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Application of motor learning and neuroscience knowledge in basketball training: case report of an under-13 winner team of the Brazilian and Sulamerican championships

Aplicação do conhecimento sobre Aprendizagem Motora e Neurociências no treinamento do basquetebol: um estudo de caso de uma equipe sub-13 campeã dos Campeonatos Brasileiro e Sulamericano

Aplicación de conocimientos de aprendizaje motor y neurociencia en el entrenamiento de baloncesto: relato de caso de un equipo sub-13 ganador de los campeonatos brasileño y sulamericano

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Abstract
This case report shows how scientific knowledge produced in Motor Learning and Neuroscience areas were applied in the training of an under-13 basketball team. The performance of five athletes was analyzed in two competitions in which the team won, the Sulamerican and Brazilian championships of the 2017 season. In the present study, less repetitive practice, control over activity length and reduced extrinsic feedback were incorporated into the daily training of the basketball athletes in order to promote better motor learning, as described by studies in the Motor Learning field. The results suggested that the training geared towards factors that contribute to processes related to slow learning during a period of eleven months was enough to bring about positive changes in collective and individual performances. In addition to improved performance, a change in tactical behavior was observed through the decentralization of moves inside the key, an aspect that reflects the better use of the offense zone. The adaptation of the theoretical knowledge to the training seems to impacts positively in the performance of the athletes in all variables evaluated.
Keywords: Motor behavior; Slow learning; Fast learning; Practical application.

Resumo
Este relato de caso mostra como o conhecimento científico produzido nas áreas de Aprendizagem Motora e Neurociências foi aplicado no treinamento de uma equipe de basquete sub-13. Foi analisado o desempenho de cinco atletas em duas competições em que a equipe venceu os campeonatos sul-americano e brasileiro da temporada 2017.

No presente estudo, a prática menos repetitiva, o controle da duração da atividade e o *feedback* extrínseco reduzido foram incorporados ao treinamento diário dos atletas de basquetebol para promover melhor aprendizagem motora, conforme descrito por estudos na área de Aprendizagem Motora. Os resultados sugeriram que o treinamento voltado para fatores que contribuem para processos relacionados à aprendizagem lenta durante um período de onze meses foi suficiente para provocar mudanças positivas nos desempenhos coletivos e individuais. Além da melhora no desempenho observou-se uma mudança no comportamento tático por meio da descentralização das jogadas dentro da chave, aspecto que reflete o melhor aproveitamento da zona ofensiva. A adaptação do conhecimento teórico ao treinamento parece impactar positivamente no desempenho dos atletas em todas as variáveis avaliadas.
Palavras-chave: Comportamento Motor; Aprendizagem Lenta; Aprendizagem rápida; Aplicação prática.

Resumen

Este reporte de caso muestra cómo los conocimientos científicos producidos en las áreas de Aprendizaje Motor y Neurociencias fueron aplicados en el entrenamiento de un equipo de baloncesto sub-13. Se analizó el desempeño de cinco atletas en dos competencias en las que ganó el equipo, los campeonatos sulamericano y brasileño de la temporada 2017. En el presente estudio, la práctica menos repetitiva, el control sobre la duración de la actividad y la retroalimentación extrínseca reducida se incorporaron al entrenamiento diario de los atletas de baloncesto para promover un mejor aprendizaje motor, como lo describen los estudios en el campo del aprendizaje motor. Los resultados sugirieron que el entrenamiento dirigido a los factores que contribuyen a los procesos relacionados con el aprendizaje lento durante un período de once meses fue suficiente para generar cambios positivos en los desempeños colectivos e individuales. Además del mejor desempeño, se observó un cambio en el comportamiento táctico a través de la descentralización de jugadas dentro de la llave, aspecto que refleja el mejor aprovechamiento de la zona de ataque. La adecuación de los conocimientos teóricos al entrenamiento parece incidir positivamente en el rendimiento de los deportistas en todas las variables evaluadas.
Palabras clave: Comportamiento motor; Aprendizaje lento; Aprendizaje rápido; Aplicación práctica.

1. Introduction

1.1 From Theory to Practice, or From Practice to Theory?

Physical Education professionals are faced, on a daily basis, with the requirement of making decisions on which methods or procedures to adopt while planning and conducting the activities of their students, clients and athletes. These decisions are traditionally based on pedagogical, physiological and psychological principles associated with logical reasoning, personal observation and intuition. This interaction between formal knowledge and experience in decision making is a phenomenon observed in different health fields (El Dib & Atallah, 2006). Because scientific knowledge has a dynamic, the updating of formal knowledge is necessary in this decision-making process. In this sense, the evidence-based practice (EBP) approach helps in the understanding and in the conscious, explicit and judicious use of the best evidence available for decision making in the health field (De Domenico & Ide, 2003). This approach involves defining a problem, searching for and critically assessing available evidence, implementing said evidence in practice and evaluating results. The present study seeks to show how practical problems experienced in technical basketball training have been addressed through scientific evidence, influencing the training process and philosophy, as well as to show the analyzed results. The implemented scientific evidence was based on knowledge generated in the Motor Learning and Movement Neurosciences fields.

The Motor Learning field produces knowledge about the acquisition of motor skills. It is a branch of study that investigates the mechanisms and processes underlying changes in an individual's motor behavior as a result of practice, as well as the factors that influence these changes (Schmidt & Lee, 2005). Despite being a field of study that essentially seeks to understand "how one learns", the knowledge produced about factors, such as organization of practice and provision of feedback, has a strong practical appeal (Tani & Correa, 2004), that is, assists in "how one teaches". In this sense, it is a consensus that information provided by research in Motor Learning can be useful in solving practical problems (Tani, 1992; Fernandes et al., 2022).

