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3D Training Control® for football training tasks: intra- and inter-observer reliability of a structural task-classification system

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ABSTRACT
Purpose. This study examined the intra- and inter-observer reliability of the 3D Training Control® (3D-TC) web-based tool for classifying structural characteristics of football training tasks and deriving a Structural Specificity Index (SSI) score.
Methods. One-hundred thirteen drills from a professional team's 2023 season were evaluated using ten predefined criteria grounded in the game's internal logic. Inter-rater agreement was assessed using Cohen's kappa, and reliability was quantified using intraclass correlation coefficients (two-way mixed-effects model, mean rating, absolute agreement, 95% confidence intervals) for intra- and inter-observer comparisons.
Results. Results showed high agreement and excellent reliability across all ten criteria for both observers and across time points. These findings support the reliability of the structural task-classification system embedded in the 3D-TC tool.
Conclusions. Further studies are required to establish the construct and criterion validity of the resulting index, including its relationship with physiological and external-load metrics and performance-related outcomes.
Key words: internal logic, football, training tasks, tasks classification, reliability, representativeness

Introduction

Football, as an invasion-based team sport, is characterised by a high density of events and constant interpersonal interactions, requiring players to execute complex technical and motor actions under dynamic conditions [1]. Throughout a match, players must jump, kick, turn, tackle, vary pace, accelerate and decelerate while continuously perceiving and responding to evolving environmental information [2–5]. These multidimensional demands compel coaches to design training processes that optimise physical, technical, tactical, and cognitive development in an integrated manner.

In this context, small-sided games (SSGs) have emerged as a prominent training strategy, as they enable practitioners to manipulate player numbers and pitch dimensions to elicit specific physiological and perceptual responses [6, 7]. By adjusting task constraints and recovery intervals, SSGs can approximate competitive conditions and enhance decision-making and tac-

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tical understanding [8]. Consequently, SSGs are frequently associated with ecological dynamics principles, as they may facilitate integrated and representative adaptations to the demands of competitive football [9, 10]. From this perspective, the manipulation of constraints, such as space, player numbers, and tactical objectives, may influence players' perceptual–motor behaviours and decision-making processes. Similarly, motor praxeology conceptualises football through its internal logic, highlighting how structural relations between players, rules, space, and time shape the functional organisation of the game [11, 12].

Despite the supposed structural resemblance to official competition, SSGs vary considerably in their configuration. Differences in pitch size, number of players, goal arrangements, and rule modifications substantially alter the physical, technical, tactical, and psychological demands imposed on players [7, 13, 14]. For instance, smaller playing fields with fewer participants may increase the frequency of high-intensity accelerations and decelerations, whereas larger formats facilitate greater distances covered and higher peak running speeds [8]. As a result, the degree of specificity compared to competitive play fluctuates across SSG formats. Nevertheless, although coaches intentionally manipulate these constraints to shape specific training outcomes, systematic and operational methods capable of objectively quantifying the representativeness of training tasks remain limited in the applied football contexts. In this regard, deriving a Structural Specificity Index may provide practitioners and researchers with a structured framework for comparing exercises according to their structural similarity to the official competition.

In this sense, several attempts have been made to conceptualise and classify structural specificity in team sports. Solé [15] proposed a theoretical model; however, it lacks clearly operationalised indicators and has not undergone empirical validation. In turn, Ibáñez *et al.* [16] introduced a flexible framework applicable across sports, yet its extensive data requirements reduce its practical feasibility. Similarly, Camenforte *et al.* [17] developed a classification system based on 28 criteria, derived from exercises performed by a single team, which may limit both its practical applicability in daily training contexts and the generalisability of the system. Díaz *et al.* [18] grounded their proposal in the internal logic of the game, although without reporting empirical reliability or validation procedures. Moreover, previous proposals have generally focused on conceptual classifications, with limited attention paid to practical applicability across coaching contexts or to the integration of structural variables into a unified scoring system.

