: acceleration; DEC: deceleration.

Equally important, are the typical, but not exact, mean physical capacities of soccer players. These typical values can found in published research (Bizati, 2016; Deprez et al., 2015; Kuki et al., 2017; Wik et al., 2018), which are summarized in Table 2.

Table 2 Mean physical capacities of soccer players

	All	GK	ED	CD	MF	W	FW
IMTP (N)	2070	-	-	-	-	-	-
Squat 1RM (Kg)	145	-	-	-	-	-	-
Bench Press 1RM (Kg)	80	-	-	-	-	-	-
CMJ (cm)	42	40	41	45	39	46	41
SJ (cm)	40	42	38	39	40	42	40
10m Sprint (s)	1.8	2	1.5	2	2	1.5	2
30m Sprint (s)	4.5	5	4	5	5	4	4

GK: goalkeeper; ED: external defender; CD: central defender; MF: midfielder; W: winger; FW: forward; IMTP: isometric mid-thigh pull; 1RM: 1 repetition maximum; CMJ: countermovement jump; SJ: squat jump;

The mean physical capacities of soccer players are divided by position for some of the variables, while others are referred as to “all” positions. This is because of the fact that the majority of the research found does not separate those variables by position, and/or other studies only consider “defenders”, “midfielders”, and “forwards” positions, instead of differentiate the variants of some of the field soccer positions.

1.3 PLAYER’S PHYSIOLOGICAL CHARACTERISTICS

Knowing the physiological characteristics of soccer players within a team is of paramount importance, as it can guide coaches and practitioners for training planning

and prescription. Also, comparing a team physiological profile with normative values found in published research may be interesting. For those reasons, the Table 3 resumes the typical, but not exact, physiological characteristics of soccer players (Alexandre et al., 2012; Bangsbo et al., 2007; Nikolaidis, 2015; Tønnessen et al., 2013).

Table 3 Mean physiological characteristics of soccer players

	All	GK	ED	CD	MF	W	FW
HRavg (b/min ⁻¹)	180	-	-	-	-	-	-
BLc (mmol/L)	4	.	.	.	.	.	-
Vo2max. (ml/kg/min)	58	54	59	58	61	58	60
MAS (Km/h)	16	14	16	15	16	17	15

GK: goalkeeper; ED: external defender; CD: central defender; MF: midfielder; W: winger; FW: forward; Vo2máx: maximal oxygen uptake; MAS: maximal aerobic speed; HRavg: average heart rate; BLc: blood lactate concentration

1.4 ANTHROPOMETRIC CHARACTERIZATION

Quantifying and monitoring the anthropometric characteristics of a soccer team is essential to ensure that players maintain their normal body composition measures throughout the season, depending on each player position. The mean typical, but not exact, anthropometric and body composition measures are detailed in Table 4 (Bizati, 2016; Leão et al., 2019).

Table 4 Anthropometric and body composition measures by position

	All	GK	ED	CD	MF	W	FW
Weight (Kg)	76	85	75	77	72	70	76
Height (cm)	179	185	179	182	175	173	181
SKF Body fat (%)	10	14	9	8	12	7	12

GK: goalkeeper; ED: external defender; CD: central defender; MF: midfielder; W: winger; FW: forward; SKF: skinfold

The methods of assessing body composition considered the “gold standard” includes: **1)** Dual-Energy X-Ray Absorptiometry (DEXA), **2)** Air displacement plethysmography and Hydrodensitometry. These methods require expensive equipment that are unpractical for the most sport contexts. However, through simple skinfold measures, it is possible to assess player’s body composition without great costs (Suarez-Arrones et al., 2018).

Skinfolds can be applied up to eight anatomical parts of the human body. Among them are: (i) tricipital; (ii) bicipital; (iii) subscapular; (iv) suprailiac; (v) supraspinal; (vi) abdominal; (vii) crural; and (viii) geminal skinfolds (Darrall-Jones et al., 2015). Furthermore, the thickness of skinfolds seems to be a good predictor of subcutaneous fat (Ackland et al., 2012).

The use of skinfold equations may consider different number of anatomical folds, age, gender, and ethnicity. For those reasons, there are several body fat predictive equations based on skinfolds (Civar et al., 2006; Evans et al., 2005; Reilly et al., 2009; Withers et al., 1987). When considering the use of those predictive equations, coaches should be aware of the context specificity and use the equation that is best suitable for their current sport and prioritize the consistency between assessments throughout the season.

1.5 SMALL SIDED AND CONDITIONED GAMES

The use of small-sided and conditioned games (SSCGs), has gained a lot of interest in the last decade given its great usefulness (Clemente et al., 2012). In fact, this training methodology was conceived to increase the coaches perception of technical and tactical problems and to better adjust and periodize training sessions (Clemente et al., 2014; Lacome et al., 2017). Furthermore, one of the main goals of SSCGs is to reproduce smaller parts of the game aiming to develop the physical, physiological, psychological, and technical and tactical aspects (Sarmiento et al., 2018).

1.6 SSCGS: PHYSIOLOGICAL DEMANDS

The SSCGs are manipulated through the adjustments of game format (number of players), field size, goals, rules modifications, training regimen, and coach encouragement (Sarmiento et al., 2018). Considering this fact, it is expected that different SSCGs manipulations produce different physiological demands. The Figure 1.1 describes the physiological demands of SSCGs with different formats and field sizes (Clemente, 2016).

Format	HRmax%	BLa (mmol/L)	RPE	Format	Field Size	HRmax%	BLa (mmol/L)	RPE
1v1	86.9-89.0	9.4-9.4	-	1v1 to 2v2	Smaller	84.2-88.0	-	-
2v2	80.1-93.3	3.5-8.1	7.6		Medium	87.4-89.0	-	-
3v3	81.4-94.0	3.3-7.5	7.7		Larger	88.1-89.0	-	-
4v4	70.6-91.5	2.6-6.9	7.9	3v3 to 4v4	Smaller	72.0-89.5	2.6-6.0	7.6-8.1
5v5	75.7-92.7	2.5-5.2	13.5 (0-20)		Medium	78.5-90.5	5.5-6.3	7.2-8.4
6v6	82.8-88.0	2.6-5.0	-		Larger	75.7-94.0	6.0-6.5	8.1-8.5
				5v5 to 6v6	Smaller	79.5-93.0	4.5-5.0	5.7-7.3
					Medium	86.4-94.6	5.0-5.0	6.7-7.6
					Larger	80.2-94.6	4.8-5.8	6.7-7.5

Figure 1.1 SSCGs format and field size physiological demands (Adapted from Filipe Manuel Clemente, 2016).

The effects of SSCGs are extensive and range from the effects on technical actions and skills (Clemente & Sarmiento, 2020), tactical behavior and collective dynamics on field (Clemente, Afonso, et al., 2020), physical qualities (Clemente et al., 2021), physiological aspects (internal loads) (Clemente et al., 2014), and on external loads (Clemente et al., 2017). Moreover, the above-mentioned effects of SSCGs are influenced by other training-related dimensions such as rules modifications/task constraints, goals used, training regimens, and coach encouragement (Sarmiento et al., 2018).

1.7 TRAINING LOAD QUANTIFICATION

Training loads (TLs) quantification is an useful tool to control and ensure that the training principles such as progression, overload and individualization are being followed by coaches (Kasper, 2019). Monitoring TLs allow coaches to avoid overreaching and promote supercompensation to occur by alternating “easy days” with “hard days” of training (Foster et al., 2017; Gabbett et al., 2017; Kenttä & Hassmén, 1998).

Training loads can be divided into two main categories: i) **external loads**, and ii) **internal loads** (Impellizzeri et al., 2019). The external loads are associated with physical and mechanical demands imposed on athletes, while internal loads are associated with athlete’s psychobiological responses to the imposed demands on athletes (Bourdon et al., 2017). Quantifying the external loads in soccer practice and competition is only possible by using equipment that gathers objective data, which may not be accessible to many soccer clubs (Kelly et al., 2020). On the other hand, internal loads can be quantified through objective and/or subjective methods (Borresen & Lambert, 2008).

As the physical demands may be dependent of the game model and playing positions (Low et al., 2020), it is of paramount importance that practitioners manage training loads (TLs) accordingly. Moreover, with the purpose of controlling sudden between-week increases or decreases of load, the acute:chronic workload ratio (ACWR) was previously introduced (Maupin et al., 2020). Other workload indices as training monotony (TM) and training strain (TS), derived by session rate of perceived exertion (sRPE) were introduced in training monitoring (Foster, 1998). Also, recent research used a new approach to control within-week training monotony and training strain derived by distance-based variables from microelectromechanical systems (MEMS) (Clemente et al., 2020).

1.8 PERIODIC ASSESSMENT AND MONITORING

1.8.1 PERIODIC ASSESSMENT

It is important to highlight the difference between periodic assessment and monitoring in the first place. While periodic assessment refers to a specific moment, usually 3 times per season (pre, mid and end season), for the assessment of the athletes'

current state with regard to anthropometric measures, body composition, physical qualities, and technical and tactical skills. Monitoring, on the other hand, focuses on gathering daily data regarding external and internal loads, wellbeing perception and readiness to train (Clemente & Silva, 2021).

1.8.2 TESTING DIMENSIONS

For soccer periodic assessments, it is important to first analyze the context that the practitioner is involved. Depending on the team's technical staff and other logistic factors that may be involved, in soccer it is common to deal with time constraints that limits the selection of periodic tests to be conducted (Turner et al., 2011). For those reasons, it is of paramount importance to choose the most transferable testing battery for assessing soccer physical typical demands (Enright et al., 2018).

An interesting testing battery for soccer, considering the time constraints, should be comprised of the following **test dimensions and order of the tests**: (i) anthropometry; (ii) power; (iii) strength; (iv) change-of-direction (COD); (v) linear speed; and (vi) aerobic tests (Turner et al., 2011). Given that, coaches and practitioners have at their disposal, a great variety of tests to choose for each of the aforementioned testing dimensions (Clemente & Silva, 2021). Also, it is fundamental that practitioners left the most metabolic tests to the end of the testing battery so that neuromuscular capacity is preserved for power and strength tests (McGuigan, 2017). Below are detailed the most common testing protocols to be used for each testing dimension.

1.8.3 AEROBIC TESTS

For the aerobic testing dimension in soccer, the most usual and practical testing protocols are the yo-yo intermittent recovery test level 1 and 2 (YYIR1/2) and the 30-15 intermittent fitness test (Grgic et al., 2020; Schmitz et al., 2018). Although the YYIR test (Figure 1.2) is a valid and easy to use test in soccer, the final outcomes are more limited than the 30-15IFT (Figure 1.3), which give coaches greater data which can be used for exercise prescription (Buchheit, 2010). The testing protocols for the YYIR1/2 and for 30-15IFT are listed below.

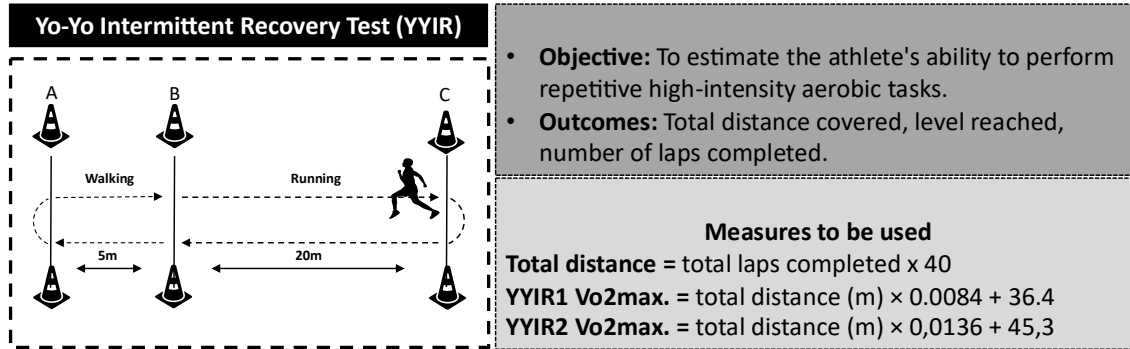


Figure 1.2 Representation of YYIR1/2 protocols.

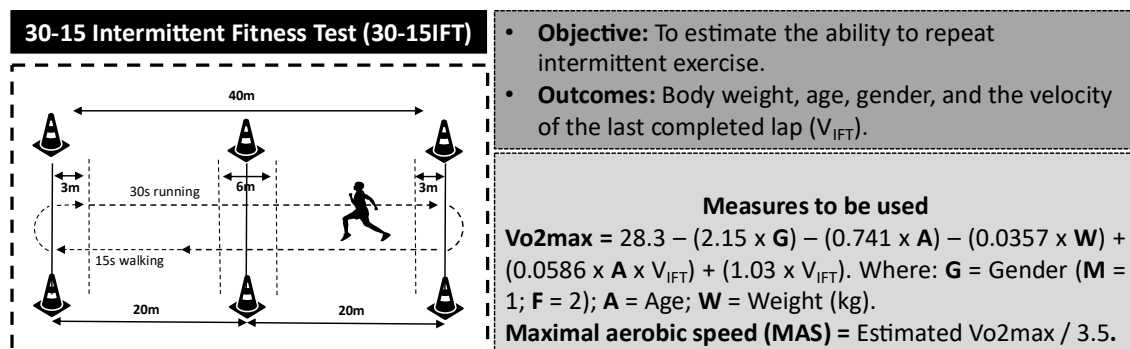


Figure 1.3 Representation of the 30-15IFT protocol.

Despite there is other tests for measuring cardiorespiratory fitness, the aforementioned tests seem to be the most used, valid and reliable tests to be used in soccer (Fanchini et al., 2014; Jeličić et al., 2020).

1.8.4 LINEAR SPEED TESTS

For measuring soccer athlete's acceleration capacity, and the ability to reach maximal speed in a linear fashion, the most practical test is a simple 30-meter linear sprint test, as shown in Figure 1.4. This test is of great usefulness as it can measure the acceleration and sprint profiles of soccer players (Altmann et al., 2019).

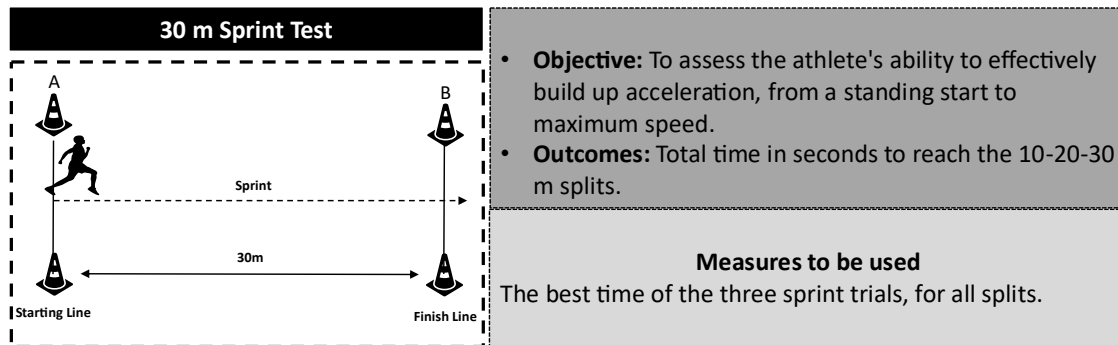


Figure 1.4 Representation of the 30-meter sprint test.

Some researchers may argue that a 30-meter sprint is not enough to measure the true sprint capacity, as some athletes may still be in an acceleration phase at the 30-meter line (Haugen et al., 2019). However, it has to be considered the fact that usually those athletes are from track-and-field context, while soccer athletes usually attain maximal speeds during 30-meter sprints (Brown & Vescovi, 2012; Young et al., 2008).

1.8.5 CHANGE-OF-DIRECTION TESTS

It has been documented an almost unanimous statement that the so-called agility tests are not measuring agility capabilities, but rather COD ability (Young et al., 2016). Although there are a great variety of COD tests, the most promising COD test seems to be the “5-0-5 agility test” (Figure 1.5), as it can assess acceleration, deceleration capacity, as well as the differences between legs (Nimphius et al., 2016, 2018).

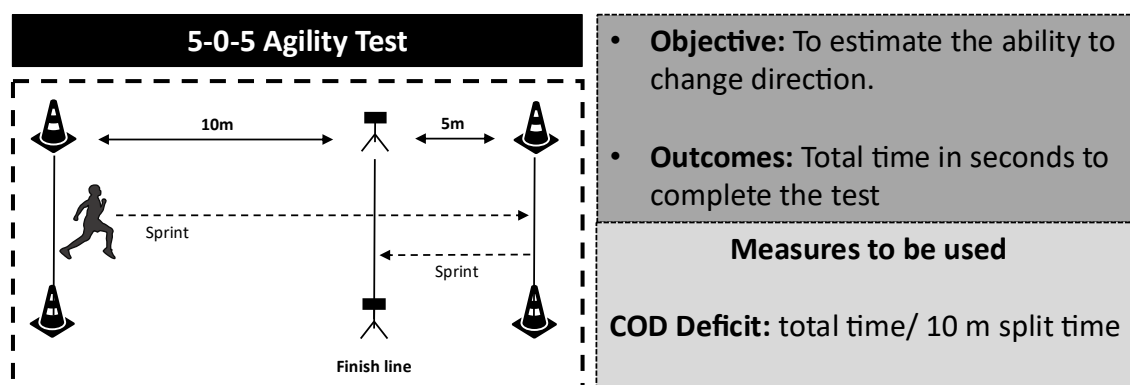


Figure 1.5 Representation of the 5-0-5 agility test.

This test also allows for a convenient way to assess movement patterns when changing direction, to detect possible disfunctions that must be addressed from an injury

prevention perspective (Nimphius et al., 2018). For the purpose of distinguishing COD ability from linear speed ability, the COD deficit is calculated as the difference between the first 10-m sprint split time during the 5-0-5 agility test (Nimphius et al., 2013).

1.8.6 POWER TESTS

The most common power tests to be used in team sports are those of jump-based measures (McGuigan, 2017). From those tests, the most used in soccer are vertical jumps, consisting of: (i) squat jump; (ii) countermovement jump; and (iii) drop jump. Furthermore, the use of horizontal jumps is valuable if used in a return-to-play setting, but are not an urgent test to be part of a soccer testing battery given the time-constraints previously mentioned (Turner et al., 2011). The commonly used vertical jump tests are listed below in Figures 1.6, 1.7 and 1.8.

Squat Jump (SJ)	• Objective: To estimate the vertical power of the lower limbs • Outcomes: Jump height (cm); Relative Strength; and Peak Power Output
	Measures to be used Jump Height = $9,81 * (\text{Flight Time})^2 / 8$ Relative Strength = Peak Force (N) / Body Mass (Kg) Peak Power Output = $60,7 \times \text{jump height (cm)} + 45,3 \times \text{body mass (kg)} - 2,055$.

Figure 1.6 Representation of Squat Jump test.

Countermovement Jump (CMJ)	• Objective: To estimate the vertical power of the lower limbs • Outcomes: Jump height (cm); Relative Strength; and Peak Power Output
	Measures to be used Jump Height = $9,81 * (\text{Flight Time})^2 / 8$ Relative Strength = Peak Force (N) / Body Mass (Kg) Peak Power Output = $60,7 \times \text{jump height (cm)} + 45,3 \times \text{body mass (kg)} - 2,055$.

Figure 1.7 Representation of Countermovement Jump test.

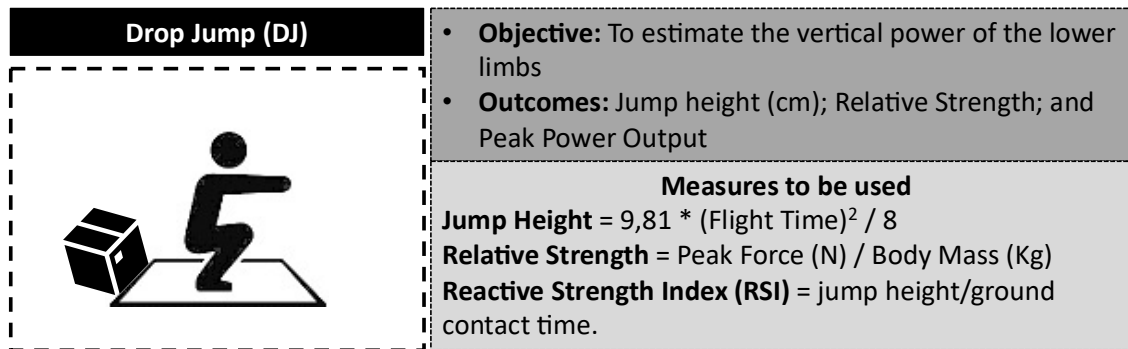


Figure 1.8 Representation of Drop Jump test.

The use of these jump tests are also suitable to analyze the contribution of the stretch-shortening cycle (SSC), through the use of eccentric utilization ratio (EUR) which is calculated as follows: EUR = countermovement jump height / squat jump height (McGuigan, 2017). By these means, coaches and practitioners can individualize and adjust training considering each player needs. The above-mentioned jump tests should be assessed using force platforms, which is the gold standard device to analyze both jump performance and strength capacity (Silveira et al., 2017). However, this type of device is not reachable for all soccer teams. Given that, the use of contact mats, infrared systems or even smartphone Apps, are valid and reliable methods of quantifying jump data (Buckthorpe et al., 2012; Glatthorn et al., 2011b; Stanton et al., 2017)

1.8.7 STRENGTH TESTS

Maintaining good levels of lower-body strength have an important role on athletes injury prevention, and is highly associated with better sprint and jump performance (Comfort et al., 2014). Given that, assessing the current status of athletes maximal strength capacity is of paramount importance (Wisløff et al., 2004). Also of great interest, is the assessment of upper-body strength as it can protect athletes against heavy body contacts (Silva et al., 2015). The use of dynamic movement exercises such as the back squat and dead lift are common forms to assess maximal strength through one-repetition maximum (1RM) direct and until technical failure methods (Jovanovic, 2019). Figures 1.9 and 1.10 show some examples of strength tests that can be used in soccer.

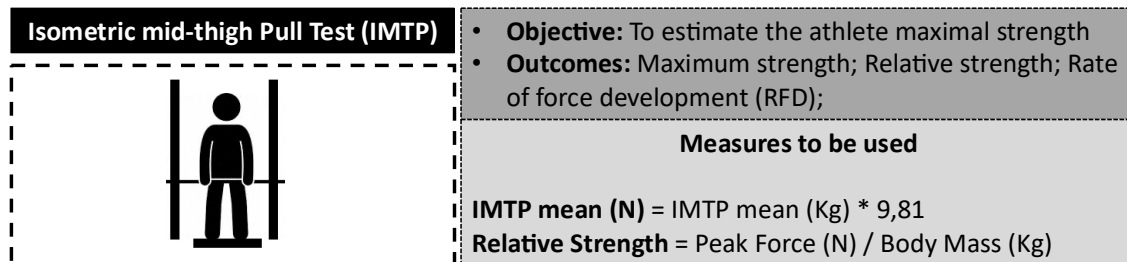


Figure 1.9 Representation of the IMTP test

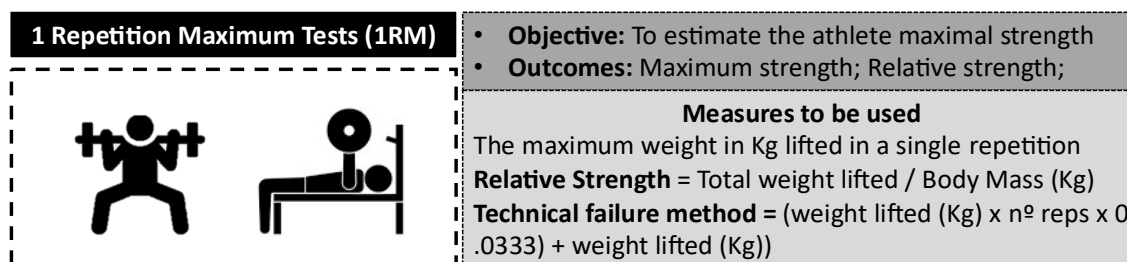


Figure 1.10 Representation of 1RM tests

As some athletes may lack the skills to produce efficient movements in this type of exercise, increasing the risks of such methods, other isometric-based tests such as the isometric mid-thigh pull (IMTP), are safer and less fatiguing methods for assessing maximal strength (Drake et al., 2017). In fact, the IMTP testing protocols has proved to be valid and reliable using both gold standard methods (force platforms) and other cheapest methods such as the use of crane scales (Urquhart et al., 2018). Furthermore, the IMTP is significantly related with athletes strength, agility, and sprint capabilities, revealing its usefulness, especially during the in-season period (Brady et al., 2020; Wang et al., 2016).

1.9 MONITORING

Monitoring focuses on the quantitative and qualitative measurement of daily training loads, both in terms of internal and external loads, well-being and readiness to train (Gabbett et al., 2017). Continuous control is part of the daily routine of the sports scientist from the perspective of highlighting the type of inter and intra individual response to the training loads imposed in order to facilitate decision making so that adjustments in training are as accurate as possible. The analysis of how athletes are responding to the imposed

training loads, using both objective and subjective data, allows for a sensitive and clear discussion when planning around training planning (Akenhead & Nassis, 2016).

1.9.1 THE ATHLETE MONITORING CYCLE

The athlete monitoring cycle is a process which consider the principle of individuality the athletes that allows for training adjustments in real-time (Gabbett et al., 2014, 2017). This process creates interesting relationships between internal loads, external loads, wellness and readiness to train (athlete monitoring cycle) to facilitate training adjustment decision-making (Gabbett et al., 2017). The Figure 1.11 illustrate those relationships.

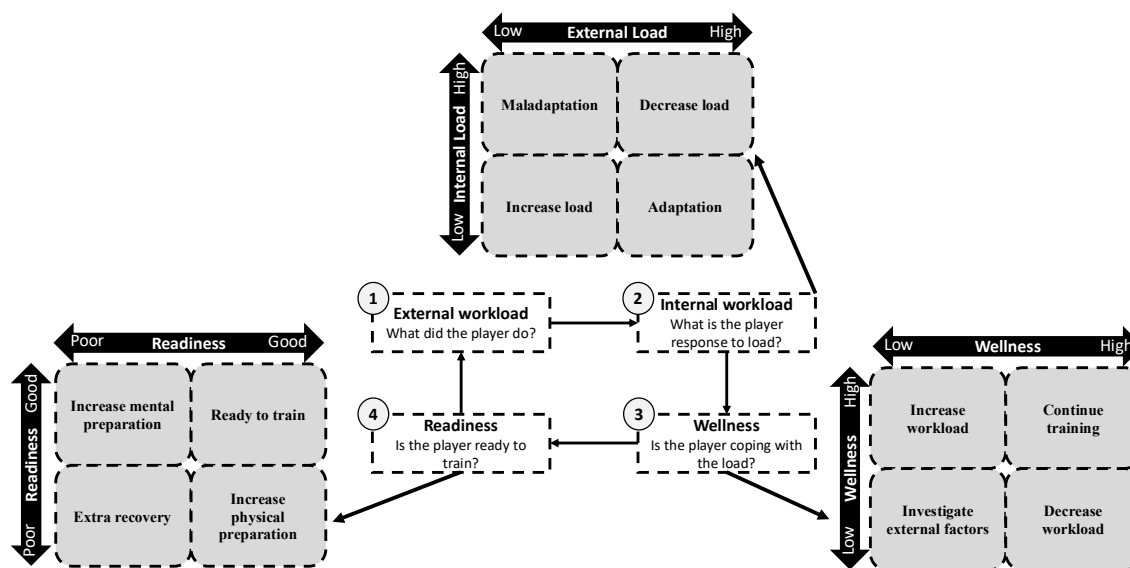


Figure 1.11 Athlete monitoring cycles relationships.

The daily monitoring of these four factors allows coaches to better track the athlete's workload responses imposed during training and competition (Gabbett et al., 2017).

1.9.2 INTERNAL LOAD

Internal loads can be monitored via objective and/or subjective methods (Foster et al., 2017). The objective measures are monitored by the athlete's heart rate, blood lactate levels, and sRPE (Pind & Mäestu, 2018). However, due to the ease of use and the validity of sRPE in relation to other objective internal load measures, sRPE is the most commonly used method of quantifying internal loads (Haddad et al., 2017). This method is calculated by multiplying the duration of the training session or match by the RPE scale and it is

expressed as arbitrary units (A.U.), which is related with the magnitude of the acute loads (ALs) imposed on athletes (Foster et al., 2001).

Also, monitoring between-week load variations to control the progression and overload principles of training, it is possible by using the ACWR (Blanch & Gabbett, 2016). The ACWR is calculated by dividing ALs (related to the last 7 days of training) by chronic loads (related to the last 28 days of training), and this ratio provides an insight of whether the chronic loads are sufficient for sustain the ALs imposed (Hulin, Gabbett, Lawson, et al., 2016). Moreover, there are two main formulas to calculate ACWR: i) rolling averages (RA) (7-day [acute] divided by 28-day [chronic] RA) and ii) exponentially weighted moving averages (EWMA) (7-day [acute] divided by 28-day [chronic] EWMA), with the EWMA method being more sensitive to control workloads (Murray et al., 2017).

In addition, other indices of workload monitoring such as TM (related to the variability of weekly loads) which is the division of daily mean load by the weekly load standard deviation, and TS (related to the weekly stress imposed) is the product of weekly training load and monotony, were introduced (Foster, 1998). These indices allow to control the exposure of within-week TLs and detect low variability of TLs, which has been associated with lower levels of performance, and an higher risk of overtraining and injury (Clemente et al., 2019; Comyns & Flanagan, 2013; Delecroix et al., 2019; Lu et al., 2017).

Although these indices are commonly derived from sRPE, a recent study conducted on 19 elite soccer players, used a novel approach for the assessment of TM and TS from external loads (distance-based metrics), in which it was found moderate effect size differences of TM and TS for the overall measures between the pre-season and the first and second halves of in-season (Clemente, et al., 2020). Thus, this kind of approach may give new insights about the variation profiling of distance-based measures.

1.9.3 EXTERNAL LOAD

In team sports such as soccer, the external loads are usually quantified by Global Positioning Systems (GPS), mainly for distance-based variables and by inertial sensor units (IMU) and accelerometers, for accelerometry-based variables (Cummins et al., 2013; Malone et al., 2017).

Although different speed ratings have been used by sport scientists (Cummins et al., 2013; Maupin et al., 2020; Rossi et al., 2018), the most commonly used distance-based metrics in soccer are: i) total distance (TD: total distances covered; ii) high speed running (HSR: distances covered $>19.8 \text{ km/h}^{-1}$); iii) sprint distances (SD: distances covered $>25.2 \text{ km/h}^{-1}$); and iv) maximal speed ($\text{Max}_{\text{speed}}$: maximal speed reached during running) (Buchheit & Simpson, 2017). On the other hand, for accelerometry-based metrics, the most commonly used metrics are i) accelerations and decelerations ($> 3\text{m.s}$); ii) player load; iii) impacts; iv) dynamic stress load; and v) metabolic power outputs (Buchheit et al., 2015; Osgnach et al., 2010; Reche-Soto et al., 2019).

