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Review paper

IS TASK ANALYSIS A CONTRIBUTING FACTOR TO PERFORMANCE ANALYSIS?

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Abstract
Introduction. With the evolution of sport, the level of athletes is increasing. To be able to win it is necessary to understand what factors influence performance in competition and training. Sports performance analysis has evolved in accordance with data collection in competition practice, with performance indicators related to actions connected to performance outcome. ***Material and Methods.*** We intend to verify the importance of task analysis in the performance analysis procedures. The review starts with task definition, then task analysis procedures and sports science application to finish with examples of performance analysis with task analysis. ***Results.*** Each task has one or more goals with actions to be carried out and with task, performer, and environment constraints that influence it. Task analysis is a methodology to have information about technique, productivity and safety that allows developing training programmes. Sports task analysis has a preparatory phase, a description (phase analysis), assessment, and an intervention. Performance analysis was based on biomechanical and notational analysis including performance indicators and afterwards reinforced with the ecological dynamics approach with an emphasis on the performer-environment relationship. Similarities between actions from different sports could be observed with performance analysis using task analysis (phase analysis with description of the segmental actions and mechanical principles). ***Conclusions.*** Performance task analysis could support evidence-based training programmes with a replication of key features and performance indicators in dry-land training tasks. Future research should identify task constraints and performance indicators with technological devices and make performance analysis more coach friendly.

Key words: task analysis, sports performance analysis, qualitative analysis, phase analysis, task constraints, training

Introduction

In sport, results improve over the years. In modalities such as athletics, it is easy to check the evolution of records (less time running, further throwing, and jumping). In sports such as gymnastics or surfing, where results are achieved through a final score awarded by judges, this evolution is not so evident. However, over the years, performance has evolved in gymnastics or surfing like in most sports. To be an elite athlete requires technical and tactical skills, complemented by physical and psychological capacities [1]. If training aims to prepare athletes for the conditions imposed by the sport/modality (different sports have different demands), then it is essential to understand which factors influence performance in competition and training. The main objective of coaching is to produce observable changes in behaviour and therefore it is necessary to know how to quantify performance and carry out a qualitative analysis of the necessary aspects related to successful performance or outcome [2].

The analysis or investigation of performance in training and competition is called Sport Performance Analysis and its main objective is to collect data during the competition practice and relating to the factors that influence athletes' performance. This use of systematic observation makes scientific development and assistance in the training/coaching process possible [3, 4, 5, 6, 7]. It all started in the late 70s with the recording of significant occurrences in different sports using pencil and paper checklist [5, 8]. A strategy was also proposed to analyse human movement considering the teaching-learning process [9]. In the 80s, development was greater with the work carried out by other authors [2, 7]. But the greatest development occurred with technological evolution (video analysis systems, tracking systems, inertial devices, advanced data processing and statistical analysis), making it easier to collect data during sports practice [8, 10, 11]. The purpose of sports performance analysis is supported in two main approaches: biomechanics and notational analysis [5]. Biomechanics focuses on individual sports techniques and identifies key features with technique analysis to improve performance. Notational analysis identifies strategic and tactical issues in sport with gross movements or movement patterns analysis in games or teams. Notation systems are used for tactical evaluation (players positions; play patterns), technical evaluation (actions with success and errors), movement analysis (number of actions, sequences, and time-motion relations), and development of a database and modelling (big data allows profiles of performance). We can see an increased sophistication on used methods in performance analysis with a wide range of research topics (critical incidents and perturbations; analysis of coach behaviour; performance indicators for different sports; work-rate analysis and evaluation of injury risk; analysis of technique; technical effectiveness; tactical patterns of play; performance profiling) that should evolve over the years according to different perspectives and research approach [6].