Given these limitations, a clear need emerges to differentiate and quantify training exercises within a holistic framework that reflects the complexity of football. Contemporary perspectives advocate integrating physical, technical, tactical, and cognitive dimensions when assessing performance and designing training [13, 19], thereby encouraging self-organisation and adaptive behaviour in response to emergent game situations [20]. Accordingly, the present study aimed primarily to examine the intra- and inter-observer reliability of a structural task-classification system designed to classify the structural characteristics of football training tasks. A secondary objective was to present the procedures used to derive a SSI at both exercise and session level. We hypothesised that structural elements embedded within the internal logic of official competition could provide a sufficiently stable basis for classifying structural specificity in football training tasks. Although integration of this index into load-monitoring frameworks may enhance training prescription, the present study focused specifically on establishing reliability. By doing so, this research sought to provide a methodological foundation for future investigations combining representativeness and workload metrics, thereby supporting evidence-based design of football training tasks.

Material and methods

Experimental approach to the problem

This investigation adopted a cross-sectional design to evaluate the intra- and inter-observer reliability of the 3D Training Control® (3D-TC) tool. 3D-TC is a web-based tool that incorporates a structural task-classification system for assessing the structural specificity of football training tasks and deriving a SSI. For the present assessment, experienced coaches used the 3D-TC tool to classify the structural characteristics of training exercises, and repeated evaluations were compared to determine consistency over time and between raters. All data collection procedures conformed to ethical standards. The head coach and club management provided informed consent for the use of training data, and no personal identifying information was collected.