1.9.4 WELLNESS

Wellness monitoring is based on subjective perception scales, and can also be applied through online questionnaires from the athletes' smartphone. The wellness questionnaire most referenced in the literature is the one originally proposed in 1995 (Hooper & Mackinnon, 1995). However, the most used questionnaire in the context of team sports, is an updated version that has the advantage of being easily perceived by all athletes (McLean et al., 2010).

Every day before training session, each athlete must fill the questionnaire comprised of 5-item short answer referring to: (i) muscle soreness; (ii) fatigue; (iii) sleep quality; (iv) stress; and (v) mood. The final result of the questionnaire is the sum of all 5-item answers. A value close to 25 determines high levels of well-being, and a value close to 5 determines low levels of well-being. Below, the Figure 1.12. illustrates a hypothetical athlete response and its final result.

	5	4	3	2	1
Muscle Soreness	Feeling great	Feeling good	Normal	Soreness increase	Very sore
Fatigue	Very fresh	Fresh	Normal	More tired than normal	Always tired
Sleep Quality	Very restful	Good	Difficulty falling asleep	Restless sleep	Insomnia
Stress	Very relaxed	Relaxed	Normal	Stressed	Very stressed
Mood	Very positive mood	Good mood	Less interested than normal	Snappiness at teammates, family and co-workers	Highly annoyed/ irritable/ down

 **Response Sum = 1+2+4+3+5 = 15**

Figure 1.12 Representation of the wellness questionnaire index

Although studies have demonstrated relationships between well-being questionnaires and training loads, there is still some controversies regarding the potential of these relationships due to methodological issues (Duignan et al., 2020). However, the above-mentioned systematic review confirmed that when the training loads are high, athletes report worse values of well-being. Therefore, these facts must be considered when using this monitoring tool. This allows practitioners to communicate with both medical and technical staff departments to sensitize them for adjusting training, considering the current athletes state (Gabbett, 2019, 2020).

1.9.5 READINESS

The most common method to assess athletes readiness to train in soccer is the use of vertical jump tests, especially the protocols using CMJ tests (Lombard et al., 2020; Watkins et al., 2017). Although there are other valid and reliable methods such as the use of the cycle ergometer (watt bike) test (Herbert et al., 2015) and the warm-up submaximal test (Rabbani et al., 2018). An important factor to be considered when using this type of tests, is to ensure that the test is capable of detecting even the smallest change in athletes performance (Beattie & Flanagan, 2015). The Figure 1.13 illustrates the most practical readiness assessments, considering the logistics and time-constraints factors.

Vertical Jumps	Cycle Ergometer Test	Warm-up Submaximal Test
Equipment ☐ Force platforms(gold standard) ☐ Contact mats ☐ Linear position transducers ☐ Inertial measurement units ☐ Smartphone Apps	Equipment ☐ Watt bike	Equipment ☐ Cardiofrequencimeters with registration in 1 in 1 second ☐ Metronome
Protocol ☐ Countermovement jump (CMJ) ☐ Squat jump(SJ) ☐ Drop Jump from 30cm box or higher (DJ)	Protocol ☐ Ensure familiarization with the test to avoid learning effects. ☐ Perform a 2-minute warm-up with an air and magnetic resistance at level 1, at a free cadence. ☐ Perform 2 maximum attempts for 6 seconds with the air resistance at level 10 and the magnetic resistance at level 4 ☐ Ensure 1min. of active rest between attempts, at a free cadence and with the air and magnetic resistances at level 1.	Protocol ☐ Athletes must run 100 m and return to a football field for 4 minutes at 12 km / h. ☐ After the 4 minutes of running, the athletes should remain standing and without moving for 1 minute, to collect the recovering heart rate.
Measures ☐ Jump height (cm) ☐ Mean/maximal power (Watts) ☐ Mean/maximal velocity (m/s)	Measures ☐ Maximal power(Watts) ☐ Mean power during the 6 seconds (Watts)	Measures ☐ Average heart rate (from the last 30 seconds of the test) ☐ Heart rate in recovery (for 1 minute after the end of the test) considering: 1) the decrease in the number of heart beats and 2) the average heart rate during the 1-minute recovery
Ratios ☐ DJ reactive strength index (RSI): $RSI = \frac{\text{Altura do salto (cm)}}{\text{Tempo de contacto (s)}}$ ☐ Eccentric utilization ratio (EUR): $EUR = \frac{\text{Altura do CMJ}}{\text{Altura do SJ}}$	Measures	
Take-home message ☐ Force platforms are more sensitive to detect performance changes. ☐ Other accessible equipment are also valid and reliable to detect neuromuscular fatigue. ☐ Jump maximal velocity seem to be more sensible to fatigue than jump power. ☐ Assess neuromuscular fatigue 48-72h after match.	Take-home message ☐ This test is quick to perform individually, but it may not be practical because it requires several watt bikes. ☐ A minimum difference of 5-7% between assessments can be considered significant. ☐ Decreases in maximum power beyond the minimum difference observed may indicate neuromuscular fatigue.	Take-home message ☐ This test is quick to perform (5 minutes) and allows to assess the whole team at once, taking advantage of the warm-up time. ☐ Ideally, this test must be performed once a week and compare data between assessments. ☐ The athlete's state of readiness can be reflected in variations between 5 to 8 beats per minute (Bpm).

Figure 1.13 Athlete's readiness assessment possibilities

Analyzing neuromuscular status after the imposed training loads on athletes, and consequently, the readiness to train are important aspects of training monitoring (Gabbett, 2016). In fact, a soccer training microcycle ending the week with an official match implies acute and residual fatigue levels that may persist up to 72h after the match (Silva et al., 2018). Given that it is essential to analyze possible variations in the athletes' current state, being privileged the individual comparison between assessments (Clemente & Silva, 2021).

1.10 ASSOCIATIONS BETWEEN WORKLOAD INDICES AND FITNESS LEVELS WITH INJURY

1.10.1 TRAINING LOAD MEDIATORS

The training load mediators are related with the monitoring of the workload indices. The workload indices used in soccer are: (i) acute loads; (ii) chronic loads; (iii) acute:chronic workload ratio; (iii) training monotony; and (iv) training strain (Windt et al.,

2017). It has been reported that sudden increases or decreases of weekly ALs above 10% may increase the risk of injury occurrence (Gabbett, 2016). However, it has been documented that higher chronic workloads allow greater injury protection when spikes in ALs occur (Hulin et al., 2016). Indeed, it was reported that moderate workloads between 0.9 and 1.3 A.U. of ACWR have a protective effect on the athlete (Malone et al., 2019).

Indeed, if chronic loads are equal or slightly above ALs, it will result in ACWR between 0.8 and 1.3 A.U. which are related with lower risk of injury (Maupin et al., 2020). On the other hand, an ACWR above 1.5 A.U. is related to up to five times greater risk of injury occurrence, and values lower than 0.8 A.U. are equally related with higher injury risk and undertraining (Gabbett, 2016; Hulin et al., 2016). In fact, ACWR values between 1.00 and 1.25 seem to be preventive in relation to the risk of injury in soccer, in which higher risk of injury was found during the pre-season than in the in-season, that may be due to higher workloads imposed at the beginning of the season (Malone et al., 2017; Windt et al., 2017).

However, if high chronic loads are combined with very high ACWR of more than approximately 1.5 A.U., the athletes are less injury protected (Gabbett et al., 2017). For those reasons, aiming to control athlete's weekly workload variations to prevent overreaching due to uncontrolled fatigue levels, ACWR values allows coaches and practitioners to understand the within and between week profiles of soccer teams (Halsen, 2014). Also, due to congested fixtures that are characteristic of the present elite soccer competitions, it is of paramount importance to monitor these workload indices for a better planning and management of loads imposed on soccer players. (Arruda et al., 2015; Rey et al., 2010).

Regarding the association between TM and TS with injury risk, it has been demonstrated that weekly monotonous TLs with low variation (high TM values) lead to increases in weekly training stress (high TS values) (Foster, 1998). However, increases in TS values seem to be more related to injury occurrence than increases in TM values (Delecroix et al., 2019), as it has been reported that the lower threshold that favors illness is ~6000 A.U. (Foster, 1998). In fact, increases in TM indices seem to be injury protective (Delecroix et al., 2019), however, TM values above ~2.0 A.U. have been associated with

higher risk of injury occurrence (Clemente et al., 2019; Fessi et al., 2016; Foster, 1998). The simplified schematic representation of training load mediators is illustrated bellow in Figure 1.14.

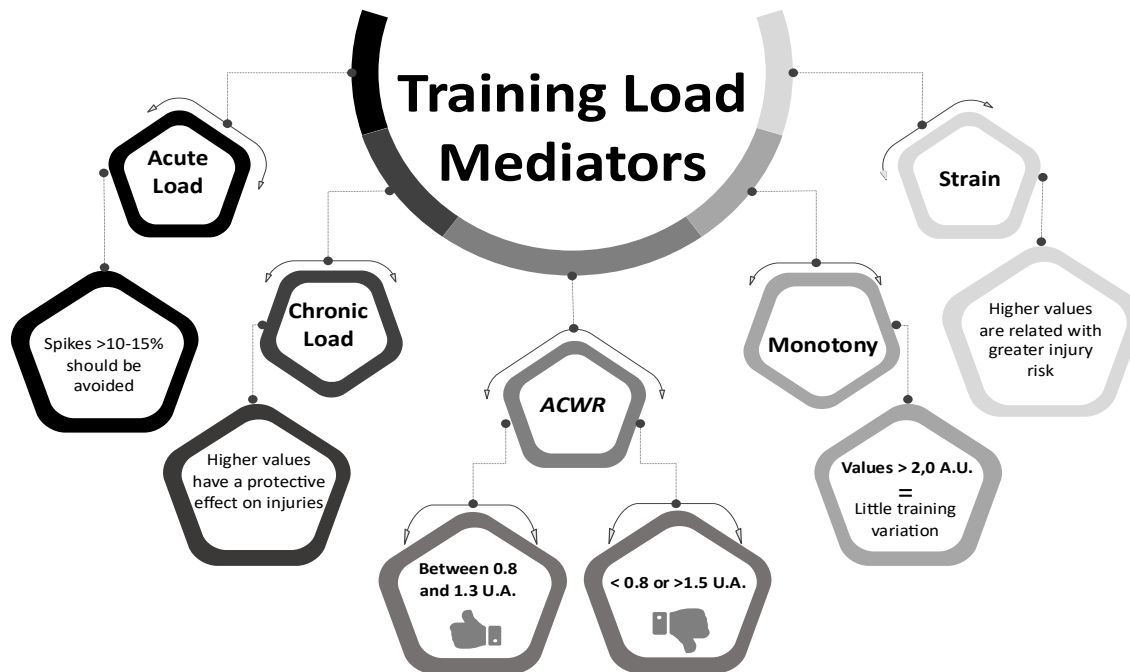


Figure 1.14 Representation of training load mediators

However, attention should be given to positional dependencies in relation to “fitness” and “fatigue”, as well as TM and TS profiling, as some players may present different values of ACWR, TM and TS values according to their positional related tasks, as well as considering match starters and non-starters (Clemente et al., 2020; Martín-García et al., 2018; Stevens et al., 2017). The knowledge about possible physical moderators and the need for their development, are imperative when analyzing weekly TLs based on different indices to decrease the risk of injury and enhance performance (Malone et al., 2019). For those reasons, knowing “what”, “how” and “when” to analyze in respect of TLs management are of paramount importance for soccer coaches and practitioners.

1.10.2 TRAINING LOAD MODERATORS

As sudden increases in ALs can happen within and between weeks of training, it is imperative that players hold good moderators and mediators determinants which allow

them to cope with “spikes” in load, preventing them from injury occurrence (Malone et al., 2017; Windt et al., 2017).

While the mediators are related with the management of workload indices, the moderators are related with the management of physical fitness determinants (Malone et al., 2019; Windt et al., 2017). In relation to moderators, maintaining good levels of aerobic capacity as well as the years of playing experience can protect players against sudden increases of ACWR values (e.g., higher ALs being imposed in relation to chronic loads) (Malone et al., 2017).

Also, developing lower body strength, repeated sprint ability, HSR and sprinting seem to protect athletes from sudden increases or “spikes” in ALs (Malone et al., 2018, 2019). In Figure 1.15 it is illustrated the representation of the most common training load moderators.

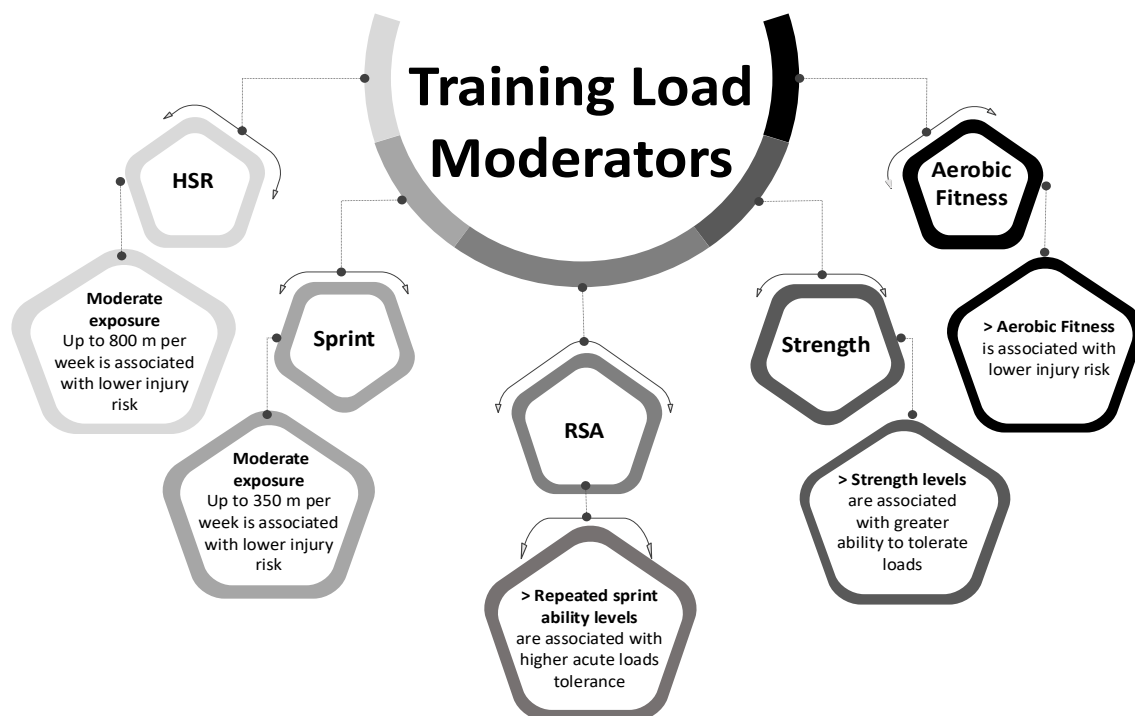


Figure 1.15 Representation of training load moderators

Moreover, it must be considered the congested fixture periods, typical of elite soccer competitions. In this cases, athletes are expected to deal with greater stress and muscle fatigue that can also impact negatively muscle stiffness and the levels of strength (mainly

on the lower limbs) that can lead to augmented injury risk (Lundberg & Weckström, 2017; Rojas-Valverde et al., 2019; Wollin et al., 2018). In fact, the cumulative fatigue is mainly caused by lower periods of recovery which is associated with higher risk of injury occurrence (Carling et al., 2015; Howle et al., 2020).

Also, greater risk of hamstring injuries are associated with temporary fatigue levels that cause decrements on high intensity efforts, mainly due to the high exposure of sprinting distances (Anderson et al., 2016; Mohr et al., 2005; Small et al., 2009), and high metabolic and mechanical loads in congested calendars (Akenhead et al., 2013).

While it has been demonstrated that distance-based measures are not dependent on congested periods (usually with 2 or 3 matches in one week) and can be more dependent from tactical choices (Buchheit & Simpson, 2017; Carling et al., 2012), the accelerometry-based variables can impact the fatigue levels due to the high metabolic demands of high accelerations and mechanical demands of high decelerations, which may increase the risk of injury, and are more independent from tactical tasks (Bowen et al., 2017; Buchheit & Simpson, 2017; Dalen et al., 2016; Osgnach et al., 2010).

Given that, maintaining greater physical fitness moderators (Malone et al., 2019) and balanced workload indices mediators (Windt et al., 2017) are of paramount importance to ensure that coaches follow the overload principle of training without worry too much about increasing loads (Gabbett, 2019). This way, coaches allow their athletes to be more tolerant to increased loads, lowering injury occurrence and enhancing performance.

1.11 INJURY OCCURENCE

1.11.1 MOST COMMON SOCCER INJURIES

A recent systematic review that analyzed the epidemiological data of the most common injuries in professional soccer athletes, revealed that the most common injuries were on muscles and tendons structures, mainly on the lower-body (López-Valenciano et al., 2020). However, it seems that minor injuries are the most usual.

Also, the same authors observed that soccer matches produce 10 times higher injury incidence rates than soccer training sessions (López-Valenciano et al., 2020). A common sense is that during the second half of a soccer match, the risk of injury occurrence is greater than during the first half, which is commonly attributed to higher fatigue levels, an hydration status of players (Ekstrand et al., 2011; Harper et al., 2019b; Hills et al., 2018).

Moreover, a 16-year follow-up study with the aim to describe the duration of absence after the most common injuries in professional soccer, revealed that there are up to 30 common injuries (Ekstrand et al., 2020). In that study, a very comprehensive explanation regarding the return-to-play (RTP) timings for each type of injury severity was made. The Figure 1.16 illustrates a simple schematic representation of injury severity and their correspondent absence timings, based on the aforementioned study (Ekstrand et al., 2020).

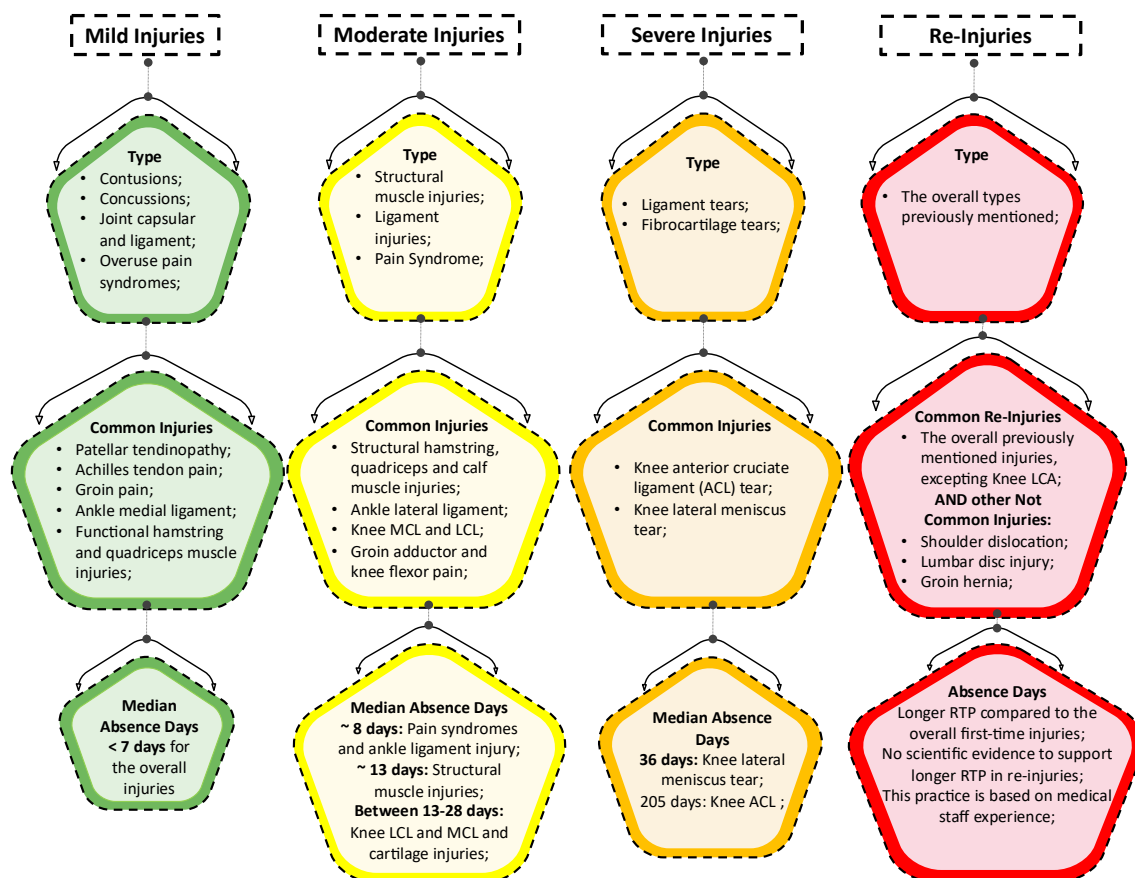


Figure 1.16 Representation of the most common injuries and severity and RTP duration.

Although severe injuries seem to be infrequent during a soccer season, this type of injury causes a training and competition absence of more than 28 days. Furthermore, the most common moderate injuries are responsible for ~60% of the absence caused by the overall injuries in soccer (Ekstrand et al., 2020). For those reasons, coaches and practitioners must understand their sport context and its related most common injuries, for ensuring a better training program that includes injury prevention sessions and strategies to minimize the risk of injury (Lahti et al., 2020; López-Valenciano et al., 2020).

1.11.2 RISK FACTORS

There are some injury risk factors that must be addressed when dealing with high performance athletes. The injury risk factors are divided into **intrinsic** and **extrinsic**, modifiable and non-modifiable factors (Bahr & Krosshaug, 2005; McCall et al., 2015). The Figure 1.17 depicts a schematic representation of the above-mentioned injury risk factors.

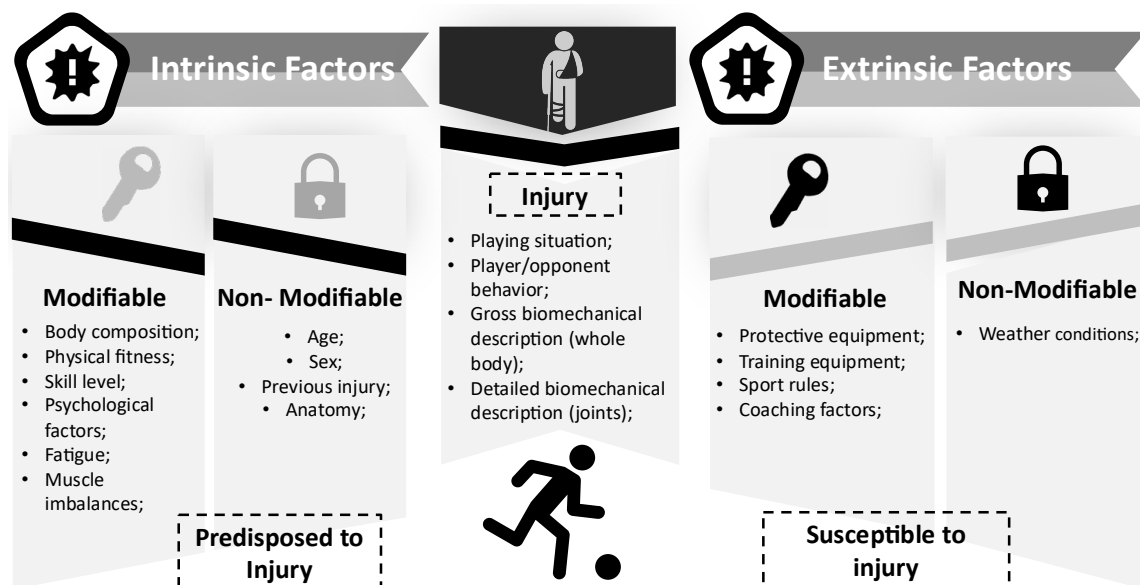


Figure 1.17 Representation of injury risk factors.

This must be considered by the medical, high-performance, nutrition, and psychology departments to sensitize both technical team and the athletes. Ensuring a communication bridge between all these departments and the athletes regarding the different dimensions of risk factors, is of paramount importance to create a team culture that may minimize the injury occurrence (Gabbett, 2019; Nédélec et al., 2012).

1.12 RETURN-TO-PLAY PROCESS

After an injury in high-performance sports, athletes' recovery becomes the responsibility of many stakeholders which includes the medical, high-performance, nutrition, and psychological departments, as well as the athlete itself (Owoeye et al., 2020). Ensuring a great communication bridge between all stakeholders becomes an obligation in the case of new injuries, especially for those with moderate-to-severe injuries.

A common mistake in the RTP process is the progression through a time-line instead of a criteria-driven process (Joyce & Lewindon, 2016). In fact, knowing when to progress in rehabilitation/training with an injured athlete, is based on the qualitative and quantitative assessment of the athlete current state, and not based on the time that has passed since the injury occurred (Gabbett et al., 2021). Also, a common training error that might occur during a rehabilitation process is the overfocus on local tissue capacity restoration.

This results in a greater local tissue healing. However, the lack of sport-specific focus during this process results in lower capacity to perform the demands of the athlete sport (Gabbett et al., 2021). Below in the Figure 1.18, is represented an example of a balanced strategy between local tissue and sport-specific capacity for the injured player.

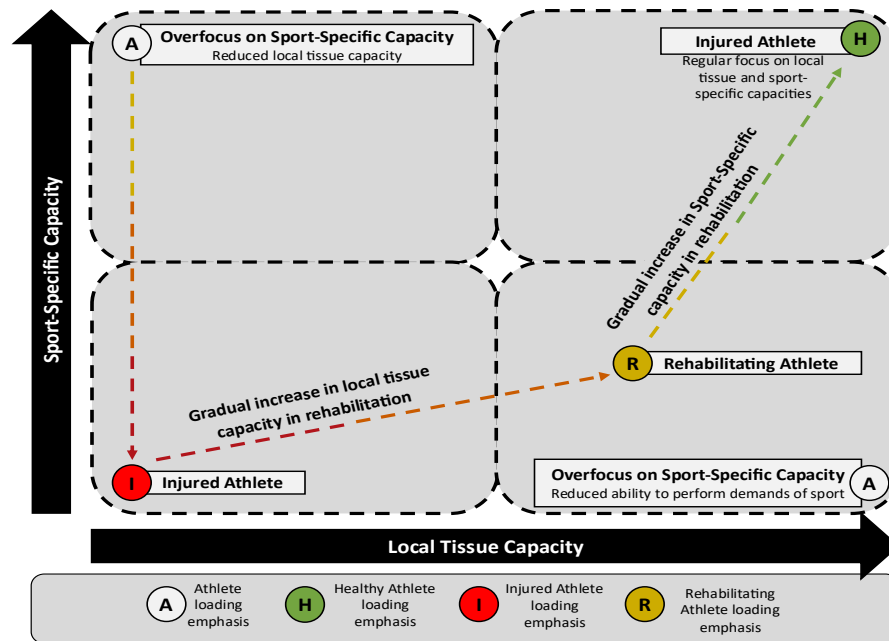


Figure 1.18 Local tissue and sport-specific capacity for the injured player (Adapted from T. Gabbett et al., 2021).

Although this balanced training strategy is a very comprehensive guideline of load progression for the injured player, the RTP process must follow a model to assist all stakeholders among a soccer team (Musahl et al., 2018). By these means, a greater transparency and communication between all departments ensure a better decision-making (Ardern et al., 2016).

1.12.1 RTP: GUIDE MODELS

To assist all the involving RTP stakeholders in the understanding the RTP process among a soccer team, there are few models that highlight diverse factors influencing RTP outcomes and decision-making. Firstly, a definition of the three elements of RTP continuum must be addressed (Ardern et al., 2016). The Figure 1.19 describes those three elements.

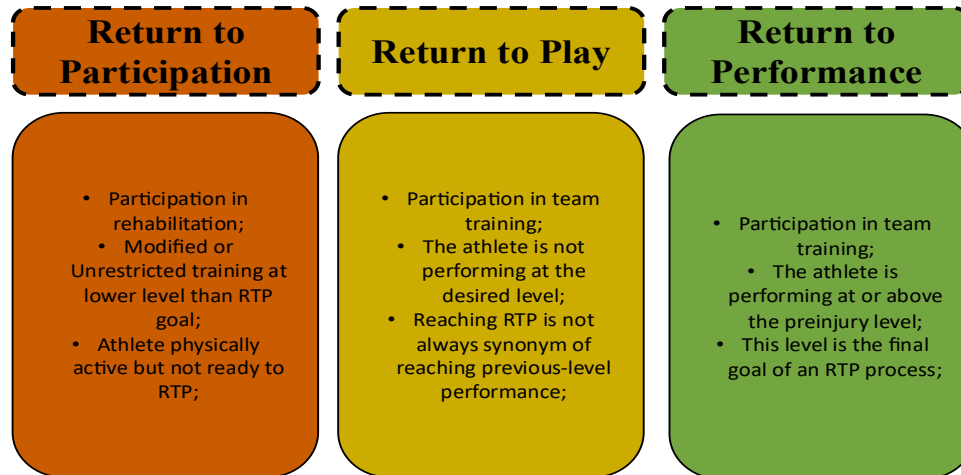


Figure 1.19 The three elements of the RTP continuum.

The definition of those three elements must be clarify among all involving departments of a soccer team. Thus, all departments must acknowledge the fact that despite an athlete might be already in the “return to play” element, it does not mean that the athlete is no more of their responsibility (Arder et al., 2016; Joyce & Lewindon, 2016).

1.12.2 STRATEGIC ASSESSMENT OF RISK AND RISK TOLERANCE

The strategic assessment of risk and risk tolerance (StARRT) framework is a model based on three main steps that can assist the stakeholders to identify the risks associated with a RTP process (Shrier, 2015). Below in Figure 1.20, it can be seen the representation of these three risk steps.