The Neurosciences deal with the study of the nervous system. An obvious entanglement is expected between Motor Learning and the Neurosciences, as the mechanisms and processes underlying the changes that characterize learning occur in the nervous system. Studies that investigate motor learning are conducted at different levels of analysis, such as (a) molecular (e.g., Apolinario-Souza et al., 2019a), which involves functional aspects and interaction between molecules, and (b) systemic (e.g., Parma et al., 2020), which considers the activity of the neuronal population. When treated as a field, "Motor Learning" will be adopted. When treated as a behavior-change phenomenon, "motor learning" will be used. The growing increase in knowledge about motor learning from the perspective of the Neurosciences strengthens the possibility of using EBP to solve practical problems. Neuroscience-based investigations have expanded the knowledge about motor learning from revelations about the relationships between cognitive processes and neural structures involved in skill acquisition (Nogueira et al., 2020).

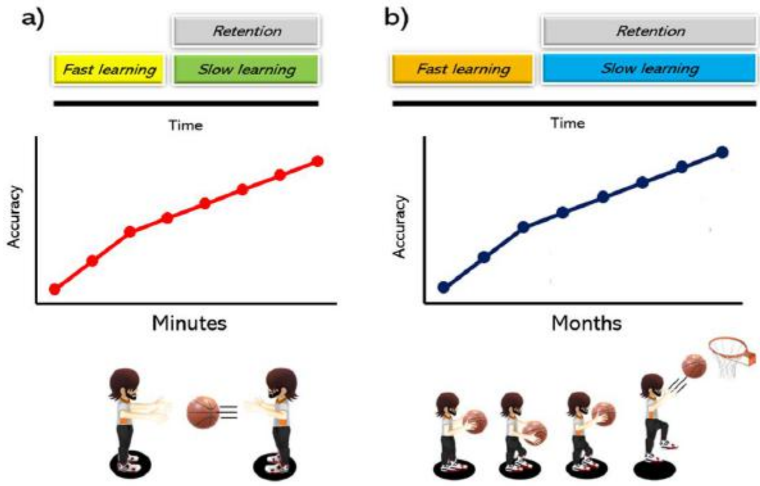
1.2 Reflections on sports training, early specialization, and the fast and slow learning memory states

One of the main guiding questions that should be on the mind of every coach who works with the sporting training of athletes is: what is the main goal of their work? The pedagogical conception (or lack of conception) and the economic and political interests of many clubs and coaches subject children to physical and psychological stimuli for which they are not yet prepared (Tani, 2002). These stimuli produce rapid gains, but do not generate effective learning. This subjection to inadequate stimuli to an athlete's training characterizes early sports specialization (Hernandes et al., 2015). During the first stages of sports training, the bases for high performance must be established, preventing demands for immediate results. Early specialization inhibits the formation of a broad base of motor experiences that, in the future, restricts the advancement of the athlete's technical performance (Pereira et al., 2018).

In the case of technical training, methods and processes can (a) facilitate rapid gain in performance, but with little retention and transfer of what has been trained, or (b) present slower gains, but which lead to strong consolidation and transfer of training. An example of these effects is observed in a more repetitive practice, such as constant practice, or in skill blocks, in which gains are rapid but not long lasting, in contrast to a less repetitive practice, such as random practice with more lasting effects (Lage et al., 2015). In this sense, what would be more important in sports training: a higher rate of improvement in technical performance, but that can lead to little retention and transfer of what is trained, or a lower rate of improvement, but that promotes more lasting changes in the athlete's performance, thus resulting in long-term gains? The expected answer would be the second option, a longer, but more solid path in the athlete's development. However, pressure from external factors, such as demand for results from clubs, and internal factors, such as the need for professional success, lead professionals to choose the fastest route, which may result in a future damage to development (Pereira et al., 2018).

Different forms of training can favor more lasting or more momentary memory states. The fast and slow learning memory states, both involved in learning and motor adaptation, can explain how internal learning-consolidation processes differ depending on the training method used in practice. Fast learning allows fast-paced learning and serves as an intermediary that retains information stored only temporarily (Doyon et al., 2003). It is a process that responds strongly to error, leading to a decrease in error in the short term, but has poor retention (Apolinário-Souza et al., 2016). Slow learning, on the other hand, allows learning at a slower pace and serves as a long-term storage (Doyon et al., 2003). It is a process that responds weakly to error, does not participate as effectively in reducing error, but contributes to long-term retention (Apolinário-Souza et al., 2016). It is important to notice that the relative length of what can be defined as fast and slow learning is highly specific to the task to be practiced by the learner (Dayan & Cohen, 2011). For example, the quick phase of learning the chest pass in basketball may take minutes, while the quick phase of learning the layup may take months. Likewise, nearly asymptotic levels (close to a straight line) in final skill measurements can be acquired very quickly when one learns the chest pass, but much more slowly when one learns the layup, as illustrated in Figure 1.

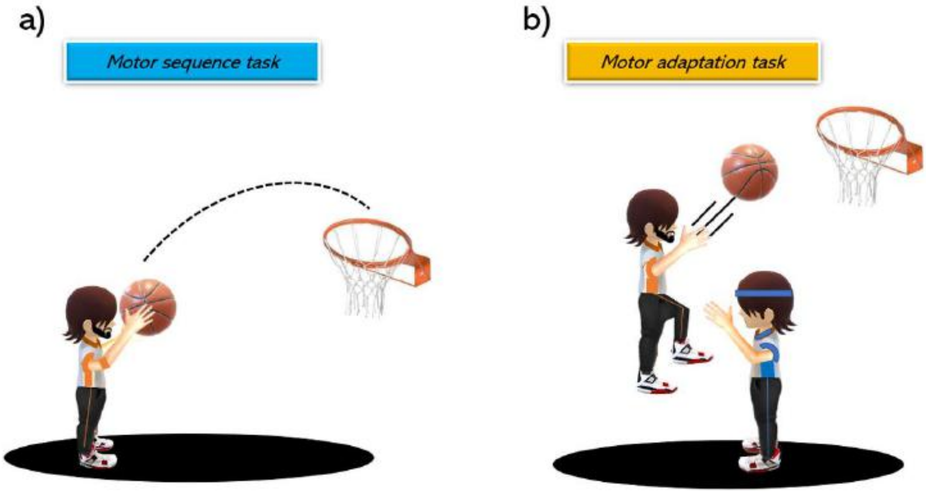
Figure 1. Fast and slow learning memory states in different basketball skills. (a) fast and slow learning memory states in the chest pass skill, length in minutes; (b) fast and slow learning memory states in the layup skill, length in months.