Almost at the beginning of sports performance research it was argued that instead of giving so much emphasis to physiological variables, it is important to find variables that are directly related to competitive outcomes of athletes or teams that supposedly influence these results [3]. In addition to the analysis of the structure of games and the behaviour of players, the use of performance indicators is a way of achieving an objective analysis and interpretation of data [3, 4]. A performance indicator is "an objectively measured performance variable, or a combination of such performance variables, related to successful performance or outcome" [4]. These authors state that performance indicators are chosen depending on the starting question and the intended analysis. In biomechanical analysis, performance indicators are kinematic variables (segment angles and speeds, ball release angle and speed, weight transfer). In notational analysis, performance indicators are match classification indicators (scores, number of shots), technical indicators (winners, errors, types of shots, tackles won and lost), and tactical indicators (pace of attack, passing distribution, field placing). The relationship between individual performance indicators and the team's result makes it possible to verify the impact of each player on the team's performance [12].

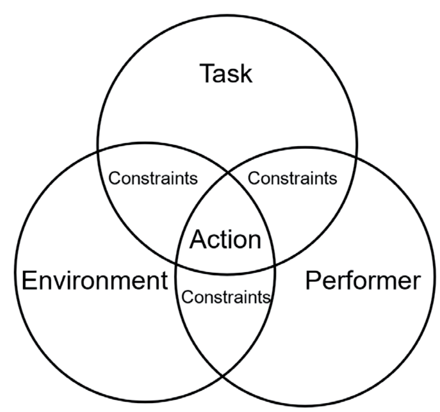
Although sports performance analysis has evolved in accordance with the methodologies used in data collection in competition practice, there are still doubts in its conceptualization. This approach is supported by the sub-disciplines of sports biomechanics and notational analysis but has little regard for other areas of sports sciences. The performance indicators used do not illustrate the entirety of human motor performance. Although this approach is increasingly recognized in the scientific community, the support given to athletes and coaches to improve performance is less clear [13]. Having identified these problems, we have the constraints-based approach as an alternative, considering that it is more accessible to athletes and coaches [13, 14]. In ecological dynamics, the constraints-based approach is used, and in performance analysis it focuses on how the performance of players and the team is regulated in competition. This performance analysis is supported by the interaction of the performer, environment and tasks constraints that shape the athlete's performance behaviours [15]. This idea is reinforced with the possibility of identifying the experts' performance through the functional relationship between the constraints of environment and the performer's resources [16]. And it is confirmed with the results of the research [17] where three constraints (athlete intentionality, wind effects on run-up and jump phases, and adhering to rules of the sport) were identified that shape the behaviour of elite long jumpers.

Although there are references to tasks carried out in sport and that performance indicators must be related to actions connected to performance outcome, it seems that not much attention is given to the analysis of the task. It is true that there are references that highlight the ecological approach in performance analysis, but the emphasis is given to the organism-environment relationship, with little emphasis on the task.

With this paper we intend to verify and reinforce the importance of task analysis and its relationship with performance analysis. Starting from the definition of task analysis, we will address the process of task analysis and its use in sports sciences. To conclude, we seek to discuss the different examples of research in performance analysis where task analysis was used.

Task definition

The task is the unit of activity, in each environment, developed according to a stimulus, which can be intrinsic or extrinsic, requires more than one operation, and has a defined goal [18, 19]. In sports science, it is normally called a motor task and it can be seen as human behaviour, framed in a system, with objectives and with an environment that presents constraints [20]. This definition includes the notion of goal that the task proposes to the performer and that of constraints, which must be respected, because they influence and limit the subject's action [18, 21, 22, 23]. So, the performer must mobilize bioenergetic, bioinformational, and affective resources, as a way of overcoming the constraints imposed on him by the task [18]. The constraints related to the task are spatial characteristics; temporal characteristics; the characteristics of the tools or objects used; the procedures imposed by the rules; the degree of uncertainty; communication (absence, cooperation, and opposition). The constraints related to the individual with morphological characteristics (weight, height, bone structure and muscular structure); neurophysiological characteristics (sensitivity of sensory receptors, visual capacity, ability to collect and process information) and technical level. The constraints related to the environment are physical variables (light, temperature, rain, wind, altitude, air, water, land); the spatial configuration; the temporal configuration; social features [18, 21, 23]. From an ecological perspective, the action (technique) is chosen by the individual, depending on the constraints of the task, environment, and the performer himself, giving rise to the final product (result), which must be compared with the objective of the task [21]. The same idea is shared by others [24], adding, however, that the action can be understood as a situational optimization, because the optimal adjustment between personal, environmental and task factors is sought.