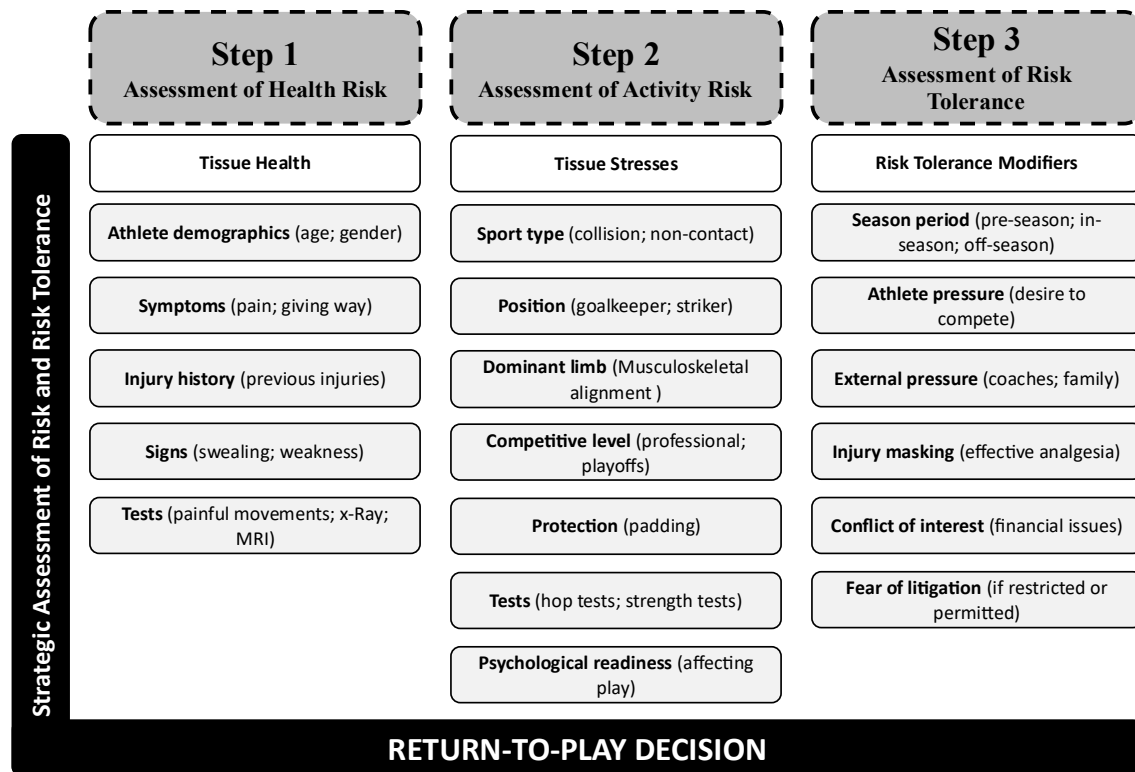


Figure 1.20 The StARRT framework (Adapted from Shrier, 2015).

According to this framework, if the risk assessment of steps 1 and 2 is below the risk tolerance threshold of step 3, the athlete is allowed to RTP. However, if the risk assessment of the first two steps is above the risk tolerance of step 3, the athlete is not allowed to RTP (Shrier, 2015).

1.12.3 OTHER MODELS

There are other models to be used such as the biopsychosocial model which considers the physical, psychological and sociological/contextual factors that may influence the RTP process (Ardern et al., 2016). Also, the athlete training load monitoring cycle previously described, is another interesting model to be used for the RTP process (Ardern et al., 2016; Gabbett, 2016; Gabbett et al., 2021). Moreover, using the athlete perceived injury psychological readiness to return to sport (IPRRS) questionnaire may assist the decision-making in the final stages of RTP (Glazer, 2009).

1.12.4 RTP: INJURED ATHLETE RECONDITIONING

There are some misconceptions regarding the right timing for an injured athlete to start the reconditioning process. It is a common practice to start the athlete reconditioning later in the rehabilitation process, as a consequence of medical departments insecurity, which lead to an excessively protection of the athletes (Joyce & Lewindon, 2016; Kraemer et al., 2009). This may limit the athletic health of the athlete, causing dysfunctional movement patterns that may last too long as a consequence of a great neuromuscular control loss even in healthy body parts (Boyle, 2016; Cook et al., 2014).

The overall medical departments vision regarding the RTP is based on injury-focus instead on athlete-focus (Knowles, 2016). The Figure 1.21 represents this injury versus athlete RTP focus.

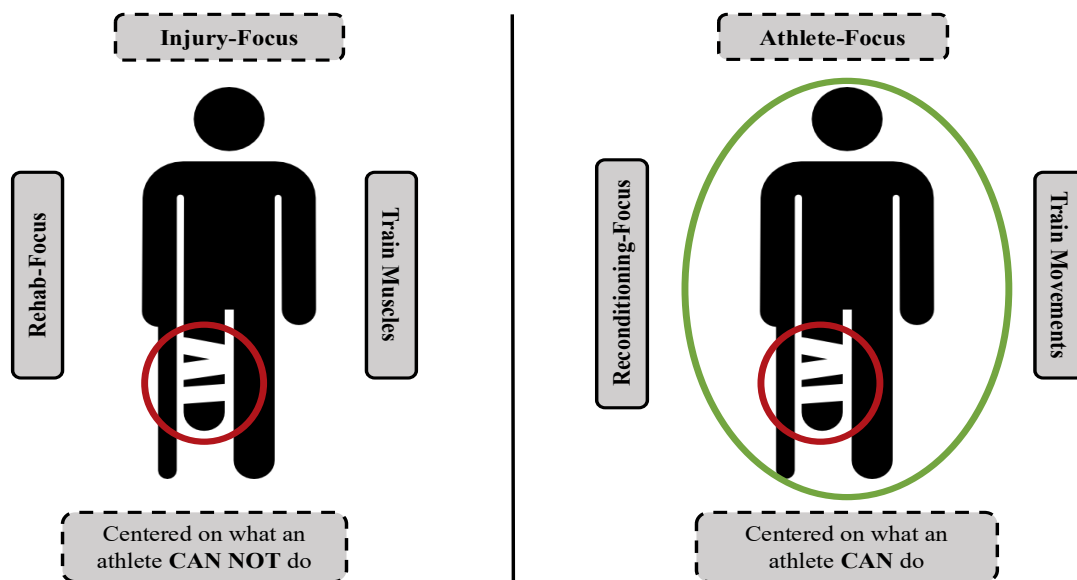


Figure 1.21 Injury versus athlete-focus concept.

The premise behind this concept is to train around the injury and avoid excessive athlete protection which limits athletic development and promotes deconditioning (Gambetta, 2007). Training around the injury can be started early, which allows athletes to enhance movement patterns. The above-mentioned author (Knowles, 2016), proposed a comprehensive athlete-based RTP model as seen in Figure 1.22.

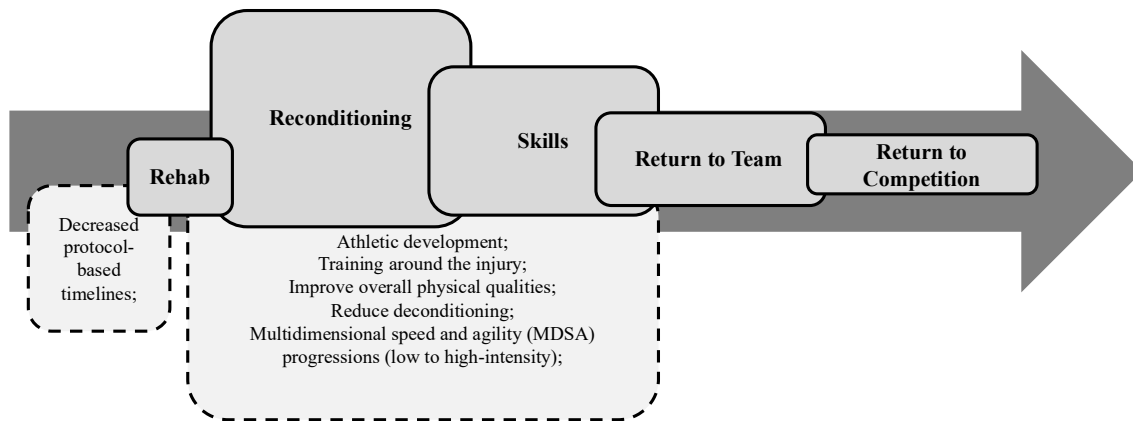


Figure 1.22 Athlete-based RTP model (Adapted from Knowles, 2016).

In this proposed model the reconditioning phase can start early, even in the rehab phase. The MDSA can also be implemented through low-intensity activities such as static running movement patterns. The intention is to progress through more complex dynamic high-intensity movements, which requires the strength levels conquered during the initial phases of this performance model (Knowles, 2016). After a successful “preparation” phase, the athletes can start the return to team training and then to competition, always maintaining the training regimen until the end of the season (Gambetta, 2007; Knowles, 2016).

1.12.5 RTP: CROSS-EDUCATION

An interesting training concept regarding the reconditioning phase of an RTP model is the cross-education phenomenon. This concept is based on the findings that strength training the unaffected limb produce strength gains in the contralateral affected limb (Farthing et al., 2009). The mechanisms of the positive effects of this phenomenon and the contextual factors behind it remains unclear (Hendy & Lamon, 2017). However, it has been well-documented the positive effects that unilateral strength training on the healthy limb has on its correspondent ipsilateral injured limb (Farthing et al., 2009; Green & Gabriel, 2018; Paillard, 2020).

Notwithstanding the positive effects of the cross-education phenomenon, it is important to highlight the fact that the type of strength training (volume, intensity, and

muscular contraction type), as well as the injury location seems to produce different effects on strength gains (Cirer-Sastre et al., 2018; Manca et al., 2017). The Figure 1.23 summarizes the findings of the two above-mentioned meta-analysis.

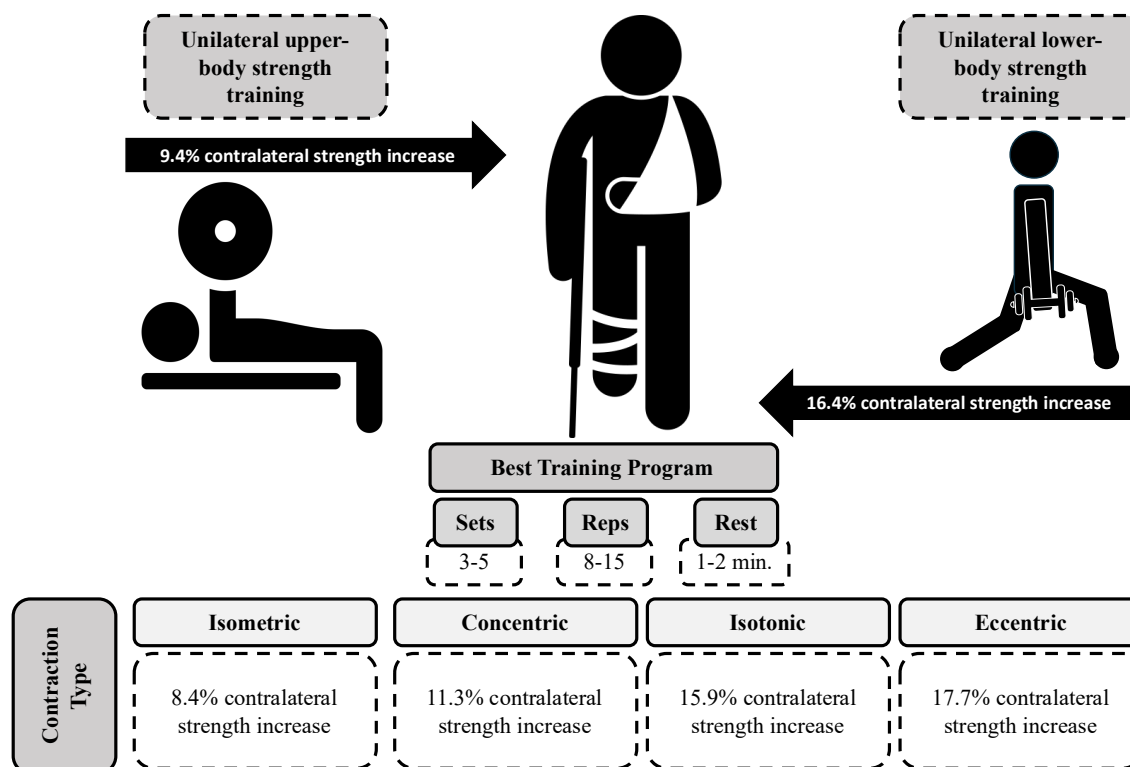


Figure 1.23 Cross-education phenomenon training effects.

Although the cross-education phenomenon seem to be promising, there is a need for further investigations as in the most recent systematic reviews and meta-analysis regarding this topic found a high risk of bias among the analyzed studies (Manca et al., 2017).

1.12.6 RTP: FIELD PHASE

Regarding the time when the athlete have the permission to start working on the field, it is imperative to increase the athlete chronic training load tolerance (Gabbett et al., 2021). In this phase, the coaches and practitioners must ensure that critical external load metrics are progressively imposed on athletes, such as HSR, Sprint, Acc, Dec distances (Gabbett, 2018). Using GPS systems in this later stage of RTP is a great way to track the above-mentioned metrics in an objective fashion (Moroski et al., 2019).

1.12.7 RTP: THE GPS CONTROL-CHAOS CONTINUUM

The control-chaos continuum (CCC) is a RTP framework for when an injured player is eligible to start the return-to-running (RTR) process, and it is based on the progression from low-intensity to high-intensity demands, similar to match. This framework follows five distinct phases, which are illustrated in the Figure 1.24 below (Taberner et al., 2020).

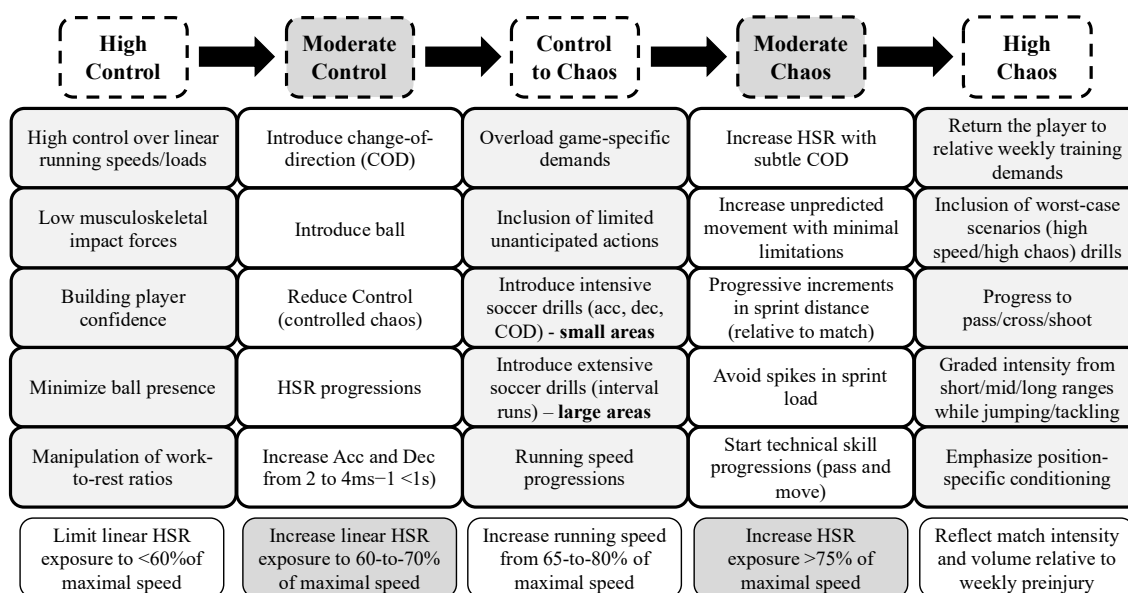


Figure 1.24 The five phases of CCC.

Using this the CCC method of RTP and RTR, coaches and practitioners have access to the objective analysis of the progressions of running loads. The GPS data used in all phases helps the RTP decision-making in the current session and phase (Taberner et al., 2020). Furthermore, if live sessions are available, the practitioner can adjust training in real-time (Buchheit & Simpson, 2017).

The above-mentioned framework went beyond the explanation of the progressions of each phase, and described the progression considerations for RTP for the most common injuries, as well as the strength and power diagnostics to be used in practice (Taberner et al., 2020). Below in Figure 1.25 it is represented the injury-specific considerations for RTP.

Injuries	Hamstring	Quadriceps	Calf	Adductor	Ankle	ACL	Fractures
RTP Planning	Progress: Runs to >70% MS; Acc/Dec intensity; Combine sprint and chaos;	Progress: Acc frequency and intensity; Run to >70% MS; COD angles (45-180°);	Progress: TD, HSR, Sprint volume; Runs to >70% MS; Acc frequency and intensity;	Progress: Acc frequency and intensity; COD angles (45-180°); passing, crossing, shooting, tackling; Combine COD, speed and chaos;	Progress: TD, HSR, Sprint volume; COD angles (45-180°); Acc frequency and intensity; Combine COD, speed and chaos; Jump/land;	Progress: TD, HSR, Sprint volume; Acc frequency and intensity; Combine HSR, COD and chaos;	Progress: TD, HSR, Sprint volume; Passing, shooting, jump/landing; tackling/volume of tackles
Strength and Power tests	Iso posterior chain/hamstring PF, RFD, SE (FP); Ecc hamstring PF (NHE); Con/ecc hamstring PT (IKD)	Iso squat PF, RFD (FP); Iso quadriceps PF (HHD); Dyn split squat force/impulse asymmetries (FP) Con/ecc quadriceps PT (IKD)	Iso soleus/gastrocnemius PF, RFD (FP) SL/DL CMJ jump height, force/power/impulse and asymmetries (FP) 10-5 hop test RSI, force/impulse asymmetries (FP)	Iso hip abductor/adductor; PF	Iso soleus/gastrocnemius PF, RFD, SE (FP) DL CMJ ecc, con, landing force/impulse asymmetries (FP) 10-5 hop test RSI, force/impulse asymmetries (FP) Hop+hold dynamic stability (FP)	DL CMJ ecc, con, landing F/imp asym (FP); SL CMJ jump height, power, imp asym; DL/SL DJ RSI (FP); Iso squat/IMTP PF, RFD (FP); Iso soleus/gastroc PF, RFD (FP); Iso posterior chain PF, RFD, SE (FP); Ecc hamstring PF (NHE); 10-5 hop test (FP); DL/SL DJ RSI (FP); Iso hip abdc/addc PF;	CMJ ecc, con, landing F/imp asym (SL, DL) (FP); Iso squat/IMTP PF, RFD (FP); Iso soleus/gastroc. PF, RFD (FP); Iso posterior chain PF, RFD (FP); Ecc hamstring PF (NHE); 10-5 hop test (FP); DL/SL DJ RSI (FP); Iso hip abdc/addc PF;

Figure 1.25 Injury-specific considerations for RTP (Adapted from Taberner et al., 2020).

It is of paramount importance for coaches and practitioners to collect all these GPS data to progress in training load volume and intensity, avoiding sudden weekly increases in load (Bowen et al., 2019). Furthermore, it is also important to ensure that the training load progressions are based on injury-specificities and are criteria-driven, through the use of specific strength and power tests (Taberner et al., 2020).

CHAPTER 2

INTERNSHIP

2 INTERNSHIP

2.1 INTERNSHIP EXPECTATIONS

Combining theoretical knowledge with practical application is what governs the path for the evolution of our professional area. For that reason, one of my main motivations for doing this internship, was to better understand the complexities of being part of a high-performance environment. Knowing how a high-performance department of a professional soccer team works, its main functions, and how their staff interact with the overall club structure were the most general factors that I was interested in.

2.2 INTERNSHIP OBJECTIVES

Before I started the internship, I had already made a list of objectives that I would like to see fulfilled. This list was as follows:

- Propose the creation of a research laboratory “VSC LAB”;
- Propose a process of periodic assessment and monitoring from U13 to “A” team;
- Propose the assessment of the peak height velocity (PHV) of youth teams;
- Propose the use of an Excel document with all teams collected data;
- Collect GPS data from “B” team;
- Collect periodic assessments and monitoring data from B team;
- Support the return-to-play of “B” team;

2.3 CHARACTERIZATION OF IMPLEMENTED TASKS

Initially, my duties as an intern were mainly to support the head of the high-performance department of the “B” team of Vitória Sport Clube. The supporting tasks were related to periodic assessments and monitoring, as well as gym pre-activations and gym-phase return-to-play processes. However, after two weeks of the internship started, I was entrusted with the process of RTP for some injured athletes, and the planning and operationalization of gym pre-activity work. Given that, my main internship tasks in “B” team were the following:

- Planning and operationalization of gym-phase RTP;

- Planning and operationalization of gym pre-activity;
- Support the periodic assessments and monitoring;
- Ensuring the communication between the medical department and technical team;
- Collect weekly CMJ data for applied research;
- Support GPS data collection and analysis;

Furthermore, during the internship, an opportunity arose to put into practice one of my main initial objectives, which was to take the first steps in the creation of the club research laboratory, the “VSC LAB”. Consequently, the propose of a standardized periodic assessment and monitoring from U13 to “A” team, and the PHV assessment of youth teams were implemented. These practices were lacking at the club structure, and such implementation may make a significant difference in the organization of the high-performance department. The main tasks were as follows:

- Presentation of the proposed project for the high-performance department staff;
- Implementation of periodic assessments and monitoring for the academy and professional teams;
- Creation and implementation of an automated Excel document for data collection of all teams;

Additionally, at the final stages of the internship, I was asked to support the GPS monitoring of “A” team. This task consisted of the following:

- Improve the GPS data analysis system;
- Implementation of GPS data alerts;
- Implementation of week-to-week training load difference analysis;

2.4 ORGANIZATION CHARACTERIZATION

2.4.1 VITÓRIA SPORT CLUBE

Vitória Sport Clube, is a club from Guimarães (Portugal), was officially founded on September 22, 1922. Currently, the main team participate in the Portuguese First League

(Liga NOS). Vitória Sport Clube has won the Portuguese Cup in 2012/13, having played seven finals. Also, in season 1988/89 the club won the Super Cup Cândido de Oliveira. The main team also has seventeen appearances in European competitions, of which there was a presence in the play-off to access the Champions League in season 2008/09.

The “B” team it was created in 2012 to compete in the second Portuguese football league, ending the season in the 21st place and were relegated to the National Senior Championship, corresponding to the Portuguese 3rd League. During this internship, the “B” team disputed the National Senior Championship “Serie B”.

2.4.2 INFRASTRUCTURES

The internship took place in the Vitória Sport Clube Academy, located in Guimarães. The club’s academy was comprised of the following infrastructures:

6 soccer fields (3 of synthetic grass and 3 of natural grass), “B” team trained on 1 synthetic grass and 1 natural grass field;

- 1 weight room, for “A” team;
- 1 improvised weight room (tent), for “B” team and below;
- 1 medical department for “A” team and 1 for “B” team;
- technical staff offices for “A”, “B”, and “U23” teams;
- 1 academy department from U19 and below;
- dining rooms;
- 1 auditorium;
- 11 changing rooms;

All home matches were disputed on the Pistas Gêmeos Castro stadium, located in Guimarães.

2.4.3 “B” TEAM HUMAN RESOURCES

The staff belonging to the “B” team was comprised of the following:

- 1 main coach (Bino Mações);
- 2 assistant coaches (Telmo Oliveira and Miguel Lopes);

- 1 goalkeeper coach (Fernando Monteiro);
- 2 scouts (Bruno Fidalgo and Sérgio Sampaio);
- 1 sports doctor (João Paulo)
- 2 physiologists (André Bernardo and Rui Silva);
- 2 physiotherapists (João Andrade and Diogo Novais);
- 1 nurse (Rui Pereira);
- 1 psychologist (Filipe Teixeira);
- 2 nutritionists (Marta Magalhães and Cátia Pereira);
- 1 team manager (Cristovão Marques);
- 1 person responsible for clothing and material (Henrique);

2.4.4 “B” TEAM SQUAD

The “B” team squad was comprised of 32 players (age: 20.3 ± 1.7 years; body mass: 70.6 ± 7.0 kg; height: 179.1 ± 7.1 cm; years of experience: 11.5 ± 2.7). There were 4 goalkeepers, 10 defenders, 8 midfielders, and 10 attackers. However, the number of players changed throughout the season depending of the coach and club’s decisions. Some players went for the “A” team (which was one of the main purposes of “B” team), and other players went for the “U23” team. On the other hand, some players of “A” and “U23” teams came for “B” team. The “B” team squad was never closed, and was adjustable in terms of players participation in training and competition.

2.5 PLAN OF INTERNSHIP ACTIVITIES

2.5.1 MACROCYCLE

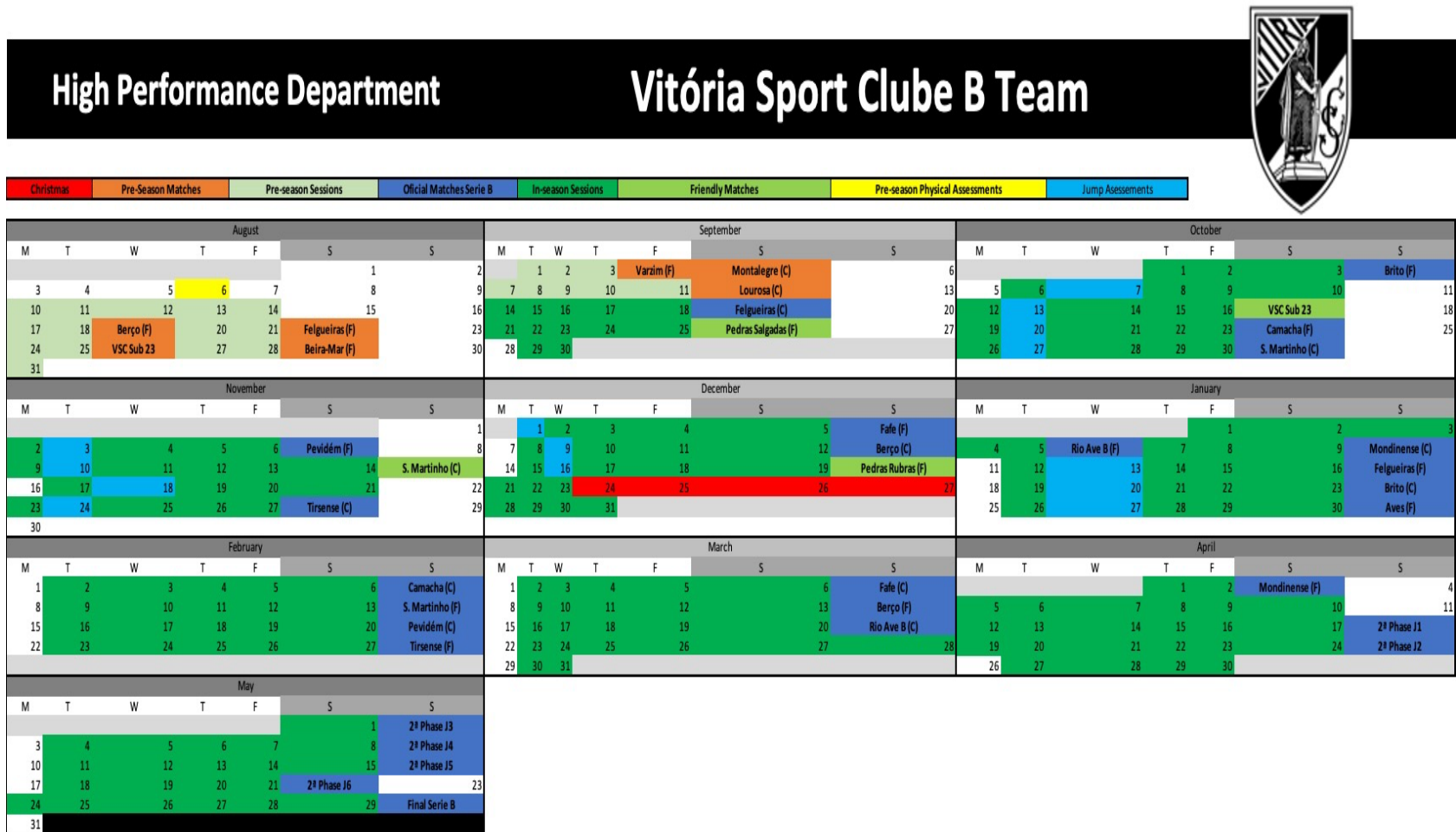


Figure 2.1 2020/21 macrocycle of VSC B Team

2.5.2 MICROCYCLE

The 2020/21 season of the “B” team had only regular weeks of training. For those reasons, the weekly microcycles were planned as illustrated below in **Figure 2.2**.

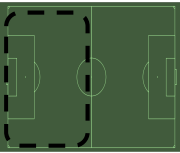
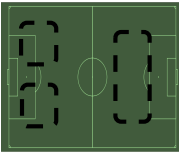
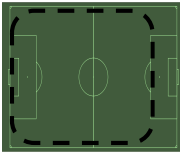
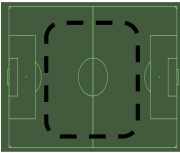
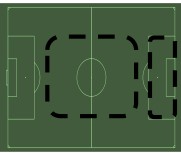
	Acquisitive Days				
	MD -5	MD -4	MD -3	MD -2	MD -1
	Recovery	Tension	Duration	Velocity	Recovery
Field Dimensions	 45x25m	 25x20 to 30x35m	 30x20 to 40x25m	 25x30m	 45x25m
Formats	7v7 to 8v8	2v2 to 4v4	7v7 to 10v10	1v1 to 3v2	7v7 to 8v8
Exercise Duration	6 to 8min.	2 to 4min.	6 to 15min.	0.5 to 2min.	5 to 10 sec.
Work-to-Rest Ratio	1:1	1:3	3:1	3:1	1:8
RPE	2 to 4	5 to 7	4 to 6	4 to 7	2 to 4
Session Duration	~ 60min.	~ 90min.	~ 100min.	~ 70min.	~ 45-60min.

Figure 2.2 Illustration of a typical “B” team regular microcycle.

Depending on the match-day, the weekly planning was adjusted, as well as considering the technical team choices regarding the days off (1 or 2 days).

2.5.3 SESSION EXAMPLE

All training sessions were planned and operationalized by the technical team of “B” team. The high-performance department from “B” team had no participation in the field session planning, excepting the injured players in the last stage of RTP. However, the high-performance department sensibilized the technical team regarding the players with alert flags on external and internal load measures. Below, the Figure 2.3 illustrates a typical training session for match-day -3.