Source: Authors.

These changes in the course of learning occur during the practice of the task (online changes) and after its completion (offline changes). Offline processes, including stabilization and improvement of skills, reflect the consolidation of motor memory. Online and offline learning gains can be maintained over time, resulting in long-term retention (Dayan & Cohen, 2011). Regarding long-term retention, changes in different brain areas depend not only on memory processes, but also on the type of task imposed on the learner. Depending on the nature of the required cognitive processes (e.g., working memory, type of error detection mechanism), similar brain areas are recruited in the early stage of learning or fast learning, such as: striatum, cerebellum and cortical motor areas (e.g., pre-motor cortex and supplementary motor area), as well as the pre-frontal and parietal areas. However, as learning progresses after consolidation in slow learning, changes are also observed. Motor sequence learning tasks (e.g., free throw) have been shown to be associated with changes in corticostriatal circuits (Doyon et al., 2003), whereas motor adaptation tasks (e.g., layup under the condition of man-to-man defense) are associated with changes in cortico-cerebellar circuits, as illustrated in Figure 2.

Figure 2. Sequence and motor adaptation tasks. (a) motor sequence tasks involve learning a sequence of motor acts that, together, make up the skill (task). These tasks are performed in more stable environments, with fewer changes in the context of execution. An example in basketball would be the execution of the free throw; (b) motor adaptation tasks also involve learning a sequence of motor acts, but performed in less stable environmental contexts. This contextual variability requires constant adjustments, changes in the way these motor acts are organized, as it requires adaptation to the context in order for the goal to be achieved. In basketball, an example is the execution of a layup under the condition of man-to-man defense.



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Though never investigated, it is possible to think that different training methods and requirements can more or less favor the formation of these memory states. As a consequence, a more or less consolidated learning would impact the athlete's technical development. Philosophically, it is plausible to associate the rapid search for performance improvement, characterized by early specialization, with training methods and requirements that favor the fast learning memory state in the acquisition of a smaller number of skills. It is also possible to consider that an athlete's training based on methods and requirements appropriate to the development moment favors the slow learning memory state, resulting in a greater repertoire of skills. In the first situation, we would have an athlete performing well in a limited range of skills, and the learning of these skills could be deficient because it emphasizes processes that do not directly help in the formation of a lasting memory. On the other hand, in the second situation, we would have an athlete who initially would not perform at a competitive level equal to that of someone who experienced fast learning most, but who would have a broader and better consolidated motor repertoire that would serve as a basis for future performances. This description of the search for rapid gains that characterizes early specialization, to the detriment of more lasting gains, appropriate to the training level, is found in the literature (Bompa, 2001).

For Bompa (2001), early specialization has as training characteristics a rapid development of performance, early peak performance, inconsistent performance in competitions, rapid saturation of athletes, and high susceptibility to injuries. In addition, a proper training process presents a slower pace of performance development, a later peak performance, suitable for psychophysiological maturation, a more consistent performance in competitions, a long useful life for athletes, and lower injury rates. As seen, reflections on possible athlete training processes, as well as their consequences, are not recent. However, recent knowledge produced in the fields of Motor Learning and Neurosciences bring greater depth to the understanding of these processes, especially when we focus on the proper training of athletes. From the logic presented, questions arise as to how to think about sports training in the long term. What are the factors experienced throughout the training process that could favor the slow learning memory state? How could coaches prescribe situations that lead to a better retention of learned skills?

Even if it takes longer for these benefits to appear. In other words, how could the athlete training process be suited to the quest for long-term rewards and not to short-term volatile achievements?

1.3 Cognitive Requirements in Training, Mental Workload and Slow Learning

More related to the slow learning state, mental workload, which is defined as a finite mental resource used to perform a task under certain operational and environmental conditions (Jiang et al., 2015), can lead to increased motor-perceptual effort during a training session, improving performance in future sessions (Lelis-Torres et al., 2017). In this context, in which a higher level of mental workload is associated with slow learning, the benefits resulting from practice reflect in a greater engagement in perceptual, cognitive and motor aspects (Lelis-Torres et al., 2017). Since the increase in mental workload is intrinsically linked to the demands of performed tasks (Borghini et al., 2014), it is necessary that coaches include in the training, whenever possible, challenging activities that increase mental effort. Although the level of mental workload is individual and varies depending on the practitioner’s expertise (Patten et al.,2006), some factors, such as organization of practice, length of activities and feedback, can be handled with a view to increasing mental effort.

The organization of practice, traditionally investigated by Motor Learning studies, can be subdivided into two categories, called constant and varied practices (Lage et al., 2011a). The difference between these practices is the number of practiced motor skills and/or the variations of these skills. In a training session, constant practice consists of performing a single motor skill, while varied practice is about performing two or more skills, or variations of one same skill (Lage et al., 2011a). Varied practice, in its turn, can be organized in three ways that differ by the number of repetitions and/or by the predictability of the sequence of skills. Block practice is characterized by making all attempts at one same skill so that another can be started (e.g., AAAABBBBCCCC, with A, B and C being hypothetical skills) (Lage et al., 2011a). Serial and random practices, on the other hand, have a non-repetitive nature, with the practiced skill varying attempt after attempt, and the difference being only in the predictability of this variation, since the variation of a serial practice is predictable (e.g., BCABCABCABCABC) and that of random practice is unpredictable (e.g., ABCBCACBABACACB) (Lage et al., 2011a).