(adapted from Nitsch & Munzert, 2002; Davis & Burton, 1991)

Figure 1. Ecological approach of action process.

Technique can be defined as "a sequence of experienced, functional and effective movements, which serves to solve a defined task in sporting situations", adding, to the others, the relationship with experience and the sporting situation [25]. That is, it corresponds to the action necessary to carry out the task. Technique is based on different arguments about the best way to perform the task, considering the individual's response capabilities and environmental constraints, including the regulation [26]. Related to the best way to perform the task and with the idea of experienced movements, the notion of ideal technique and objective technique was presented [25, 26]. The ideal technique is associated with the suitable procedure to perform the task, based on current scientific knowledge, where it is considered a reference execution based on the understanding of the technique. The objective technique is the resolution of the task, depending on the ideal technique adapted to the response capabilities of individuals, associated with the explanation and adaptation of the technique, to the conditions of the performer and the environment.

We therefore understand that the technique is a set of motor actions to achieve the goals proposed by the tasks in an efficient way, based on the execution pattern and depending on the objective technique, where the constraints of the performer and the environment are considered.

Task classification

There are classification principles for classifying tasks, which allow identifying which attributes to consider: observation and description of execution, identification of necessary behaviours, necessary skills, related to the description of the task based on process, function or performance, and the characteristics of the task associated with the conditions and components of the task [18, 27]. The domain of classification is divided into cognitive, affective, and psychomotor domains [28]. There was an attempt to classify psychomotor behaviours as a function of task variables [29], and other attributes considering the existence of the categories of closed and open movements. *Closed tasks* are those where environmental conditions are constant during execution and open tasks are those where the objects and people involved move [30]. Regarding the conditions imposed by the environment, the task could be with a rhythm imposed by the subject (*self-paced*), since the environment is static, or with a rhythm imposed by the subject (*externally paced*), if the environment is dynamic. Through the presence of feedback, it is possible to make a distinction between closed-loop tasks, where it can be present continuously, and open-loop tasks, where its presence is terminal [31]. With a classification of the task from an ecological perspective, the categories are according to function and intention and not by mechanism. In other words, the same function can be achieved by different anatomical or neurological mechanisms. So, they have a proposal with just two categories, *functional tasks*, and *related tasks*, but movement patterns and performance outcomes must be considered [21]. There are *fixed sequence tasks* which are tasks with pre-determined actions and can be described with a flow diagram and *variable sequence tasks* which are more complex tasks such as sports tasks with unpredictable sequences [32].

Task analysis

Definition and types of task analysis

Through task analysis we are able to find information that can be used, for example, in terms of safety, productivity, personal characteristics, technique and performance acquisition [33]. We can consider that it is a prerequisite for the development of a training programme, helping to identify needs, specify objectives, as well as content [34]. Task analysis can be defined as the study of actions, or cognitive processes, developed by a performer, or set of performers, to achieve an objective [21, 33].

The different types of task analysis that exist are, depending on the dimensions of the analysis process [34]: *Purpose* – the analysis can have several objectives and the techniques used can serve several purposes; *Subject* – analysis can be task or individual oriented; *Nomenclature* – task analysis is a more comprehensive term than technique analysis, which can be seen as the analysis of motor actions or as the analysis of relationships between different techniques through taxonomy; *Descriptive terms* – arise depending on the subject, with the descriptions of a task-oriented analysis (motor aspects) being different from one oriented to the individual (cognitive aspects); *Structuring procedures* – descriptive terms are structured or classified with a theoretical, practical, or statistical basis; *Data sources* and *collection methods* – there are different data sources and collection methods. Within this logic there are different types of motor task analysis depending on the procedures: *information processing*, where a cause-and-effect relationship is sought between stimuli and responses; *rational*, when seeking ideal performance, depending on motor skills or anatomical description; *development*, when identifying the physical principles, environmental factors and elements of movement and then stipulating, for each of the factors, a level of complexity, between simple and complex; *ecological*, when it takes into account the relationship between the needs of the task and the constraints of the performer and involvement [21].