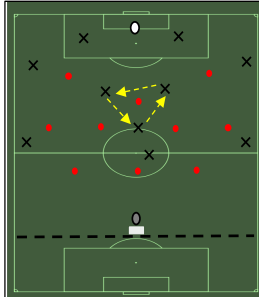
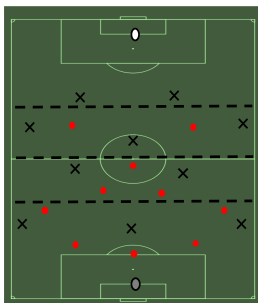
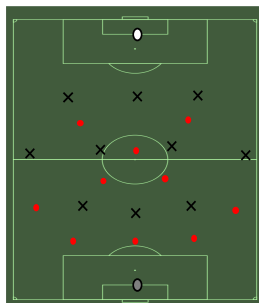
Session 55	Exercise 1: Ball Possession Maintenance 9'		MD -3 Duration
Wednesday – 28/10/2020	Exercise 2 a): Offensive Organization (Phase I High Pressure)		
Field 5 - Academy	Exercise 2 b): Offensive Organization (Phase II, II, and III)		
21 Players + 3 GK	Exercise 2 b): Formal Game		
Exercise 1	Objective	Exercise 2 a)	Objective
7v7 w/floater Possession	Maintaining ball possession	Offensive Org. 10v10	Phase I w/high pressure
	Energetic System		Energetic System
	Anaerobic		Aerobic
	Exercise Duration		Exercise Duration
	3x3'		1x10'
	Success Criteria		Success Criteria
	Keep the ball moving; 1-2 touches on the ball; Score after 8 touches		Keep the ball moving; Create offensive support triangles;
Exercise 2 b)	Objective	Exercise 2 c)	Objective
Offensive Org. 10v10	Between-lines Phases I, II and III	Formal Game	Maintaining ball possession
	Energetic System		Energetic System
	Aerobic/Anaerobic		Anaerobic/Aerobic
	Exercise Duration		Exercise Duration
	1x12'		3x8'
	Success Criteria		Success Criteria
	Create between-line connections; Enter the last defensive block without losing possession;		All criteria of all previous exercises;

Figure 2.3 Training session example.

Depending on each feedback given from both high-performance department and medical department, the technical team adjusted the training session accordingly.

2.6 GAME MODEL

The game model of “B” team was well-defined by the main coach and his assistant coaches, as well as the main scout. Although the game model used by “B” team must remain confidential, there are some details that can be described. The team used a 1-3-4-3 or -1-3-5-2 tactical system, depending on the players available. The game model was based on the ability to impose the idea that the coaches had for the concept of “a TEAM”, which consisted of the following:

- High collective sense of the game;

- Train hard to play hard;
- Maximal tactical concentration;
- Great mental capacity;
- Aggressive attitude;
- Strong collective organization in all phases of the game;

Offensive organization:

- Play short for the central defenders;
- Positional play, maintaining ball possession;
- Between-lines ball circulation;
- Ensuring offensive support;
- Create offensive triangles;
- Ball circulation from side-to-side until create free space;

Defensive organization:

- High-pressure with a high defensive block;
- High-pressure on the player with the ball;
- Ensuring defensive support;
- Create defensive triangles;
- Zone pressing defense;
- Aggressive stopping opponent moves;

Offensive transition:

- Maintain the defensive organization with a high block;
- Take the ball out of the pressure zone oriented towards the teammate;
- Play in depth;
- Rapidly ensure a compact offensive organization;
- Explore free spaces;

Defensive transition:

- High-pressure on the player with the ball;

- High-pressure on the ball surrounding space;
- React maximally and aggressively;
- Rapidly ensure a compact defensive organization;
- Create triangles for support defense;
- Make strategic faults before the opponent pass the defensive block;

2.7 INTERNSHIP ACTIVITY REPORT

2.7.1 PERIODIC ASSESSMENTS

My first internship day was precisely the day when the “B” team went to the club's stadium to carry out the first periodic assessments of the season, before the start of the pre-season. The testing battery was comprised of the following tests:

- Knee flexors isometric bilateral and unilateral test;
- Knee extensors isometric bilateral and unilateral test;
- Adductors squeeze isometric test at 0 and 45° tests;
- Triple hop test;
- Crossover test;
- Squat jump (SJ), countermovement jump (CMJ) and drop jump (DJ) tests;

No aerobic fitness tests were conducted in this testing battery as the technical team did not allow it. Also, it was supposed to conduct another periodic assessment in January but it was not possible due to time and logistic constraints.

The raw data of knee flexors and extensors isometric tests can be seen below in Figure 2.4 and Figure 2.5.

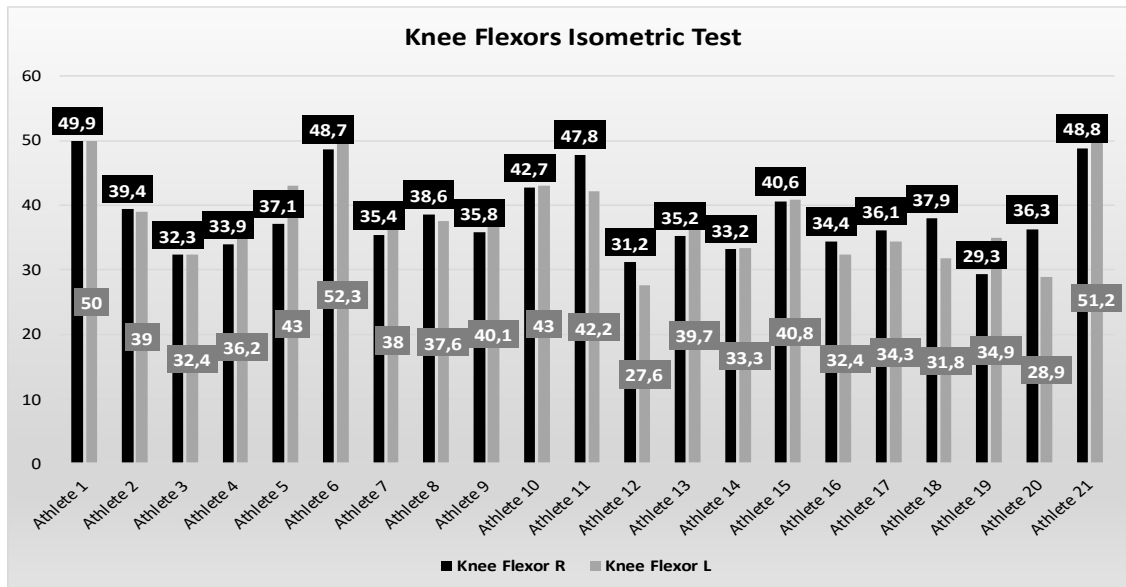


Figure 2.4 Raw data of the knee flexors isometric test.

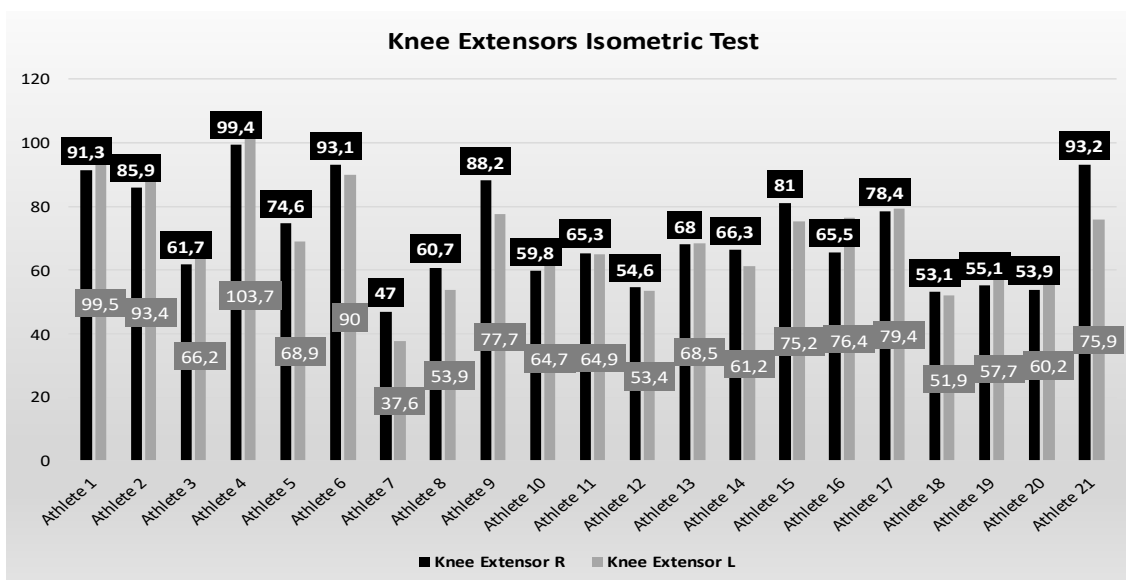


Figure 2.5 Raw data of the knee extensors isometric test.

In Figure 2.6 is represented the pre-season percentage differences of force production between the right and left leg of each athlete, for the knee flexors and extensors isometric tests.

	M	N	O	P	Q
1	Name	Knee Flexors R/L %Dif	Knee Extensors R/L %Dif	Triple Hop R/L %Dif	Crossover R/L %Dif
2	Athlete 1	-0,2	-8,2	-5,3	-3,0
3	Athlete 2	1,0	-8,0	-0,7	3,0
4	Athlete 3	-0,3	-6,8	-5,0	9,0
5	Athlete 4	-6,4	-4,1	7,8	-5,8
6	Athlete 5	-13,7	8,3	0,0	-3,5
7	Athlete 6	-6,9	3,4	3,1	4,5
8	Athlete 7	-6,8	25,0	2,9	6,1
9	Athlete 8	2,7	12,6	2,1	4,9
10	Athlete 9	-10,7	13,5	0,8	-6,4
11	Athlete 10	-0,7	-7,6	-15,5	-10,4
12	Athlete 11	13,3	0,6	0,8	-5,7
13	Athlete 12	13,0	2,2	-2,6	-3,0
14	Athlete 13	-11,3	-0,7	-6,4	-1,3
15	Athlete 14	-0,3	8,3	-1,4	-0,5
16	Athlete 15	-0,5	7,7	-0,3	-6,5
17	Athlete 16	6,2	-14,3	-3,4	3,0
18	Athlete 17	5,2	-1,3	7,0	-7,7
19	Athlete 18	19,2	2,3	1,1	-5,1
20	Athlete 19	-16,0	-4,5	-6,2	-5,1
21	Athlete 20	25,6	-10,5	0,3	8,7
22	Athlete 21	-4,7	22,8	4,2	0,3

Figure 2.6 Percentage differences between the right and left leg.

The conditional formatting in Excel to produce the flag alerts was set as follows:

- **>10% = Red flag;**
- **Between 10 and -10 = Green flag;**
- **< -10 = Red flag;**

These iterations were based on previous research which indicates that lower limb muscle imbalances above 15% were predictors of muscle injuries (Fousekis et al., 2011). However, I decided to set flag alerts immediately above 10% of difference to ensure that the technical team were more sensibilized with the alerts.

Thus, a negative percentage value represents a greater force production on the left than in the right leg. While a positive value represents a greater force production on the right than the left leg.

Furthermore, the raw data of adductor squeeze tests at 0 and 45° tests, as well as the abductor isometric test can be seen below in Figure 2.7.

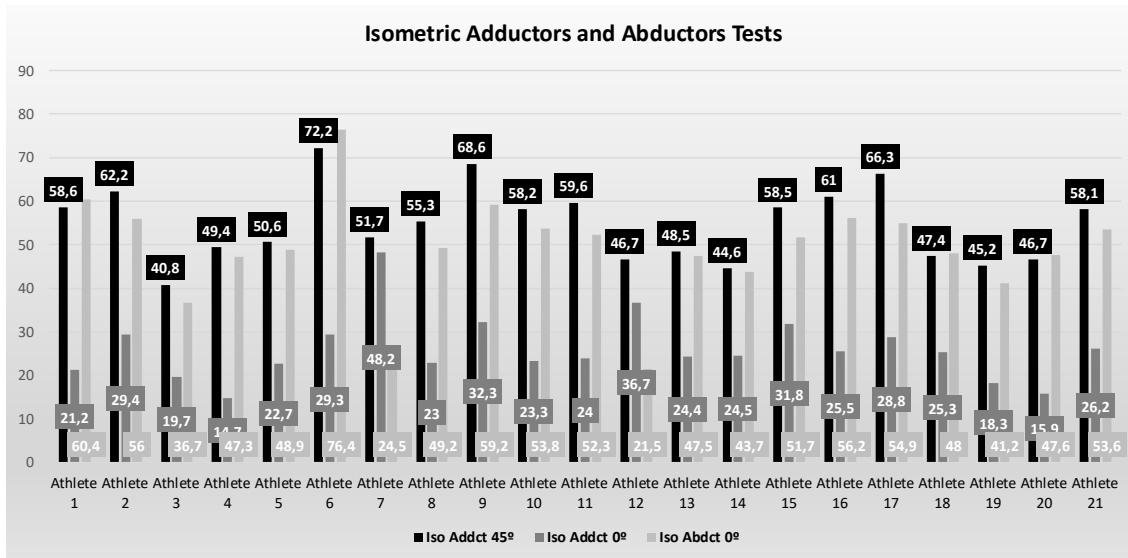


Figure 2.7 Raw data of the adductors and abductors isometric tests.

Moreover, the raw data of the triple hop test and crossover test from the whole team are illustrated in Figures 2.8 and 2.9. The “R” means right leg and the “L” means left leg, as these two tests were performed on both legs.

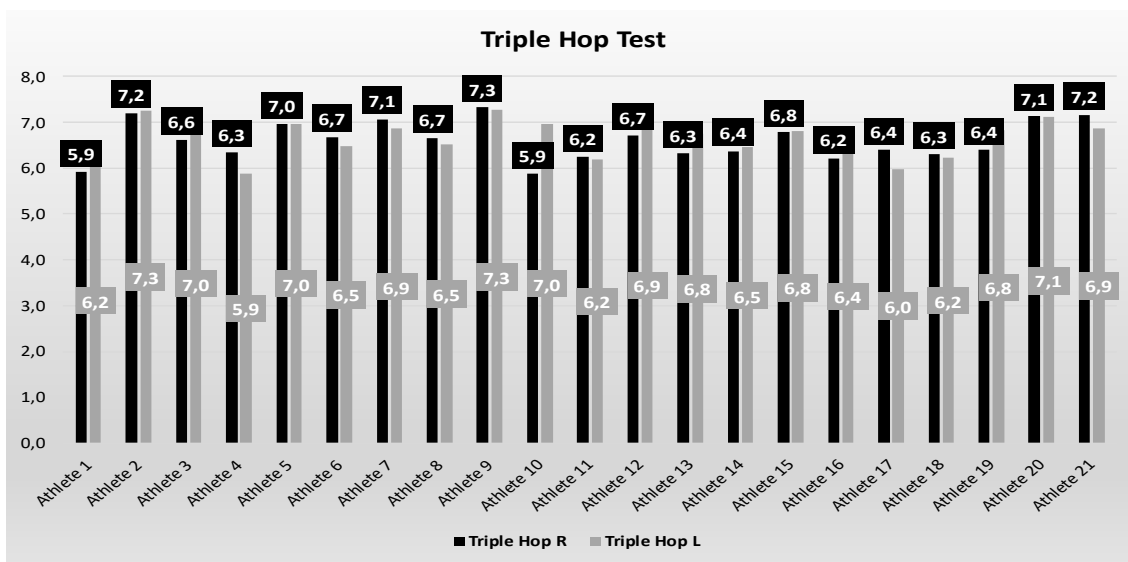


Figure 2.8 Raw data of the triple hop test.

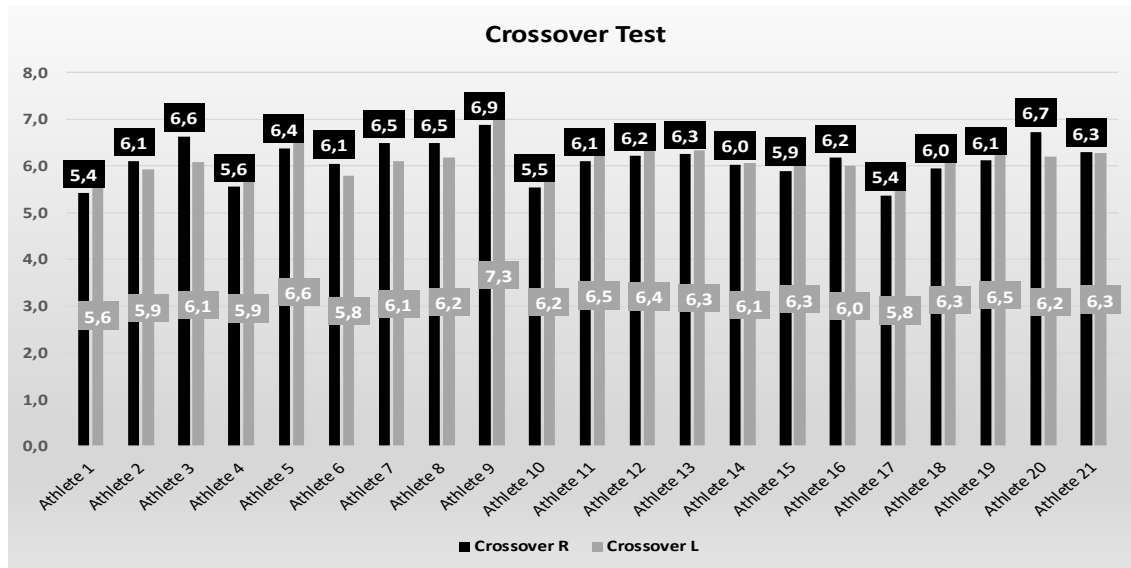


Figure 2.9 Raw data of the Crossover test.

Regarding the jump assessments (SJ, CMJ and DJ), the Figure 2.10 shows the raw data of all jumps heights that were also assessed during the same day of the other assessments described above.

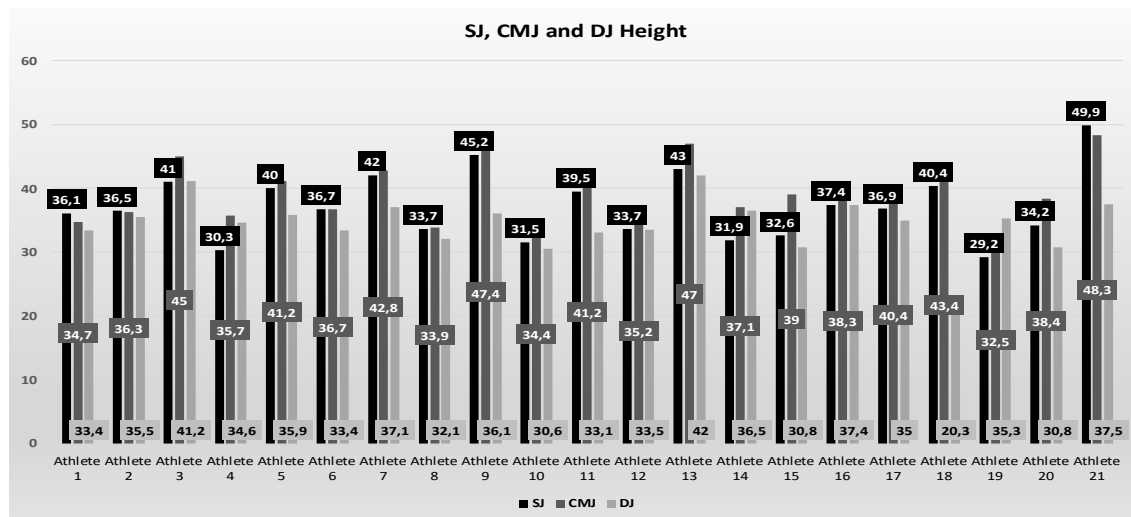


Figure 2.10 Raw data of all vertical jump assessments.

From the jump assessments, I used the reactive strength index (RSI) and the eccentric utilization ratio (EUR) values for further analysis. The Figure 2.11 below shows the team RSI and EUR values.

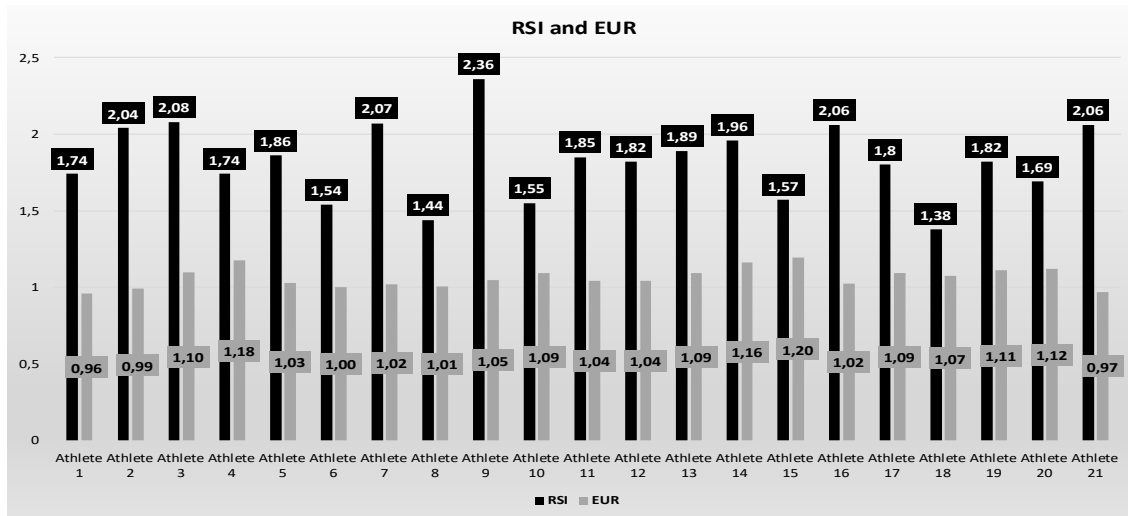


Figure 2.11 RSI and EUR indices.

These values are important to analyze as they can give coaches and practitioners a picture of the current training needs of each athlete (McGuigan et al., 2013). In fact, the DJ test measures the reactive power of athletes through the fast stretch-shortening cycle (SSC), while the CMJ test measures the lower body vertical power through the slow SSC. On the other hand, the SJ test measures also the lower body vertical power of athletes but without the use of any SSC capacity, given its static position without the eccentric phase of the movement (McGuigan, 2017).

The Figure 2.12 shows the further analysis that I have made, using the data collected from all vertical jump performances of all team, as well as the training needs of each player according each index value.

	A	B	C	D	E	F	G
2	Name	SJ	CMJ	DJ	RSI	EUR	Training Emphasis
3	Athlete 1	36,1	34,7	33,4	⇒ 1,74	● 0,96	Moderate-Intensity Plyometric
4	Athlete 2	36,5	36,3	35,5	↑ 2,04	● 0,99	High-Intensity Plyometric
5	Athlete 3	41	45	41,2	↑ 2,08	● 1,10	Maximal Strength
6	Athlete 4	30,3	35,7	34,6	⇒ 1,74	● 1,18	Maximal Strength
7	Athlete 5	40	41,2	35,9	⇒ 1,86	● 1,03	Maximal Strength
8	Athlete 6	36,7	36,7	33,4	⇒ 1,54	● 1,00	Maximal Strength
9	Athlete 7	42	42,8	37,1	↑ 2,07	● 1,02	Maximal Strength
10	Athlete 8	33,7	33,9	32,1	↓ 1,44	● 1,01	Maximal Strength
11	Athlete 9	45,2	47,4	36,1	↑ 2,36	● 1,05	Maximal Strength
12	Athlete 10	31,5	34,4	30,6	⇒ 1,55	● 1,09	Maximal Strength
13	Athlete 11	39,5	41,2	33,1	⇒ 1,85	● 1,04	Maximal Strength
14	Athlete 12	33,7	35,2	33,5	⇒ 1,82	● 1,04	Maximal Strength
15	Athlete 13	43	47	42	⇒ 1,89	● 1,09	Maximal Strength
16	Athlete 14	31,9	37,1	36,5	⇒ 1,96	● 1,16	Maximal Strength
17	Athlete 15	32,6	39	30,8	⇒ 1,57	● 1,20	Maximal Strength
18	Athlete 16	37,4	38,3	37,4	↑ 2,06	● 1,02	Maximal Strength
19	Athlete 17	36,9	40,4	35	⇒ 1,8	● 1,09	Maximal Strength
20	Athlete 18	40,4	43,4	20,3	↓ 1,38	● 1,07	Maximal Strength
21	Athlete 19	29,2	32,5	35,3	⇒ 1,82	● 1,11	Maximal Strength
22	Athlete 20	34,2	38,4	30,8	⇒ 1,69	● 1,12	Maximal Strength
23	Athlete 21	49,9	48,3	37,5	↑ 2,06	● 0,97	High Intensity Plyometric

Figure 2.12 Training need emphasis of each athlete.

It has been documented that athletes with RSI values above 2.0 are capable of sustaining high-intensity plyometric training, while those with RSI between 1.5 and 2.0 are capable of sustaining moderate-intensity plyometric training and those with RSI values below 1.5 are capable of sustaining only low-intensity plyometric training (Flanagan et al., 2008). For those reasons, the conditional formatting in Excel for the RSI values were the following:

- **>2** = Green Up arrow;
- **Between 2 and 1.5** = Yellow Side arrow;
- **< 1.5** = Red Down arrow;

On the other hand, the EUR values are based on the division of the CMJ values by the SJ values. It has been documented that EUR values ≥ 1.1 are related to a great ability to use the SSC by the athlete, and in this case, the athletes would benefit more from maximal strength and loaded power training. While, EUR values < 1.0 are related to a lower ability use the SSC by the athlete, and in this case, the athletes would benefit more from high-, moderate- or low-intensity plyometric training, depending on each athlete RSI values as described above (McGuigan et al., 2013). For those reasons, the conditional formatting in Excel for the EUR values were the following:

- **>1** = Black circle;

- < 1 = Grey circle;

It must be noted that although the training emphasis might be plyometric, maximal strength or loaded power, it is not supposed to ensure only one type of training to the same athlete. For example, the “athlete 3” from the Figure 2.12 above, have a maximal strength training emphasis due to his EUR value. However, if we look to his RSI value (>2.0), it is important to ensure that this athlete have a high-intensity plyometric stimulus as a secondary training focus.

Although I made this type of analysis, unfortunately the technical team of “B” team did not allow the high-performance department to conduct neither maximal strength nor loaded power or plyometric training. However, this type of analysis served for us as a picture of the current state of our athletes, and to compare with the values of a possible second and third periodic assessment if allowed.

2.7.2 MONITORING

The monitoring practices at the “B” team were comprised of the four dimensions of the athlete monitoring cycle as follows (Gabbett et al., 2017): (i) subjective internal loads (s-RPE); (ii) external loads (GPS); (iii) wellness; and (iv) readiness (CMJ).

2.7.3 INTERNAL LOADS

For internal load quantification, the “B” team used only the subjective measures through the s-RPE. From the s-RPE we used its related workload indices such as the ACWR, TM and TS. Every day, 10 to 30 minutes after each training session, all the players received a link from Google forms on their smartphones to answer the question “how hard was your session?”, as previously documented (Foster et al., 2001).

The CR-10 scale was used to quantify each player session effort (Borg, 1998). Based on CR-10 scale, 1 means “very light activity” and 10 means “maximal exertion”. Each player rated the effort individually without the influence of others, using a smartphone questionnaire questioning “how hard was your training?”. Although it is allowed to use decimals in that scale, we only used absolute values. All the new players were previously familiarized with the scale, while the players from the last season were already accustomed with these practices. The internal training loads were then obtained

by multiplying each player training session-RPE (s-RPE) by the absolute time of each session in minutes (Foster, 1998).

To obtain the weekly ALs (sum of the last 7 days of training), TM (average weekly loads divided by its standard deviation), and TS (TM multiplied by weekly ALs) values, the calculations were performed as shown in Figure 2.13. The values presented in Figure 2.13 are from an external defender who belongs to VSC “B” team, and were randomly selected just to serve as an example. In this particular case, these values were extracted from week 16 of the in-season period.

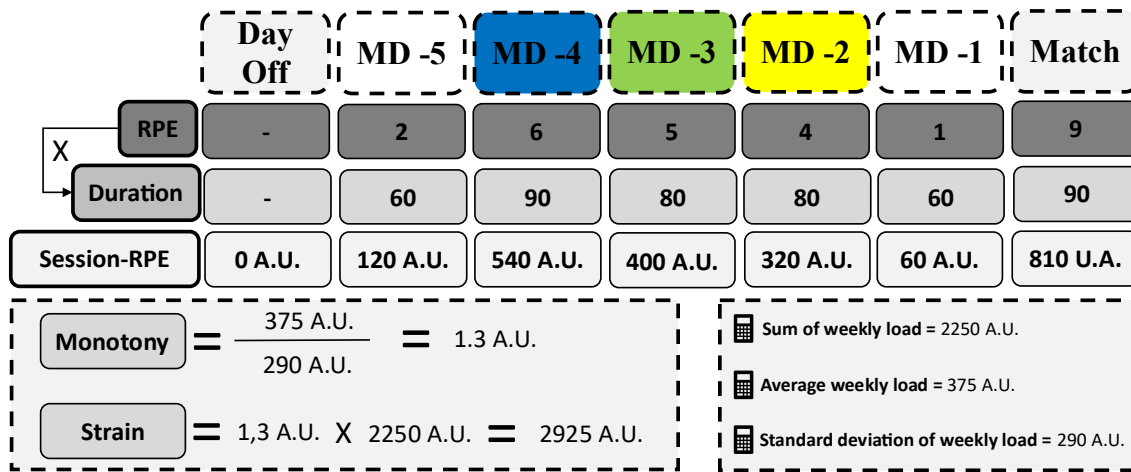


Figure 2.13 Calculation of weekly ALs, TM, and TS values.

Furthermore, for the analysis of ACWR, we used the EWMA calculation (7-day [acute] divided by 28-day [chronic] EWMA), in which the chronic load is calculated from a weighted model where the most recent load receives a higher weight compared to the previous ones (Williams et al., 2017). The calculation of the EWMA ACWR consists of the following:

$$EWMA_{today} = Load_{today} \times \lambda_a + ((1 - \lambda_a) \times EWMA_{yesterday})$$

Where λ_a is a value between 0 and 1 that represents the decrease and that can be determined from the following:

$$\lambda_a = 2/(N + 1)$$

Where N is the constant of decrease (usually 7 to 28 days, for acute and chronic load, respectively) (Williams et al., 2017).

In our daily practice, we use all these calculations in Excel software. Moreover, to obtain the EWMA ACWR value, we need to calculate the ALs (7-day workloads) and CLs (28-day workloads) according to the above-mentioned EWMA calculation. As an example, if an athlete has an $Load_{today}$ of 320 A.U. and an AL $EWMA_{yesterday}$ of 335.9, the EWMA acute load would be calculated in Excel as follows (Clemente & Silva, 2021):

$$EWMA \text{ acute load} = 320 * (2 / ((7)+1)) + ((1 - (2 / ((7)+1))) * 335.9)$$

$$EWMA \text{ acute load} = 331.9$$

It is worth noting that the number seven (7) highlighted in bold in the above-calculation, is referred to the last 7 days of training.

