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ON THE RELATIONSHIP BETWEEN INTERNAL TRAINING LOAD AND COGNITIVE, PHYSICAL, AND TECHNICAL PERFORMANCE IN FUTSAL ATHLETES

TESE DE DOUTORADO

RENATO RIBEIRO AZEVEDO

Uruguaiana

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Tese de Doutorado apresentada ao Programa Multicêntrico de Pós-graduação em Ciências Fisiológicas da Universidade Federal do Pampa, como requisito para obtenção do título de Doutor em Ciências Fisiológicas.

Orientador: Prof. Dr. Felipe Pivetta Carpes

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Dedico este trabalho à minha família, à minha noiva Suellen, pelo apoio irrestrito e pelo companheirismo de sempre, essa conquista também é tua, e à minha filha Helena, dona do meu coração e razão da motivação diária.

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“Lembre-se que as pessoas podem tirar
tudo de você, menos o seu conhecimento.”

Albert Einstein

ABSTRACT

The precise control of internal training loads considering exercise stimuli and recovery is a challenge in sports. The manipulation of external load variables and the understanding of internal load variables affecting performance seem to be decisive for the success of sports training. The rate of perceived exertion is the most common tool for estimating internal load. It is easy to implement daily, low cost, and validated by Borg scale. The internal load is also related to psychobiological and neuromuscular aspects of exercise, as well the particularities of different sport disciplines. In this thesis, our goal was to better understand the relations between training load and cognitive, physical, and technical performance in futsal athletes during a competitive season. We conducted three studies aiming: 1) determine which physical/cognitive aspects determine the perception of internal load in high-performance futsal athletes, 2) investigate whether internal load relates with technical performance during official matches, and 3) determine the impact of the of internal load's perception on the capacity to produce force, acceleration and tasks to change direction. Our main findings were that internal load is influenced differently by cognitive and neuromuscular factors at different stages of the season, the internal load experienced by athletes in the week before seems to slightly influence the technical performance in an official match, and the capacity to produce force and change of direction are negatively affected by the internal load experienced. Our results have potential for application in the field of futsal, especially considering the inclusion of physiological testing combined with biomechanics and cognitive tests in the routine of athletes' assessment. A better understanding of relationship between training load and cognitive, physical, and technical performance in futsal can help to improve performance monitoring and planning of training sessions over a competitive season.

Keywords: team sports; training load; sports training; anaerobic power; session-RPE;

RESUMO

O controle preciso das cargas internas de treinamento considerando os estímulos do exercício e a recuperação é um desafio no esporte. A manipulação das variáveis de carga externa, bem como o entendimento das variáveis de carga interna que afetam o desempenho, parecem ser decisivos para o sucesso do treinamento esportivo. A taxa de esforço percebido é a ferramenta mais comum para estimar a carga interna. É de fácil implementação no dia a dia, baixo custo e validado pela escala de Borg. A carga interna também está relacionada aos aspectos psicobiológicos e neuromusculares do exercício, bem como às particularidades das diferentes modalidades esportivas. Nesta tese, nosso objetivo foi compreender melhor as relações entre a carga de treinamento e o desempenho cognitivo, físico e técnico em atletas de futsal durante uma temporada competitiva. Realizamos três estudos com o objetivo de 1) determinar quais aspectos físicos/cognitivos determinam a percepção da carga interna em atletas de futsal de alto rendimento, 2) investigar se a carga interna se relaciona com o desempenho técnico durante partidas oficiais e 3) determinar o impacto da percepção de carga interna sobre a capacidade de produzir força e tarefas de mudança de direção. Nossos principais achados foram que a carga interna é influenciada de forma diferente por fatores cognitivos e neuromusculares em diferentes estágios da temporada esportiva, a carga interna experimentada pelos atletas na semana anterior parece influenciar ligeiramente o desempenho técnico em uma partida oficial e a capacidade de produzir a força e a mudança de direção são afetadas negativamente pela carga interna experimentada. Nossos resultados têm potencial de aplicação na área de futsal, principalmente considerando a inclusão de testes fisiológicos combinados com biomecânica e testes cognitivos na rotina de avaliação de atletas. O melhor entendimento das relações entre a carga de treinamento e o desempenho cognitivo, físico e técnico no futsal pode ajudar a melhorar o monitoramento do desempenho e o planejamento das sessões de treinamento ao longo de uma temporada competitiva.

Palavras-chave: equipes esportivas; carga de treinamento; treinamento esportivo; potência anaeróbica; PSE da sessão;

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1. INTRODUCTION

This thesis describes three studies that address the main objective of a research project developed over the past four years. The work is organized in sections, starting with an introduction on the main topics of the study, followed by the main and specific objectives for each of the three conducted studies. The next section is a narrative review of literature, aiming to summarize the state of the art, considering relevant research papers published on the subject in recent years. After literature review, the methods employed to address each of the three studiy objectives are detailed. The results section describes the outcomes from each of the studies. We understand that this structure of the three experiments division into the methods section, and then doing the same in the results section might not be the clearest way to provide a good reading flow, however, we are requested to respect the normative format of our graduate and university program. A doctoral thesis composed of individual chapters to present each study individually is only allowed if at least two of their papers are accepted for publication in a high standard journal, according to CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, i.e. Coordination of Improvement of Higher Level Personnel, in the acronym in Portuguese) (e.g., Qualis A). The text follows with the discussion section and final considerations. Additional sections are included, such as the list of references cited in the document, and supplemental files considered pertinent to the reader and for the assessment of this work, for instance, the ethics approval.

1.1. Statement of the problem

Sports training involves a series of organized actions aiming to improve, maintain, or acquire a standard of performance. One of the biggest challenges in sports training is the control of external and internal training loads, considering an adequate interval period between stimulation and recovery (Issurin 2010; Brink, Frencken et al. 2014). The training loads are organized by coaches in programming based on different levels of stimuli and intensities at different phases of a sports season (Tonnessen, Svendsen et al. 2015). These stimuli must be accurate to result in a positive adaptation. If the stimuli are insufficient, it could cause poor performance; on the other hand, stimuli that are too high may cause injury or overtraining, and end up negatively affecting the performance (Carfagno and Hendrix 2014; Halson 2014; Gabbett, Kennelly et al. 2016). Therefore, training gains will depend on the adequate planning of the training program, which is closely related to adequate programming.

The success of training prescription depends on correct adjustment of the training load; therefore, it is necessary to evaluate the individual not only at a time of the season, but also during the season to adjust the training stimuli (Dupont, Nedelec et al. 2010). Training control depends on the balance of external and internal loads (Brink, Frencken et al. 2014; Rabelo, Pasquarelli et al. 2016), whereas external loads are controlled by coaches (Brink, Frencken et al. 2014). There are numerous variables that can be controlled to prescribe and control the external load in a training program such as distance, speed, power, cadence, intensity, and session duration, among others (McLaren, Macpherson et al. 2017). Still, internal loads refer to biochemical, physiological, psychological and biomechanical responses, usually estimated based in the perceived exertion rate and depending on individual characteristics such as body composition, physical fitness and age (Rabelo, Pasquarelli et al. 2016). However, this relationship requires a complex experimental approach, since in addition to the factors mentioned, the training configuration (number of sessions) and the training level (whether a beginner or already adapted to the effort or well trained) can also have an important influence on the behavior of internal loads.

Variables such as heart rate (HR) (Impellizzeri, Rampinini et al. 2005), neuromuscular activation (Nakamura, Pereira et al. 2016; Rabelo, Pasquarelli et al. 2016; Djaoui, Haddad et al. 2017), neuromuscular efficiency (Azevedo, Perlingeiro et al. 2014), muscle fatigue (Stanley, Peake et al. 2013), loss of contractility (Murtagh, Nulty et al. 2017), changes in motor units firing rate (Hug and Dorel 2009), as well as the desired strength levels for certain movement patterns directly interfering with performance (Briscoe, Forgach et al. 2014) help to understand both external and internal load relationships. Just as neuromuscular fatigue seems to be a determinant for changes in movement patterns, mental fatigue is capable of altering the internal loads in athletes, impairing performance in endurance sports (Twomey, Aboodarda et al. 2017). It is also reported that this relationship between external and internal loads seems to be non-linear, largely due to the influence of cognitive and psychosocial factors that can influence the internal training load (Schmitt, Regnard et al. 2015). Recently, the interest in understanding how internal loads can be influenced by cognitive factors has increased (McLaren, Macpherson et al. 2017). One of the factors that could explain this influence is mental fatigue, which can impair performance (Weippert, Behrens et al. 2017) in addition to increasing the perceived exertion rate (Halson 2014). In soccer players, mental fatigue significantly reduced running distance and impaired technical performance (Smith, Coutts et al. 2016). Acute and chronic exercise seems to have a pronounced effect on the memory function among young and middle-aged adults (Pageaux and Lepers 2016), which can also influence executive functions inherent to sports practice (Kunzler and Carpes 2020).

Therefore, some methods to assess the internal load of athletes have gained prominence in training routines. The perceived exertion rate (RPE) is commonly used to assess internal load markers in training cycles (Brink, Frencken et al. 2014; McLaren, Macpherson et al. 2017). Its relationship with external loads occurs because RPE is related to physiological variables such as HR, oxygen consumption and blood lactate concentration (Day, McGuigan et al. 2004; Brink, Frencken et al. 2014). Furthermore, RPE responses during resistance training are associated with the magnitude of musculoskeletal recruitment measured by neuromuscular activation (Groslambert and Mahon 2006; McGuigan, Al Dayel et al. 2008).

A difference is in the recovery of HR at rest, that in trained subjects occurs faster than untrained subjects due to training status (Eston and Connolly 1996). Oxidative stress is higher in untrained individuals than highly trained athletes exercising at high intensity (Carlier, Delevoye-Turrell et al. 2017). Untrained individuals also show higher concentrations of muscle damage markers when compared to trained individuals performing the same task (Borg, Hassmen et al. 1987).

Finally, even if you know which external loads are associated with which internal responses, these relationships do not change significantly along, say, a season? Additionally, does the internal load, measured through perceived exertion, is related to technical performance and ability to accelerate and change direction?