Stages of task analysis process

Task analysis process is a methodology, with a certain number of techniques, which is divided into four stages: data collection, description, analysis, and application [33, 35]. The first stage of task analysis is *data collection* and itself consists of different methods, according to several authors [33, 34], from which we highlight: *Document analysis* – through consultation, compilation, and interpretation of existing data in various documentation, it is possible to find information on different aspects relating to the new analysis to be carried out; *Observation* – through direct observation or video recordings it is possible to collect information to identify the tasks and actions carried out, their frequency, the sequences carried out and the time spent; *Critical incidents* – through data relating to incidents, with influence on the performance of tasks, with positive or negative effects on achieving objectives; *Questionnaires* – through a set of questions organized on a sheet for the person carrying out the task to answer, they make it possible to quickly collect a lot of information from many individuals; *Interviews* – through a set of questions posed by the interviewer, which may or may not be structured in a pre-defined order, they allow the interviewee's answers to be known, which can be recorded in audio records; *Inventories* – through a list of tasks or techniques organized according to who performs them and the opinion of experts, it is possible to evaluate the quality of the performance and diagnose training needs.

The second stage of task analysis is *description*, which also consists of several methods, according to several authors [20, 27, 33, 34], highlighting: *Diagrams* – a way of representing tasks or techniques in a schematic and sequential way, with concise content and quick reading; *Decomposition* – by dividing the task into parts, it allows the information to be detailed with the most detailed description of each of these task elements; *Hierarchical task analysis* – the description is hierarchical with the identification of intermediate tasks and operations necessary to achieve the objectives, allowing an analysis in detail, whether reduced or extensive, depending on needs; *Taxonomies* – through the classification of tasks and techniques it is possible to identify their components more easily, as well as the relationship between tasks, allowing learning levels to be structured [36, 37].

The third stage of task analysis is *analysis* which consists of identifying the factors (task, environment, and performer constraints) that influence the performance outcome and what must be done (action/technique) to achieve the task goal [21, 33]: *Assessment of behaviours* – as a way of knowing what could be wrong when performing the task; *Needs assessment* – to know the context in which the task takes place and the conditions necessary for its execution. For this analysis we have the *essential variables* (invariant features) that are related to movements that ensure the dynamics of the action and allow achieving the task goal, and *nonessential variables* (task variations) can be the scale changes, within which the essential variables are constants (length, mass, time, direction, used objects size and weight) [21]. The variables related to the performer can be height, weight, limbs size, feet and hands size, and physical capacity (coordination, flexibility, speed, strength). The variables related to the environment can be light, floor characteristics, temperature, wind, and rain, among others.

The fourth stage of task analysis is *application* where you try to make the necessary changes to achieve the task goal or to improve performance outcome. With the relationship between the task variables and the performer variables, previously identified, it is possible to provide more favourable situations to achieve the task goal or provide more difficult tasks without changing the task goal (in throwing, the size or weight of the object can be changed, as well as the distance to be covered). This approach allows changes in the movement pattern and performance outcomes [21].

Sports task analysis

In sports sciences we can consider that there are examples of its use in ergonomics, psychomotor rehabilitation, physiotherapy, dance and of course in sports performance. Sports task analysis has been developed with the aim of better understanding techniques, improving coaches' intervention and athletes' performance, through identifying flaws in execution [38, 39]. However, the terminology is as varied as the intervention perspectives: sports analysis [40]; task analysis [41]; technique analysis, which also takes on different terms such as “skill” [42] and “technique” [39]; movement analysis [9, 38, 43].

The analysis is differentiated depending on the nature of the data collected and the way in which the collection is carried out, with several methods available for each type of analysis: *Qualitative analysis* is considered a more accessible instrument because it is more subjective in nature, but it is based on scientific methods, requires data from several disciplines and involves a systematic application [38, 39]; *Quantitative analysis* makes it possible to measure aspects related to the technique, called performance parameters, associated with biomechanics and physiology [38, 39]; *Predictive analysis* emerged with the development of computer technology, which enabled the creation of mathematical models that allowed computer simulations of the execution of tasks. These systems allow controlling different variables, making it possible to predict the outcome of simulated situations [39]; *Structural analysis* makes it possible to understand and explain tasks through the systematization of task components and constraints, the individual and the context, taking as a reference the characteristics of the activity [44].