Considering the $Load_{today}$ of 320 A.U. for the same athlete, with an CL $EWMA_{yesterday}$ of 310, the EWMA chronic load would be calculated in Excel as follows (Clemente & Silva, 2021):

$$EWMA \text{ chronic load} = 320 * (2 / ((28)+1)) + ((1 - (2 / ((28)+1))) * 310)$$

$$EWMA \text{ chronic load} = 310.7$$

From these calculations, we now calculated the ACWR value through the EWMA method, by simply dividing the $EWMA \text{ acute load}$ value by the $EWMA \text{ chronic load}$ value, as follows:

$$EWMA \text{ ACWR} = \frac{EWMA \text{ acute load}}{EWMA \text{ chronic load}}$$

$$EWMA \text{ ACWR} = \frac{331.9}{310.7}$$

$$EWMA \text{ ACWR} = 1.1 \text{ A.U.}$$

As mentioned before, we applied this type of analysis using the Excel software for “B” team. Fortunately, I had the opportunity to improve their system of analysis to ensure a more comprehensive understanding of the collected data. The Figure 2.14 illustrates

an example of the above-mentioned calculations for the ALs, CLs, and ACWR of a 28-day training period, regarding the RPE values collected from a single athlete.

SOMA    f_x =G32*(2/((28)+1))+(1-(2/(28)+1))*A131)							
	AH	AI	AJ	AK	AL	AM	AN
1							
2	Today's ACWR		1,0	Today's TM		1,9	Today's TS
3	Sessão_PSE						
4	CA	CC	ACWR	Desvio-Padrão	Monotony	Soma Carga	Strain
5	380	380	 1,0	0	#DIV/0!	380	#DIV/0!
6	356	373	 1,0	48	 7,5	665	 4988
7	386	380	 1,0	78	 5,0	1140	 5672
8	289	354	 0,8	178	 1,6	1140	 1857
9	217	330	 0,7	196	 1,1	1140	 1265
10	275	338	 0,8	197	 1,4	1590	 2224
11	326	348	 0,9	197	 1,7	2070	 3428
12	293	337	 0,9	197	 1,5	1882	 2803
13	272	328	 0,8	197	 1,4	1807	 2490
14	249	318	 0,8	177	 1,4	1512	 2126
15	246	312	 0,8	154	 1,6	1747	 2790
16	184	291	 0,6	154	 1,2	1747	 2093
17	269	307	 0,9	169	 1,6	1819	 2900
18	314	317	 1,0	163	 1,9	1789	 3443
19	294	311	 0,9	161	 1,8	1832	 3339
20	268	303	 0,9	163	 1,6	1810	 2979
21	280	303	 0,9	160	 1,7	1945	 3394
22	272	300	 0,9	160	 1,7	1960	 3340
23	204	279	 0,7	160	 1,3	1960	 2505
24	213	276	 0,8	125	 1,7	1678	 2850
25	272	288	 0,9	125	 2,2	1678	 3642
26	304	296	 1,0	137	 2,2	1843	 4084
27	322	301	 1,1	138	 2,3	2030	 4728
28	320	302	 1,1	138	 2,3	2030	 4702
29	319	303	 1,1	137	 2,3	2095	 4862
30	239	282	 0,8	137	 1,7	2095	 3646
31	212	272	 0,8	149	 1,4	1987	 2836
32	259	(28)+1)+1	 0,9	142	 1,8	1937	 3545

Figure 2.14 Illustration of load mediators using EWMA method in Excel.

As seen in the above figure, I used alert flags for each workload indices (load mediators) according to the values that are associated with danger zones and safe zones as previously documented (Foster, 1998; Gabbett, 2016). The use of this type of iterations using alert flags was previously recommended (Robertson et al., 2016).

Also, as requested by the “B” team technical staff, we compared the current (today) RPE and s-RPE average with the last four weeks (28-Days) for the correspondent day of the week. As an example, the Figure 2.15 represents the s-RPE analysis of day -4 of the week 7 from pre-season, for each player.

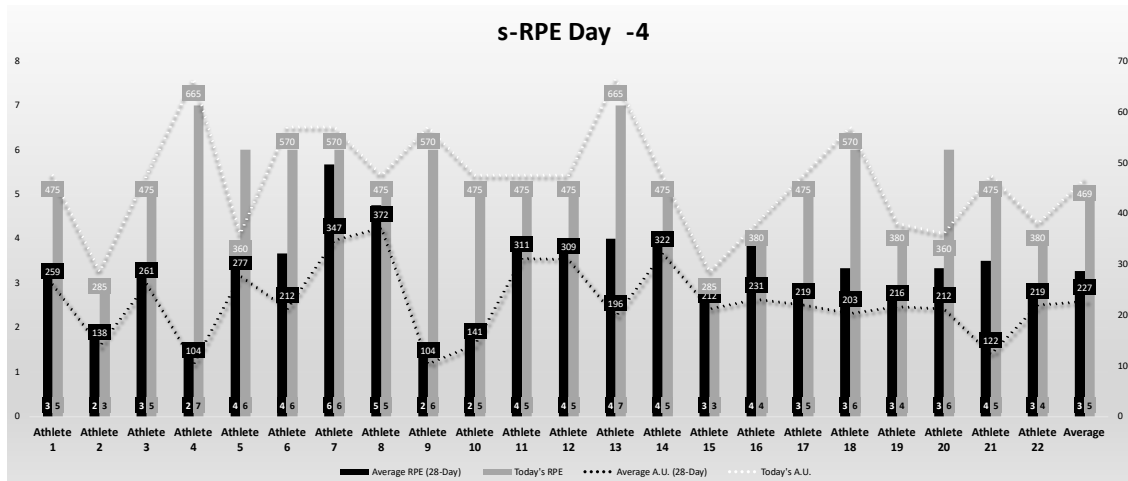


Figure 2.15 Comparison between s-RPE of current day -4 and the last 28-Days.

2.7.4 EXTERNAL LOADS

For the quantification of external loads of “B” team, each player used the same 18-Hz GPS units (STATSports, Apex, Northern Ireland). These GPS units have an integrated 100-Hz gyroscope, a 100-Hz tri-axial accelerometer and a 10-Hz magnetometer. The GPS model that we used throughout the season was previously tested for its validity and reliability, revealing good levels of accuracy and variability at different speed thresholds, and excellent inter-unit reliability for peak velocity (Beato et al., 2018; Beato & de Keijzer, 2019). The GPS units were placed in a specific vest in which the unit was fixed between the scapulae of each player. The data collected during training sessions and matches were always imported from the STATSport Sonra software (version 3.0), for further analysis.

The following measures were daily collected during each training session and match: (i) total distance (TD: consisting in the total distance covered by players); (ii) distance covered at high-speed running (HSR: distances covered at a speed of 19.8 km·h⁻¹ or above); (iii) high metabolic load distances (HML: distances covered at a speed of > 19.8 km·h⁻¹ while accelerating/decelerating at ≥ 2 m/s²); (iv) high intensity accelerations and decelerations (HA and HD: number of accelerations and decelerations at ≥ 3 m/s²); (v) zone entries 6 (Z6: distances covered at a speed of 25.2 km/h⁻¹ or above); (vi) number of sprints at 80% of maximal speed (80%NS: number of times that a speed corresponding to 80% of the actual maximal speed of each player was reached

during running); (vii) sprint distances at 80% of maximal speed (80%SD: distances covered at a speed corresponding to 80% of the actual maximal speed of each player); (viii) maximal speed (MS: maximal speed tracked for each player).

For the sake of simplicity, and to facilitate the communication between the high-performance department and the “B” team technical team, we only transmit the values of the following GPS measures to the technical team:

- Total distance;
- High-speed running;
- High accelerations;
- High decelerations;
- Sprint distance;
- High-metabolic load distance;

For all those used GPS measures we also used the same calculations as for the previously described subjective internal loads, through the EWMA calculation method. Thus, we used only the ACWR values to communicate to the technical team. The Figure 2.16, illustrates an example of ACWR calculation with alert flags for total distance in Excel, extracted from a randomly selected player from the “B” team.

SOMA ↑ ✖ ✓ $f_x = K18/L18$							
	K	L	M	N	O	P	Q
1	Total Distance						
2	Today's ACWR		1,14	Today's TM	1,8	Today's TS	36385
3	AL	CL	ACWR TD	DP	Monotony	Soma Carga	Strain
4	9597,00	9597,00	● 1,00	0	#DIV/0!	9597,00	#DIV/0!
5	7197,75	8935,14	● 0,81	4798,5	● 1,50	9597,00	● 14395,50
6	6638,81	8661,13	● 0,77	3918,71688	● 1,69	14559,00	● 24664,83
7	6011,61	8348,64	● 0,72	3408,11798	● 1,76	18689,00	● 32965,69
8	6860,46	8421,63	● 0,81	3588,74236	● 1,91	28096,00	● 53710,01
9	5629,59	7974,41	● 0,71	3551,85842	● 1,58	30033,00	● 47601,44
10	4222,19	7424,45	● 0,57	3725,77757	● 1,13	30033,00	● 34034,55
11	4729,90	7343,66	● 0,64	2794,18966	● 1,69	31774,00	● 53785,80
12	4818,67	7187,89	● 0,67	3197,32324	● 1,51	26812,00	● 40408,25
13	3614,00	6692,18	● 0,54	3194,98508	● 1,13	26448,00	● 29916,63
14	3652,00	6490,37	● 0,56	2248,41718	● 1,62	20903,00	● 33951,80
15	3704,50	6309,10	● 0,59	2221,45884	● 1,67	21410,00	● 35703,29
16	3389,38	6042,54	● 0,56	2924,35616	● 1,16	31480,00	● 36485,84
17	5059,53	6320,30	● 0,80	3194,15888	● 1,58	25227,00	● 39959,45
18	3794,65	5884,42	$=K18/L18$	3181,59365	● 1,19	25026,00	● 29848,22

Figure 2.16 Example of the calculations of ACWR for total distance in Excel.

The alert flags used in this example were based on the following conditional format in Excel:

- **1.3 A.U. (Red)** = Danger Zone (overreaching);
- **Between 1.3 A.U. and 0.8 A.U. (Green)** = Safe Zone;
- **<0.8 A.U. (Yellow)** = Danger Zone (detraining);

The Figure 2.17, illustrates an example of TM calculation with alert flags for total distance in Excel, extracted from a randomly selected player from the “B” team.

SOMA ✖ ✓ f_x =K18/N18							
	K	L	M	N	O	P	Q
1	Total Distance						
2	Today's ACWR		1,14	Today's TM	1,8	Today's TS	36385
3	AL	CL	ACWR TD	DP	Monotony	Soma Carga	Strain
4	9597,00	9597,00	● 1,00	0	#DIV/0!	9597,00	#DIV/0!
5	7197,75	8935,14	● 0,81	4798,5	● 1,50	9597,00	● 14395,50
6	6638,81	8661,13	● 0,77	3918,71688	● 1,69	14559,00	● 24664,83
7	6011,61	8348,64	● 0,72	3408,11798	● 1,76	18689,00	● 32965,69
8	6860,46	8421,63	● 0,81	3588,74236	● 1,91	28096,00	● 53710,01
9	5629,59	7974,41	● 0,71	3551,85842	● 1,58	30033,00	● 47601,44
10	4222,19	7424,45	● 0,57	3725,77757	● 1,13	30033,00	● 34034,55
11	4729,90	7343,66	● 0,64	2794,18966	● 1,69	31774,00	● 53785,80
12	4818,67	7187,89	● 0,67	3197,32324	● 1,51	26812,00	● 40408,25
13	3614,00	6692,18	● 0,54	3194,98508	● 1,13	26448,00	● 29916,63
14	3652,00	6490,37	● 0,56	2248,41718	● 1,62	20903,00	● 33951,80
15	3704,50	6309,10	● 0,59	2221,45884	● 1,67	21410,00	● 35703,29
16	3389,38	6042,54	● 0,56	2924,35616	● 1,16	31480,00	● 36485,84
17	5059,53	6320,30	● 0,80	3194,15888	● 1,58	25227,00	● 39959,45
18	3794,65	5884,42	● 0,64	3181,59365	=K18/N18	25026,00	● 29848,22

Figure 2.17 Example of the calculations of TM for total distance in Excel.

The alert flags used in this example were based on the following conditional format in Excel:

- **>2 A.U. = Red**, Danger Zone (too low training variation);
- **Between 2 A.U. and 0.8 A.U. = Green**, Safe Zone;
- **< 0.8 A.U. = Yellow**, Danger Zone (too high training variation);

The Figure 2.18, illustrates an example of TS calculation with alert flags for total distance in Excel, extracted from a randomly selected player from the “B” team.

SOMA fx =O18*P18							
	K	L	M	N	O	P	Q
1	Total Distance						
2	Today's ACWR	1,14	Today's TM	1,8	Today's TS	36385	
3	AL	CL	ACWR TD	DP	Monotony	Soma Carga	Strain
4	9597,00	9597,00	1,00	0	#DIV/0!	9597,00	#DIV/0!
5	7197,75	8935,14	0,81	4798,5	1,50	9597,00	14395,50
6	6638,81	8661,13	0,77	3918,71688	1,69	14559,00	24664,83
7	6011,61	8348,64	0,72	3408,11798	1,76	18689,00	32965,69
8	6860,46	8421,63	0,81	3588,74236	1,91	28096,00	53710,01
9	5629,59	7974,41	0,71	3551,85842	1,58	30033,00	47601,44
10	4222,19	7424,45	0,57	3725,77757	1,13	30033,00	34034,55
11	4729,90	7343,66	0,64	2794,18966	1,69	31774,00	53785,80
12	4818,67	7187,89	0,67	3197,32324	1,51	26812,00	40408,25
13	3614,00	6692,18	0,54	3194,98508	1,13	26448,00	29916,63
14	3652,00	6490,37	0,56	2248,41718	1,62	20903,00	33951,80
15	3704,50	6309,10	0,59	2221,45884	1,67	21410,00	35703,29
16	3389,38	6042,54	0,56	2924,35616	1,16	31480,00	36485,84
17	5059,53	6320,30	0,80	3194,15888	1,58	25227,00	39959,45
18	3794,65	5884,42	0,64	3181,59365	1,19	25026,00	=O18*P18

Figure 2.18 Example of the calculations of TS for total distance in Excel.

The alert flags used in this example were based on the following conditional format in Excel:

- >50000 A.U. = Red, Danger Zone;
- Between 50000 A.U. and 40000 A.U. = Yellow, Alert Zone;
- <40000 A.U. = Green, Safe Zone;

We also used the values of TM and TS for each metric according to recent research (Clemente et al., 2020; Clemente et al., 2020). However, we did not communicate any of the TM and TS values and their respective alert flags for any external measure, as future research is needed to determine thresholds to the analyzed values.

As requested for the “B” team technical staff, we compared the current (today) each GPS measures average with the last four weeks (28-Days) for the correspondent day of the week. As an example, the Figure 2.19 represents this analysis for total distance of day -4 of the week 7 from pre-season, for each player.

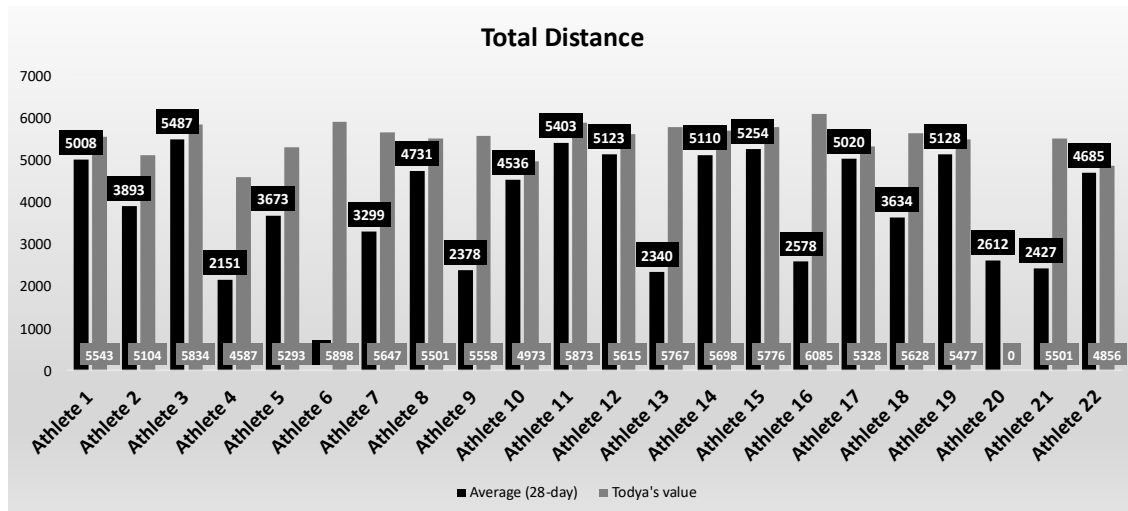


Figure 2.19 Comparison between TD of current day -4 and the last 28-Days.

As members of the high-performance department from the club structure, it was of our responsibility to ensure this type of analysis to communicate to the technical team. However, we had to filter some aspects of the analysis in order to instigate a more practical and effective communication. Also, we have to be open to the suggestions of the technical team.

2.7.5 WELNESS

Regarding the wellness status of the “B” team players, it was the responsibility of the medical department to ensure its monitoring. The questionnaire used by the medical department was comprise of two distinct parts: (i) sleep quality, fatigue and muscle soreness questions; and (ii) covid-19 symptomatology.

For the sleep quality and fatigue levels, the answers were numerical (from 1 to 5). For sleep quality 1 was “too bad” and 5 was “too good”, while for fatigue levels 1 was “too high” and 5 “too low”. However, for muscle soreness the answer was qualitative, where each player had to describe the location of their pain. As seen, this practice is not supported by the available evidence regarding the monitoring of wellbeing as previously described in this report in Chapter I.

However, I had the opportunity to improve this method of wellness monitoring in the later stages of the internship for the overall teams. I will discuss this later in this Chapter.

2.7.6 READINESS

For readiness monitoring, the “B” team had a device to assess jump performance which was the Optojump photoelectric cells system (Microgate, Bolzano, Italy). However, the team did not use this method of monitoring, or any other method. For those reasons, I insisted to start using this method and the head of high-performance department and technical staff of the “B” team allowed me to go forward with this monitoring. However, for unknown reasons, after several months of analysis, it was decided to stop with this monitoring.

Still, for the readiness monitoring, I requested each player to complete 4 CMJ repetitions interspersed by 3 to 5 seconds of recovery between jumps, as previously recommended (Mathieu & Peeters, 2017). Players were instructed to maintain both hand on their hips during the 4 trials, to keep their back straight without swinging the leg forward during the flight phase and to try to land at the same place they took-off with their tip-toes first. They were allowed to do the CMJ depth that was more suitable for them.

All jumps were assessed using a Optojump connected to a portable computer with the software of the same manufacturer (Optojump software, version 1.10.19). The Optojump system allowed to measure the flight time CMJ trials with an accuracy of 1/1000 seconds (1 kHz), and jump height was then automatically estimated by the testing device and was used to further analysis (Glatthorn et al., 2011a). A standardize warm-up consisting of ankle mobility and knee range of motion exercises, followed by 3 to 5 submaximal CMJs was conducted. Also, the CMJ protocol was always applied 72h after the match, in day -4.

Bellow in Figure 2.20, it can be seen an example of the “B” team CMJ heights from week 10 to 11 with an official match in between, during the initial stage of in-season period.

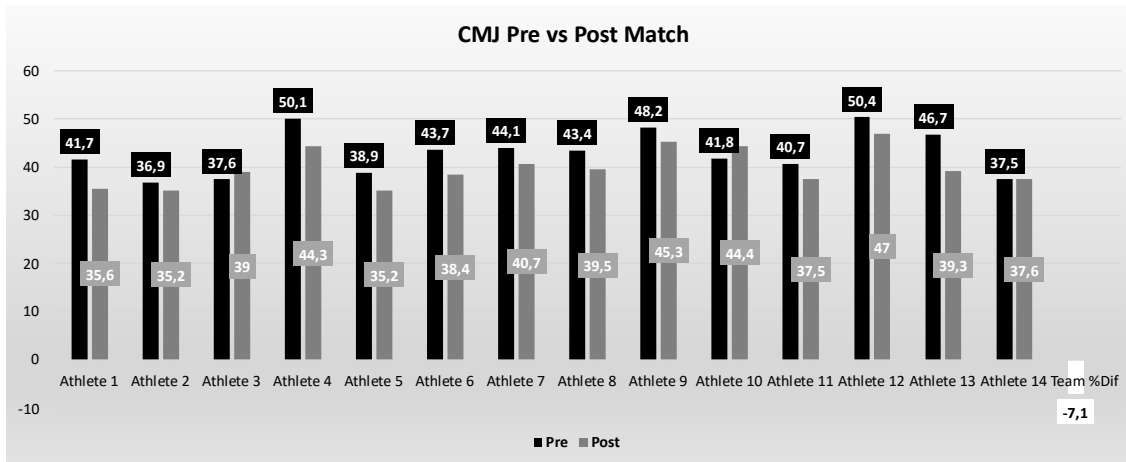


Figure 2.20 Raw comparison between Pre and Post match CMJ performance.

After analyzing the raw data, I proceeded to a further analysis of the Z-scores of both pre- and post-match assessments. The use of Z-scores makes it possible to analyze the variation between -3 and +3 standard deviations in relation to the team average. For instance, if an athlete has a Z-Score of -1.5 it indicates that the athlete is at -1.5 standard deviations from the team average.

As an example, the Figure 2.21 represents the Z-scores from the same sample shown in the previous Figure 2.20, belonging to the same players, from the same week. In the example below, conditional formatting was used for the Z-scores.

SOMA fx $= (B2 - \$B\$17) / \$B\$18$					
	A	B	C	D	E
1	Name	Pre_Match	PRE_CMJ_Zscore	Post_Match	Post_CMJ_Zscore
2	Athlete 1	41,7	$\frac{B2 - \$B\$17}{\$B\$18}$	35,6	-1,1
3	Athlete 2	36,9	-1,3	35,2	-1,2
4	Athlete 3	37,6	-1,2	39	-0,2
5	Athlete 4	50,1	1,6	44,3	1,1
6	Athlete 5	38,9	-0,9	35,2	-1,2
7	Athlete 6	43,7	0,2	38,4	-0,4
8	Athlete 7	44,1	0,2	40,7	0,2
9	Athlete 8	43,4	0,1	39,5	-0,1
10	Athlete 9	48,2	1,1	45,3	1,4
11	Athlete 10	41,8	-0,3	44,4	1,1
12	Athlete 11	40,7	-0,5	37,5	-0,6
13	Athlete 12	50,4	1,6	47	1,8
14	Athlete 13	46,7	0,8	39,3	-0,2
15	Athlete 14	37,5	-1,2	37,6	-0,6
16					
17	Mean	43,0		39,9	
18	SD	4,6		3,9	

Figure 2.21 Z-scores from each athlete CMJ.

The formatting rules for the Z-scores were the following:

- >0.5 (green);
- between 0.0 and -1.49 (yellow);
- <-1.5 (red).

This type of iterations were based on the previously mentioned literature regarding this topic (Robertson et al., 2016). Furthermore, I used percentual differences between the pre and post assessments as seen in the Figure 2.22.

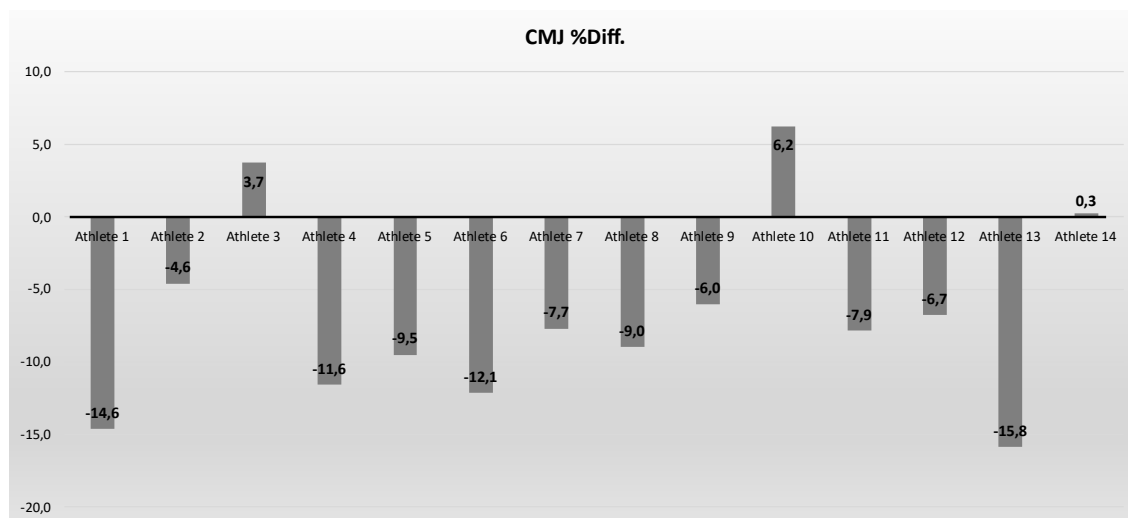


Figure 2.22 Percentual differences between pre- and post-match assessment.

Also, I used magnitude-based inference statistics through the use of standardize differences based on Cohen's d effect size (ES) (Cohen, 1988). While, the interpretation of inference magnitudes were based on Hopkins recommendations (Batterham & Hopkins, 2006). The Figure 2.23 below illustrates the calculations of effect sizes in Excel for the CMJ assessments of the same sample in the examples above.

SOMA $\uparrow$ $\times$ $\checkmark$ f_x $= (AF3-Y3)/AG3$																
	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
1	Name	PreMatch1	PreMatch2	PreMatch3	PreMatch4	Max.	Mean	DP	PostMatch1	PostMatch2	PostMatch3	PostMatch4	Max.	Mean	DP	ES
2	Athlete 1	41,7	40,0	41,0	35,0	41,7	39,4	3,0	35,6	35,5	34,7	34,6	35,6	35,1	0,5	-8,273
3	Athlete 2	35,9	36,9	36,5	36,8	36,9	36,5	0,5	32,9	35,2	32,8	34,8	35,2	33,9	1,3	$= (AF3-Y3)/AG3$
4	Athlete 3	37,6	37,6	35,2	32,5	37,6	35,7	2,4	38,2	39,0	34,7	35,1	39,0	36,8	2,2	0,473
5	Athlete 4	46,2	43,7	48,5	50,1	50,1	47,1	2,8	44,3	42,7	39,4	43,7	44,3	42,5	2,2	-2,105
6	Athlete 5	38,7	38,9	36,8	37,2	38,9	37,9	1,1	34,4	35,2	33,7	31,6	35,2	33,7	1,5	-2,705
7	Athlete 6	43,7	43,7	43,0	36,9	43,7	41,8	3,3	37,2	36,3	38,4	36,5	38,4	37,1	0,9	-4,981
8	Athlete 7	41,5	41,0	40,1	44,1	44,1	41,7	1,7	39,3	40,7	40,0	38,3	40,7	39,6	1,0	-2,050
9	Athlete 8	43,4	41,7	40,2	37,9	43,4	40,8	2,3	39,5	37,8	38,9	36,5	39,5	38,2	1,3	-1,989
10	Athlete 9	46,7	47,9	48,2	46,4	48,2	47,3	0,9	43,1	43,5	45,3	38,6	45,3	42,6	2,8	-1,641
11	Athlete 10	41,1	38,3	41,8	40,0	41,8	40,3	1,5	41,5	41,1	44,4	40,2	44,4	41,8	1,8	0,826
12	Athlete 11	39,4	41,0	40,7	40,4	41,0	40,4	0,7	36,9	37,4	37,5	36,3	37,5	37,0	0,6	-6,091
13	Athlete 12	46,8	50,4	49,1	48,0	50,4	48,6	1,5	45,6	45,9	47,0	46,7	47,0	46,3	0,7	-3,456
14	Athlete 13	46,4	45,0	46,7	42,7	46,7	45,2	1,8	39,0	38,0	39,3	36,9	39,3	38,3	1,1	-6,352
15	Athlete 14	36,1	33,9	36,8	37,5	37,5	36,1	1,6	37,6	35,3	37,1	35,3	37,6	36,3	1,2	0,208
16																
17	Team	Pre	Post													
18	Mean	43,0	39,9													
19	SD	4,5	3,9													
20	Effect Size	-0,676														

Figure 2.23 Effect size calculation for each player CMJ assessments.

The interpretation of inference magnitudes I used were as follows (Hopkins et al., 2009):

- <0.2 = trivial ES;
- Between 0.2 and 0.6 = small ES;
- Between 0.6 and 1.2 = moderate ES;
- Between 1.2 and 2 = large ES;
- 2 = very large ES;

As seen in the example above, for that randomly selected week of training, the effect size used in Excel was based on the following calculation (Clemente & Silva, 2021):

$$ES = \frac{\text{Average CMJ Post} - \text{Average CMJ Pre}}{\text{Standard Deviation CMJ Pre}}$$

Where “Average CMJ Post” is the average of the 4 CMJ trials for each player after the match of that week. The “Average CMJ Pre” is the average of the 4 CMJ trials of each player before the match of that week, and the “Standard Deviation CMJ Pre” is the standard deviation of the 4 CMJ trials of each player before the match of that week. Moreover, I used the same ES calculation considering the team’s average and standard deviation as seen in cell “20” of column “T” of the Figure 2.23 above.

As can be seen in the Figure 2.23 above, the team revealed a meaningful decrease between weeks with a match in-between (dif: -7.1%; $d = -0.676$, moderate ES). In this

case, we inferred and communicate to the technical team that the overall team had meaningful decreases in neuromuscular performance after the last match. However, more important than the team values are the outliers. Given that, we and the coaches wanted to know which players were with the worst neuromuscular performance and adjust training for those players.

As represented in Figure 2.22 regarding the percentual differences between pre- and post-match CMJ assessments, it is possible to observe that almost all players had decreased neuromuscular performance after the last match. However, the “athlete 13” was the player with the highest meaningful decrease (dif: -15.8; $d = -6.352$, very large ES). Despite the “athlete 1” had a lower percentage difference than “athlete13”, he presented a greater meaningful change in CMJ performance (dif: -14.6; $d = -8.273$, very large ES). In this case, we had to communicate to the medical department and to technical team regarding those players with the greatest meaningful decreases.

2.8 GYM PRE-ACTIVITY

The high-performance department of “B” team was not allowed by the technical team to conduct any strength training to the team. This was because of the technical team training ideologies. For those reasons, we were only allowed to do pre-activity work before the first three sessions of the week, corresponding to MD -5 (recovery), -4 (tension) and -3 (duration).