In general, it is established by the literature that less repetitive practices (serial and random) provide better motor learning compared to more repetitive ones (constant and in blocks) (Lage et al., 2015). Although there are some divergences as to the explanations for the superiority of less repetitive practices, the continuous variation of the practiced skill provides a greater mental effort by increasing the requirement for interpretation and storage of information, as well as for the elaboration of strategies and planning towards the goal (Lage et al., 2015). Expanding the knowledge hitherto consolidated, by means of electroencephalographic measurements, Lelis-Torres et al. (2017) identified that, in addition to greater mental effort related to memory and executive functions, less repetitive, random practice (which, from now on, will only be referred to as random practice) also increases engagement in cognitive processes involved in sensory processing. Returning to the precepts of mental workload and slow learning, practices organized at random, for being more challenging, raise the level of mental workload, causing a greater participation of slow learning in the learning process.

Certainly, in a view aimed at early specialization, more repetitive practices are adopted for being more associated with fast learning, since improvement in the performance of a technique can be easily achieved with little practice. Opposing to this view, especially in open-skill sports such as basketball, football and volleyball, more than the execution of a perfect technique, the athlete needs to be able to adapt to the different unpredictable contexts that these modalities impose (Lage et al., 2011b). Thus, despite showing a lower specific performance during practice, the variation of stimuli and skills during training is essential for the athlete to be able to perform a technique or make successful decisions in the context of the game. In this regard, it is important to note that, despite their lower performance during the training session, less repetitive practices, for requiring more from the cognitive and perceptual processes of athletes (Lelis-Torres et al., 2017), lead to a better consolidation of learning after a period without practice via slow learning.

In addition to the organization of practice, coaches must also be concerned about the length of the activities so that there is no significant reduction in attention and mental effort during training. It is known that attention plays a crucial role in motor learning and that sustaining it over time in a given activity is essential for proposed objectives to be achieved. Some factors, such as time and fatigue, can act as agents that hinder the maintenance of attention, impairing performance and the consolidation of learning (Ling & Carrasco, 2006). Thus, prolonged activities can be harmful even if they are organized in a less repetitive way. Just as attention, mental effort also changes over time, causing engagement in cognitive and perceptual processes to decrease (Bicalho et al., 2019; Lelis-Torres et al., 2017). Consequently, a reduction in mental effort during a training session can make slow learning difficult. Considering the implications of time for attention and mental effort, shorter activities combined with less repetitive practices can favor slow learning by maintaining a high level of mental workload.

A third factor that should be noted when it comes to mental workload and slow learning is the frequency of extrinsic feedback. Conceptually, feedback comprises any sensory-response information from a previously performed action and can be classified as intrinsic or extrinsic. Intrinsic feedback refers to response information from the individual themselves, such as sight, hearing, proprioception and touch. On the other hand, extrinsic feedback is related to information transmitted by sources external to the individual (Ferreira et al., 2019). Especially in the initial stage of learning, in which the practitioner is unable to efficiently interpret and use intrinsic feedback (Fitts & Posner, 1967), the provision of extrinsic feedback by the coach is essential for the athlete to be able to perceive and, mainly, to correct errors, thus improving performance.

Although extrinsic feedback is paramount for training, when provided too often it can cause a negative dependence effect (Salmoni et al., 1984), making the athlete disregard their own intrinsic feedback. In this context, the strengthening of intrinsic feedback is of great importance, considering that, to reach the most advanced stage of learning, the practitioner must be able to make a quality use of intrinsic feedback in order to independently identify and correct their own mistakes (Fitts & Posner, 1967). Aiming at a greater participation of intrinsic feedback in the learning process, it has been shown that a low frequency of extrinsic feedback (e.g., 50% feedback) generates a lower performance during the practice phase, but leads to better learning compared to high frequency (e.g., 100% feedback) (Salmoni et al., 1984). As noted, just as in less repetitive practices, a reduced frequency of extrinsic feedback demands greater cognitive effort, which may favor the slow learning memory state and decrease the participation of fast learning by requiring a greater processing of intrinsic feedback. Together, the planning of a training session with short activities, organized in a less repetitive manner and with a lower frequency of extrinsic feedback, suits the objectives of sports training directed to factors that contribute to slow-learning processes.

1.4 How is Random Practice Associated with Memory Formation?

Although the nature of the task to be learned leads to different types of recruitment of brain areas in advanced learning stages, the way in which practice is structured can also contribute to these differences in recruitment. Shimizu, Wu and Knowlton (2016) investigated whether cerebellar activation during a motor sequence learning task could be associated with better transfer to a new motor sequence. Their results showed that the involvement of cortico-cerebellar circuits can be different depending on the way in which practice is structured. The random practice of motor sequences was related to the greater plasticity of the cortico-cerebellar circuits than a more repetitive practice was, thus allowing the formation of a more generalized representation of the practiced skill (Shimizu et al., 2016).

The main point with respect to the participation of the cortico-cerebellar circuits and the structuring of practice is that random practice requires adjustments following every attempt at the skill, which can generate a demand for cerebellar activity similar to that required when one practices a motor adaptation task. Cortico-cerebellar circuits participate in learning by updating motor commands via error correction or contextual requirement (Doppelmayr, Pixa, & Steinberg, 2016), such as in a match situation. In random practice, there is a need for the updating of motor commands, attempt after attempt, and the level of errors remains higher even in the advanced phases of practice (Lage et al., 2015). Thus, at a more macroscopic level of analysis (at the level of the brain circuit), the way in which practice is structured can also influence changes in the representation of brain areas, in addition to memory states, as mentioned earlier.