Task analysis begins with the description of the techniques to be used, through a taxonomy, and subsequently the analysis of the task components is carried out [45]. Or by choosing the technique to be analysed and identifying the components and environmental factors that influence the task [21]. But also, it can begin with the structural analysis of the activity, to then consider the specificities of the modalities, through the rules, and finally analyse the parameters of the game, the tactical, technical and mechanics [4]. Task analysis is to identify the components of the technique and the way in which they should be presented in the learning process, facilitating the teacher's intervention in planning the session and managing it [41]. This analysis must begin with the determination of a terminal and more general goal, and then describe the tasks/techniques necessary to achieve that goal, which can be divided into different levels. The Matrix of Analysis for Sports Tasks (MAST) was proposed based on a qualitative method to improve performance [46]. The teaching and training strategies to improve performance are reached after task analysis with a prior context description supported with a sports taxonomy.

Task analysis procedures

Task analysis has a preparatory phase where pre-observation is carried out [38]. This phase must be supported by an analysis of the documentation but can be reinforced with information provided by experts and finally by observation of identical tasks. This phase must begin with the structural analysis of the sport, to then consider the specificities of the modalities, through the rules, and finally analyse the general match indicators, including the tactical, technical, and mechanical indicators. In addition to this analysis, it is important to identify the general and specific goals [4, 46]. Tasks have as their general goal a function or what is necessary to achieve by the performer. The specific goal is related to the actions (skill or movement execution) required to achieve the general goal [21]. At this stage it is important to prepare what will be analysed by observing and video recording from different angles [47]. To cross-reference information and identify relevant details, it is important to see the performance from both sides and from the front and rear. It is possible to have more viewpoints depending on the different types of tasks. In addition to the different viewing angles, it is important to watch the videos several times (at least five replays; [38]), at a normal speed. The number of viewings depend on observers’ expertise, sports knowledge, task and action complexity, performers’ expertise. Before the next phase, it could also be important to watch the task in slow motion.

Afterwards, the task description must be carried out with the phase analysis model [39]. It should start with the phase’s identification. The *preparation phase* corresponds to the moment when the performer prepares the next motion and is ready for action (i.e., end of approach run, ball throwing for tennis serve, approach of the supporting foot to the ball for kicking, ...). The *retraction phase* corresponds to the last preparatory action which consists of a starting movement normally in a direction opposite to the main action to enhance it (i.e., arm backswing on final step for a jump, arm backswing for tennis serve, kicking leg backswing for ball kick, ...). The *action phase* corresponds to the main motion to achieve the task goal (i.e., take-off and flight for a jump, arm forward swing for tennis serve, kicking leg forward swing for ball kick, ...). The *follow-through* phase corresponds to the final motion to slow down the main action and link under control with next movement or skill (i.e., landing from a jump, tennis serve arm deceleration and first steps, kicking leg deceleration and next step, ...). As a way of guiding this process of dividing up a movement into phases, some authors [39, 48] defend the idea of using a template that must contain an illustration of the movement with video frames to make it easier to understand. Each phase must have at least three frames, but in ballistic movements, images with a frame rate of 25 to 30 fps only allows you to have two frames in the retraction phase. To guarantee more images with the detail of the interception of moving objects, or trampoline take off, a frame rate of 200 to 1000 fps is required [38]. For a better illustration it is important to have a frame from phase beginning, another one in the middle, and the last one in the phase end. The video should be with the video camera in a 90° angle with the plane of movement and, if possible, with the action from left to right. If the movement is right-left orientated, the frames sequence should be presented in a right-left sequence. The analysis must be through the description of high-level executions from top class athletes [47]. This is a body action description that could be supported with *key elements* which are essential actions to achieve the goals of each phase. In the preparatory phase, the key elements may be related to the beginning of the movement and the back swing actions, so it is expected to find actions with some range of movement and speed, and a transfer of weight between feet or hands. For the observer's attention to be focused on spatial aspects, the observation should be oriented towards bodily components, initially looking for the central part of the movement (placement and displacement of the centre of mass), and then observing the trunk and finally the extremities (head, legs, and arms) [42]. In agreement regarding the orientation of observation, we have 10 key points to focus attention: the range of movement; the speed of movement; number of segments; segment mobility; balance; coordination; compression; extension at launch/contact; aerial trajectory; rotation [49]. If each one is considered in an easily identified range, knowing the upper and lower limits, it can be manipulated like a potentiometer, which will facilitate the analysis process. A description of the body's actions can then be carried out for each of the phases. This description must begin in the anatomical position and may have a down-up or up-down sequence (feet, knees, hip, trunk, arms, and head) [48]. Considering the planes of movement, the actions of flexion or extension, adduction or abduction, dorsiflexion or plantar flexion and eversion or inversion (feet), circumduction and elevation or depression (arms), and forward or backward tilt (pelvic girdle), must be identified. Regarding the actions on the axes, we must identify whether the rotation in the frontal axis is forward or backward, in the sagittal axis or in the vertical axis, if it is to the left or to the right [43]. The description must be completed with the identification of the mechanical principles of the movement. It is necessary to identify whether the movement is linear or rotational, and what the body or segmental speed is, and whether there is linear or rotary stability, identifying the position of the centre of mass (CoM), the line of gravity (LG) and its relationship with the base of support (BoS). The movement can also be with an aerial trajectory or with projection of objects, which is why it is necessary to consider the release angle or take-off angle, the height of the flight and the flight trajectory (CoM trajectory). Finally, we have mechanical aspects related to the environment, with hydrostatic pressure (fluids), drag and lift forces normally being present [43, 47, 48]. Since observation is the stage where information is collected, it can be direct or through recording of events, and it is from there that the evaluation takes place [9]. It is at this point that we look for the positive and negative aspects of the execution and the diagnosis is made, deciding on the possibilities of intervention [38].