Motivated by these queries, which have practical application and impact on the performance of different sports and rehabilitation professionals, our studies seek to answer these questions.

1.2. Purpose

The purpose of this thesis was to determine the physical and cognitive factors that determine internal loads reported by professional futsal athletes during a competitive season, as well as to determine whether the internal loads have a direct influence on athletes' technical performance, acceleration and change of direction capacities.

2. LITERATURE REVIEW

2.1. Search strategy and article inclusion

The database chosen for the literature review of this work was MEDLINE, because both it has a large coverage on biomedical area and it is the most used in the world. The interface chosen for the search was the PubMed of National Library of Medicine – NLM (producer of MEDLINE).

The language used for the research was English. The keywords used were: "training," "training load," and "internal load," combined separately with "external load," "futsal." and "cognition." Original articles that considered human participants and published in the last 10 years were included. Older references were used throughout the text when considered fundamental. From the search results, the articles were also filtered first by reading the title and the abstract. Articles that did not fit the central theme of this thesis were discarded.

The objective of this narrative review of literature was to summarize what is known about the internal load behavior during a competitive season in high performance sport, and the influence of internal load on physical, technical and cognitive performance of athletes. An attempt was made to outline some reflections and criticisms regarding current knowledge on this topics.

2.2. Training load

Training loads are defined as the relative biological (both physiological and psychological) stressors imposed on the athlete during training or competition (Bourdon, Cardinale et al. 2017), they can be classified as external or internal. One of the main goals of coaches and physical trainers is the adequacy and combination of the application of training loads and rest periods, enabling a positive adaptation of athletes and, consequently, improving performance (Fox, Stanton et al. 2018). Training loads are often related to performance and risk of injury in high performance athletes (Jaspers, Brink et al. 2017; Eckard, Padua et al. 2018). When the training load is related to fatigue markers, there are several studies that investigate acute responses in performance variables, their recovery and strategies for the acceleration of this process (Taylor, West et al. 2015).

Regarding the risk of injury, periods of high load, such as the pre-season, with athletes coming from a rest period, as well as periods with a greater number of competitions, tend to enhance the risk of injury due to increased external and internal load experienced by athletes (Rogalski, Dawson et al. 2013). Weeks with higher loads during a pre-season increased the likelihood of soft tissue injury in professional rugby athletes (Gabbett 2010). Two studies have shown that short recovery periods between official matches also increase the risk of injury among athletes (Bengtsson, Ekstrand et al. 2013; Dellal, Lago-Penas et al. 2015). Another risk factor related to training load and injuries is accumulated overload. Athletes who participate in more competitions, and consequently train and compete more during the season, tend to suffer more injuries than athletes with fewer competitions (Ekstrand, Walden et al.

2004). The injury incidence seems to be influenced by the training load, injury severity also seems to be influenced, at least in rugby athletes. Athletes with greater internal load suffered more severe injuries (Brooks, Fuller et al. 2008) especially muscle injuries. With regard to performance, there are several studies aiming to identify the best strategies to optimize the performance of athletes. For example, when investigating strength/power training protocols, there are several studies that research to determine the ideal training load for positive adaptations. Training protocols that use "optimal load" as a load parameter have gained relevance (Loturco, Nakamura et al. 2016; Bordelon, Jones et al. 2020). Exposure and intensity measures are also related to changes in performance of athletes. In terms of intensity, the distance traveled at high speed was positively correlated with changes in vagal-related HR variability (HRV) (Thorpe, Strudwick et al. 2015). It was also found that a longer time exposed to a match can result in a higher 5 meter (Silva, Magalhaes et al. 2011), 15 meters (Arcos, Martinez-Santos et al. 2015) and 30 meters sprint speed (Silva, Rebelo et al. 2014).

2.3. Internal load

Internal load, as defined by the athlete's responses to an external demand (McLaren, Macpherson et al. 2017) can be estimated by perceived exertion and directly relates to physiological performance markers such as blood lactate concentration and heart rate (Borg, Hassmen et al. 1987). The rate of perceived exertion (RPE) is the most common tool to estimate internal load (Borg, Hassmen et al. 1987) as well as psychobiological (Marcora, Staiano et al. 2009) and neuromuscular aspects (McLaren, Macpherson et al. 2017). The measurement of internal load through the RPE has been widely used in several sports (Johnson, Pryor et al. 2017; Slimani, Davis et al. 2017), considering the facility and confiability of the measure. In Gaelic Football players, the internal load was related to injuries, with high specificity and low sensitivity (O'Keeffe, O'Connor et al. 2020). In American football athletes, the internal load, measured from the RPE, showed a relationship with external load measurements, and this relationship depends on the duration of the session (Sobolewski 2020). This relation is also observed between internal and external load in soccer athletes, on this the authors point out that the RPE can even be used to prescribe training sessions (Enes, Oneda et al. 2021), as well as in strength training protocols (Martorelli, De Lima et al. 2021). In rugby athletes, the variance in session perception can be explained by some factors: distance covered, number of impacts, body load and training impulse (Lovell, Sirotic et al. 2013). Several studies indicate that the time spent in high-intensity activities, measured through impulse training, indicates positive changes in aerobic capacity in athletes (Castagna, Impellizzeri et al. 2011; Malone, Hughes et al. 2019), while using RPE, correlations were also found between the total perception of the session and aerobic performance (Dobbin, Hunwicks et al. 2018). RPE has also been correlated with performance in agility tasks (preseason) sprint speed of 10, 20 and 40m (preseason, early competition and late competition phases) (Gabbett and Domrow 2007). When analyzing only the muscular RPE and neuromuscular performances, there seems to be a correlation between the RPE and the height of the countermovement jump (Arcos, Martinez-Santos et al. 2015) and the 15m sprint time (Arcos, Yanci et al. 2014). Therefore, it is observed that the internal load measured from the perceived exertion rate is very useful in training protocols of several sports modalities, being an important tool for coaches, who must be aware of the limitations of the measure.

2.4. Critical analysis

Compared to other sports, scientific production in futsal is quite scarce, although the use of RPE's internal load measurement is quite common in the papers produced.

It has already been observed, for example, that the internal load tends to be higher, as well as muscle pain and fatigue in weeks with fewer games and more training sessions (Clemente, Martinho et al. 2019). As in other sports, measurements from RPE strongly correlate with heart rate measurements and training impulse (Wilke, Ramos et al. 2016). When using the RPE in Futsal to determine periods of high and low training load, it was observed that in periods of high accumulated load, futsal athletes are more susceptible to upper respiratory tract infection (Moreira, de Moura et al. 2013). In a study published in 2014, the authors point out that both aerobic capacity and the ability to perform repeated high-intensity actions are the main responsible for determining the internal load of futsal athletes (Miloski, Moreira et al. 2014). In another similar study, the authors point out that maximum oxygen consumption is essential to determine IL (Milanez, Pedro et al. 2011). In a study that analyzed futsal athletes in the pre-season period, it was observed that faster athletes perceive a higher IL when compared to slower athletes (Nakamura, Pereira et al. 2016).

Therefore, it is observed that there are some gaps in the specialized literature regarding RPE and futsal. Some points need to be better clarified, such as: what are the factors that determine the internal load experienced during different moments of the season; if there is a relationship between RPE and technical performance; and the influence of RPE in specific tasks of the sport.

3. METHODS

In this chapter, we describe the experimental procedures carried out in the three studies that we developed to answer the questions proposed in this thesis. The instruments, procedures and approach for data collection will be described, so that later the results of each specific experiment are presented.

3.1. Ethical principles

Participants in all experiments signed an informed consent form in which they agreed to participate in this study, in accordance with the Declaration of Helsinki and in accordance with the recommendations of the ethics committee of the Federal University of Pampa, where this project was approved (85233618.6.0000.5323) (Appendix A).

3.2. Procedures

Training sessions

For the realization of the studies, all training sessions of the analyzed team were followed for 2 years.

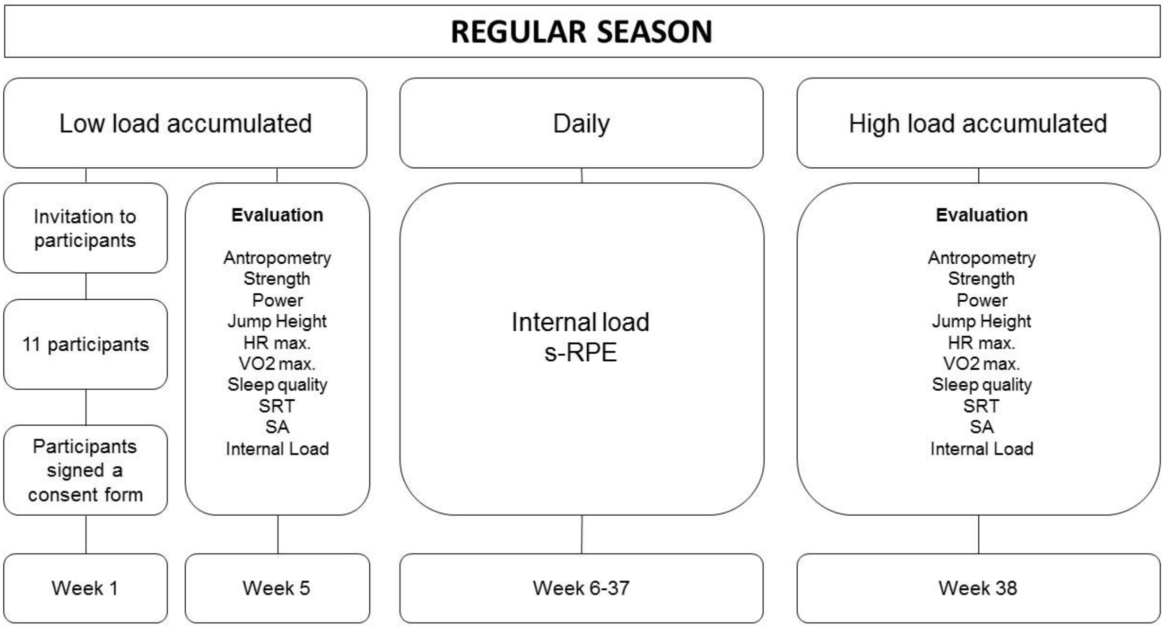
The training sessions of the teams evaluated during the studies comprised a total of 7-9 weekly training sessions, for 10 months per year, composed on average of: 2-3 strength/power training sessions, 1-2 training sessions injury prevention, 5-6 technical/tactical training..