At a more microscopic level of analysis, studies have shown differences between memory strengthening processes and practice structures (Apolinário-Souza et al., 2019a, 2019b). In general, the process of strengthening motor memory has two distinct states, already mentioned, a rapid initial improvement in performance, followed by a gradual change associated with the memory state. In addition, there is the idea of greater memory strengthening through random practice. The study conducted by Apolinário-Souza et al. (2019b) sought to investigate the association between practice structures (random and constant) and the fast and slow learning memory states. Their results showed that random practice was more associated with slow learning. In another research, Apolinário-Souza et al. (2019a) sought to investigate the association between the glutamate, n-methyl-D-aspartate (NMDA) and alpha-amino-3-hydroxy-5-methyl-4-isoxazolepropionic (AMPA) receptors and the constant and random practice structures. Their results showed that random practice was more associated with the NMDA receptor and had a greater expression of the AMPA receptor compared to constant practice (Apolinário-Souza et al., 2019a). It is possible that random practice produces higher levels of long-term potentiation (LTP) (Apolinário-Souza et al., 2019a), a cellular mechanism underlying the consolidation of memory and learning (Apolinário-Souza et al., 2016), via NMDA, increasing the insertion of new AMPA receptors. These findings advance the understanding of the molecular mechanisms underlying the greater memory strengthening produced by less repetitive practice, as proposed by behavioral hypotheses (Apolinário-Souza et al., 2019a) (e.g., distinct elaboration/processing, reconstruction of the action plan/forgetfulness).

Based on the theoretical knowledge available on Motor Learning and Neurosciences, this research, characterized as a case study, aimed (a) to describe the theoretical bases applied to the technical and tactical training of a U-13 basketball team, (b) to present changes in collective and individual performances as a result of this new approach, in the interval between two championships, and (c) to associate the changes in performance with the theoretical basis applied to training.

2. Methodology

This research, characterized as a case study, analyzed data collected from an Under-13 basketball team. Data anonymity and confidentiality were guaranteed, and so was the compliance with research ethics standards. The study received institutional approval and that the participants' informed consent was obtained. The object of the case study is the analysis of a unit of study. It aims at the detailed examination of an environment, a subject or a particular situation. It has become a common practice in the quest to understand how and why certain phenomena happen. Analyzes events over which the possibility of control is reduceded or when the phenomena analyzed are current and only make sense within a specific context (Neves, 1996; Yin, 2015).

2.1 Samples

Data were collected from 5 athletes in the Under-13 men's basketball team, during two major competitions in 2017. The 2017 season was composed of 3 official competitions in the following periods: (1) Metropolitan – first phase –, with 15 matches between March 1st and July 12th; (2) South American, with 7 matches between July 16th and July 24th; (3) Metropolitan – second phase –, with 11 matches between the August 1st and the October 30th; (4) Club Brazilian Cup, with 6 matches between November 26th and December 1st. Data on the performance of the 5 athletes in the two biggest competitions of 2017, the South American and the Club Brazilian Cup, were analyzed. The team won both. Because they were away for a sufficient period (4 months) for changes in performance, resulting from the application of the training philosophy, to occur, they were chosen to be analyzed.

2.2 Procedures

The training macrocycle started in February of that year. In February, March and April, the training philosophy based on Motor Learning and Neurosciences knowledge was emphasized. Emphasis was placed on aspects that favored the slow-learning process. Errors were still very frequent, and the corrections and improvements in performance came slowly and gradually. Although the tactical performance concerning the decentralization of the dependence of few players is developing, good results were seen on the court, culminating in the team winning the South American championship. One of the main objectives was to make a better use of the court spaces and to enable a higher frequency of attempts at mid-range shots, based on an adequate decision making, always aiming at the formation of all athletes in the long term; the victories were secondary, despite having happened. Peak performance was reached at the end of November. However, because the training philosophy understands motor learning as a continuous process, what was defined here as "peak" was the best performance of the athletes at that moment in their training; theoretically, some athletes could even reach a higher "peak" if they were being stimulated only by fast-learning processes, but the players were within a slow learning "planning" aimed at a higher performance peak in the future. A point to be highlighted would be that club (team) has a universal sports initiation program together with competition teams, and these athletes were already practicing in younger age categories. The concepts mentioned in the article and the way they were applied, bearing in mind that they are recent in the sports/academic universe, were applied for the first time and showed a promising context to be used in training.

2.3 Reports on the methods and processes used by the coach are presented below:

"Every day we would do technical exercises (shots, layups, passes, etc.), but perceptual variables (visual, sound and tactile) were added to the exercises considered traditional, or also to the creation of new (non-traditional) exercises. These strategies gave the task a random character and, mainly, the athletes always had to react and were taken by surprise about what to do next. This approach I call random, unpredictable exercises. We can say that, in the pre-season (February and April), about 40 minutes per training session were focused on this concept and, during the season (May to December), 20 minutes were dedicated to this context."

"I used exercises based on the concept of mental workload; in few minutes, after the brain adapted to information, motor programs and parameters, I'd change some variable so that he (the athlete) would continue the same motor program, but would always be taken by surprise, needing to make a decision and then execute the technique, never letting the brain rest."

"I used approaches with the athletes based on their different responses to intrinsic and extrinsic feedback. We need balance in the amount of extrinsic feedback. Usually, we, coaches, want to give feedback at all times, always in search of perfection, whether in terms of technical details or tactical issues. The internal processes involving the adjustment and understanding of the movement, mainly when it comes to the comparison of the goal with the performed movement, was used during the season, mainly with my adaptation about the frequency of extrinsic feedback, I had to control the instinct of wanting to give tips all the time."

"I work predominantly with my teams in the sense of understanding the game via perceptual, cognitive, motor and emotional aspects, we know about the direct relationship between these aspects and decision making in sports. Corrections related to gestural/technical improvement were always present during training and are very important, but at the tactical moment (e.g., 2x2, 3x3, numerical advantage, 5x5, etc.), there were more corrections aimed at decision making. So, oftentimes, the athlete missed the basket but received a compliment for having made the right decision. As an analogy, if the feedback given corresponded to 100%, then 90% was a compliment on decision making, if it was correct, and 10% was a tip or correction of some technical aspect, if it occurred. In many moments, the athlete would execute the whole technique "correctly" but, due to the natural complexity of basketball, error is always present. If even the highest-level professionals in the world makes mistakes, imagine those in the initiation and improvement process. These strategies clearly favored the following aspects:

- ❖ Athlete-coach relationship;
- ❖ Reception of extrinsic feedback;
- ❖ Reaction to one's own mistakes (intrinsic feedback);
- ❖ Confidence for the next attempt;
- ❖ Reduced fear of making mistakes;
- ❖ Better understanding of the game and decision making;
- ❖ Reduced emotional weight of the technical error for a developing athlete.