The assessment is then based on two methods for identifying faults: sequential, by dividing the movement into phases and subsequent comparison with the correct movement; and mechanical, where the evaluation is made based on mechanical data, comparing them with those achieved by the best performers [50]. The notion of correct movement is identical to that of ideal technique, already presented, but which is complemented with its graphic representation for each of the phases of the movement, giving rise to a formatting of the technique that will serve as a reference for the evaluation [50]. However, this method limits a critical analysis of the technique performed and can therefore be used inappropriately [39]. But in the diagnosis process, the strategies, such as the need to relate the problems observed with previous events, which are often the causes of the error, help to find solutions to apply them in sequence, from the beginning to the end of the movement and from the easiest to the most difficult, as well as correcting from bottom to top from the base of support [38]. These strategies reinforce the assessment process and facilitate intervention.

The last stage is about improving performance or correcting errors and must begin with identifying the most relevant parameters, leaving the others for future analysis and intervention. It is essential to fit this intervention into the season planning considering the time needed to achieve results in these performance improvements. Sometimes the lack of time can mean that it is a better choice to make minor changes [47]. One of the main solutions to improve performance is the use of *augmented feedback*. This can be with information about the result of the movement and its relationship with the objectives (knowledge of results), or with information about the movement process related with the execution (knowledge of performance). Sometimes this feedback could be with visual models or with manual and mechanical guidance. Another approach may be through changes in practice. These changes can be made manipulating task constraints (modifying the environment and the equipment used), but also by changing the techniques used, as long as the task goal remains [22, 38, 46].

Performance analysis with task analysis

With the collection of information carried out regarding performance analysis, we found references that refer to biomechanical analysis and notational analysis as the main methodologies [13]. Performance indicators were also presented as individual, or team variables related to successful outcomes [4]. However, we found that there are doubts regarding the lack of support from other areas of sports science as well as real support for athletes and coaches to improve performance [13]. The ecological dynamics approach is presented as a possible solution and although the constraints of the task, the performer and the environment are identified, it is the relationship between these last two that receives the most attention [13, 14]. Both for the quality of data analysis and for intervention, it is important to understand the tasks and manipulate them to improve performance. Therefore, it is important to reinforce performance analysis by paying greater attention to task analysis. This path is already being followed with some research carried out, but it is important that this message reaches coaches and athletes to make their work easier. In this final section of our paper, we will analyse some of the published research with a few of the examples that we can follow.