3.2.1. Study 1: Cognitive and neuromuscular influences on perceived exertion during a competitive season in futsal

Participants and study design

This is an observational study and was conducted at a professional men's futsal club. Participants were those main team athletes who remained active (no injury, time off, or transfer between teams) throughout the entire season. The participants were enrolled in regular futsal training for 6 days a week, including matches that were part of the state level competition calendar. To participate in the study, athletes were required to attend at least 80% of training sessions and all official matches during the season. None of the participants suffered injuries to the lower limbs during the last year. They did not present characteristics that could influence the conclusions of this study, such as chronic pain. Participants were assessed for the magnitude of external loads at two times during the season, classified as follows: low cumulative load (beginning of season - week 4) and high cumulative load (end of season - week 37). In these specific weeks we evaluated the internal load, muscle strength (lumbar and handgrip), lower limb power, jump height, maximal oxygen uptake (VO2max), maximal heart rate (HRmax), reaction time, selective attention, and sleep quality. All participants signed a consent form agreeing to participate in this study, which was approved by the ethics committee of the local institution. Figure 1 illustrates the experimental design.

Figure 1. Experimental design



At the end of the season, we were able to collect data from eleven athletes with a mean body mass of 75 (9) kg, height of 174 (5) cm, age 26 (6) years, and experience time of 7 (2) years futsal training. The limited sample size is a common characteristic between studies following sports team over the complete season (Moreira, de Moura et al. 2013; Miloski, Moreira et al. 2014; Beato, Coratella et al. 2017).

Cognitive performance

Cognitive tests were performed with the participants comfortably seated in front of a 14" screen 1 m away at eyes level. They respond to stimuli presented on the screen. The stimuli were configured using PsychoPy (Peirce 2007), a custom software written in Python language and allowing measurement of motor responses to visual stimuli. Simple reaction time (SRT) and selective attention (SA) were determined in two tests considering average responses and individual variability. SRT was defined by the time between the presentation of a visual stimulus (aleatory symbol) and pressing any button of a joystick. SA task, how an impulse inhibition test, was defined by the time response to the correct answers in an adaptation of Stroop task (JR 1935) . In this task participants needed to press a specific joystick button for congruent and another for an incongruent response. Half of the trials was congruent and the other half incongruent. The SA was defined by the time between the presentation of a visual stimulus (word/color) and pressing the correct button. Only correct answers were considered. The wrong answers were quantified. For both tests each participant performed blocks of 10 trials. Before each test, a signal of attention was presented on the screen. The stimuli were presented randomly at intervals of up to 2000 ms. All tests were performed in a controlled temperature and noise environment and the order of testing for SA and STR was randomized between the participants. All cognitive assessments were performed between 8:00 am and 11:00 am.

Perceived exertion assessment

The individual perceived exertion was assessed on a daily basis using the perception of exertion in the session (s-RPE)(Foster 1998) throughout the 37 weeks of the season. The daily load was determined through the product between the perception of effort and the duration of training sessions (RPE x session duration, in minutes). Approximately 15 minutes after the end of each training session, players reported the intensity of the entire session using the same scale. The weekly load was determined from the sum of the daily loads (Rabelo, Pasquarelli et al. 2016). For all statistical analysis we considered the 4 weeks after the two times periods of external load evaluation during the season (low accumulated load and high accumulated load). To normalize a possible difference in the number of training sessions at different analysis times, the total perceived effort of each moment was divided by the number of training sessions of the period, resulting in the perceived effort per session.

Muscular strength

Muscle strength was estimated by lumbar dynamometry using a lumbar dynamometer (Crown, Filizola Brazil). During the evaluation, the participants were barefoot, standing with the spine erect during anterior trunk flexion, keeping the arms extended in front of the body. Participants were instructed to perform maximum traction attempts for approximately 3 seconds. Three attempts were performed and the highest value was considered. We also evaluated the handgrip strength with a hydraulic hand dynamometer (Jamar, Sammons Preston Rolyan, Bolingbrook, Canada). All participants performed the handgrip test standing with shoulder along the trunk with elbow at 90° flexion with no radioulnar deviation. The participants were required to squeeze the handle maximally for 3 seconds. Measurements were performed for both the hands. Participants performed three maximum attempts for each grip strength measurement, and the maximum value among the trials was recorded. One-minute rest was given between each attempt, and hands were alternated to minimize fatigue effects. Results were recorded in kilogram force (kgf).

Cardiorespiratory performance

Maximum oxygen uptake (VO2 max.) was determined indirectly by the Yo-yo Intermittent Recovery Test Level 1 (Hermassi, Aouadi et al. 2015). Participants were instructed and verbally encouraged to perform as much effort as possible during the evaluation. Maximum heart rate (HRmax) was determined during an incremental treadmill test (Gait Trainer 3, Biodex, Brazil) using a cardiac monitor (Polar H1, Polar, Finland). Participants warmed up during 5 min of light treadmill running. After warming up, they started running at a speed of 9 km/h, with increments of 1 km/h every minute. Test was ended when participant was no longer able to sustain the belt speed.

Jump power

To determine jump power and height participants were requested to continuously jump as high as possible during 30 s over a force plate, with their hands placed at their waist(Dainese Hatt, Quadroni et al. 1997). The researchers performed strong verbal encouragement during the test to ensure the maximal performance. Ground reaction force data were recorded at 1200 Hz sampling rate by a force platform (OR6-2000 AMTI Inc., Watertown, USA). The height of the jump was estimated considering the flight time and normalized by the participants' individual height. The jump power was determined from the force data and normalized by the body mass of each participant. For the statistical analysis, the value of the jump with the highest power recorded was considered

Statistical analysis

The normality of data distribution was verified with the Shapiro Wilk test. Pearson and Spearman tests were performed to verify correlations between the variables of interest. Variables showing significant correlation with total perceived effort and perceived effort per session were used to create simple and multiple linear regression models at different times of the season. The significance level adopted was 0.05 for all procedures.

3.2.2. Study 2 : Relationship between rate of perceived exertion and performance over a competitive season in a professional futsal team

Study design and participants

This study was conducted at a professional futsal club. The male athletes from the main team who remained active throughout the season served as participants. At the end of the season, we were able to consider in our analysis the data from 16 athletes with an average body mass of 72 (8) kg, height of 174 (6) cm, age of 24 (6) years and competitive experience time of 5 (3) years. All participants signed an informed consent, agreeing to participate in this study, which was approved by the ethics committee of the local institution (85233618.6.0000.5323).

Along the season they participated in regular futsal training, 6 days a week, and competed in the state championship. All of them participated in at least 80% of training sessions and official matches during the course of the season. None of them suffered an injury to the lower limbs during the last year, nor did they present any characteristics that could influence the conclusions of this study, such as chronic pain.

The internal load in the training sessions and matches was monitored during the 38 weeks of the regular season. The results of the matches from the regular season were obtained through the official report from the Futsal Federation organizing the competition. We correlated the internal load responses between weeks preceding the different match performance.

Procedures

Internal load quantification

The internal load was estimated by the session rate of perceived exertion (s-RPE). Data were collected during the 38 weeks of the regular competitive season. The daily load was determined through the product between the perceived exertion and the duration of the training session (RPE x session duration, in minutes). Approximately 30 min after the end of each training session, players were asked to report the intensity of the entire session using the Borg scale. Week loads were determined from the sum of the daily loads. For all statistical analyses, the s-RPE from the 7 days preceding each match, and the data from the 14 athletes who participated in each match were considered.

Team performance

The athletes' performance was analyzed considering the video analysis and scouting of 10 official matches, considering the following parameters: completes passes (%), incompletes passes (%), right finishes (%), wrong finishes (%), won tackles (%), loss tackles (%), goals and assists.

Stastical analysis

The normality of data distribution was verified with the Shapiro Wilk test. The correlation between the internal load experienced for each week before official match and the technical performance for each official match was tested using the Spearman correlation test. The significance level adopted was 0.05 for all analyzes.

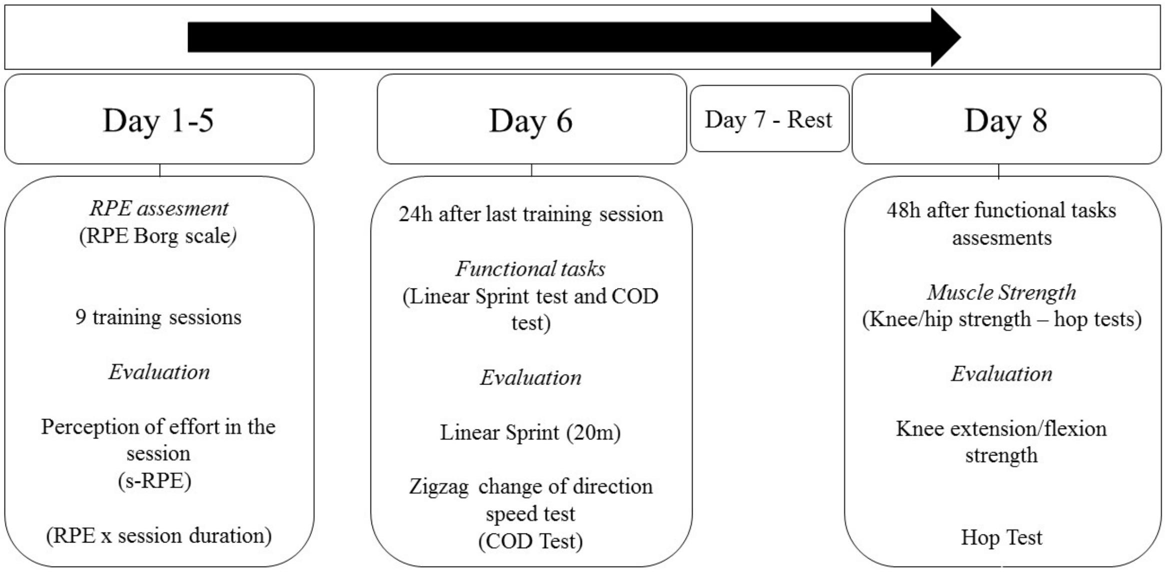
3.2.3. Study 3: Relationship between rate of perceived exertion, strength, and change of direction performance in elite futsal athletes

Participants and study design

This study was conducted at a professional male futsal club. Participants were those athletes from the main team who remained active (no injury, time off, or transfer between teams) throughout the entire season (35 weeks). The participants were enrolled in regular futsal training six days a week, including matches that were part of the state competition calendar. We only included athletes who attended at least 80% of the training sessions. None of the participants suffered injuries in the lower limbs during the past year. They did not present characteristics that could influence the conclusions of this study, such as chronic pain.