The athlete's motivation and joy in continuing to practice, because the environment was not predominantly one of criticism, but one of dialogue, favoring the sporting teaching-learning process."

As for the training and match methodology, the concept of 5-Out Motion Offense was used because, the team being U-13, the goal was to give all athletes an opportunity to experience all positions, thus preventing early specialization, by which the athlete takes only specific positions within the same modality (Pereira et al., 2018). Although there was a natural inclination to certain positions, due to differences in skills and physical characteristics, this was not an objective. In planning, the aim is to make one free to shoot, infiltrate and execute all actions of the game, based on proper decision making in the face of the dynamics of the match.

2.4 Statistical Analysis

Data on four variables were collected from the 5 players during the matches in the South American and Club Brazilian Cup championships, namely: (1) total number of points in the championships; (2) number of points per player in the championships; (3) number of scored free throws; (4) distribution of the players' finishing-move areas in the championships. The analyses were performed using descriptive statistics.

3. Results

3.1 Total Number of Points and Points per Player in the Championships Total Number of Points and Points per

Descriptive analyses are shown in Table 1. There was an increase in the number of points from one championship to the other. Most players raised their score between championships – players 1 (126%), 4 (136%) and 5 (76%). The other ones lowered their scores – players 2 (-24%) and 3 (-9%). The total score increased by 17% from one championship to the other.

Table 1. Total score and score per player between championships.

	South American	Brazilian	Difference (%)
Player 1	35	79	126%
Player 2	135	103	-24%
Player 3	87	79	-9%
Player 4	25	59	136%
Player 5	17	30	76%
Total	299	350	17%

Source: Authors.

3.2 Number of Scored Free Throws

Descriptive analyses are shown in Table 2. There was an increase in the number of scored free throws from one championship to the other. Most players raised their number of scored moves – players 1 (from 42.9% to 76.9%), 2 (from 61% to 73.3%), 4 (from 37.5% to 50%) and 5 (from 66.7% to 100%). Player 3 lowered his number of scored moves (from 54.1% to 50%). The total number of scored moves increased from one championship to the other, the South American Under-13 Championship (54.7%) and the Brazilian Under-13 Championship (70.5%). However, despite the increase in the number of scored free throws, there was a decrease in the number of attempted free throws from one championship to the other.

Table 2. Number of scored free throws from one championship to the Other.

	South American		Brazilian	
	Attempts	Scored moves (%)	Attempts	Scored moves (%)
Player 1	14	6 (42.9)	13	10 (76.9)
Player 2	41	25 (61)	15	11 (73.3)
Player 3	37	20 (54.1)	6	3 (50)
Player 4	8	3 (37.5)	6	3 (50)
Player 5	6	4 (66.7)	4	4 (100)
Total	106	58 (54.7)	44	31 (70.5)

Source: Authors.

3.3 Distribution of the Players' Finishing-Move Areas in the Championships

Descriptive analyses are shown in Figure 3. There was a greater distribution as to the players' finishing-move areas from one championship to the other. In the South American U-13 Championship, the players were more restricted to the key, with a greater number of attempts from the right side. Mid-range shots were performed more often from inside the key, and when the attempts were made from outside the key, the right side was predominant as well. In the Brazilian U-13 Championship, despite a visible concentration in the key, the players showed a better distribution in their attempts at throwing, which can be observed by their distancing from the key. Thus, there was a greater balance between the number of attempts from the right versus the left side, and an increase in the number of attempts at throwing from behind the three-point line. Furthermore, the players took more advantage of all areas of the court, which had a direct relationship with an evolution in