Task analysis to research/understand performance

1-Long jump [17]

In this first example, ecological dynamics in performance analysis of long jump in elite level competitions (Diamond League, World Championships, and Olympic Games) was used.

The variables that could potentially influence performance were identified through other investigations, as proposed in the first phase of the task analysis procedures. The main personal constraint is specific intentions during the performance. Environment constraints include physical and social variables. Task constraints include rules of a sport and the presence of the 20 cm wide take-off board. Through descriptive statistics, the effects of competition on jump length, jump classification (legal or foul jumps), round and years were analysed. To identify which variables best contribute to predicting the horizontal jump distance, a mixed linear model was developed. As a result of this research, it is suggested that the main constraints of the performer in the long jump are their expected goals and their relationship with the next jump. The main environment constraint is the wind strength and direction, and the task constraint is requirement for front foot relation with the take-off board. The main conclusions highlight the importance of coaches designing training tasks in an ecological logic and based on the main constraints of competition. But they also highlight the possibility of this approach revealing more information about performance variables, which can be shaped by competition, and which can be related to other sports with identical situations (i.e., run-up present in the long jump as in vault jump in gymnastics, among others). In this research, sports task analysis was partially used, with the idea that a prior characterization of the modality would reinforce the possibility of similarity of actions, as well as a phase analysis that would better explain the relationship between movements (actions). A more in-depth task analysis could also help to better identify task constraints and explain solutions to tasks to be presented in training.

2 - Football hand-ball fouls [51, 52]

Because of the difficulties of football referees and assistant referees in analysing and applying the rules when it comes to calling the ball foul, task analysis research was carried out. The first phase consisted of bibliographical support of reference studies and experts' opinions (experienced Portuguese top-standard referees and assistant referees) to identify the most common situations and where they had the most difficulty in identifying fouls. As we know, in these refereeing situations, the main constraint of the task are the rules of the game, which includes a subjective feature called "deliberate act" (in Law XII, FIFA booklet Laws of the Game). Because the deliberate act is considered one of the most difficult to identify, the movement patterns of situations such as running, vertical jumping and raising the arm to reach the ball present in other sports were analysed (phase analysis). The experts also mentioned that it is difficult to identify the infringement when it is related to the distance between the opponent and the ball. 2.5 m or more was identified as the distance from which it is possible to react intentionally to the trajectory of the ball. This value is achieved through phase analysis, where the time of the action phase (between the toe-off and the ball-contact) and the constraints of the performer (visuomotor delay) and the task (ball speed) are identified. As a conclusion, it is mentioned that the referees' knowledge regarding the analysis of the most common movements must be improved. A more in-depth task analysis could also help to better identify referees' performance with major competitions research and presenting solutions to tasks to be used in referees' training.

Task analysis to find identical goals and train in different environments to improve performance

1 - Gymnastics [53, 54]

The research was carried out to understand if the double somersault with half twist performed in different environments associated with different gymnastics disciplines would have identical performance indicators. The aim was also to justify new evidence-based training tasks if these similarities occurred. A phase analysis was presented for the Handspring 1½ front jump with ½ twist (vault artistic gymnastics), Barani out in Trampoline and in Double mini trampoline (trampoline gymnastics) with the description of the segmental actions and the mechanical principles. With the identification of performance indicators, 13 performances of international level Portuguese gymnasts were analysed (biomechanical data of CoM velocity, trunk angle, and take-off angle). Through the description it was possible to see that all executions have a similar action, with the vault being slightly different because it has an arm thrust in the first somersault. Task constraints are different because there are three different types of apparatus, but the task goal is similar. The CoM speed is greater in tasks with run-up but is similar at the time of take-off. The difference in the vault is in the trunk angle and the take-off angle naturally due to the presence of the platform (task constraint). With the similarities found, they concluded that training on trampolines could complement and benefit the vault training. Coaches designing training tasks could improve with these performance indicators. A more in-depth task analysis could also help to better identify task constraints and have more information about performance indicators while looking for evidence-based training solutions.