Given that, I suggested the use of an interesting pre-activity protocol which could be used as a form of minimizing the risks of injury occurrence, based on a very recent research paper (Lahti et al., 2020). This paper sought to elaborate a multifactorial programme with an emphasis on hamstring muscle injury prevention. They were based on the modifiable intrinsic factors of hamstring muscle injuries which includes:

- Hamstring strength;
- Lumbo-pelvic strength;
- Strength imbalances;
- Range of motion (ROM);
- Lack or excess of sprints;

- Sprinting technique;

This study suggested the use of some tests to analyze mobility deficiencies, strength imbalances and flexibility issues to individualize training according to each player's needs. However, we had to rely on our own data from the testing battery we made at the beginning of the season, as we could not conduct any other tests due to time and logistic constraints. However, I have communicated with the medical department about this topic, and they told me which players were signaled by them regarding mobility and flexibility deficits. The pre-activity protocol adaptation based on that research can be seen in Figure 2.24.

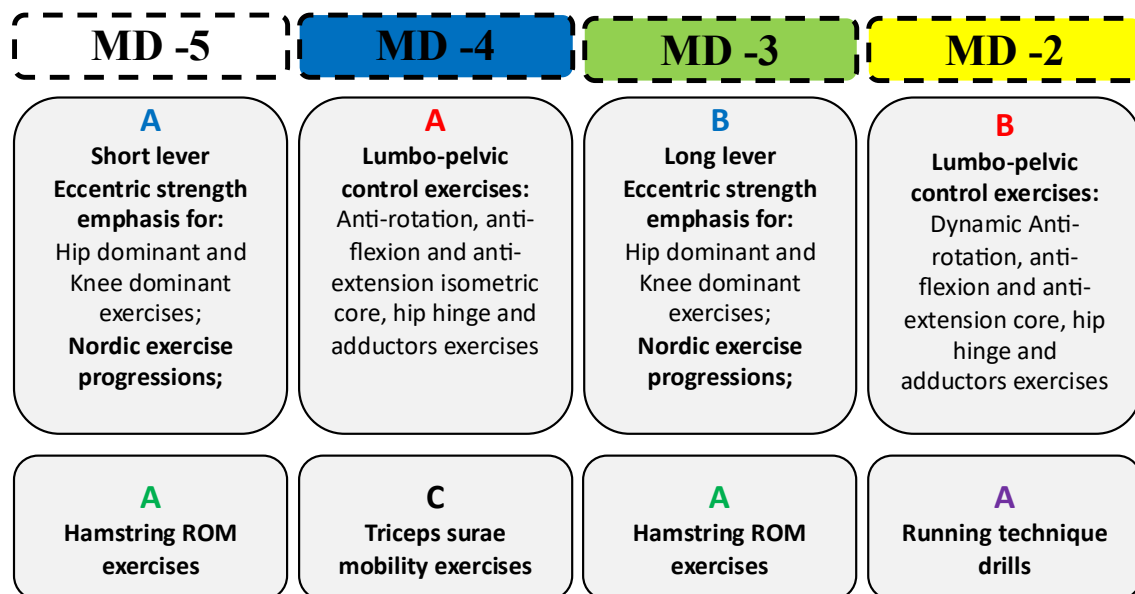


Figure 2.24 Multifactorial pre-activity protocol.

As mentioned above, due to time, logistic and technical team constraints, this pre-activity protocol was an adaptation of the protocol suggested by Lahti et al. (Lahti et al., 2020).

2.9 RETURN-TO-PLAY

Regarding the RTP process, my main tasks were: (i) to communicate with the medical department about the current state of each injured player; (ii) to know the injury mechanism of each player; (iii) to work with the athlete on the unaffected members before clinical discharge; and (iv) to conduct the RTP work on the affected member at the gym,

after clinical discharge. I was entrusted for carry out the return-to-play process for the players with minor injuries at first. However, I was responsible for the early stages of the RTP of an athlete with a patellar tendinopathy, which is discussed below.

2.9.1 RTP: A CASE OF PATELLAR TENDINOPATHY

This athlete with the patellar tendinopathy had this injury for about four years, and was never treated before. His tendon was very damaged as it was possible to see in the magnetic resonance imaging (MRI). Also, the “B” team medical department does not follow the criteria-based RTP as described in Chapter I. Instead, they follow more traditional medical-based protocols that excessively protects the players with all types of reasons. For those reasons, after a discussion with medical department staff, I proposed to conduct a criteria-based rehabilitation that was comprised of three main stages with a total duration of 12 weeks, which consisted on the following (Rutland et al., 2010):

- Stage 1: Initial rehab, controlled rest;
- Stage 2: Progression;
- Stage 3: Return-to-play (after clinical discharge);

The explanation of the three rehabilitation stages adapted from the above-mentioned evidence-based protocol is shown in Figure 2.25.

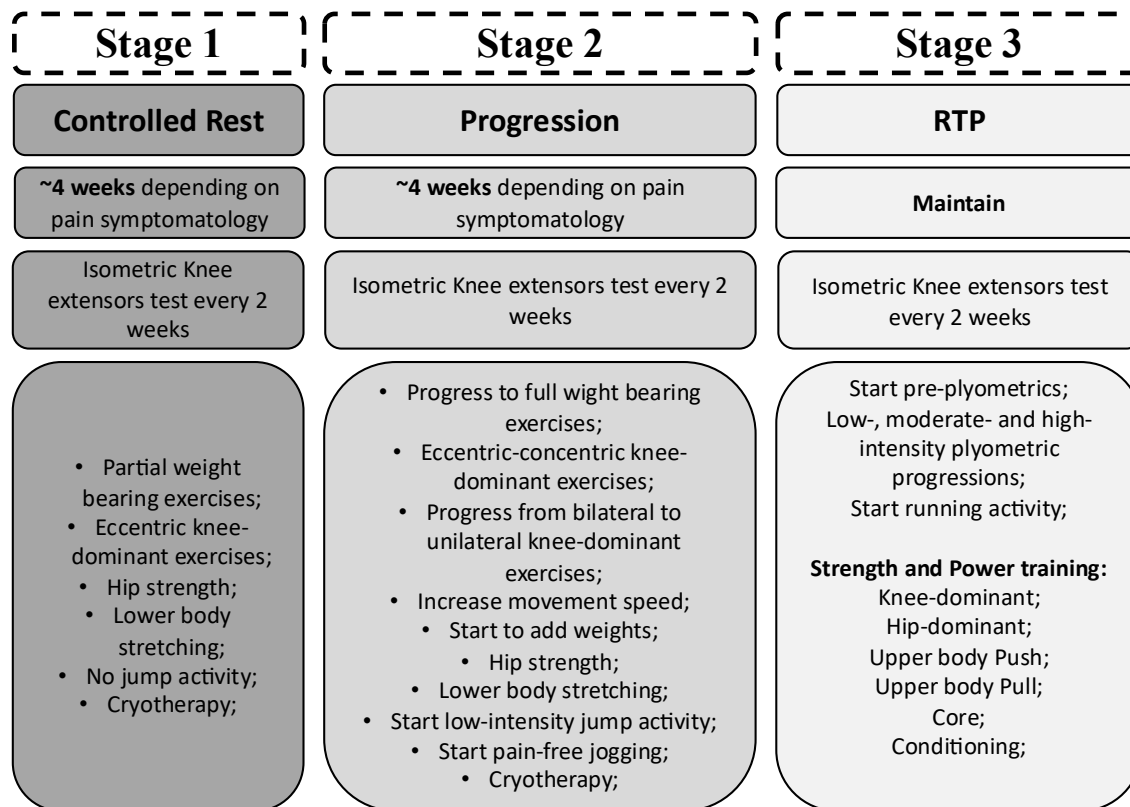


Figure 2.25 Patellar tendinopathy rehabilitation protocol stages.

All exercises conducted on this athlete, were initially pain-free, which was a progression criterion for more complex and loaded exercises. However, at advanced stages, a pain threshold of “3” from a 0-to-10 point scale was allowed, as previously recommended (Breda et al., 2021; Malliaras et al., 2015).

2.9.2 RTP: GYM WORK FOR INJURED PLAYERS

For the overall injured players, I ensured the strength and power training after the clinical discharge from the medical department. All training sessions during this phase of RTP were comprise of the following movement categories (Boyle, 2016):

- Lower body knee-dominant exercises;
- Lower body hip-dominant exercises;
- Upper body push exercises;
- Upper body pull exercises;
- Anti-rotation, flexion, and extension core exercises;

Given that, an example of a strength and power training session for an injured player in the gym phase of RTP can be seen in Figure 2.26.

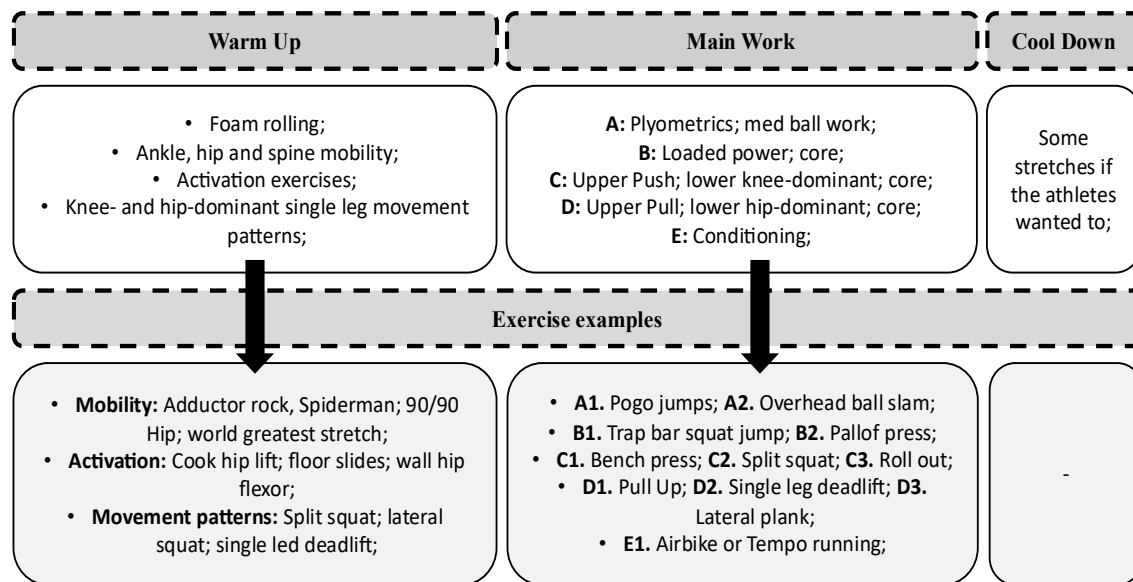


Figure 2.26 Example of a typical gym-based training session.

2.9.3 RTP: MICROCYCLE PERIODIZATION

Considering the microcycle periodization, the weekly training frequency of injured players were of approximately 5-to-6 training sessions. From those 5-6 training sessions, 4 sessions were comprised of the above-mentioned movement categories. The other 1-2 sessions were just light sessions comprised of mobility work and stability.

2.9.4 RTP: MESOCYCLE PERIODIZATION

Regarding the mesocycle periodization, I always ensured three training phases, with a duration of approximately 3-to-4 weeks for each phase. The first phase was comprised of higher volume and lower intensity (higher rep ranges), the second phase was comprised of lower volume and higher intensity (lower rep ranges). While, the third phase was usually an eccentric phase emphasis, or contrast training, depending on each athlete (Boyle, 2016). This is equal to 9-12 weeks of training, and after that I asked the head of high-performance department from “B” team and medical department to re-evaluate the strength levels of the athletes before return to full sport.

2.9.5 RTP STAGES

The RTP process in “B” team was always discussed with the medical department and one member of the technical team once a week. During each meeting, we discussed the current evolution of each injured player and the possible progressions to be made. The usual RTP stages that the “B” team followed can be seen in the Figure 2.27 below.

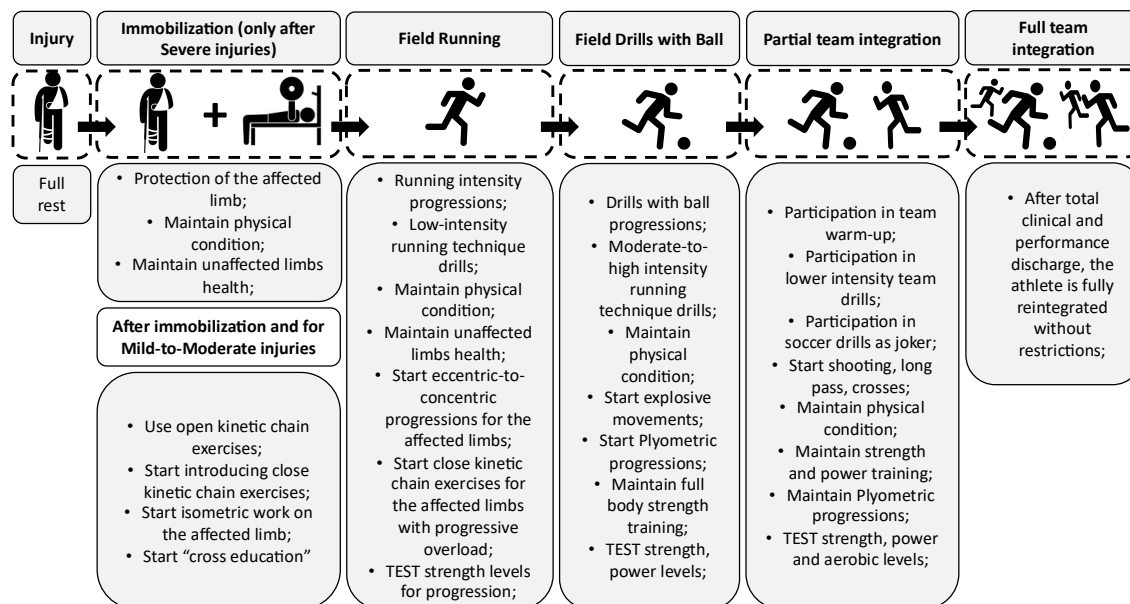


Figure 2.27 Typical RTP stages of “B” team.

During the first days or weeks after a new injury, depending on the severity and location of the injury, the athletes were the responsibility of the medical department. During this stage, the athletes performed gym work to maintain their physical condition and to ensure that the unaffected body parts maintained healthy during the RTP process.

For instance, an athlete with a hamstring muscle injury in the right leg, performed the same training session structure as illustrated in the Figure 2.27 above. However, the affected limb maintained immobilized and protected. Although working only on the unaffected limb during a period of time scared some athletes (an injury on the right leg and working the left one), a very interesting phenomenon called “cross-education”, which was described in Chapter I, helped me explain to athletes why I use such a training method, so that they would trust my work.

2.10 VSC LAB: PROPOSAL

Regarding my proposal of creating the Vitória Sport Clube researching laboratory (VSC LAB), I presented a project to the head of high-performance department from “A” team, which consisted of the following main objectives:

- Early Talent Selection;
- Identify the evolution status of the academy athletes;
- Identify the athletes with greater and lesser potential;
- Enhance the tactical and physical qualities of athletes longitudinally;
- Create a culture of periodic assessment for athletes and coaches from U13 and above;
- Create a training monitoring culture for athletes and coaches from U15 and above;

Furthermore, the presented project had secondary objectives which consisted of the following:

- Monthly internal courses/learning sessions about different soccer training topics;
- Produce scientific research with the data collected from all teams;
- Promote external courses;

Regarding the monthly internal courses/learning sessions, the objective was to strengthen the competence of the club's human resources. Through the production of scientific research, the objectives were the following:

- Disseminate the club in the scientific community;
- Promote the club as a research and qualification entity;
- Promote attraction to the club;
- Invite national and international authors to participate and support the club's research;

Moreover, the periodic assessments proposal for all the club's teams can be seen in the Figure 2.28.

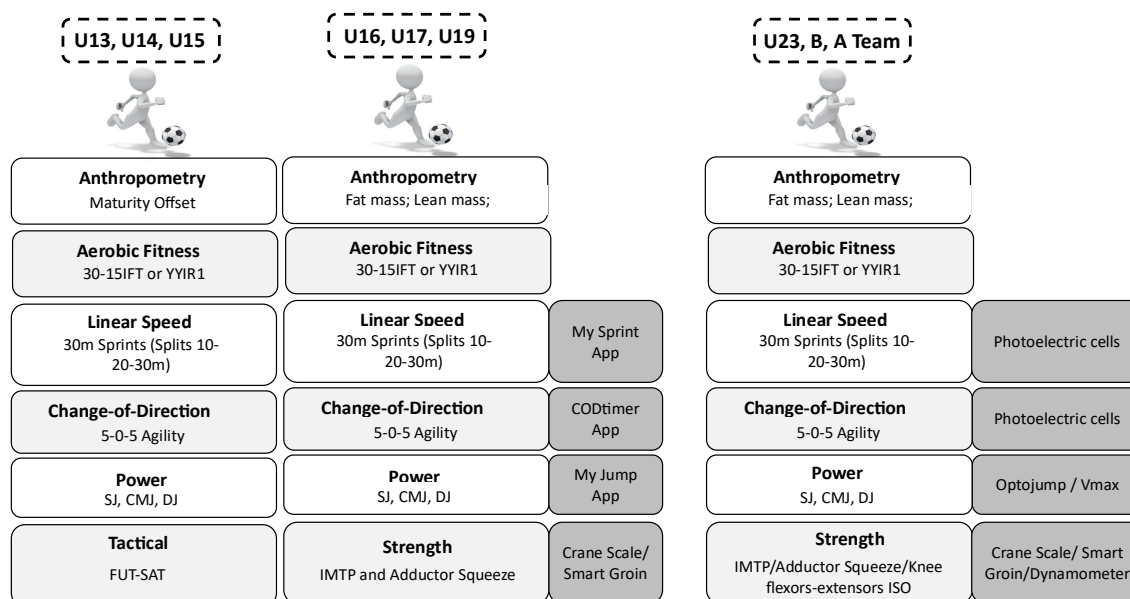


Figure 2.28 Periodic assessments proposal.

For training monitoring practices, the proposal that I made was comprised of the following dimensions shown in Figure 2.29:

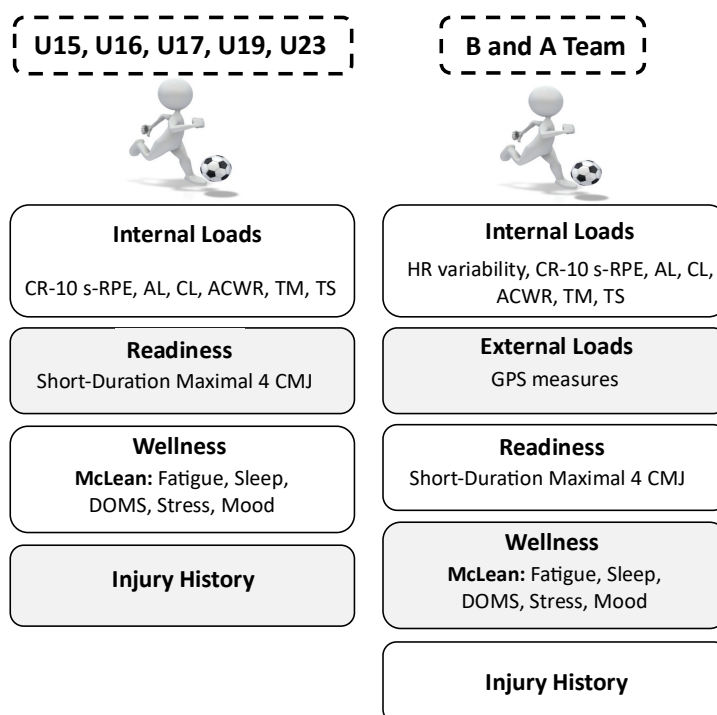


Figure 2.29 Training monitoring proposal.

2.10.1 VSC LAB: DATA COLLECTION

As mentioned earlier, I proposed the use of an automated Excel document with all teams collected data. The objective was to gather all data from all teams in a uniformized fashion to avoid possible data loss. This way, we could use all this information to produce scientific research base on club's own data. Bellow in Figure 2.30 it can be seen all the tests used in the Excel file and its respective Z-scores.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Nome	CMJ Zscore	SJ Zscore	DJ Zscore	RSJ Zscore	30m Sprint Zscore	20m Split Zscore	10m Split Zscore	5-0-5 Zscore	Add Squeeze (45°) Zscore	30-15IFT Zscore	30-15IFT (Vo2max) Zscore	30-15IFT (MAS) Zscore
2	Athlete 1	1,8	2,2	-3,2	-3,2	-2,9	-2,3	-0,3	-0,4	0,9	-2,0	-1,5	-1,5
3	Athlete 2	-2,3	-0,5	0,6	-3,2	-0,2	0,4	-0,3	1,0	-1,9	-0,8	-1,1	-1,1
4	Athlete 3	0,2	0,6	0,6	-3,2	0,5	-0,5	1,1	-1,0	0,2	0,8	1,2	1,2
5	Athlete 4	0,5	-0,8	-0,3	-3,2	-0,2	1,3	1,8	-1,0	1,2	0,8	0,7	0,7
6	Athlete 5	-1,1	-0,2	0,6	-3,2	-0,2	0,4	1,8	1,0	1,0	-0,8	-0,8	-0,8
7	Athlete 6	-0,1	0,9	0,2	-3,2	-0,2	1,3	-1,0	1,0	-0,8	-0,8	-1,0	-1,0
8	Athlete 7	0,5	-0,8	-0,2	-3,2	-0,2	-0,5	-1,0	1,0	0,6	0,8	0,8	0,8
9	Athlete 8	-0,5	-1,4	0,3	-3,2	1,1	-0,5	0,4	-1,0	-0,2	-0,8	-1,1	-1,1
10	Athlete 9	-0,5	-0,2	0,4	-3,2	1,1	0,4	-0,3	-1,0	-0,6	0,8	0,6	0,6
11	Athlete 10	0,8	0,3	0,0	-3,2	0,5	-0,5	-0,3	1,0	0,6	0,8	0,9	0,9
12	Athlete 11	-0,5	-0,8	0,3	-3,2	-0,2	-0,5	-0,3	1,0	1,0	0,8	1,0	1,0
13	Athlete 12	0,5	-0,5	0,5	-3,3	0,5	-0,5	-1,0	-1,0	-1,3	0,8	1,0	1,0
14	Athlete 13	0,8	1,2	0,1	-3,2	0,5	1,3	-1,0	-1,0	-0,8	-0,8	-0,5	-0,5
15	Athlete 14	-2,6	0,3	0,3	-3,2	1,1	-0,5	1,1	-1,0	0,6	0,8	0,4	0,4
16	Athlete 15	0,2	-3,4	0,2	-3,2	0,5	0,4	1,1	1,0	-1,1	0,8	0,3	0,3
17	Athlete 16	-2,3	0,9	0,3	-3,3	0,5	0,4	-1,0	-1,0	1,0	0,8	0,6	0,6
18	Athlete 17	-2,9	-0,2	0,3	-3,2	0,5	0,4	1,1	1,0	-1,9	-0,8	-0,4	-0,4
19	Athlete 18	1,1	0,9	0,1	-3,2	1,1	-0,5	0,4	-1,0	-0,6	-0,8	-1,0	-1,0
20	Athlete 19	-2,3	0,3	0,4	-3,2	1,8	1,3	-1,0	-1,0	-1,3	0,8	0,7	0,7
21	Athlete 20	0,2	-1,7	0,2	-3,2	-0,2	0,4	0,4	3,0	0,8	-0,8	-0,9	-0,9

Figure 2.30 Z-scores of the tests used for all teams.

Moreover, I made a section for comparisons between pre and post assessments in percentage differences with flag alerts >10%. The Figure 2.31 illustrates the between-assessment percentage differences section.

	A	B	C	D	E	F	G	H	I	J
1	Nome	CMJ Best_av1	CMJ Best_av2	CMJ Best_%Dif	SJ Best_av1	SJ Best_av2	SJ Best_%Dif	DJ Best_av1	DJ Best_av2	DJ Best_%Dif
2	Athlete 1	47,4	48	1,3	48,4	20	-58,7	2,49	1,2	$=(I2-H2)*100/H2$
3	Athlete 2	37	42	13,5	36	43	19,4	45	33	-26,7
4	Athlete 3	39	29	-25,6	44	32	-27,3	28	41	46,4
5	Athlete 4	43	29	-32,6	44	44	0,0	41	41	0,0
6	Athlete 5	42	35	-16,7	44	42	-4,5	36	30	-16,7
7	Athlete 6	36	30	-16,7	38	33	-13,2	31	45	45,2
8	Athlete 7	41	41	0,0	40	39	-2,5	34	34	0,0
9	Athlete 8	43	42	-2,3	43	37	-14,0	39	44	12,8
10	Athlete 9	42	28	-33,3	29	37	27,6	44	40	-9,1
11	Athlete 10	43	34	-20,9	39	41	5,1	31	37	19,4
12	Athlete 11	40	33	-17,5	45	45	0,0	36	31	-13,9
13	Athlete 12	44	30	-31,8	39	38	-2,6	30	35	16,7
14	Athlete 13	42	43	2,4	39	39	0,0	36	38	5,6
15	Athlete 14	43	28	-34,9	43	40	-7,0	39	29	-25,6
16	Athlete 15	42	42	0,0	44	42	-4,5	45	31	-31,1
17	Athlete 16	31	37	19,4	44	28	-36,4	33	31	-6,1
18	Athlete 17	43	38	-11,6	42	41	-2,4	45	35	-22,2
19	Athlete 18	45	28	-37,8	43	37	-14,0	39	28	-28,2
20	Athlete 19	41	28	-31,7	44	42	-4,5	36	33	-8,3
21	Athlete 20	40	32	-20,0	45	44	-2,2	28	31	10,7

Figure 2.31 Between-assessment percentage differences.

From those differences, a graphic was produced for each test percentual differences of each athlete. The Figure 2.32 illustrates an example.

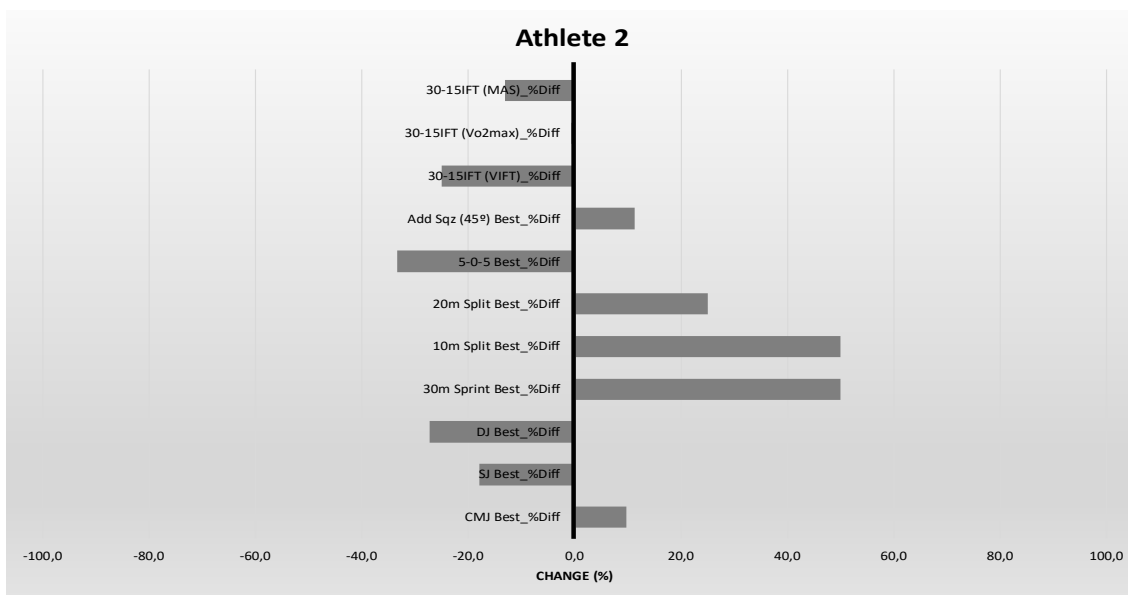


Figure 2.32 Example of a percentual difference graphic for periodic assessments.

For each athlete, it was also produced the smallest worthwhile changes (SWC) for each of the tests used. The Figure 2.33 illustrates the calculation of such magnitude-based method.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1		CMJ Best	SWC	SJ Best	SWC	DJ Best	SWC	RSI	SWC	30m Sprint Best	SWC	10m Split Best	SWC	20m Split Best	SWC	5-0-5 Best	SWC	Add Squeeze (45°) Best	SWC	30-15IFT (Vo2max)	SWC	30-15IFT (MAS)	SWC
2	Athlete 1	47,4	51,4	48,4	52,4	2,49	6,5	2,3	2,5	4	3,2	4	3,3	4	3,6	2,3	2,1	47,4	51,7	3,2	3,6	5,6	5,7
3	Athlete 2	37	41,0	33	37,0	38	42,0	2	2,2	8	7,2	7	6,3	4	3,6	2	1,8	45	49,3	4	4,4	5,8	5,9
4	Athlete 3	34	38,0	41	45,0	43	47,0	1	1,2	8	7,2	7	6,3	5	4,6	2	1,8	44	48,3	5	5,4	6,7	6,8
5	Athlete 4	45	49,0	39	43,0	37	41,0	2	2,2	9	8,2	6	5,3	3	2,6	2	1,8	44	48,3	5	5,4	6,5	6,6
6	Athlete 5	45	49,0	45	49,0	42	46,0	2	2,2	10	9,2	6	5,3	5	4,6	3	2,8	48	52,3	3	3,4	5,3	5,5
7	Athlete 6	39	43,0	38	42,0	41	45,0	2	2,2	8	7,2	6	5,3	3	2,6	2	1,8	38	42,3	3	3,4	5,2	5,4
8	Athlete 7	41	45,0	37	41,0	45	49,0	2	2,2	8	7,2	7	6,3	6	5,6	2	1,8	32	36,3	5	5,4	6,5	6,7
9	Athlete 8	42	46,0	45	49,0	45	49,0	2	2,2	9	8,2	6	5,3	3	2,6	3	2,8	49	53,3	3	3,4	5,2	5,3
10	Athlete 9	37	41,0	44	48,0	31	35,0	2	2,2	8	7,2	6	5,3	4	3,6	2	1,8	45	49,3	4	4,4	5,9	6,0
11	Athlete 10	39	43,0	40	44,0	43	47,0	2	2,2	8	7,2	6	5,3	3	2,6	2	1,8	45	49,3	4	4,4	6,0	6,2
12	Athlete 11	45	49,0	42	46,0	35	39,0	2	2,2	8	7,2	8	7,3	3	2,6	2	1,8	47	51,3	3	3,4	5,5	5,7
13	Athlete 12	39	43,0	38	42,0	41	45,0	2	2,2	9	8,2	6	5,3	3	2,6	2	1,8	47	51,3	4	4,4	6,0	6,2
14	Athlete 13	35	39,0	42	46,0	42	46,0	2	2,2	8	7,2	8	7,3	6	5,6	2	1,8	44	48,3	4	4,4	6,0	6,1
15	Athlete 14	40	44,0	43	47,0	45	49,0	2	2,2	8	7,2	9	8,3	4	3,6	2	1,8	45	49,3	5	5,4	6,3	6,5
16	Athlete 15	43	47,0	38	42,0	37	41,0	2	2,2	8	7,2	7	6,3	6	5,6	2	1,8	35	39,3	5	5,4	6,3	6,5
17	Athlete 16	44	48,0	37	41,0	42	46,0	2	2,2	12	11,2	6	5,3	5	4,6	2	1,8	34	38,3	3	3,4	5,4	5,5
18	Athlete 17	45	49,0	45	49,0	43	47,0	2	2,2	10	9,2	7	6,3	4	3,6	4	3,8	41	45,3	5	5,4	6,5	6,7
19	Athlete 18	44	48,0	44	48,0	40	44,0	2	2,2	8	7,2	6	5,3	5	4,6	3	2,8	47	51,3	4	4,4	5,8	6,0
20	Athlete 19	38	42,0	44	48,0	41	45,0	2	2,2	9	8,2	7	6,3	4	3,6	2	1,8	43	47,3	3	3,4	5,4	5,6
21	Athlete 20	45	49,0	42	46,0	43	47,0	2	2,2	9	8,2	6	5,3	3	2,6	2	1,8	50	54,3	5	5,4	6,4	6,5
22	Athlete 21	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
23	Athlete 22	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
24	Athlete 23	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
25	Athlete 24	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
26	Athlete 25	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
27	Athlete 26	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
28	Athlete 27	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
29	Athlete 28	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
30	Athlete 29	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
31	Athlete 30	0	4,0	0	4,0	0	4,0	0	0,2	0	-0,8	0	-0,7	0	-0,4	0	-0,2	0	4,3	0	0,4	7,5	7,6
32																							
33	Mean	27,5		27,5		25,9		1,3		5,6		4,4		2,8		1,5		29,0		2,7		6,4	
34	DP	20,0		20,0		20,1		1,0		4,2		3,3		2,2		1,2		21,3		2,0		0,8	
35	SWC	4,0		4,0		4,0		0,2		0,8		0,7		0,4		0,2		4,3		0,4		0,2	

Figure 2.33 SWC calculation for each test.