The participants' RPE was assessed daily after each training session. Linear acceleration and COD performance were evaluated 24 h after the last training session of the 27th week of the season. Hop test and isokinetic concentric and eccentric strength for knee flexion and extension were assessed on an isokinetic dynamometer after one day of rest according to the experimental design illustrated in Figure 2.

Figure 2. Experimental design. RPE: rate of perceived exertion; s-RPE: rate of perceived exertion for the exercise session; COD: change of direction.



At the end of the experimental phase, we were able to include data from 14 athletes with a mean (standard deviation) age 24 (5) years, body mass of 72 (8) kg, height of 174 (5) cm, and 5 (2) years of futsal professional training. The limited sample size is typical in studies following sports teams over the complete season (Miloski, Moreira et al. 2014). All participants signed a consent form agreeing to participate in this study, which was approved by the ethics committee from the local institution and conducted following the declaration of Helsinki.

Procedures

Rate of perceived exertion - RPE

The individual RPE was assessed daily using the rate of perceived exertion in the session (s-RPE) (Foster 1998). The daily load was determined by the product between the RPE and the training session duration in minutes. Approximately 15 minutes after the end of each training session, players reported the intensity of the entire session, always using the same scale. The weekly load was determined from the sum of the daily loads (Rabelo, Pasquarelli et al. 2016) and monotony was determined by the product between the average internal training load and its standard deviation. The tension was calculated using the product between the weekly load and the monotony (Foster 1998).

Muscle strength

Participants performed a maximum strength test on an isokinetic dynamometer to determine the knee flexor and extensor strength. Before the isokinetic testing, the participants completed a five-minute warm-up on a cycle ergometer at freely chosen load and cadence. For the bilateral assessment of concentric and eccentric peak isokinetic knee torques participants assumed a seated position on an isokinetic dynamometer (Biodex Medical Systems Inc., Shirley, NY, USA) with the hip flexed at approximately 85 degrees. Body positioning was stabilized using straps placed around the trunk, waist, and distal femur of the limb, being tested to minimize additional movement and ensure the same conditions for all participants. The dynamometer axis was visually aligned with the lateral femoral condyle while the knees were flexed at 90 degrees. The length of the dynamometer lever arm was set individually based on the participant's lower leg length, and the resistance pad was placed proximal to the medial malleolus. Following direct measurement of the mass of the lower limb lever system at 30 degrees of knee extension, gravity correction procedures were applied according to the manufacturer's specifications. The participants performed a maximum of five repetitions at an angular speed of 60 degrees/second, and the results were stored for analysis. The same examiner, who was trained and experienced in the use of isokinetic testing devices, tested all participants. Peak torque values were normalized to the individual body mass (Nm/kg). The hamstring to quadriceps muscle ratio was calculated for concentric and eccentric trials as the ratio between the peak knee flexor (Hpeak), and extensor torques (Qpeak); H:Q ratio = [(Hpeak/Qpeak)×100].

Linear sprint test

Four pairs of cones were positioned at the starting line and at the distances of 5, 10, and 20 m where athletes sprinted at their maximal speed. Participants ran twice, starting from a standing position and 0.3 m behind the starting line. The sprint tests were performed on an indoor running track to avoid weather influences. Sprint velocity (VEL) was calculated considering the time to cover the distances and time using a manual stopwatch.

Zigzag change of direction speed test

The COD course consisted of four 5-m sections marked with cones set at 100° angles on an indoor court. Athletes were required to decelerate and accelerate as fast as possible without losing body balance. Two maximal attempts were performed with a 5-min rest interval in between. The fastest time from the two attempts was registered for further analysis. An adapted COD deficit calculation was used to evaluate the efficiency of each athlete's ability to produce linear speed during a specific COD task (Nimphius, Callaghan et al. 2016). The COD deficit was calculated as follows: COD deficit = (20-m velocity – Zigzag test velocity).

6-m timed hop test

For the performance of the hop test participants kept their arms crossed in the region of the lumbar spine and were instructed to jump, maintaining stability at the time of landing. Before each data collection, two jumps were performed to familiarize the participant with the tests, followed by three attempts for data collection. All participants were instructed to jump as quickly as possible until they reach a distance of 6 meters (Munro and Herrington 2011). Performance was quantified for both legs.

Statistical analysis

The normality of data distribution was verified with the Shapiro Wilk test. Pearson and Spearman's tests were performed to verify the correlation between the variables of interest. The significance level adopted was 0.05 for all procedures.

4. RESULTS

4.1. Study 1

Table 1 presents the descriptive data of the parameters evaluated in the group of athletes.

Table 1. Mean (standard deviation) of variables of interest measured at different times of the competitive season.

Variables	Low load	High load	p-value
Lumbar strength (kgf)	125.18 (31.28)	136.45 (28.62)	0.04
Handgrip strength (kgf)	36.36 (8.76)	32.75 (6.67)	0.06
Jump height (% stature)	14.13 (1.90)	14.94 (2.84)	0.12
Power (W/kg)	10.90 (0.90)	10.72 (1.67)	0.75
Internal load (a.u)*	20425 (764)	23450 (1061)	0.01
Internal load for session (a.u)	537 (20)	808 (36)	0.01
Maximal heart rate (bpm)	190 (8.2)	185 (7.5)	0.09
VO_2 max. (ml/kg/min)	48.41 (3.9)	50.54 (3.8)	0.01
SRT (ms)	313.35 (63)	342.31 (68)	0.32
SA (errors)	0.27 (0.6)	0.64 (1.5)	0.45

* the internal load refers to 4 weeks after the evaluation. a.u: arbitrary units.

In the period of low accumulated load, the total perceived effort and perceived effort per session showed a direct correlation with errors in the Stroop test (rho = 0.60; p = 0.048). Simple linear regression analysis determined that the amount of errors in the Stroop test explains 36.4% of the variance in total perceived effort and per session (Table 2).

In the period of high accumulated load, the total perceived effort and perceived effort per session showed an inverse correlation with jump power (r = - 0.721; p = 0.02). The multiple linear regression model determined that power explains 52% of the variance in total perceived effort and per session (Table 2).

Table 2. Correlation between the analyzed variables and internal loads for low and high cumulative load periods.

Variables	Low load	High load
Lumbar strength (kgf)	-0.11	0.16
Handgrip strength (kgf)	0.20	0.16
Jump height (% stature)	-0.02	-0.23
Power (W/kg)	-0.29	-0.72
Maximal heart rate (bpm)	0.06	0.22
VO2 max. (ml/kg/min)	-0.57	-0.02
SRT (ms)	-0.03	-0.12
SA (errors)	0.60	-0.15

Table 3. Simple linear regression equations for low and high cumulative load periods.

Independent variable	Regression equation	r	r²	p
Low load accumulated				
Internal load Stroop test error	{[(713.4788*Error Stroop) + 20230.870]}	0.60	0.36	0.04
Internal load for session Stroop test error	{[(18.776* Error Stroop) + 532.390]}	0.60	0.36	0.04
High load accumulated				
Internal load Power	{[(-459.493*power) + 28374.93]}	-0.72	0.52	0.03
Internal load for session	{[(-15.844*power) + 978.441]}	-0.72	0.52	0.03

4.2. Study 2

Table 4 presents technical variables (%), internal load and variability for all matches analyzed.

Table 4. Technical variables, internal load, and variability.

Technical Variables	Average per athlete (%)	SD	Minimum – Maximum
Complete passes	68.3	12	40 - 90
Incomplete passes	31.7	12.2	10 – 60
Tackles won	9	2.6	4 – 15
Tackles losses	10	2.7	5 – 15
Shots on target	60.1	9.5	40 – 80
Shots of target	39.9	9.6	20 – 65
Assists	0.35	0.5	0 – 2
Goals scored	0.41	0.7	0 – 3
Internal Load per session (a.u.)	601	90.8	457 - 883

Internal Load per session = absolutes values.

When correlated the internal load with the technical variables present in the official matches, we found that there is a significant correlation between the PSE experienced during the training weeks and the number of hits and errors in some technical actions considering all matches. The lower the internal load, the greater the number of technical adjustments (complete passes – r=-0.21; p=0.02; goals scored – r=-0.20; p=0.03) and the smaller the number of errors. (Table 2)

Table 5. Correlation between technical variables and internal load during the official matches.

Technical Variables	Internal load	
	r	p
Complete passes	-0.21	0.02*
Incomplete passes	0.21	0.02*
Tackles won	-0.03	0.74
Tackles losses	0.08	0.35
Shots on target	-0.09	0.31
Shots of target	0.07	0.43
Assists	-0.17	0.07
Goals scored	-0.20	0.03*

4.3. Study 3

Table 6 shows the descriptive data of the different parameters evaluated in the group of athletes.

Table 6. Mean (standard deviation) of variables of interest.