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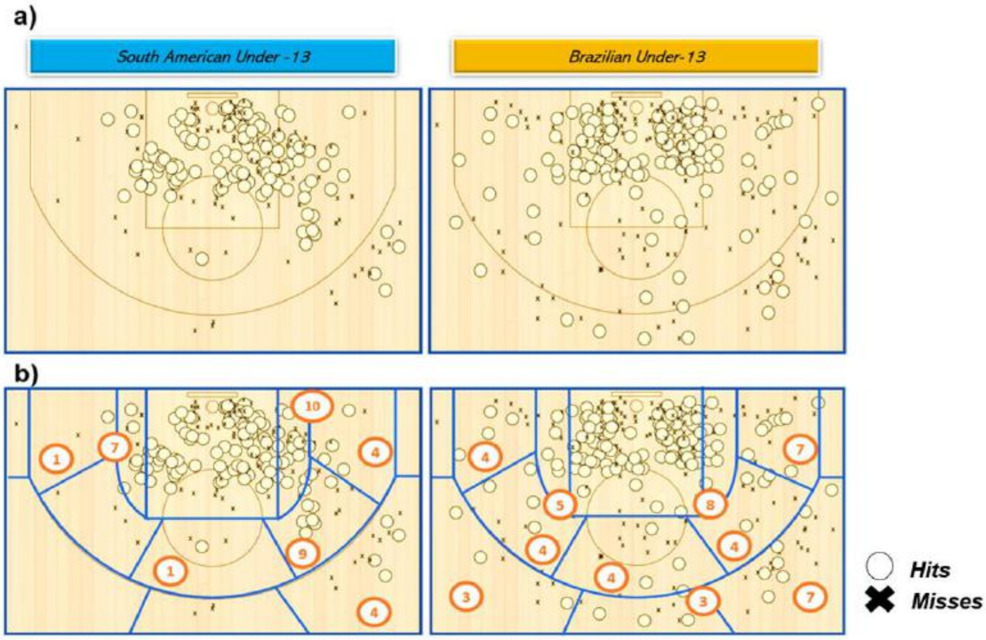
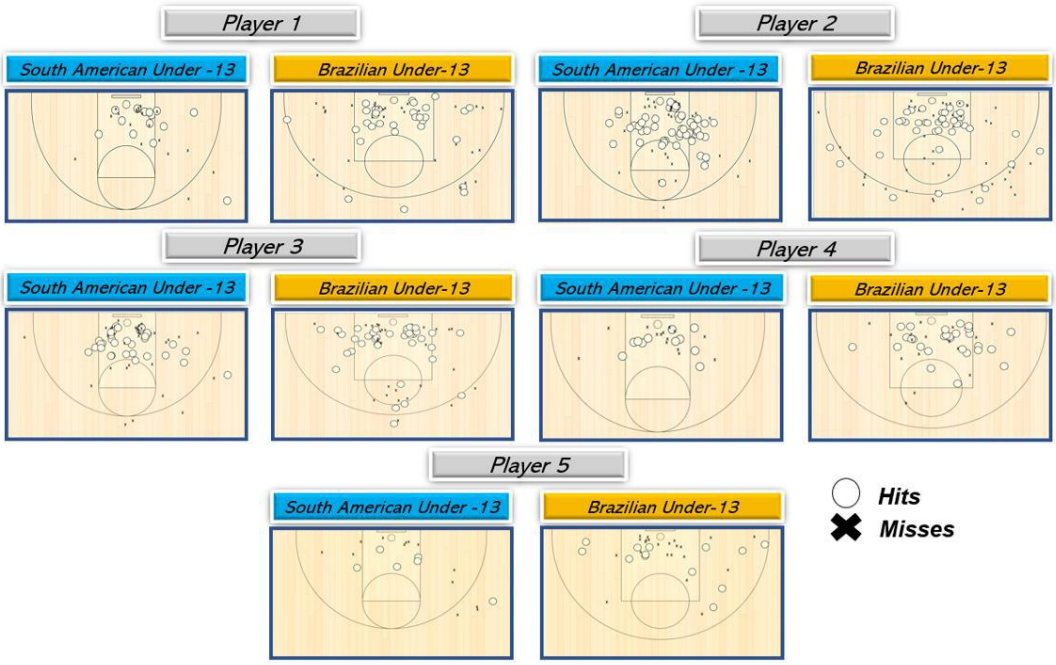
their tactical behavior while playing (Bredt et al., 2017). Figure 4 shows the changes in distribution as to the finishing-move areas per player in the championships.

Figure 3. a) Grouped representation of the distribution of the finishing-move areas of all players in the championships; b) number of scored moves divided by areas outside the key.



Source: Authors.

Figure 4. Representation of the distribution of finishing-move areas per player in the championships.



Source: Authors.

4. Discussion

This case study aimed to describe the theoretical bases applied to the technical and tactical training of a U-13 basketball team, and to present changes in their collective and individual performances as a result of this new approach during one season (11 months) and in the interval between two championships. In general, the results suggested that the training geared towards factors that contribute to processes related to slow learning during a period of eleven months was enough to bring about positive changes in collective and individual performances. In addition to improved performance, a change in tactical behavior was observed through the decentralization of moves inside the key, an aspect that reflects the better use of the offense zone (Greco et al., 2010). Three central points regarding the results will be discussed in greater depth, namely: scoring, free throws and tactical behavior. Within each point, the theoretical bases described in the introductory part of the text will be revisited with the intention of showing how an approach focused on slow learning can reconcile sporting success (winning championships) with the long-term training of athletes.

In team sports in which the rules do not allow the possibility of a tie – as in basketball –, technique and, especially, the tactical strategies adopted for surpassing the opponent’s score are sine qua non conditions for the team’s success (Sampaio, 1998). Thus, a good indication of improvement in collective and individual performances is the rise in points scored in championships played during and between seasons. Along with other variables, variation in scores throughout the year can serve as feedback to coaches and the coaching staff and assist them in their decision on maintaining or changing the training method (Sampaio, 1998). In the present study, less repetitive practice, control over activity length and reduced extrinsic feedback were incorporated into the daily training of the basketball athletes in order to promote better motor learning, as described by studies in the Motor Learning field (Lage et al., 2011a; Lage et al., 2015; Ling & Carrasco, 2006; Salmoni et al., 1984). In this regard, the 17% increase in the collective score achieved in the Brazilian Under-13 Championship, compared to the South American Under-13 Championship, showed that the method used during training was effective in improving the team’s performance in the matches. Considering that less repetitive practices generate better learning, but worse momentary performance (Lage et al., 2015), it is important that this variation is not incorporated into training sessions suddenly, close to competitions of interest to the team. It takes time to adapt to a greater demand for mental effort (Lage et al., 2015). Thus, it is essential that changes in the training method aiming at the slow learning memory state is aligned with the periodization of the team. This change should take place preferably in the pre-season, when a temporary decline in technical performance does no harm, since physical and regenerative training are a priority in this period.

Concerning the results for individual performances, three of the five athletes raised their scores from the first to the second championship (players 1, 4 and 5), while two lowered their scores (players 2 and 3). At first glance, these results suggest that the adopted training method did not benefit all athletes, and may therefore be dependent on individual characteristics. However, carefully analyzing the data of the South American U-13 Championship, players 2 and 3 together were responsible for 74.25% of all points, being the greatest scorers. On the other hand, in the Brazilian Under-13 Championship, there was a clear decentralization in the game due to players 2 and 3, who scored only 52% of all points. An in-depth analysis of these results indicates that the positive effect of mental effort on performance can help reduce the dependence of the most skilled athletes. This proposition can be supported by the fact that a less repetitive practice allows a better transfer of the practiced motor skill. In this context, a less repetitive practice can expand one’s ability to successfully adapt the execution of motor skills (Lage et al., 2011a) before the various unpredictable variations imposed on team sports. This better ability to adapt movements, promoted by a less repetitive practice, may indirectly indicate the strengthening of the cortico-cerebellar circuits in the more advanced stages of learning. Thus, through the training method adopted in this study, a greater ability to diversify motor skills may have provided players 1, 4, and 5 with new motor resources that reduced their dependence on other players.