2 - Surfing [48]

This research is about performance indicators of elite surfing aerial manoeuvres with 360° rotation to find evidence-based solutions for training and injury prevention [48]. Task analysis was performed including the identification of manoeuvres' general goal (surfer's goal), identification of manoeuvres' specific goal (execution), and a phase analysis. Including the key features of body actions, principles of movement, and surfboard movement, it was presented for Frontside Air Reverse 360 (FSAR360) and Backside Air Reverse 360 (BSAR360), Frontside Air (FSA) and Backside Air (BSA). Quantitative analysis was carried out at FSAR360 (n = 68) and BSAR360 (n = 29) in a total of 97 manoeuvres, and the aerial height, the base of support (BoS) width, the knee and ankle angles were identified as performance indicators. Through the description at qualitative analysis, it was possible to identify body actions and principles of movement that seem to be common to all aerials (rotation of the head and trunk; head, trunk, and arms flexion; triple-flexion of the lower limbs; widening of the BoS). The results of the quantitative analysis were presented with average values for the performance indicators: aerial height (169.60 ± 52.85 cm), BoS width (79.17 ± 13.72 cm), and flexion angles of front knee (113.78 ± 19.90°) and front ankle (32.74 ± 14.51°) during landing. These authors conclude that the study was the first of a kind to use the task analysis methodology in surfing with true performance indicators because they were recorded based on performance in competition. The data from this task analysis could support evidence-based training programmes to improve aerials performance with a replication of these key features and performance indicators in dry-land aerial simulation tasks. This is really one of the best examples of performance analysis with task analysis and can be a model to follow. It can be reinforced with the collection of data from other performance indicators with methodology supported by other technological devices.

Conclusions

To identify a task, it is necessary to know what goals are to be achieved, what actions should be taken, and what constraints are related to the environment, the performer, and the task itself. The best way to perform the task related with the expertise leads us to the technique definition. Task analysis is a methodology originally used in different areas such as engineering, ergonomics and more recently in the human-computer interaction. It is important to collect information about technique acquisition, productivity and safety that will allow us to develop training programmes and design a computer system [33, 55, 56]. Task analysis process is divided into four stages: data collection, description, analysis, and application [33, 34, 35].

In sports science, task analysis is also used but with different terminologies (sports analysis, task analysis, technique analysis, movement analysis) according to the intervention perspective. Sports task analysis must begin with the identification of general and specific goals [21], and has a preparatory phase, a task description (phase analysis), assessment (identifying faults), and an intervention (improving performance or correcting errors with feedback and manipulating task constraints). As a methodology, sports task analysis allows a better understanding of techniques, improving coaches' intervention and athletes' performance.

Initially, performance analysis was based on biomechanical and notational analysis with the identification of performance indicators. Seeking to include other scientific areas of sports science, the ecological dynamics approach was proposed, giving greater emphasis to the performer-environment relationship [13, 14]. The analysis of individual performance can be carried out in any type of sport (individual, team, racket, combat), and depending on the characteristics of each one, the constraints of the performer, the environment and the task are considered. If performance is directly affected by changes in task or environmental conditions (constraints), then performers must know what might happen. Therefore, they must know the actions available to solve potential problems, requiring performance analysis using task analysis. Apparently, there are only a few investigations that use task analysis, but the ones we found seem to be a good contribution to performance analysis. The description of the segmental actions and the mechanical principles allows us to find similarities between actions of different sports modalities or disciplines. Which means the data from performance task analysis could support evidence-based training programmes with a replication of key features and performance indicators in dry-land simulation tasks. The performance task analysis of the most common movements could improve the referees', judges', or coaches' analysis practice that will lead to a higher quality intervention.

Task analysis is a contributing factor to performance analysis, but a more in-depth task analysis should be applied to better identify task constraints and have more information about performance indicators looking for evidence-based training solutions. It is also important that performance indicators are related to actions associated with performance outcome and in accordance with sport and task knowledge. Future research should include data collection of performance indicators supported by other technological devices, e.g. inertial measurement units. We believe it is important to develop more research with this methodology, seeking to make performance analysis more coach friendly.

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