Variables	Mean (SD)	CV	CI 95%
Training load (a.u)	6233 (369)	5.9	6021 - 6447
Monotony	1.5 (0.1)	2.6	1.51 – 1.55
Tension	9554.8 (637)	6.6	9187 - 9923
Peak torque extensor, right (Nm/kg) (Conc)	3.1 (0.5)	15.8	2.8 - 3.3
Peak torque extensor, left (Nm/kg) (Conc)	3.1 (0.5)	17.4	2.8 – 3.4
Peak torque flexor, right (Nm/kg) (Conc)	2.0 (0.5)	25.6	1.7 – 2.3
Peak torque flexor, left (Nm/kg) (Conc)	1.9 (0.5)	24.7	1.5 – 2.1
Peak torque extensor, right (Nm/kg) (Ecc)	2.0	14.9	1.8 – 2.2
Peak torque extensor, left (Nm/kg) (Ecc)	2.2	22.6	1.9 – 2.4
Peak torque flexor, right (Nm/kg) (Ecc)	2.7	20	2.4 – 3
Peak torque flexor, left (Nm/kg) (Ecc)	2.5	25.9	2.1 – 2.9
H:Q ratio, right (%) (Conc)	69.1	43.7	51.6 – 86.5
H:Q ratio, left (%) (Conc)	61.3	37.6	47.9 – 74.6
H:Q ratio, right (%) (Ecc)	138.4	21.6	118 – 151.6
H:Q ratio, left (%) (Ecc)	119.3	27.1	100.6 - 138
Timed Hop Test, right (s)	1.5 (0.2)	14.4	1.3 – 1.5
Timed Hop, Test left (s)	1.5 (0.2)	12.1	1.3 – 1.5
VEL linear (m/s)	6.4 (0.4)	6.8	6.1 – 6.6
COD speed (m/s)	3.8 (0.5)	12.8	3.4 – 4
COD deficit (m/s)	2.6 (0.1)	5.4	2.5 – 2.6
Preferred leg	12 R; 2 L	-	-

H:Q ratio: hamstring to quadriceps ratio; CV(%): coefficient of variation defined by the standard deviation to mean ratio; CI 95%: confidence interval; R: right; L: left; (Conc): concentric; (Ecc): eccentric.

The weekly training load showed an inverse relationship with concentric knee flexion strength (right: r = -0.60, p = 0.02; left: r = -0.55, p = 0.04, Figure 3) and eccentric knee flexion strength (right: r = -0.62, p = 0.02). No significant relationships were found between weekly training load and knee extensor strength. The weekly training load showed inverse correlation with COD velocity ($r = -0.54$, $p = 0.04$) and a direct relationship with COD deficit ($r = 0.62$, $p = 0.01$). Tension showed a direct correlation with COD deficit ($r = 0.61$, $p = 0.02$;).

COD velocity was directly related to peak isokinetic flexor torque (right: $r = 0.56$, $p=0.04$, left: $\rho = 0.55$, $p = 0.04$). COD deficit was directly related with the peak isokinetic extensor torque (right: $\rho = 0.54$, $p = 0.04$) and inversely related to the H:Q ratio (right: $\rho = -0.60$, $p = 0.02$). The eccentric H:Q ratio was directly correlated with COD deficit (right: $\rho = -0.58$, $p = 0.03$).

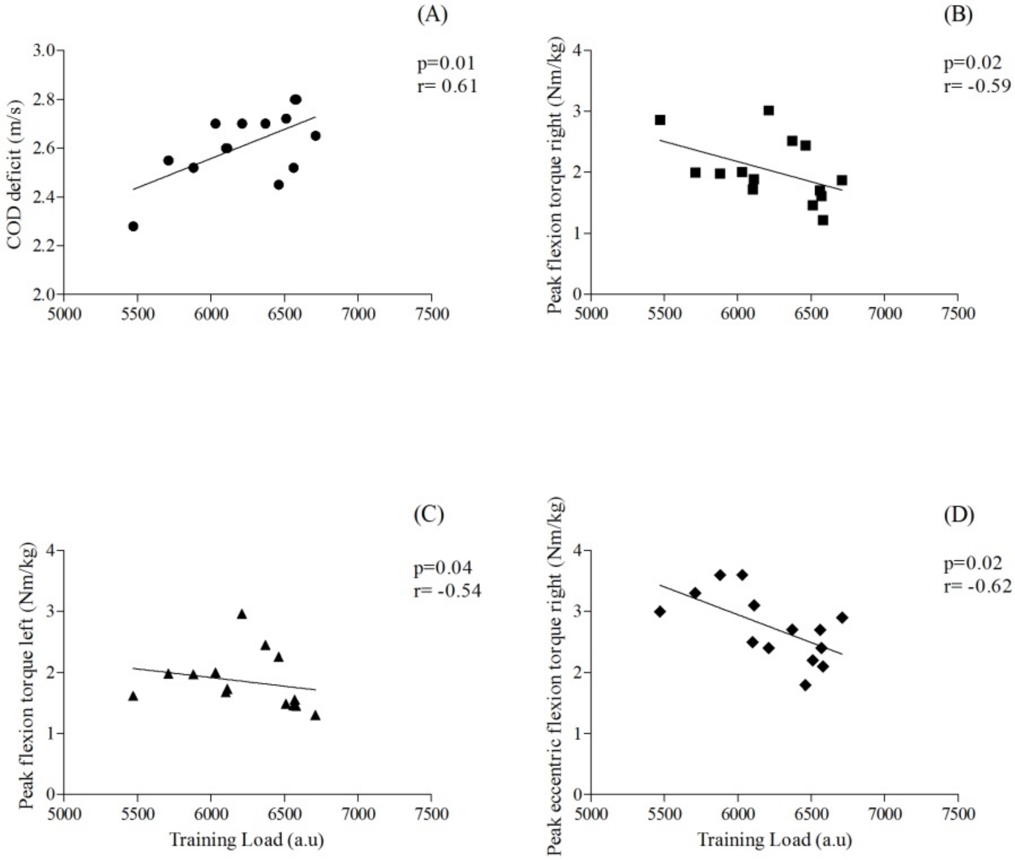


Figure 3. Correlations found for training load with COD deficit and peak isokinetic concentric and eccentric flexion torques. (A) Training load x COD deficit; (B) Training load x peak isokinetic concentric flexion torque right; (C) Training load x peak isokinetic concentric flexion torque left; (D) Training load x peak isokinetic eccentric torque right.

5. DISCUSSION

5.1. What are the physical and cognitive characteristics that influence the internal load in futsal athletes? Are there discrepancies at different stages of the season?

In this study we determine which physical and cognitive characteristics influence the perception of effort in professional futsal athletes at different times of a regular competitive season. One of our main findings refers to the distinct influence of cognitive performance and jump power output at different times of the season on perceived effort. The monitoring of loads throughout the season allowed us to observe these relationships that have important implications for futsal training and competition. Beyond that, load monitoring routine has become popular in futsal, and the addition of some assessments at specific times of the season can provide important insights for coaches when defining training approaches, as well as performance monitoring.

Futsal involves significant cognitive demand for decision making, focus of attention and error minimization (Naser, Ali et al. 2017). We found that selective attention capacity seems to have important relevance for perception of effort among futsal athletes during a period of low accumulated load. Athletes with less performance in selective attention task report higher levels of perceived exertion. Our findings are new to the literature, and future studies should focus on investigating the mechanisms that may explain this effect, and also how this relationship can directly affect performance of athletes during the matches. In other sports conditions, cognitive performance involving for example selective attention has proved to be important for both performance and decision making (Castella, Boned et al. 2019). On the other hand, this type of relationship can be influenced by the athlete's fitness level (Wang, Moreau et al. 2019). As the phase of low accumulated load was at the beginning of the season, it is possible that this relationship was not maintained at the end of the season because important indicative of physical conditioning showed important improvements at the end of the season (Table 1), most likely a result of training in previous weeks (Pind, Maestu et al. 2019).

In the period of high accumulated load, the jump power seems to be the preponderant physical quality influencing the perception of effort in futsal athletes. While aerobic capacity and the ability to perform high intensity repeated stimuli are related to the perception of internal load (Miloski, Moreira et al. 2014), our study points out that the ability to produce explosive force has a greater ability (higher than 50%) to explain internal charges at the end of the season. This relationship has important practical implications as the maximum sprints common in futsal (Naser, Ali et al. 2017) require high power output capacity. In addition, power is increasingly being highlighted as a factor related to several important aspects of futsal, such as linear sprints and change of direction performance (Bishop, Berney et al. 2019). In rugby athletes, it is observed that higher values of perceived effort are directly related to the incidence of non-contact injuries (Gabbett and Jenkins 2011). As higher power values appear to decrease internal load, apparently higher power may also decrease the risk of non-contact injury due to residual fatigue. Thus, increasing power in futsal athletes seems to be beneficial both in terms of performance, due to increased strength and injury prevention, as well as being able to decrease perceived exertion and possible mental stress.

Our findings provide important and novel information that can assist in training programs especially in a period that is characterized by decisive matches and requires efficient methods. Plyometric trainings (Neves da Silva, Aguiar et al. 2017) and resistance training with loads in optimal zones (Loturco, Ugrinowitsch et al. 2013) or near these zones (Loturco, Pereira et al. 2019) should be encouraged at this stage as they are able to increase power output and, according to our results, decrease the perceived at a turning point in the season.

No significant differences were found in the values of strength and power when compared to the period of low and high accumulated load, indicating that even with few changes in these variables, power became determinant at the end of the season in this period of high accumulated load. Therefore, adopting a monitoring program for both power levels and effort perception levels is critical in a competitive, high-performance futsal environment where small changes in perceived effort levels can have a final outcome in power level produced, and directly interfere with performance at key moments of a sporting season.

Based on our findings, we recommend that cognitive characteristics should be considered during some periods of the sporting season, especially in the preseason. Our findings also indicate that power output should be determined and monitored throughout the season, during training sessions, and pre-competition, as it strongly related to the level of perceived exertion especially in the final phase of the season.

Over the course of a competitive futsal season various aspects of neuromuscular and cognitive function influence the perception of the internal load, so we believe that especially at the beginning of the season coaches should perform cognitive assessments to determine levels of selective attention and decision-making skills, important skills in futsal performance and which may influence the perception of effort. Tests that use specific game situations should be encouraged, as well as assessments using quizzes and software.