The SWC magnitude-based method is of great usefulness for high-performance sports as it is sensible to even the smallest changes (Swinton et al., 2018). In high-performance, a little change may mean a lot. Also, the SWC colored in green for each athlete, as seen above in Figure 2.33, can be used as a goal to achieve in the next assessment. This may increase the competition between athletes, and their commitment to pursue such objectives.

The final section of this Excel file, is related to the maturity offset to be used for the youth teams. Below, the Figure 2.34 illustrates the calculations in Excel.

$$=-9,236+0,0002708*[@[Leg length (cm)]]*[@[Seated Height (cm)]]-0,001663*[@Age]*[@[Leg length (cm)]]+0,007216*[@Age]*[@[Seated Height (cm)]]+0,02292*([@[Seated Height (cm)]]-[@[Seated Height (cm)]])/[@[Height (cm)]]$$

	G	H	I	J	K	L	M	N	O	P	Q	R	S
			Nome	Age	Body Mass (Kg)	Height (cm)	Seated Height (cm)	Leg length (cm)	Maturity Offset				
			Athlete 1	14	62	170	80	90					
			Athlete 2	16	57	160	67	93	-2,3				
			Athlete 3	14	49	159	63	96	-3,5				
			Athlete 4	15	56	165	74	91	-1,7				
			Athlete 5	15	62	170	60	110	-3,7				
			Athlete 6	15	68	175	75	100	-1,6				
			Athlete 7	14	65	170	72	98	-2,3				
			Athlete 8	16	59	166	73	93	-1,4				
			Athlete 9	15	60	165	60	105	-3,6				
			Athlete 10	14	61	164	64	100	-3,4				
			Athlete 11	14	58	166	64	102	-3,4				
			Athlete 12	14	57	165	71	94	-2,4				
			Athlete 13	14	64	159	68	91	-2,8				
			Athlete 14	15	66	149	67	82	-2,5				
			Athlete 15	15	71	170	66	104	-2,8				
			Athlete 16	14	70	178	69	109	-2,8				
			Athlete 17	14	60	167	61	106	-3,8				
			Athlete 18	15	67	180	67	113	-2,7				
			Athlete 19	14	69	166	70	96	-2,6				
			Athlete 20	15	65	165	63	102	-3,2				
			Athlete 21	0	0	0		0	#DIV/0!				
			Athlete 22	0	0	0		0	#DIV/0!				
			Athlete 23	0	0	0		0	#DIV/0!				
			Athlete 24	0	0	0		0	#DIV/0!				
			Athlete 25	0	0	0		0	#DIV/0!				
			Athlete 26	0	0	0		0	#DIV/0!				
			Athlete 27	0	0	0		0	#DIV/0!				
			Athlete 28	0	0	0		0	#DIV/0!				
			Athlete 29	0	0	0		0	#DIV/0!				
			Athlete 30	0	0	0		0	#DIV/0!				

Figure 2.34 Maturity offset calculation.

My perspectives were for all staff from the club's high-performance department to use this file for their data collection and training prescription. Fortunately, this was possible, and all teams started to collect data with this file and all the above-mentioned strategies.

CHAPTER 3

3 APPLIED RESEARCH

3.1 PAPER 1

Physical fitness changes among amateur soccer players: Effects of the pre-season period.

Silva, R., Lima, R., Camões, M., Leão, C., Matos, S., Pereira, J., Bezerra, P., & Clemente, F. M. (2021). Physical fitness changes among amateur soccer players: Effects of the pre-season period. *Biomedical Human Kinetics*, 13(1), 63–72.
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Physical fitness changes among amateur soccer players: effects of the pre-season period

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Abstract

Study aim: To assess changes in physical fitness of amateur soccer players after a pre-season training period and baseline fitness dependencies. **Material and methods:** Twenty-one amateur soccer players were assessed during the pre-season. The following physical variables were assessed before and after a two-month pre-season training period: (i) cardiorespiratory fitness, (ii) strength and power, and (iii) change of direction (COD). **Results:** Significant decreases were found for countermovement jump (CMJ) ($p < 0.001$; $d = 1.161$), drop jump (DJ) ($p = 0.014$; $d = 0.958$), and horizontal jump (HJ) ($p = 0.042$; $d = 0.640$), while no significant changes were found for the overall variables from the beginning to the end of pre-season. Fit players revealed significant decreases for CMJ ($p = 0.002$; $d = -2.495$), DJ ($p = 0.004$; $d = -1.760$), HJ ($p = 0.028$; $d = -1.005$), COD deficit ($p = 0.034$; $d = 1.013$), and maximal aerobic speed (MAS) ($p = 0.026$; $d = -4.053$). No significant changes were found for unfit players. **Conclusions:** Amateur soccer coaches should consider assessing physical qualities at the beginning of pre-season and use the free-of-charge monitoring tools such as session-rate of perceived exertion (s-RPE) during the training process.

Keywords: Soccer; Performance; Sports training; Physical fitness; Pre-season

Introduction

Soccer is characterized by its intermittent nature, in which players are expected to perform mainly low-intensity running activities interspersed with high-intensity explosive actions during both training and competition [2]. This requires that soccer players maintain adequate aerobic and anaerobic capacity. Soccer players have shown average of VO₂max values between 51 and 62.9 ml · kg⁻¹ · min⁻¹ [5], and maximal aerobic speed ranging between approximately 13 and 17 km/h [3]. Considering the high-intensity actions, players are required to perform sprints, jumps, changes-of-direction, accelerations and decelerations during training and competition, which are associated with the athletes' strength and power capacity [39].

On one hand, during training, adult elite soccer players can cover total distances that reach approximately 7000 m during a training/practice session, of which 990 m are covered at high speeds and approximately 337 to 444 m are covered at sprint speeds [8]. Up to 178 m can be covered while accelerating, and up to 162 m can be covered while decelerating [13]. On the other hand, during a match, elite players can perform a total of approximately 15 header jumps and can cover a total distance of about 10 km to 13 km [2]. Meanwhile, amateur players tend to cover about 5% less distance. However, elite players cover about 2.43 km while running at a high intensity and 0.65 km at a sprint, with amateur players covering 28% and 58% less, respectively, at these speeds [23]. Also, recent research has revealed the importance of strength in the overall soccer training process, which seems to be associated with greater physical fitness development [26, 32]. As mentioned above, soccer players need high levels of aerobic capacity to sustain the more than 70% of lower-intensity actions during a match [2]. Also, they need high levels of strength, which is related to acceleration and sprint ability, as well as power-related tasks such as vertical jumps that are required for disputes in the air and scoring header goals [37, 39].

Based on the training loads and other multifactorial life stressors, variations throughout the season should be addressed with regard to players' body composition, level of physical fitness, and motor skills [22]. The season can be organized into three different phases with different types of stimuli, and it would be convenient to expect changes in the aforementioned variables as a result [2]. For instance, the aerobic power

and the time to exhaustion seem to increase throughout the first phase of the season. This is typically followed by a maintenance phase through to the end of the season [22]. Also, there seem to be differences in squat jump (SJ) and countermovement jump (CMJ) performance between the pre-season and the middle of the season. Specifically, a 10.1% increase in the height reached in the SJ and a 9.8% increase for the CMJ have been reported. Furthermore, a 13.7% increase in 1 repetition maximum (1RM) for the deadlift during the pre-season has been observed, and this increased to 6% during the mid-season [15]. It has been reported that strength training of the upper body improves VO₂max by 2.6% and of upper body maximal strength by 30%, resulting in gains related to the ability to react faster and engage in body contact with opponents [31]. The changes observed in physical fitness in adult athletes have been well documented. In fact, improvements in aerobic and anaerobic fitness were shown after the pre-season period, in a study conducted on 23 male soccer players from a first league Israeli team, in which the authors associated those improvements with the type of training implemented during that particular period of the season [21].

Soccer players have demonstrated reasonable levels of physical fitness, with high values of VO₂max. [7]. However, these values can vary according to the different tactical positions of the players. Midfielders have the highest VO₂max values, followed by defenders, forwards, and, finally, goalkeepers [33]. At the beginning of the pre-season, the athletes have a relatively low level of fitness due to the off-season period, presenting lower VO₂max values, although improvements of 7% versus the post-preseason are achieved and only 2% of improvements remain until the mid-season, and VO₂max is then maintained for the rest of the season [21].

The changes observed during the season seem to depend on the values observed at the beginning of the pre-season, which may be related to the low values that the players present at the end of the off-season. In fact, a recent study conducted on 130 elite Spanish soccer players showed that the assumption that at the end of a pre-season period an improvement in aerobic fitness is expected may not be so straightforward as the changes observed after the pre-season period tend to vary significantly between seasons [18]. Thus, the effect of training stimuli significantly increases these values until a

plateau is reached [22]. In addition, the improvements in VO₂max allow athletes to cover 20% greater distances at high intensities (i.e., at >90% of their maximal heart rate). Positive changes have also been found in terms of athletes' physical fitness during the three different periods of the season (off-season, pre-season and in-season). The time spent in the 40-m and 20-m sprint decreases by 2% from the pre-season to the off-season. This decrease could be related to the soccer conditioning and might be subject to variations in the different periods of the season [14].

Furthermore, a decrease in the time of execution of the pro-agility test of approximately 3% has been observed from the pre-season to the post-season. Also, decreases of 3%, 4%, and 1% have been reported for the 10-m, 30-m, and 40-m sprint, respectively, from the pre-season to the post-season [19]. To assess the maximum strength of soccer athletes, the isometric mid-thigh pull (IMTP) test has been used, and it seems to be correlated with movements that are typical of good performance in soccer players, such as sprint speed and vertical jump height [36]. For instance, an investigation aimed to assess the relationship between strength, sprint speed, agility, and IMTP test performance in rugby athletes. Positive correlations were observed between the IMTP and 1RM squat, the time to complete a 5-m sprint, and the time taken in the pro-agility test [36], which is perceived as a viable test for measuring the motor skills that are inherent in soccer performance.

Anthropometric, physical fitness, and motor skill changes are well documented in elite soccer players [17, 20]. However, there is a lack of evidence about the influence of the pre-season period on changes in the fitness status of amateur players. Evidence is also scarce concerning the role of baseline values in such changes. The evidence above demonstrates the importance of an adequate understanding of the physical demands of soccer and their changes even in amateur competitions. In addition, it is essential to collect data on the athletes' initial state at the beginning of the season, to track positive or negative changes during the training process. This provides amateur soccer coaches and athletes with the tools necessary for better training planning and to adjust training accordingly.

For those reasons, the first purpose of this study was to investigate changes in fitness levels after a pre-season training period; and the second purpose was to describe amateur players' physical changes in relation to their base- line fitness levels. We hypothesize that physical fitness will improve after a training period in the different outcomes.

Material and methods

Participants

The sample consisted of 21 amateur soccer players (age: 23.6 ± 7.3 years old; body height: 178.2 ± 0.1 cm; body mass: 75.2 ± 9.2 kg in the first assessment and 76.0 ± 9.2 kg in the second assessment; fat mass percent- age: $11.5 \pm 2.0\%$ in the first assessment and $10.9 \pm 1.7\%$ in the second assessment). All players were from the same team and were competing in the 2019/2020 season of the first division of the Portuguese Amateur Championship.

The participants comprised two goalkeepers, four central defenders, one external defender, six midfielders, five wingers, and two forwards. Players were assessed at two different times: (i) at the beginning of the pre-season phase (July 2019) and (ii) two months later (i.e., at the end of the pre-season) (September 2019). During the pre-season period, players trained four times a week (~90 minutes/ session) and participated in one friendly match each week. The inclusion criteria were: (i) participation in both assessments and (ii) not being injured throughout the period of assessment and between assessments for more than one week. Before being assessed, the player was informed of the study's protocol and procedures. After their voluntary agreement, they signed a free informed consent form. The study followed the ethical standards of the Declaration of Helsinki for research in humans. The study was approved by the local scientific committee with the code number ESDL.2019.07.001.

Study design

This study used a within-subjects observational cohort design to examine changes in participants' aerobic and anaerobic performance via physical performance tests. Anthropometric measures (body mass, height, fat mass percentage), cardiorespiratory fitness (Bronco test, maximal aerobic speed), strength and power (isometric mid-thigh pull, squat jump, countermovement jump, drop jump, horizontal jump), and agility and speed (pro-agility) were assessed twice – once before the beginning of the pre-season training phase (July 2019) and again at the end of the pre-season period (September 2019). After the first assessment (baseline), the median values for each fitness test were determined. Based on these values, players within the upper limit (better than the median) were classified as fit players, and the other players were classified as unfit players. This classification was done for each test; thus, a player may have been classified as fit in some tests and unfit in others. We decided to analyze the changes between the baseline and the post-training assessments for fit and unfit players in order to verify whether baseline levels influenced improvements or declines in players' performances. Both assessments took place under similar conditions. Both were done 48 hours after the last training session/ match, on the same day of the week (Monday) at the same time (5:00 p.m.) on natural turf and were carried out by the same trained sports science technicians.

Anthropometrics and body composition

Body weight was measured to the nearest 0.1 kg using a Tanita BC-601 instrument, and height was measured using a stadiometer to the nearest 0.1 cm (Seca 217, Hamburg, Germany). Skinfold thickness was measured at eight sites (triceps, biceps, subscapular, suprailiac, supraspinal, abdominal, thigh, and calf) using a skinfold caliper (Harpenden, West Sussex, UK). Girth was measured at four sites (arm relaxed, arm flexed, thigh, and calf) using a Cescorf flexible anthropometric tape. Body fat percentage was calculated using the formula recommended by Reilly [29].

All measurements were performed by the same experienced and certified observer who had a level 2 certification from the International Society for the Advancement of Kinanthropometry (ISAK), using the standardized techniques of the ISAK.

Cardiorespiratory fitness

To assess cardiorespiratory fitness, all players performed the 1200-m shuttle run test (Figure 1) (also known as the Bronco test), as previously described by Kelly and Wood [16]. Players had to perform five repetitions as fast as they could, starting at a baseline cone and then running forward to the next cone 20 m away. They then returned to the baseline and performed another forward run to a cone 40 m away. They returned to the baseline once again before making a final forward run to a cone 60 m away and finishing the test by returning to the baseline. Players were familiarized with the test before performing it, thus increasing the accuracy of their pace during the test.

To determine the lowest speed at which VO₂max occurred (e.g., the maximal aerobic speed (MAS)), the total time, in seconds, taken to complete the test was recorded. MAS was then calculated by dividing the 1200-m distance by the recorded time. However, the time recorded for each player was corrected according to the following equation: $MAS = 1200 / (\text{time in seconds} - 20.3)$ [1].

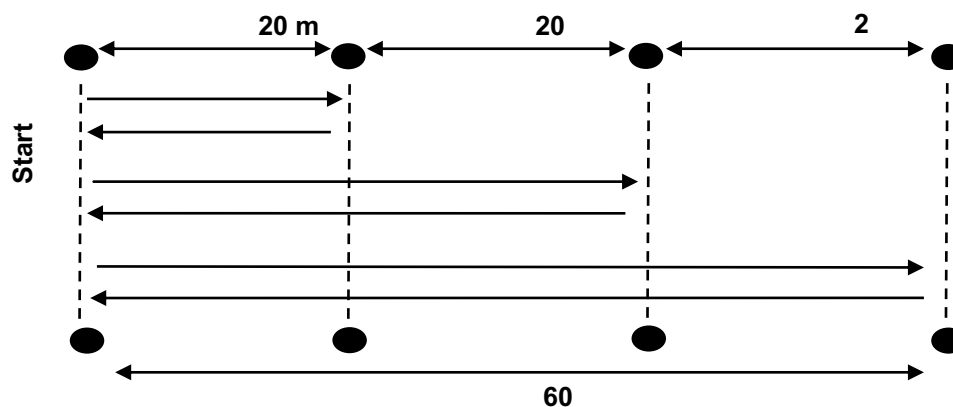


Figure 3.1. 1200-m shuttle (The Bronco) test configuration

Strength and power

For the assessment of strength and power, the isometric mid-thigh pull test (IMTP), squat jump (SJ), counter-movement jump (CMJ), drop jump (DJ), and horizontal jump

(HJ) tests were conducted on all players. A description and demonstration of the procedures were given before the test commenced.

For the IMTP test, a single ratchet strap was placed around a weight plate and attached to a crane scale that was already attached to a bar. The players were instructed to adjust the position of the bar to a comfortable (mid- thigh) position by shortening or lengthening the ratchet straps before performing the pull. Then, the players were instructed to pull the bar with the maximum strength they could and to maintain the pull for three seconds. They were then given five seconds to rest. This process was then repeated twice. The peak force produced during the test was registered by recording all the trials on video and later analyzing them in slow motion. All measurements were recorded in kg but were later converted into newtons (N) by calculating the peak force in kg multiplied by gravity. The average of peak force, both in kg and N, for each of the three trials was calculated. The relative force was also recorded by dividing the peak force, in N, by the player's body mass. The IMTP test using a crane scale has been documented and proven to be a valid and reliable method that is not significantly different from the force plates method [35].

The vertical SJ, CMJ, and DJ tests were performed on a DIN-A2 contact platform (Chronojump, Spain) connected to a Chronopic 3 microcontroller. This device was connected to a portable computer with Chronojump free software installed so that it could analyze the received information. The Chronojump contact platform, micro- controller, and software used are known to be valid and reliable tools for measuring vertical jump times. For all frequencies at which the microcontroller was tested, the mean absolute errors were 0.13% and 0.14% for contact time and in-flight time, respectively. Also, a difference of only $1.40 \pm 0.92\%$ was found, and an intraclass correlation coefficient (ICC) of 0.95 was observed between the DIN-A2 contact platform and the Ergojump-Boscosystem platform reference measure [4].

All players were told to stand on top of the contact platform and perform a practice jump for each jump test. Then, three trials were performed; each player's best score of the three vertical jump tests was recorded. For the SJ test, players were instructed to place their hands on their hips during the full movement to prevent arm swinging, and

they were to start the movement from a knee flexion position that they were to hold for three seconds before jumping as high as possible and landing in the same place on the contact platform.

For the CMJ test, players started from a standing position with both hands on their hips and allowed their comfortable depth of knee flexion in the descending phase of the jump to be determined. During the flight, players had to maintain hip and knee extension while jumping as high as possible and landing in the same place and with both feet at the same time without removing their arms from their hips.

For the assessment of reactive jump capacity, the DJ test was performed. Players started from a standing position on top of a 30-cm-high box with both hands on their hips. When the players were instructed to start the test, they initiated the movement by stepping a single leg out of the box and then dropping their body on the force plate. Then, as the players reached the ground, they started the vertical take-off as fast as possible with their knee and hip joints extended. This was followed by the second landing, for which players were instructed to land with their weight correctly distributed and to assume a half-squat position to absorb the impact of the jump.

For the assessment of the horizontal jump, players started from a standing position and were allowed to swing their arms and bend their knees in a comfortable position. They were then to jump as far as possible without losing their balance when landing with both feet simultaneously. A loss of balance resulted in a null attempt, meaning that the player needed to repeat the trial. A metric measuring tape was attached to the ground to measure the jump length, and a take-off line was placed on the ground using tape. The measurement was taken at the back of which- ever heel was the furthest back. All horizontal jumps were repeated three times, and the best score was recorded.

Change of direction and speed

For the assessment of speed and change of direction (COD), the pro-agility test (Figure 2) was conducted as previously described [34], in which three pairs of photocells (Witty Gate, Microgate, Italy) were placed at distances of 0 m (starting point), 5 m to the

right, and 5 m to the left. The players started from a three-point stance at the 0 m starting point. The first 5-m run was taken in the direction of the hand that was in contact with the ground. When the players reached the first 5-m external line, they touched the line with their lead foot and hand. They then ran forward as fast as possible to the opposite 10-m external line, again touching it with their lead foot and hand when they reached it. Finally, they ran forward to the 0-m starting point, completing the test when they crossed the starting line. All players were instructed to perform the test three times on each side; trials were separated by two minutes of rest.

For the purpose of distinguishing COD ability from linear speed ability, the COD deficit (previously recommended by Nimphius [25]) was calculated as the difference between the first 10-m sprint split time during the 20-m pro-agility test.

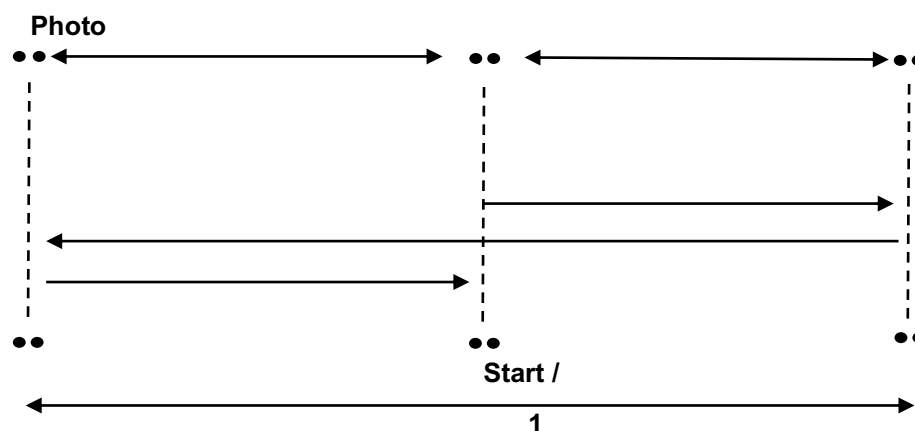


Figure 3.2. Pro-agility test configuration

Statistical procedures

The results were expressed as mean (standard deviation). After confirmation of normality ($p > 0.05$) and homogeneity ($p > 0.05$) assumptions, a paired sample t-test was used to determine the differences between the pre and post assessments, followed by Cohen's d to analyze the effect size (ES). The following classification to measure the magnitude of ES was used: ≤ 0.2 , from 0.3 to 0.6, from 0.6 to 1.2, from 1.2 to 2.0 and > 2.0 were considered trivial, small, moderate, large and very large, respectively. An independent sample t-test was used to determine the differences between the baseline and post assessments for fit and non-fit players. All statistical analyses were performed

using SPSS statistical analysis software (SPSS version 24.0, IBM corp., Chicago, USA). The level of statistical significance was set at $p < 0.05$.

Results

Table 1 presents a descriptive analysis of the different fitness variables in the pre and post pre-season periods. Significant decreases in performance were found from the baseline to the post period assessment for counter- movement jump (mean percentage change [dif]: -13.7% ; $p < 0.001$; $d = 1.161$, moderate effect size), for drop jump (dif: -10.0% ; $p = 0.014$; $d = 0.958$, moderate effect size) and for horizontal jump (dif: -3.0% ; $p = 0.042$; $d = 0.640$, moderate effect size).

Table 1. Physical fitness changes in pre-season training period.

Fitness determinants	Pre (mean/SD)	Post (mean/SD)	%change (Post-Pre) (SD)	<i>p</i>	<i>d</i>
IMTP Peak [kg]	128.42(26.11)	127.14(27.19)	-1.5(5.5)	0.747	0.048 <i>trivial</i>
IMTP Avg [kg]	119.07(24.92)	120.07(26.35)	0.5(5.1)	0.763	-0.039 <i>trivial</i>
Relative Force [N/Kg]	16.57(4.05)	16.43(3.25)	-0.6(7.1)	0.834	0.038 <i>trivial</i>
CMJ [cm]	35.71(4.20)	30.93(4.03)	-13.7(4.8)	0.000	1.161 <i>moderate</i>
DJ [cm]	31.07(4.29)	27.71(2.49)	-10.0(6.1)	0.014	0.958 <i>moderate</i>
HJ [cm]	227.64(10.69)	220.71(10.95)	-3.0(2.5)	0.042	0.640 <i>moderate</i>
ProAgility [s]	5.14(0.22)	5.07(0.27)	-1.4(2.0)	0.279	0.284 <i>small</i>
COD Deficit [s]	0.07(0.33)	0.22(0.10)		0.138	-0.615 <i>moderate</i>
Bronco [s]	305.71(38.82)	320.43(37.10)	4.9(6.8)	0.260	-0.387 <i>small</i>
MAS [$\text{m}\cdot\text{s}^{-1}$]	3.95(0.46)	3.78(0.40)	-4.6(6.7)	0.234	0.394 <i>small</i>

SD: standard deviation; Mean dif.: mean differences; *p*: *p*-value; *d*: standardized effect size of cohen; IMTP Avg = Average Isometric mid-thigh pull; CMJ = countermovement jump; DJ = drop jump; HJ = horizontal jump; COD = change of direction; MAS = maximal aerobic speed;

A comparison between the baseline values (first assessment) and the post values of the players categorized as fit was made and can be found in Table 2. Significant differences for fit players were found between the base- line and post assessments for countermovement jump (dif: -16.8% ; $p = 0.002$; $d = -2.495$, very large effect size), drop jump (dif: -15.5% ; $p = 0.004$; $d = -1.760$, large effect size), horizontal jump (dif: -3.2% ; p

= 0.028; d = -1.005, large effect size), and for change of direction deficit (dif: 413%; p = 0.034; d = 1.013, moderate effect size). Also, a significant difference was found for maximal aerobic speed (dif: -16.5%; p = 0.026; d = -4.053, very large effect size).

Table 2. Fit player changes between baseline and post assessments

Fitness determinants	Pre (mean/SD)	Post (mean/SD)	%change (Post-Pre) (SD)	p	d(SD)
IMTP Peak [kg]	149.11(18.46)	144.9(16.16)	-2.7(7.1)	0.477	-0.219(0.58) <i>small</i>
IMTP Avg [kg]	135.99(17.35)	137.60(14.02)	1.4(6.5)	0.726	0.108(0.50) <i>trivial</i>
Relative Force [N/Kg]	18.59(3.40)	17.53(3.66)	-6.2(6.0)	0.119	-0.352(0.35) <i>small</i>
CMJ [cm]	38.70(2.49)	32.38(4.08)	-16.8(6.1)	0.002	-2.495(0.99) <i>very large</i>
DJ [cm]	33.17(3.25)	28.04(2.82)	-15.5(6.7)	0.004	-1.760(0.83) <i>large</i>
HJ [cm]	235.33(4.72)	228.00(10.08)	-3.2(2.1)	0.028	-1.005(0.67) <i>large</i>
ProAgility [s]	4.93(0.15)	4.93(0.087)	0.0(3.1)	1.000	0.008(1.02) <i>trivial</i>
COD Deficit [s]	-0.23(0.31)	0.20(0.11)	413.8(587.4)	0.034	1.013(0.61) <i>moderate</i>
Bronco [s]	279.13(5.62)	314.41(46.49)	11.8(10.1)	0.077	5.217(4.24) <i>very large</i>
MAS [m.s ⁻¹]	4.28(0.10)	3.89(0.43)	-16.5(7.0)	0.026	-4.053(3.08) <i>very large</i>

SD: standard deviation; % change: percentage of change; p: p-value; d: standardized effect size of cohen; IMTP Avg = average isometric mid-thigh pull; CMJ = countermovement jump; DJ = drop jump; HJ = horizontal jump; COD = change of direction; MAS = maximal aerobic speed; bw = body weight

A comparison between the baseline values (first assessment) and the post values of the players categorized as unfit was made and can be found in Table 3. No significant differences for unfit players were found.

Table 3. Unfit player changes between baseline and post assessments

Fitness determinants	Pre (mean/SD)	Post (mean/SD)	%change (SD) (Post-Pre)	p	d(SD)
IMTP Peak [kg]	107.70(12.23)	109.34(24.79)	-0.1(10.2)	0.787	-0.007(0.81) <i>trivial</i>
IMTP Avg [kg]	96.55(10.85)	97.02(19.87)	-0.6(10.8)	0.932	-0.053(0.88) <i>trivial</i>
Relative Force [N/Kg]	13.14(1.93)	14.42(1.14)	10.5(20.4)	0.316	0.668(1.23) <i>moderate</i>
CMJ [cm]	31.85(2.04)	28.95(2.76)	-9.3(9.0)	0.102	-1.605(1.63) <i>large</i>
DJ [cm]	27.04(2.11)	27.24(1.39)	0.9(9.3)	0.866	0.122(1.24) <i>trivial</i>
HJ [cm]	221.88(10.37)	215.25(8.40)	-3.0(4.5)	0.249	-0.581(0.91) <i>small</i>
ProAgility [s]	5.29(0.15)	5.17(0.31)	-2.4(2.9)	0.181	-0.675(0.82) <i>moderate</i>
COD Deficit [s]	0.29(0.07)	0.23(0.09)	-23.2(32.1)	0.288	-1.003(1.54) <i>moderate</i>
Bronco [s]	331.70(40.27)	325.84(27.30)	-1.4(9.2)	0.729	-0.132(0.85) <i>trivial</i>
MAS [m.s ⁻¹]	3.48(0.36)	3.62(0.32)	4.2(14.3)	0.569	0.372(1.24) <i>small</i>

Discussion

The aims of the present study were to investigate the changes in fitness levels after a pre-season training period, and to describe amateur players' physical changes, considering their baseline fitness levels. The results revealed significant changes only in the jump performance assessments after the pre-season training period. The level of changes to the analyzed period depended on each player's baseline fitness level, and the impact was greater among the baseline considered-fit soccer athletes.