From the collective results and the more effective participation of players 1, 4 and 5 in the Brazilian Under-13 Championship, it was possible to observe benefits without resorting to early specialization. In sports, early specialization has been associated with a higher incidence of injuries, overtraining and burnout (Brenner, 2007), and can limit the learning of motor skills. Although elite high-performance athletes usually do not specialize until late adolescence, early specialization, strangely, is seen as a mechanism for sporting success (Brenner, 2016). Given the scientific studies that have identified possible harms resulting from early specialization (Hernandes et al., 2015), it was to be expected, in particular, that the training of junior categories would be directed to a broad and diversified development of athletes, but this is not a reality. There seems to be, therefore, a wide gap between theory and practice responsible for a constant reproduction of outdated methods that do not befit the evidence described in the literature. Greater interaction between theoretical knowledge and professional practice can be achieved through the coaches' own interest, as well as the clear, natural and direct writing of articles to favor understanding for people who seek information but are not familiar with academic writing (Barbanti, Tricoli, & Ugrinowitsch, 2004). In order to provide athletes with a training method aligned with scientific precepts, the present study, through practical application, showed that it is possible to win championships by aiming at long-term training.

Training benefits were also identified as to free throws. According to Sampaio (1998), the effectiveness of free throws contributes significantly to determining the final outcome in balanced matches. Being decisive, the free throw, which is a shot variation, should be one of the focus of planning. Just as the penalty kick in football and the 7-meter throw in handball, the free throw can be classified as a closed motor skill, in which external factors cause little interference in performance. Because it is a closed motor skill, the best way to become skilled at the free throw would be through constant practice, which makes it possible to refine the movement more and more (Gentile, 1972). In a way, unlike the proposition of Gentile (1972), in this study, a less repetitive practice seems to have contributed to raising the percentage of scored moves between championships. With the exception of player 3, all the other players raised their percentage of scored free throws in the Brazilian Under-13 Championship. There was also an increase of 15.8% in the percentage of scored collective moves. It is important to highlight that, although less repetitive practice was prioritized during the daily training of the athletes, more repetitive practices were used, when necessary. Despite better performance in closed motor skills being more associated with constant practice (Gentile, 1972), the results suggest that less repetitive practice, when combined with constant practice, is capable of bringing additional benefits to the performance of free throws in comparison with constant practice in isolation. In this regard, it is possible that random practice, by increasing the corticospinal excitability of the primary motor cortex (Lage et al., 2015), also favored the execution of closed motor skills, resulting in a rise in the percentage of scored free throws between championships. Another curious result was the decrease in opponent fouls that led to free throws. In the South American U-13 Championship, there were 106 attempts at free throws, but this number dropped to 44 in the Brazilian U-13 Championship. This reduction may have been caused by a better use and exploration of the offense zone.

Through the decentralization of the game from the key, it was possible to notice a clear change in the team's tactical behavior, which can explain much of the results. The better use of the offense zone in the Brazilian Under-13 Championship enabled more shots and scores from outside the key, which may have contributed to reducing opponent fouls, since the largest number of fouls in basketball happens near the basket. Moreover, it was possible to see an increase in shots from the left side of the offense zone, suggesting that the training aimed at improving dribbling, shots after dribbling, and layups with the left hand was effective. Considering the need to adapt movements quickly in accordance with the context of the match, training the non-dominant hand is paramount (Stockel & Weigelt, 2012). The ability to successfully adapt motor skills in time-pressure situations requires good performance with both hands in order to broaden the motor resources available at the time of decision making (Stockel & Weigelt, 2012). From the positive correlation found between better performance with the non-preferred hand and the athletes' level of expertise, Stockel and Weigelt (2012) suggested that bilateral practice can be used in training to cause changes in hand preference, specifically to motor skills, towards a greater use of both hands in competitions. Efficiency in performing actions with non-preferred limbs can favor the development of procedural tactical knowledge, which has to do with the ability to operationalize decisions in the context of the game (Anderson et al., 2004). In addition to bilateral training, the focus on exercises that require decision making, combined with random practice, may have contributed to increasing the players' procedural tactical knowledge, thus changing their tactical behavior, as observed in the Brazilian Under-13 Championship. Given the importance of decision making in team sports, training methods that value the cognitive processes involved in decision making are fundamental for the development of athletes aiming at tactical knowledge (Apolinário-Souza & Fernandes, 2018).

5. Final Considerations

The results of this study showed that the adoption of a training method aimed at the long-term development of athletes was effective in improving the collective and individual performance of an Under-13 basketball team. By prioritizing less repetitive practices, controlling the length of activities and reducing extrinsic feedback, it was possible to observe a positive change in scores and in the effectiveness of free throws between the investigated competitions. There was also a clear change in the team's tactical behavior, which made it possible to make a better use of the offense zone through the decentralization of the game from the key and the right side of the court. Thus, the application of knowledge on Motor Learning and Neurosciences had a positive impact on basketball training. This fact shows that using the available theoretical knowledge to guide training planning seems to be more efficient than the focus on early specialization, which the scientific literature questions so much.

Although the present study provides good indications that training aimed at promoting the slow learning memory state, through different strategies, can reconcile sporting success with the long-term training of athletes, limitations as to its sample size prevented data from being analyzed by means of inferential statistics. Since the results came from a combination of several factors manipulated simultaneously during training, it is difficult to say precisely if there was any factor that had the greatest impact on the changes observed between championships. Therefore, further studies are needed in order to identify the weight of each factor in the collective and individual performances of athletes, and with representative samples. In the case of team sports, future studies should check whether the training method used in this one is equally effective in other sports categories and contexts.

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