5.2. Is there a relationship between the internal load experienced by futsal athletes and technical performance during official matches?

Here, we propose that the relationship between perceived exertion and performance in futsal athletes is verified during a competitive season. Our main finding concerns the correlation, even if weak, between the internal load measured using PSE and the technical performance of professional futsal athletes in official matches. Following a professional team over several weeks, we found that a lower internal load may be related to greater technical accuracy by the athletes in complete passes and goals scored. Otherwise, a greater internal load can lead to a greater number of errors (incomplete passes) and a smaller number of goals scored.

The relationship between internal load and performance outcomes may have particular characteristics depending on the sport. As we mentioned before, long-distance runners reporting lower RPE showed better performance in countermovement jump (Foster, Florhaug et al. 2001), while in cyclists a higher RPE direct relates to the distance covered in a cycling trial (Parry, Chinnasamy et al. 2011). Futsal athletes are prone to present greater fatigue, delayed onset muscle soreness and muscle damage in routines of one match per week compared to routines of more than one match per week. It happens because training load is usually smaller when you have more than one match per week (Clemente, Martinho et al. 2019). In our study, athletes had 7 days between each match. Each training week consisted of at least nine (9) training sessions where we cannot exclude that possible effects such as fatigue, muscle pain and muscle damage have influenced athletes' perception of effort. In addition, a higher internal load is also related to a higher perception of fatigue, poor sleep quality and higher stress (Moalla, Fessi et al. 2016; Clemente 2018), factors that may be determinant in the success of a futsal match and technical capacities. Although we did not give details in this study, we periodically evaluated the athletes to ensure that no symptom of overtraining was present.

There is a consensus in the literature about the effects of fatigue in the technique of specific soccer movements (Smith, Coutts et al. 2016; Maly, Sugimoto et al. 2018). A higher internal load is related to a greater possibility of fatigue, unsatisfactory sleep and a higher level of stress. This might partly explain the lower number of goals scored and the higher number of incomplete passes when the internal load was higher, possibly influenced by these deleterious effects, even if the relationship is weak (Moreira, Bradley et al. 2016; Clemente 2018; Maly, Sugimoto et al. 2018). Furthermore, it is common for coaches to plan and organize their training aiming at a certain perception of effort, and athletes end up experiencing a perception of greater effort, also depending on the moment of the season (Brink, Frencken et al. 2014).

Coaches must find a training load zone capable of promoting performance gains during matches (stimulus x recovery), thus determining an "optimal zone" of performance. In this case, it is worth remembering that the programming used in the competitive period by the team analyzed was very similar between the training weeks, in terms of volume and intensity in the training sessions. A high training load affects important neuromuscular characteristics in futsal athletes, such as the ability to perform vertical jumps and sprints (Teixeira, Nunes et al. 2018), and consequently has an impact on performance during official matches, especially in high-performance athletes. Our study was one of the first to correlate the internal load and the technical performance of futsal athletes, and not only the physical performance.

The lower internal load in the weeks prior to matches can be an important indicator for coaches and may also serve to help determine which players can stay on the court the longest during the match, but can also be a factor in choosing technique of the players to be chosen for the match.

The futsal is a sport that involves fast action [12], great aerobic and anaerobic demands [13], with offensive actions when in possession of the ball, as well as rapid decomposition when in defensive actions, quick decision making is essential. So, considering that a high internal load can also be influenced by cognitive factors [2] , and that the technical actions of futsal (passing and kicking) also require a high level of decision-making [14], such a point can be decisive for inferior technical performance in the presence of high internal load and vice versa.

Considering our interpretation of the results, we suggest that the perception of effort can be another variable to be analyzed as a possible performance indicator in official high-performance futsal matches. Identifying and determining a weekly training load pattern using PSE capable of promoting satisfactory performance during matches seems to be an interesting path for practitioners, given the correlation between PSE and some technical variables. However, our study has limitations: One of the challenges for using the RPE is the ability of players to accurately communicate their levels of perception. Considering that the athletes were used to report the RPE in previous seasons, we consider that this limitation was minimized in our study (Brink, Frencken et al. 2014; Rabelo, Pasquarelli et al. 2016). Another limitation we perceived is the use of RPE as the sole marker of training load, although this is a valid measure.

5.3. Is there a relationship between weekly training load and the strength capacity and speed performance in linear sprint and change of direction tasks performed by professional futsal players?

In this study, we have verified the relationship between week training load and the strength capacity and speed performance in linear sprint and change of direction tasks performed by professional futsal players. We found that futsal athletes with lower knee strength reported higher training loads in the week, and athletes with higher training load were slower and showed larger deficits in COD task. The variety of relationships found may suggest that in addition to RPE, the analysis of internal loads should also consider speed and agility tests as important indicators of training responses in futsal athletes, including attention to the knee flexor strength. Previous studies reported the relationship between strength and performance in COD task (Nimphius, Callaghan et al. 2016), which here we extend to relations with the RPE and knee flexor strength as well.

The magnitude of training load is an important aspect to consider when discussing the relationships found here. Our athletes showed a high week training load (average 6233 a.u.) in comparison to other studies that investigated RPE in futsal players (de Freitas, Pereira et al. 2015; Nakamura, Pereira et al. 2016). Athletes faster in linear tasks may have a greater accumulation of potential energy during the flight phase and, consequently, may experience a greater need for eccentric force during the support phase in COD (Mero and Komi 1986). This ability can be affected by possible residual fatigue (Halson 2014) due to the high tension sustained during the week (Foster 1998). On the other hand, assessing athletes at lower levels of internal load could limit the applications of our study, as we aimed to identify and discuss different strategies and tools that may help coaches better monitor training loads.

The relationship between strength capacity and movement production seems to reflect internal training load responses. We found athletes with weaker knee flexors reporting higher training loads. The weakness of the flexor group may help to explain the relationship between TL and COD deficit. COD requires rapid and systematically coordinated force and impulse capacity during the braking, support, and propulsive phases of movement while maintaining optimal body positioning (Dos'Santos, Thomas et al. 2018). In general, athletes with higher levels of strength and power are less efficient in changing direction than they are for running at maximum speed in a straight line (Bishop, Berney et al. 2019). It may result in difficulties to cope with the high entry (and exit) velocity during directional changes and the greater moment of inertia during the task (Freitas, Pereira et al. 2019). Again, the higher training load reported may be associated with some degree of fatigue, resulting in impaired force production to perform the task. As fatigue results in a complex condition to quantify in court, the results association from different motor tasks in addition to RPE may provide a more precise framework of the athlete's condition.

Suppose a higher training load impairs knee flexor strength capacity. In that case, this measure could help to explain the greater COD deficit observed, probably impairing the athletes' ability to produce eccentric force and fast braking. We also measured eccentric strength and found eccentric flexor strength from the right leg showing a correlation with training load. Additionally, the relationship between training load with concentric and eccentric strength varied between the right and left legs. It may provide support to this hypothesis considering that the relative braking force during the deceleration phase is essential to reduce the speed of the mass center and allow the body to rotate and align in the desired new direction (Jindrich, Besier et al. 2006), and differences depending on the body side contribute to the deficit (Bishop, Berney et al. 2019).

Furthermore, we identified that a higher tension correlates with a higher COD deficit. High monotony and tension are considered signs of overtraining syndrome (Foster 1998), and the increase in the COD deficit could indicate an increased risk of illness. Future studies should identify whether the COD deficit has the potential to identify signs of overreaching or overtraining. This approach may also consider the important role described for knee flexors strength and the inherent risk of injury to this muscle group in futsal (Ribeiro-Alvares, Dornelles et al. 2019).

As we mentioned before, our athletes showed a higher training load than reported in previous studies. The week in which we were able to submit them to the isokinetic test may have influenced the results. However, this condition did not affect the relationships between COD deficit and the strength and power capacity previously reported (Bishop, Berney et al. 2019). It is worth mentioning that significant relationships were found mainly for the right leg, which was the preferred leg for kicking for most athletes (12 out of 14). It may suggest that the functional specialization of the leg for an action requiring power (i.e., kicking) may influence the relationship. We did not cover this discussion because the differences between the right and left legs did not reach a statistical significance.

The association of training load with knee flexor weakness also influenced the relationship between the H:Q ratio and COD deficits. A weaker knee flexor significantly affects the H:Q ratio, and we found that athletes with greater strength H:Q imbalances have lower performance in COD task. The strength imbalance between quadriceps and hamstrings is a source of muscular injuries in futsal (Martinez-Riaza, Herrero-Gonzalez et al. 2016). This relation between the H:Q ratio and COD deficit can be interpreted together with the correlation between knee flexor strength and training load (see Figure 2). The flexor strength weakness and the different relationship for right and left legs, which we hypothesize were probably caused by these muscle imbalances quantified by the H:Q ratio, affects RPE and consequently the training load. But it also influences a COD deficit that depends much on strength and power. The strength imbalance possibly impaired the capacity of eccentric force production resulting in less braking capacity in the phase of great acceleration.

Our research design was a cross-sectional study and limited to a group of professional futsal athletes. Future studies should investigate the relationship between strength production capacity and performance in functional tasks with more extended periods of control for internal load control, which could help better understand if the relations may change over the season.

6. CONCLUSIONS

Considering the results described in this thesis, the following interpretations are provided:

- Muscle power is very important at all stages of the futsal season, including at the end of the season, where the impact of this physical quality can be a determining factor in RPE;

- The internal load reported by high-performance futsal athletes in the week before a game may have an negative influence on technical performance during official games;

- Athletes with greater internal load may have worse technical performance in official matches.

- Training load in high-performance futsal athletes is related directly to lower limb strength;

- Higher training loads combined with muscle weakness negatively affect the ability to change direction in the presence of high training loads;

- We recommend considering strength tests, especially for the knee flexors, and monitoring the H:Q ratio as a complementary tool for controlling training loads and their effects on performance.