During the pre-season, it is expected that soccer players will be exposed to greater loads because they need to compensate for drops in fitness levels that can occur during the off-season [2]. Therefore, respecting the principle of overload and training progression [28], it is expected that positive changes will occur in aerobic capacity, strength endurance, and repeated sprint ability [38]. However, considering the first objective of the present study, the athletes presented significant lower jump performance values and no significant changes in the overall variables after pre-season. The results of the present study contrast with other studies that have reported significant improvements in vertical jump performance after pre-season training [6, 40]. In fact, a study conducted on 13 semiprofessional soccer players competing in England that analyzed seasonal fitness variations revealed significant improvements of aerobic, vertical jump and change of direction performance from the beginning to the end of the pre-season period. The decreases in jump performance after pre-season, found in the present study, can possibly be linked with neuromuscular fatigue factors due to the higher volume of training in this period. Or it could be that only soccer practice, in this soccer team, may not be enough for a better stretch-shortening cycle [24].

As mentioned earlier, improvements in aerobic capacity were reported at the end of the pre-season period [7, 21]. Those improvements may be due to the higher training loads that are associated with greater volumes, with little variation observed in the training

load variables [20], thus revealing higher values of training monotony and strain [10]. Therefore, and considering that in the present study we did not consider the training loads imposed on athletes during the pre-season, we only may suggest that the training principles were not properly followed. These discrepancies might be due to inadequate adjustments made during the pre-season training process or the number of games performed by players (which was also not controlled in the present study). Significant improvements were expected for all the analyzed variables, with greater emphasis on aerobic capacity due to the training process. Also, given the fact that amateur soccer players come from a longer off-season period than elite athletes, it is imperative to assess the athletes' physical fitness at the beginning of the season to adjust training in a manner that allows for positive changes over time.

Players with higher levels of physical performance (fit) at the baseline experienced decreases in overall physical performance during the pre-season period, whereas unfit players did not show any significant changes. The study conducted by Los Arcos et al. [18] showed that the players with the best baseline performances improved less than the players with the worst baseline performances in aerobic fitness. This is in line with our findings, although the present study revealed decreased physical performance values for fit players after the pre-season period. These decreases might be due to the need for more intense stimuli in order for changes to occur [27]. Therefore, these decreases might indicate a lack of individualization in the training program. Also, the players who started the pre-season with lower physical performance values may have experienced physical improvements because the coaches and players failed to check whether fitness levels were maintained during the off-season, during which time a decrease in aerobic performance is expected [30]. The team assessed is from an amateur soccer league. Thus, there might be no planned activities for these players to perform during the off-season, and their off-season is longer than those of elite soccer teams. These factors could have also influenced the present findings.

This study had some limitations. One was related to the sample size, as we assessed only one soccer team; the assessment of another senior team under the same conditions and in the same context was not possible. Another limitation is the fact that

only pre – and post-assessments for the pre-season period were considered. It would be interesting to analyze intra- and inter-week team variations in physical performance and load during the competition phase. It would also be worthwhile to examine within- and between-variations data among different playing positions during the pre-season in amateur soccer teams, given the differences in the training approaches between amateur and elite leagues. Despite these limitations, to the best of our knowledge, this was the first study to investigate the variations in physical fitness determinants and to analyze Portuguese amateur soccer players' responses to the training process over the pre-season. Therefore, this study provides new insight into amateur football and presents several practical implications.

Amateur soccer teams might lack the conditions to monitor internal loads and, more specifically, external loads because these teams cannot afford external load monitoring equipment such as global positioning systems, which could be essential for the monitoring of training during the pre-season [9]. Fortunately, even amateur teams can afford to monitor internal loads via the subjective session-rate of perceived exertion (s-RPE) modified by Foster et al. [11]. From s-RPE, coaches can gather more training load data regarding the acute and chronic loads and their ratio (acute:chronic load), which prevents spikes in load, and reaching detraining and/or overreaching [11, 12]. Also, from the same subjective monitoring tool, coaches can analyze weekly training variability and tension from the calculation of training monotony and strain, respectively. Given that, even with low budgets, coaches can plan and adjust pre-season training programs with discretion that will improve players' performance.

Conclusion

The present study aimed to analyze the changes in physical variables among players from an amateur soccer team after the pre-season. The results revealed a lack of significant positive changes after the assessed period. Only the players considered fit at the baseline presented significant performance decreases. As amateur soccer players have a longer off-season period, the assessment of individual physical qualities at the beginning of pre-season is imperative to allow coaches to plan and apply the necessary

adjustments of training loads, and to track meaningful changes after this critical period. Also, even in amateur soccer contexts, coaches and athletes would benefit from the use of tools such as s-RPE for a better understanding of what is happening during the training process.

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3.2 PAPER 2

Relationships between training load and match running performance in men's
soccer

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Relationships between training load and match running performance in men's soccer

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Abstract

Objectives: The main aim of this study was to test the relationship of volume and weekly training intensities with match-running demands of professional male soccer players. **Methods:** The training volume and intensity load and match demands of 18 professional soccer players (age: 20.7±1.8 years) were monitored daily for 15 weeks. **Results:** Match high-speed running (mHSR) and match accelerations (mACC) were found to be moderately positively correlated with weekly HSR (wtHSR) and weekly ACC volume (wtACC) ($r = 0.497$; $p < 0.01$; $r = 0.367$; $p < 0.01$), respectively. Moderate positive correlations were also found between mHSR, mACC and HSR (mtHSR) and ACC training

intensity (mtACC) ($r = 0.366$; $p < 0.01$). **Conclusions:** Weekly HSR and ACC training volume and intensity have moderate associations with match HSR and ACC loads. Planning lower weekly training low-intensity activity volume concomitant with higher high-intensity activities may be better for prepare athletes for the worst-case scenario.

Keywords: football; athletic performance; performance analysis; sports training.

Introduction

The quantification of professional male soccer players' running demands during training and competitions has gained an enormous amount of interest from sports scientists and coaches [1]. From a team sports perspective, soccer is documented as being one of the most demanding sports in terms of total distance (TD) covered [2]. Indeed, several studies have analyzed match external load demands [3-5]. In fact, it has been documented that during a soccer match players can reach approximately 11.000 m of TD, 900 m of HSR, 2472 m of HML, 61 n ACC ($\geq 3 \text{ m/s}^2$) and 58 DEC ($\geq 3 \text{ m/s}^2$) [6,7]. Also, men' s soccer involves intermittent activity characteristics composed of low-intensity actions interspersed with high-intensity actions [4].

The monitoring of the external loads imposed on athletes are part of the monitoring cycle framework proposed by Gabbett et al. [8]. This proposal is comprised of four main objective and subjective dimensions, which englobes the monitoring of external and internal loads, wellness, and readiness to train. In the specific case of subjective internal load measures, the use of session-rate of perceived exertion (s-RPE) has been proved to be a great tool for internal load quantification [9]. The s-RPE is calculated by multiplying the score reported on a 10-point scale of exertion [10] by the duration of the training session (in minutes) [11]. Furthermore, considering the relevance of assessing the current state of thletes for training regulation, the above-mentioned practices can assist coaches in monitoring weekly training and competition loads [12].

Training load quantification allows practitioners to monitor whether important training principles, such as progressive overload, individualization, and variation, are

being ensured [13,14]. Studies on this topic focus on two main categories of training load quantification: (i) external load (physical demands imposed by training tasks) and (ii) internal load (biological responses to a given external stimulus) [15]. In men' s team sports, the most commonly used methods for quantifying external loads are global positioning systems (GPS), accelerometers, and inertial measurement units, the latter two of which are usually embedded in modern GPS devices [16,17]. The common GPS metrics used in men' s soccer are distance-based measures covered at different speed thresholds (arbitrarily defined velocities [km/h] for each metric), accelerometry-based measures such as high metabolic load (HML) (distances covered at a speed of >19.8 km/h while accelerating and decelerating), and actions related to changes in velocity (accelerations [$ACC \geq 3 \text{ m/s}^2$] and decelerations [$DEC \geq 3 \text{ m/s}^2$]) [18-20].

Recently, research has analyzed the accumulated weekly external training loads (both using distance- and accelerometry-based metrics) and their related workload indices [21,22]. Also, other research has focused on analyzing weekly training (wt) external loads relative to match loads [6,23]. For instance, Stevens et al. [6] revealed that weekly total distance, high-speed running HSR (>19.8 km/h) distance, high-intensity ACC, and DEC ($\geq 3 \text{ m/s}^2$) were lower than corresponding match loads. Also, ACC and DEC seem to be more closely related to match loads than other training load metrics [6]. In fact, that study which was conducted on professional soccer players from the English Premier League, revealed that soccer players can reach approximately 20.000 m of TD, and 440 m of HSR during a training week [24]. Also, other study conducted on Dutch professional soccer players revealed weekly HML distances of approximately 3848 m, 181 n of ACC ($\geq 3 \text{ m/s}^2$) and 131 n of DCC ($\geq 3 \text{ m/s}^2$) [6].

Despite there are some studies comparing accumulated training load relative to match load [6,23], there are few studies regarding possible associations between mean training load intensity with match running performance in men' s soccer. In fact, one of the few studies on this topic [25] revealed that match running performance metrics, especially total distance and high-speed running, had strong associations with the previous weekly training workload volume. However, that study did not directly test the relationships between training intensity with match loads.

Given the aforementioned evidence—and considering that some distance-based metrics can depend on tactical characteristics and other contextual factors [25,26] and that accelerometry-based measures seem to be useful for monitoring neuromuscular status [27], the aim of this study is to test the relationships of weekly training volumes and intensities with match-running demands in professional male soccer players.

Methods

Experimental approach to the problem

An observational analytic cohort design was conducted in this study. A correlational study design was conducted to test possible relationships between weekly training load (volume and intensity) and the load intensity of a match during the same week. For each of the analyzed weeks, only the players participating in all training sessions and the match were included (Table 1).

The volume of weekly training load (wt) represents the sum of all accumulated load demands in all the training sessions of any given week. The intensity of the training sessions represents the mean intensity of all training (mt) sessions. Thus, the volume represents the total number of meters covered or the total number of actions performed in a week; meanwhile, intensity represents the mean number of meters covered per minute of training or the number of actions made per minute of training. For matches, only the intensity was considered, with the aim to standardize the playing time of each player. The period of observation corresponded to microcycles six to twenty-nine of the season.

Participants

Eighteen professional men soccer players (age: 20.7 ± 1.8 years; body mass: 69.8 ± 5.9 kg; height: 179.2 ± 5.0 cm; years of experience: 11.0 ± 2.8) participated in the study. All players belonged to the same club, which competed in the 3rd Portugal league. During the observational period, the team had 4-6 training sessions per week, with an average time of session of 78.8 ± 15.6 minutes with one official match per week. For each week,

the inclusion criteria for a player to be included in this study was: (i) the player was involved in all the training sessions and in the match; (ii) the player was not injured, or ill in the week that was part in the match. The exclusion criteria was: (i) do not participate in all training sessions the week before the match; (ii) do not participate in match. All players were informed regarding the study design, protocol, benefits and its related risks of this study participation. All athletes signed an informed consent in which was explicit that they were free to give up on the process at any time. The study protocol was approved by a scientific council of the local university (CTC-ESDL-CE002-2021) and followed the ethical standards of Declaration of Helsinki for the study in humans.

Rate of perceived exertion

For collecting the internal loads, the subjective rate of perceived exertion (RPE) was collected 10 to 30 min training and match, as previously documented [28]. To monitor players' RPE, the CR-10 method was used [10]. Based on CR-10 method, 1 refers to "very light activity" and 10 refers to "maximal exertion". Each player answered to RPE individually without the influence of their colleagues, using a smartphone to answer the question "how hard was your training? All the players were previously familiarized to this kind of perceptual effort rating. The internal training loads were then obtained by multiplying each player s-RPE by the absolute time of each session in minutes [29].

External load

Every athlete used the same 18-Hz GPS (STATSports, Apex, Northern Ireland) during the observational period. The GPS units have an integrated 100-Hz gyroscope, 100-Hz tri-axial accelerometer and 10-Hz magnetometer. Also, the GPS model used was previously tested for its validity and reliability [30,31]. Typical error as coefficient of variation was 1.6% at 400-m distance and 0.7% at 20-m peak speed [31]. The GPS units were placed in a specific vest in which the unit was fixed between the scapulae. The data collected during training sessions and matches were imported and processed in the STATSports Sonra software (version 3.0).

The GPS measures were collected daily during each training session and match, and were comprised of the following: (i) total distance (TD: consisting in the total distance covered by players); (ii) distance covered at high-speed running (HSR: distances covered at a speed of 19.8 km·h⁻¹ or above); (iii) high metabolic load distances (HML: distances covered at a speed of > 19.8 km·h⁻¹ while accelerating/decelerating at ≥ 2 m/s²); (iv) high intensity accelerations and decelerations (ACC and DEC: number of accelerations and decelerations at ≥ 3 m/s²) [30].

Statistical procedures

Descriptive statistics was presented in forms of tables, using mean and standard deviation. Normality of the sample was observed using Kolmogorov-Smirnov test ($p > 0.05$). Pearson r correlation test (r) was executed to determine the relationships between training load (volume and intensity) and match-running intensity measures. Magnitude of correlations were interpreted using the following thresholds [32]: 0.0-0.1, trivial; 0.1-0.3, small; 0.3-0.5, moderate; 0.5-0.7, large; 0.7-0.9, very large; >0.9, nearly perfect. The statistical procedures were executed on SPSS software (version 25.0, IBM, USA) for a $p < 0.05$.

Results

Descriptive statistics of training load (volume and intensity) and match running demands over the period of observation can be found in table 2.

Relationships between volume of training load (sum of weekly training load for different measures) and match-running intensity can be found in table 3. Moderate correlations were found between match HSR and volume of HSR in weekly training ($r = 0.497$; $p < 0.01$). Also, Moderate correlations were found between match ACC and volume of ACC in weekly training ($r = 0.367$; $p < 0.01$).

Relationships between intensity of training load (mean of weekly training load intensity for different measures) and match-running intensity can be found in table 4.

Moderate correlations were found between match HSR and intensity of HSR in weekly training ($r = 0.498$; $p < 0.01$) and between match accelerations and intensity of accelerations in weekly training ($r = 0.366$; $p < 0.01$).

Figure 1 presents the scatterplot for the relationships between mHSR and wtHSR ($R^2 = 0.247$) and mtHSR ($R^2 = 0.249$).

Discussion

The purpose of this study was to analyze the relationships of weekly training volume and intensity with relative match physical demands in professional male soccer players. The primary findings revealed that both weekly HSR and ACC training volume and intensity had moderate positive relationships with match relative HSR and ACC demands.

First, the weekly training volume and intensity TD and HSR reported in the present study are in concordance with other research conducted on Dutch professional male soccer players [6]. In fact, the study of Stevens et al. [6], revealed that wtTD and wtHSR were 22454 ± 1444 m and 811 ± 78 m, and their corresponding intensities were 72.6 ± 7.8 and 2.6 ± 0.1 , respectively. The authors of the above-mentioned study analyzed only four training sessions before match (match day [MD]-4 to MD-1), while in the present study, the overall analyzed weeks had five training sessions before match (MD-5 to MD -1). However, the training volume and intensity of MD-5 (the day after day-off) are usually low [33]. This may explain why our reported weekly values are similar to the study of Stevens et al. [6], even with one more training session per week. However, other studies have reported higher weekly training volumes for both distance-based and accelerometry-based metrics than those used in the present study [21,22]. These discrepancies might be due to the number of weekly sessions analyzed in each study, as the speed thresholds in our study are the same as those used in the three aforementioned studies [6,21,22]. Indeed, one study only analyzed four weekly training sessions [6]. On the other hand, despite the overall analyzed weeks of other two studies had five training sessions, the authors considered the absolute match demands as part of weekly accumulated load.

Regarding the relationships of weekly training volume and intensity with relative match demands in professional male soccer players, it was observed that relative HSR and ACC match demands tend to be higher when weekly HSR and ACC training volume and intensity are higher. However, thresholds are yet to be determined. A recent study conducted on 18 professional male soccer players from the English Championship revealed that prior training workloads had trivial-to-moderate relationships with subsequent match performance in terms of high-intensity actions such as HSR, ACC, DEC, and HML distances [34]. The present study also revealed similar relationships to the study of Springham et al. [34], between prior weekly training volume and subsequent relative HSR and ACC match physical demands, but not for DEC and HML measures. However, that study only tested the relationships between weekly training volume and match intensity. The lack of significant relationships in the present study, between both DEC and HML weekly training volume and intensity and relative match demands for those measures, might be due to other contextual factors such as the quality of opposition during official matches, winning or losing, fatigue, tactical determinants, among others [35]. Interestingly, also considering the weekly accumulated training loads and match loads, Clemente et al. [23] revealed only trivial-to-small correlations between them, suggesting that soccer training loads are independent of subsequent match loads, due to the above-mentioned contextual factors.

Notwithstanding the above discussed relationships between training volume and relative match demands, our results revealed positive moderate relationships between prior training workload intensity and relative match demands. In fact, another study on 56 male professional soccer players from two different teams confirmed that the physical performance exhibited during a match could be predicted based on the training workload volume of the week leading up to the match [25]. Our findings are in contrast with the above-mentioned study which revealed that mTD and mHSR had strong associations with the previous wtTD and wtHSR loads—in terms of wtTD. Also, the same authors [25] suggested that may be preferable to maintain training intensity high while maintaining training volumes low. This may be reflected by lower total distances covered and higher high-intensity activity during training. The differences in speed thresholds for each GPS metric used between our study and the above-mentioned study, can make comparisons

with our results difficult [19]. Considering that both HSR and ACC weekly training volume and intensity were associated with HSR and ACC match performance in the present study, it would be beneficial for soccer athletes to be exposed to HSR and ACC demands similar to those observed during matches.

It was previously documented that TD and the number high ACC during the training week are three-to-four times greater than the match demands, and that HSR are one-to-two times greater [23]. The same authors attributed those findings to the fact that Portuguese coaches use small-sided games as a training philosophy which causes an higher frequency of ACC and lower of HSR. In fact, a study conducted on twelve elite soccer players from the English Premier League revealed that the majority of weekly training distances covered were comprised of low-intensity activities, while the the majority of high-intensity distances were completed during the match [7]. This may suggest that soccer training focusing more on volume than intensity might not prepare the athletes for the match worst case scenario [36]. Since soccer is an intermittent sport characterized by high-intensity activity, it would be important to ensure a progressive overload on high-intensity demands without severely increasing the training volume in terms of wtTD [37]. Coaches must ensure that athletes are exposed to moderate weekly high-intensity activity to better cope with match demands [38,39].

This study has its limitations. One of the main limitations was related to the small sample size, which makes it difficult to generalize the results. This is a very common issue among studies conducted in professional team settings. Also, we did not analyze weekly training and match loads in a continuous fashion, which may interfere with the inferences made in the present study. However, this issue was inevitable, as we did not consider congested weeks in the analysis. Finally, the players included in the weeks analyzed were not always the same, since they were selected or not for the match based on coaches selection. This may represent an issue in heterogeneity from week to week analysis. Future studies should be conducted on congested fixtures to analyze the effects of training volume and intensity with the matches in between.

Conclusions

The main findings of the present study revealed that weekly HSR and ACC training volume and intensity had moderate relationships with match relative HSR and ACC loads. Considering the high-intensity nature of soccer, ensuring lower weekly training volumes and higher high-intensity activities may be more beneficial in terms of match performance. As such, a healthy balance between training volume and intensity must be promoted by coaches during a men's soccer microcycle prior to an official match.

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Table 1. Eligible players for each analyzed week.

	Training sessions (N)	Players eligible (N)
Week 6	5	11
Week 8	5	12
Week 10	5	12
Week 11	5	13
Week 13	5	11
Week 14	6	12
Week 16	5	10
Week 17	5	10
Week 18	5	9
Week 22	4	10
Week 23	6	9
Week 26	5	8
Week 27	4	11
Week 28	5	7
Week 29	5	10

Table 2. Descriptive statistics for weekly training load (accumulated load), weekly intensity training load (mean per each measure, standardized to minutes) and match intensity load (mean per each measure, standardized to minutes)

Volume Training	wtTD (m)	wtHSR (m)	wtACC (n)	wtDEC (n)	wtHML (A.U.)	wtSRPE (A.U.)
Mean±SD	23126±3882	1166±437	274±67	235±58	3731±806	1533±379

Intensity training	mtTD (m/min)	mtHSR (m/min)	mtACC (n)	mtDEC (n)	mtHML (A.U.)	mtsRPE (A.U.)
Mean±SD	61.9±5.7	3.07±1.07	0.73±0.14	0.62±0.12	9.85±1.59	306.3±63.4
Match intensity	mTD (m/min)	mHSR (m/min)	mACC (n/min)	mDEC (n/min)	mHML (A.U./min)	msRPE (A.U.)
Mean±SD	95.3±32.0	6.59±3.41	0.85±0.38	0.87±0.35	18.4±6.89	566.0±214.4

wt: weekly training load (accumulated load of the sessions previous to the match); mt: mean training load (mean of intensity in weekly training sessions); TD: total distance; HSR: high speed running; ACC: accelerations; DEC: decelerations; HML: high metabolic load; sRPE: session-RPE; n: number; m: meters; min: minutes; A.U.: arbitrary units; SD: standard-deviation

Table 3. Correlations (mean and 95% confidence interval) between weekly training load (accumulated volume) and the intensity of match-running demands in the match.

	wtTD (m)	wtHSR (m)	wtACC (n)	wtDEC (n)	wtHML (A.U.)	mtsRPE (A.U.)
mTD (m/min)	0.155 [0.16;0.31]	0.132 [-0.03;0.28]	0.099 [-0.06;0.25]	0.172* [0.01;0.32]	0.163* [0.01;0.31]	0.073 [-0.09;0.23]
mHSR (m/min)	0.172 [0.01;0.32]	0.497** [0.37;0.61]	0.143 [-0.01;0.29]	0.175* [0.02;0.32]	0.261** [0.11;0.40]	0.098 [-0.06;0.25]
mACC (n/min)	0.150 [-0.01;0.3]	0.123 [-0.04;0.28]	0.367** [0.22;0.50]	0.291** [0.14;0.43]	0.244** [0.09;0.39]	0.151 [0.01;0.30]
mDEC (n/min)	0.077 [-0.08;0.23]	0.206** [0.05;0.35]	0.169* [0.01;0.32]	0.254** [0.10;0.40]	0.195* [0.04;0.34]	0.078 [-0.08;0.23]
mHML (A.U./min)	0.118 [-0.04;0.27]	0.221** [0.07;0.37]	0.142 [-0.02;0.29]	0.203* [0.05;0.35]	0.218** [0.06;0.36]	0.111 [-0.05;0.26]
msRPE (A.U.)	-0.076 [-0.23;0.8]	-0.114 [-0.27;0.04]	-0.077 [-0.23;0.08]	-0.067 [-0.22;0.09]	-0.060 [-0.22;0.10]	-0.122 [-0.27;0.04]

wt: weekly training load (accumulated load of the sessions previous to the match); * Correlation is significant at the $p < 0.05$; ** Correlation is significant at the $p < 0.01$; TD: total distance; HSR: high speed running; ACC: accelerations; DEC: decelerations; HML: high metabolic load; sRPE: session-RPE; n: number; m: meters; min: minutes; A.U.: arbitrary units

Table 4. Correlations between mean of intensity of training load demands and the intensity of match-running demands in the match.

	mtTD (m)	mtHSR (m)	mtACC (n)	mtDEC (n)	mtHML (A.U.)	mtsRPE (A.U.)
mTD (m/min)	0.105 [-0.05;0.26]	0.116 [-0.04;0.27]	0.049 [-0.11;0.21]	0.143 [-0.01;0.29]	0.121 [-0.04;0.27]	0.024 [-0.13;0.18]

mHSR	0.114	0.498**	0.095	0.134	0.253**	0.076
(m/min)	[-0.04;0.27]	[0.37;0.61]	[-0.06;0.25]	[-0.02;0.29]	[0.10;0.39]	[-0.08;0.23]
mACC	0.036	0.082	0.366**	0.271**	0.194*	0.111
(n/min)	[-0.12;0.19]	[-0.08;0.24]	[0.22;0.50]	[0.12;0.41]	[0.04;0.34]	[-0.05;0.26]
mDEC	0.014	0.201*	0.171**	0.283**	0.193*	0.034
(n/min)	[-0.14;0.17]	[0.04;0.35]	[0.01;0.32]	[0.13;0.42]	[0.04;0.34]	[-0.12;0.19]
mHML	0.077	0.221**	0.118	0.197*	0.219*	0.069
(A.U./min)	[-0.08;0.23]	[0.07;0.37]	[-0.04;0.27]	[0.04;0.34]	[0.06;0.36]	[-0.09;0.22]
msRPE	-0.016	-0.068	-0.021	-0.030	-0.005	-0.173*
(A.U.)	[-0.17;0.14]	[-0.22;0.09]	[-0.18;0.14]	[-0.19;0.13]	[-0.16;0.15]	[-0.32;-0.02]

mt: mean training load (mean of intensity in weekly training sessions); * Correlation is significant at the $p < 0.05$; ** Correlation is significant at the $p < 0.01$; TD: total distance; HSR: high speed running; ACC: accelerations; DEC: decelerations; HML: high metabolic load; sRPE: session-RPE; n: number; m: meters; min: minutes; A.U.: arbitrary units

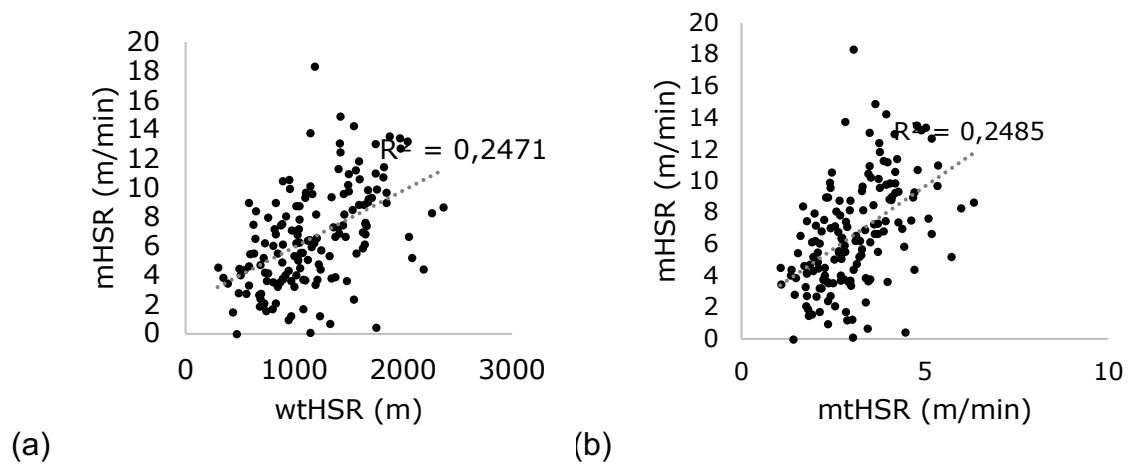


Figure 1. Scatterplot for relationships between mHSR and (a) wtHSR and (b) mtHSR.

CHAPTER 4

4 GENERAL CONCLUSIONS

4.1 CONCLUSIONS

This internship made possible the experience of having an excellent contact with a reality that I only knew in theory. Thus, I was able to develop practical skills combined with a great scientific support. Indeed, since the beginning of this master course until this internship stage, I discovered a huge interest in scientific production and developed my researching skills throughout these two years.

This experience has confirmed that professional soccer involves a multitude of unexpected situations that require great resilience levels. Communication skills in this context is fundamental, and sometimes this was a great difficulty, which I have felt in several occasions. Throughout the internship, the technical team, medical department, and the high-performance department trusted me some responsibilities, such as the rehabilitation process of some of their injured athletes, which gave me a more robust “know-how” to cope with the management of RTP. I made some mistakes during the internship that at the moment I make them it affected me a lot, but at this moment I realize that it was these mistakes that made me learn. Trial and error were part of the whole process.

My tasks during the internship in Vitória Sport Clube “B” team, allowed me to have an even greater awareness about the importance of monitoring the training imposed on athletes daily. Assessing and monitoring training, allowed us to know the athlete's current state, as well as the direction of the loads imposed daily. It allowed us, as members of a high-performance department, to objectively sensitize coaches regarding the individual needs of each athlete among the team. Assessing the athletes current state before the start of the season, and subsequently quantifying the loads imposed on the athletes during training, assumes a major role in measuring the impacts/effects that the training process produced, which is possible by conducting a new assessment at a more advanced stage of the season. Decision making, whether to allocate a day of rest to an athlete who has high training loads, or to allow the reintegration of an injured athlete into training, it is the responsibility of a robust communication between all the stakeholders involved in the process. This communication should be, as much as possible, based on the quantitative and qualitative knowledge of the athlete's current state.

Finally, the Sports Training master course and this internship, presented me with opportunities that would never have appeared if I had not risked taking this step forward. This internship allowed me to be invited to remain in the club to play the role of physiologist and researcher in the research laboratory that I initially proposed to create. Furthermore, scientific production is a great passion that I discovered on this path and that I will continue to follow.

4.2 FUTURE PERSPECTIVES

After these two years of the master course in sports training including this internship experience, I created high expectations regarding my professional path. I developed a great interest in training monitoring throughout this experience, both in order (science) and in chaos (practice) as well and combining both, which is the main purpose of nowadays practices. I feel very balanced between the order and chaos paths. Given that, my main perspectives are to: (i) become a scientific researcher; (ii) start a PhD in sports science; (iii) become Professor; and (iv) be part of a technical team form a first league soccer team. Although these perspectives are not easy to reach, I maintain the resilience needed to learn, work, and fight for this to become a reality. Chaos ceases to be chaos only if we allow ourselves to have order.

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