7. REFERENCES

Arcos, A. L., R. Martinez-Santos, et al. (2015). "Negative Associations between Perceived Training Load, Volume and Changes in Physical Fitness in Professional Soccer Players." J Sports Sci Med **14**(2): 394-401.

Arcos, A. L., J. Yanci, et al. (2014). "Rating of muscular and respiratory perceived exertion in professional soccer players." J Strength Cond Res **28**(11): 3280-3288.

Azevedo, L. F., P. S. Perlingeiro, et al. (2014). "Sport Modality Affects Bradycardia Level and Its Mechanisms of Control in Professional Athletes." Int J Sports Med.

Beato, M., G. Coratella, et al. (2017). "Evaluation of the external and internal workload in female futsal players." Biol Sport **34**(3): 227-231.

Bengtsson, H., J. Ekstrand, et al. (2013). "Muscle injury rates in professional football increase with fixture congestion: an 11-year follow-up of the UEFA Champions League injury study." Br J Sports Med **47**(12): 743-747.

Bishop, C., J. Berney, et al. (2019). "Bilateral Deficit During Jumping Tasks: Relationship With Speed and Change of Direction Speed Performance." J Strength Cond Res.

Bordelon, N. M., D. H. Jones, et al. (2020). "Optimal Load Magnitude and Placement for Peak Power Production in a Vertical Jump: A Segmental Contribution Analysis." J Strength Cond Res.

Borg, G., P. Hassmen, et al. (1987). "Perceived exertion related to heart rate and blood lactate during arm and leg exercise." Eur J Appl Physiol Occup Physiol **56**(6): 679-685.

Bourdon, P. C., M. Cardinale, et al. (2017). "Monitoring Athlete Training Loads: Consensus Statement." Int J Sports Physiol Perform **12**(Suppl 2): S2161-S2170.

Brink, M. S., W. G. Frencken, et al. (2014). "Coaches' and players' perceptions of training dose: not a perfect match." Int J Sports Physiol Perform **9**(3): 497-502.

Briscoe, M. J., M. S. Forgach, et al. (2014). "Validating the EMG(FT) from a single incremental cycling test." Int J Sports Med **35**(7): 566-570.

Brooks, J. H., C. W. Fuller, et al. (2008). "An assessment of training volume in professional rugby union and its impact on the incidence, severity, and nature of match and training injuries." J Sports Sci **26**(8): 863-873.

Carfagno, D. G. and J. C. Hendrix, 3rd (2014). "Overtraining syndrome in the athlete: current clinical practice." Curr Sports Med Rep **13**(1): 45-51.

Carlier, M., Y. Delevoye-Turrell, et al. (2017). "Tolerance to exercise intensity modulates pleasure when exercising in music: The upsides of acoustic energy for High Tolerant individuals." PLoS One **12**(3): e0170383.

Castagna, C., F. M. Impellizzeri, et al. (2011). "Effect of training intensity distribution on aerobic fitness variables in elite soccer players: a case study." J Strength Cond Res **25**(1): 66-71.

Castella, J., J. Boned, et al. (2019). "Jump and free fall! Memory, attention, and decision-making processes in an extreme sport." Cogn Emot: 1-11.

Clemente, F. M. (2018). "Associations between wellness and internal and external load variables in two intermittent small-sided soccer games." Physiol Behav **197**: 9-14.

Clemente, F. M., R. Martinho, et al. (2019). "Training load and well-being status variations of elite futsal players across a full season: Comparisons between normal and congested weeks." Physiol Behav **201**: 123-129.

Dainese Hatt, P., M. Quadroni, et al. (1997). "Concentration of, and SDS removal from proteins isolated from multiple two-dimensional electrophoresis gels." Eur J Biochem **246**(2): 336-343.

Day, M. L., M. R. McGuigan, et al. (2004). "Monitoring exercise intensity during resistance training using the session RPE scale." J Strength Cond Res **18**(2): 353-358.

de Freitas, V. H., L. A. Pereira, et al. (2015). "Sensitivity of the Yo-Yo Intermittent Recovery Test and cardiac autonomic responses to training in futsal players." Int J Sports Physiol Perform **10**(5): 553-558.

Dellal, A., C. Lago-Penas, et al. (2015). "The effects of a congested fixture period on physical performance, technical activity and injury rate during matches in a professional soccer team." Br J Sports Med **49**(6): 390-394.
Djaoui, L., M. Haddad, et al. (2017). "Monitoring training load and fatigue in soccer players with physiological markers." Physiol Behav **181**: 86-94.
Dobbin, N., R. Hunwicks, et al. (2018). "A Reliable Testing Battery for Assessing Physical Qualities of Elite Academy Rugby League Players." J Strength Cond Res **32**(11): 3232-3238.
Dos'Santos, T., C. Thomas, et al. (2018). "The Effect of Angle and Velocity on Change of Direction Biomechanics: An Angle-Velocity Trade-Off." Sports Med **48**(10): 2235-2253.
Dupont, G., M. Nedelec, et al. (2010). "Effect of 2 soccer matches in a week on physical performance and injury rate." Am J Sports Med **38**(9): 1752-1758.
Eckard, T. G., D. A. Padua, et al. (2018). "The Relationship Between Training Load and Injury in Athletes: A Systematic Review." Sports Med **48**(8): 1929-1961.
Ekstrand, J., M. Walden, et al. (2004). "A congested football calendar and the wellbeing of players: correlation between match exposure of European footballers before the World Cup 2002 and their injuries and performances during that World Cup." Br J Sports Med **38**(4): 493-497.
Enes, A., G. Oneda, et al. (2021). "Determinant Factors of the Match-Based Internal Load in Elite Soccer Players." Res Q Exerc Sport **92**(1): 63-70.
Eston, R. and D. Connolly (1996). "The use of ratings of perceived exertion for exercise prescription in patients receiving beta-blocker therapy." Sports Med **21**(3): 176-190.
Foster, C. (1998). "Monitoring training in athletes with reference to overtraining syndrome." Med Sci Sports Exerc **30**(7): 1164-1168.
Foster, C., J. A. Florhaug, et al. (2001). "A new approach to monitoring exercise training." J Strength Cond Res **15**(1): 109-115.
Fox, J. L., R. Stanton, et al. (2018). "The Association Between Training Load and Performance in Team Sports: A Systematic Review." Sports Med **48**(12): 2743-2774.
Freitas, T. T., L. A. Pereira, et al. (2019). "Influence of Strength and Power Capacity on Change of Direction Speed and Deficit in Elite Team-Sport Athletes." J Hum Kinet **68**: 167-176.
Gabbett, T. J. (2010). "The development and application of an injury prediction model for noncontact, soft-tissue injuries in elite collision sport athletes." J Strength Cond Res **24**(10): 2593-2603.
Gabbett, T. J. and N. Domrow (2007). "Relationships between training load, injury, and fitness in sub-elite collision sport athletes." J Sports Sci **25**(13): 1507-1519.
Gabbett, T. J. and D. G. Jenkins (2011). "Relationship between training load and injury in professional rugby league players." J Sci Med Sport **3**: 204-209.
Gabbett, T. J., S. Kennelly, et al. (2016). "If overuse injury is a 'training load error', should undertraining be viewed the same way?" Br J Sports Med **50**(17): 1017-1018.
Groslambert, A. and A. D. Mahon (2006). "Perceived exertion : influence of age and cognitive development." Sports Med **36**(11): 911-928.
Halson, S. L. (2014). "Monitoring training load to understand fatigue in athletes." Sports Med **44 Suppl 2**: S139-147.
Hermassi, S., R. Aouadi, et al. (2015). "Relationships between the yo-yo intermittent recovery test and anaerobic performance tests in adolescent handball players." J Hum Kinet **45**: 197-205.
Hug, F. and S. Dorel (2009). "Electromyographic analysis of pedaling: a review." J Electromyogr Kinesiol **19**(2): 182-198.
Impellizzeri, F. M., E. Rampinini, et al. (2005). "Physiological assessment of aerobic training in soccer." J Sports Sci **23**(6): 583-592.
Issurin, V. B. (2010). "New horizons for the methodology and physiology of training periodization." Sports Med **40**(3): 189-206.

Jaspers, A., M. S. Brink, et al. (2017). "Relationships Between Training Load Indicators and Training Outcomes in Professional Soccer." Sports Med **47**(3): 533-544.
Jindrich, D. L., T. F. Besier, et al. (2006). "A hypothesis for the function of braking forces during running turns." J Biomech **39**(9): 1611-1620.
Johnson, E. C., R. R. Pryor, et al. (2017). "Precision, Accuracy, and Performance Outcomes of Perceived Exertion vs. Heart Rate Guided Run-training." J Strength Cond Res **31**(3): 630-637.
JR, S. (1935). "Studies of interference in serial verbal reactions." J Exp Psychol.: 643-662.
Kunzler, M. R. and F. P. Carpes (2020). "Intense Cycling Exercise Improves Acute Cognitive Responses." Int J Sports Med.
Loturco, I., F. Y. Nakamura, et al. (2016). "Traditional Periodization versus Optimum Training Load Applied to Soccer Players: Effects on Neuromuscular Abilities." Int J Sports Med **37**(13): 1051-1059.
Loturco, I., L. A. Pereira, et al. (2019). "Power training in elite young soccer players: Effects of using loads above or below the optimum power zone." J Sports Sci: 1-7.
Loturco, I., C. Ugrinowitsch, et al. (2013). "Training at the optimum power zone produces similar performance improvements to traditional strength training." J Sports Sci Med **12**(1): 109-115.
Lovell, T. W., A. C. Sirotic, et al. (2013). "Factors affecting perception of effort (session rating of perceived exertion) during rugby league training." Int J Sports Physiol Perform **8**(1): 62-69.
Malone, S., B. Hughes, et al. (2019). "Effect of Training Load Distribution on Aerobic Fitness Measures in Hurling Players." J Strength Cond Res **33**(3): 825-830.
Maly, T., D. Sugimoto, et al. (2018). "Effect of Muscular Strength, Asymmetries and Fatigue on Kicking Performance in Soccer Players." Int J Sports Med **39**(4): 297-303.
Marcora, S. M., W. Staiano, et al. (2009). "Mental fatigue impairs physical performance in humans." J Appl Physiol (1985) **106**(3): 857-864.
Martinez-Riaza, L., H. Herrero-Gonzalez, et al. (2016). "Epidemiology of injuries in the Spanish national futsal male team: a five-season retrospective study." BMJ Open Sport Exerc Med **2**(1): e000180.
Martorelli, A. S., F. D. De Lima, et al. (2021). "The interplay between internal and external load parameters during different strength training sessions in resistance-trained men." Eur J Sport Sci **21**(1): 16-25.
McGuigan, M. R., A. Al Dayel, et al. (2008). "Use of session rating of perceived exertion for monitoring resistance exercise in children who are overweight or obese." Pediatr Exerc Sci **20**(3): 333-341.
McLaren, S. J., T. W. Macpherson, et al. (2017). "The Relationships Between Internal and External Measures of Training Load and Intensity in Team Sports: A Meta-Analysis." Sports Med.
Mero, A. and P. V. Komi (1986). "Force-, EMG-, and elasticity-velocity relationships at submaximal, maximal and supramaximal running speeds in sprinters." Eur J Appl Physiol Occup Physiol **55**(5): 553-561.
Milanez, V. F., R. E. Pedro, et al. (2011). "The role of aerobic fitness on session rating of perceived exertion in futsal players." Int J Sports Physiol Perform **6**(3): 358-366.
Miloski, B., A. Moreira, et al. (2014). "Do physical fitness measures influence internal training load responses in high-level futsal players?" J Sports Med Phys Fitness **54**(5): 588-594.
Moalla, W., M. S. Fessi, et al. (2016). "Relationship between daily training load and psychometric status of professional soccer players." Res Sports Med **24**(4): 387-394.
Moreira, A., P. Bradley, et al. (2016). "Effect of a congested match schedule on immune-endocrine responses, technical performance and session-RPE in elite youth soccer players." J Sports Sci **34**(24): 2255-2261.
Moreira, A., N. R. de Moura, et al. (2013). "Monitoring internal training load and mucosal immune responses in futsal athletes." J Strength Cond Res **27**(5): 1253-1259.

Munro, A. G. and L. C. Herrington (2011). "Between-session reliability of four hop tests and the agility T-test." J Strength Cond Res **25**(5): 1470-1477.
Murtagh, C., C. Nulty, et al. (2017). "The Neuromuscular Determinants of Unilateral Jump Performance in Soccer Players are Direction-Specific." Int J Sports Physiol Perform: 1-28.
Nakamura, F. Y., L. A. Pereira, et al. (2016). "Monitoring weekly heart rate variability in futsal players during the preseason: the importance of maintaining high vagal activity." J Sports Sci **34**(24): 2262-2268.
Nakamura, F. Y., L. A. Pereira, et al. (2016). "Faster Futsal Players Perceive Higher Training Loads and Present Greater Decreases in Sprinting Speed During the Preseason." J Strength Cond Res **30**(6): 1553-1562.
Naser, N., A. Ali, et al. (2017). "Physical and physiological demands of futsal." J Exerc Sci Fit **15**(2): 76-80.
Neves da Silva, V. F., S. D. S. Aguiar, et al. (2017). "Effects of short-term plyometric training on physical fitness parameters in female futsal athletes." J Phys Ther Sci **29**(5): 783-788.
Nimphius, S., S. J. Callaghan, et al. (2016). "Change of Direction Deficit: A More Isolated Measure of Change of Direction Performance Than Total 505 Time." J Strength Cond Res **30**(11): 3024-3032.
O'Keeffe, S., S. O'Connor, et al. (2020). "Are internal load measures associated with injuries in male adolescent Gaelic football players?" Eur J Sport Sci **20**(2): 249-260.
Pageaux, B. and R. Lepers (2016). "Fatigue Induced by Physical and Mental Exertion Increases Perception of Effort and Impairs Subsequent Endurance Performance." Front Physiol **7**: 587.
Parry, D., C. Chinnasamy, et al. (2011). "Cognition and performance: anxiety, mood and perceived exertion among Ironman triathletes." Br J Sports Med **45**(14): 1088-1094.
Peirce, J. W. (2007). "PsychoPy--Psychophysics software in Python." J Neurosci Methods **162**(1-2): 8-13.
Pind, R., E. Maestu, et al. (2019). "Internal Load From Hard Training Sessions Is Related to Changes in Performance After a 10-Week Training Period in Adolescent Swimmers." J Strength Cond Res.
Rabelo, F. N., B. N. Pasquarelli, et al. (2016). "Monitoring the Intended and Perceived Training Load of a Professional Futsal Team Over 45 Weeks: A Case Study." J Strength Cond Res **30**(1): 134-140.
Ribeiro-Alvares, J. B., M. P. Dornelles, et al. (2019). "Prevalence of Hamstring Strain Injury Risk Factors in Professional and Under-20 Male Football (Soccer) Players." J Sport Rehabil: 1-7.
Rogalski, B., B. Dawson, et al. (2013). "Training and game loads and injury risk in elite Australian footballers." J Sci Med Sport **16**(6): 499-503.
Schmitt, L., J. Regnard, et al. (2015). "Typology of "Fatigue" by Heart Rate Variability Analysis in Elite Nordic-skiers." Int J Sports Med **36**(12): 999-1007.
Silva, J. R., J. F. Magalhaes, et al. (2011). "Individual match playing time during the season affects fitness-related parameters of male professional soccer players." J Strength Cond Res **25**(10): 2729-2739.
Silva, J. R., A. Rebelo, et al. (2014). "Biochemical impact of soccer: an analysis of hormonal, muscle damage, and redox markers during the season." Appl Physiol Nutr Metab **39**(4): 432-438.
Slimani, M., P. Davis, et al. (2017). "Rating of Perceived Exertion for Quantification of Training and Combat Loads During Combat Sport-Specific Activities: A Short Review." J Strength Cond Res **31**(10): 2889-2902.
Smith, M. R., A. J. Coutts, et al. (2016). "Mental Fatigue Impairs Soccer-Specific Physical and Technical Performance." Med Sci Sports Exerc **48**(2): 267-276.
Sobolewski, E. J. (2020). "The Relationships between Internal and External Load Measures for Division I College Football Practice." Sports (Basel) **8**(12).

Stanley, J., J. M. Peake, et al. (2013). "Cardiac parasympathetic reactivation following exercise: implications for training prescription." Sports Med **43**(12): 1259-1277.

Taylor, T., D. J. West, et al. (2015). "The impact of neuromuscular electrical stimulation on recovery after intensive, muscle damaging, maximal speed training in professional team sports players." J Sci Med Sport **18**(3): 328-332.

Teixeira, A. S., R. F. H. Nunes, et al. (2018). "Different Pathways Leading up to the Same Futsal Competition: Individual and Inter-Team Variability in Loading Patterns and Preseason Training Adaptations." Sports (Basel) **7**(1).

Thorpe, R. T., A. J. Strudwick, et al. (2015). "Monitoring Fatigue During the In-Season Competitive Phase in Elite Soccer Players." Int J Sports Physiol Perform **10**(8): 958-964.

Tonnessen, E., I. S. Svendsen, et al. (2015). "The annual training periodization of 8 world champions in orienteering." Int J Sports Physiol Perform **10**(1): 29-38.

Twomey, R., S. J. Aboodarda, et al. (2017). "Neuromuscular fatigue during exercise: Methodological considerations, etiology and potential role in chronic fatigue." Neurophysiol Clin **47**(2): 95-110.

Wang, C. H., D. Moreau, et al. (2019). "The influence of aerobic fitness on top-down and bottom-up mechanisms of interference control." Neuropsychology **33**(2): 245-255.

Weippert, M., M. Behrens, et al. (2017). "Cycling before and after Exhaustion Differently Affects Cardiac Autonomic Control during Heart Rate Matched Exercise." Front Physiol **8**: 844.

Wilke, C. F., G. P. Ramos, et al. (2016). "Metabolic Demand and Internal Training Load in Technical-Tactical Training Sessions of Professional Futsal Players." J Strength Cond Res **30**(8): 2330-2340.

APÊNDICE

Apêndice A – APROVAÇÃO DO COMITÊ DE ÉTICA EM PESQUISA

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FUNDAÇÃO UNIVERSIDADE FEDERAL DO PAMPA - UNIPAMPA

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PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: ESTUDO DAS CARGAS DE TREINAMENTO NO ESPORTE

Pesquisador: Felipe Pivetta Carpes

Área Temática:

Versão: 2

CAAE: 85233618.6.0000.5323

Instituição Proponente: Fundação Universidade Federal do Pampa UNIPAMPA

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.669.256

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Plataforma Brasil

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1072191.pdf	28/04/2018 13:37:03		Aceito
Outros	carta_resposta_pendencias.pdf	28/04/2018 13:36:35	RENATO RIBEIRO AZEVEDO	Aceito
Outros	Declaracao_coparticipante.pdf	28/04/2018 13:29:35	RENATO RIBEIRO AZEVEDO	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	28/04/2018 13:26:58	RENATO RIBEIRO AZEVEDO	Aceito
Folha de Rosto	folhaderosto_atual.pdf	28/04/2018 13:25:54	RENATO RIBEIRO AZEVEDO	Aceito
Outros	formulario_avaliacao.pdf	22/04/2018 23:02:46	RENATO RIBEIRO AZEVEDO	Aceito
Projeto Detalhado / Brochura Investigador	PROJETO_MODELO_SIPPEE.pdf	13/03/2018 18:52:31	RENATO RIBEIRO AZEVEDO	Aceito
Declaração de Pesquisadores	TERMO_CONFIDENCIALIDADE_RENATO.pdf	13/03/2018 18:31:51	RENATO RIBEIRO AZEVEDO	Aceito
Declaração de Pesquisadores	TERMO_CONFIDENCIALIDADE_FELIPE.pdf	13/03/2018 18:31:16	RENATO RIBEIRO AZEVEDO	Aceito

Situação do Parecer:
Aprovado