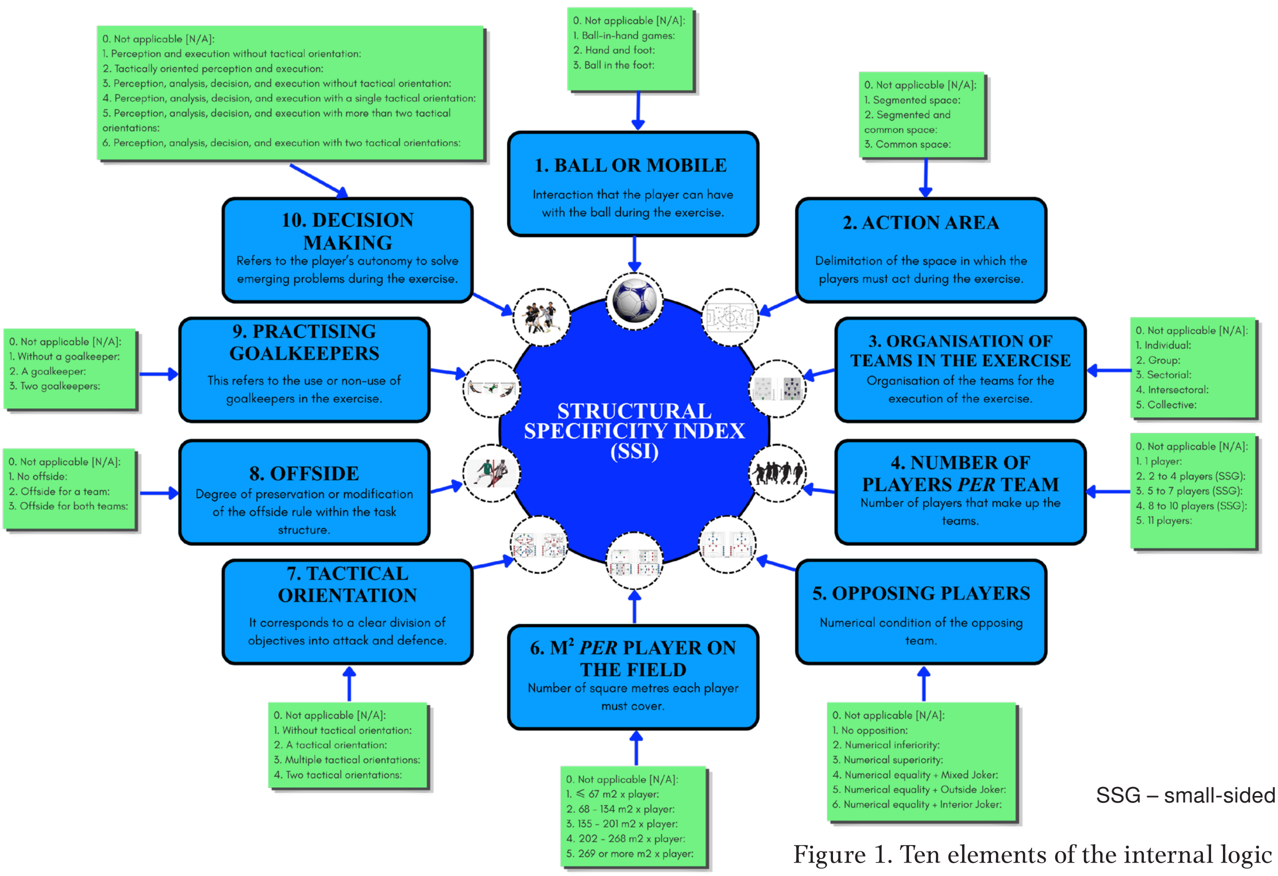
Construction procedures

Development of the structural task-classification system followed a structured content validation process. Five experts were recruited based on their research and coaching credentials: four held doctoral degrees in sport science (10 years' experience), while one held a master's qualification in coaching (15 years' experience). One of these five experts was a UEFA (Union of European Football Associations) Pro-licensed coach with more than a decade of professional coaching experience, three were UEFA B coaches (6 years' experience), and one was a UEFA C coach (5 years' experience). All were 40 years of age on average. The first version of the 3D-TC tool was distributed by email. Experts were then given two weeks to evaluate the structure, clarity, and applicability of each criterion. They all returned their feedback, recommending minor adjustments to wording and categorisation. These suggestions were incorporated to enhance clarity without altering the theoretical framework. To generate data for reliability testing, the coaching staff of a professional club competing in the second division provided documentation of a competitive mesocycle (four micro-cycles) from the 2022–2023 season. This dataset comprised 19 training sessions, four official matches, and 113 exercises.

Structural task-classification system embedded in the 3D-TC tool

The structural task-classification system embedded in the 3D-TC tool is grounded in the theory of motor praxeology [21], which conceptualises games and sports through their internal logic the system of relationships that governs interactions between players. Internal logic provides an "identity card" for each game, requiring players to resolve relations with others, with physical space, with time, and with materials. Drawing on this framework, and following the classification of internal logic parameters for football [22], the tool organises the analysis of training tasks into five macrostructures presented below, and detailed descriptions of their corresponding elements are presented in Table S1 of the Supplementary material:

1. Temporal elements: date, microcycle (MC), number of contests in the MC (NCMC), session (Ss) and exercise number (EN).
2. General objectives: general principles of orientation for the exercises (GPOE), reference game situations and others (RGSO), and game principles to be developed in the exercise and others (GPDEO).
3. Density: number of repetitions, duration *per* repetition, pause time, total duration, and density (percentage of effective work time).
4. Structural elements of the game's internal logic: ten parameters capturing structural constraints (Figure 1); (1) ball or mobile (BoM), (2) action area (AE), (3) organisation of teams in the exercise (OTE), (4) num-



SSG – small-sided game

Figure 1. Ten elements of the internal logic of the game used to determine the of Structural Specificity Index (SSI) of the game and training exercises

ber of players *per* team (NPT), (5) opposing players (OP), (6) m^2 *per* player on the field (m^2-PF), (7) tactical orientation (TO), (8) offside (OS), (9) practising goalkeepers (PGK), and (10) decision making (DM).

5. Results: indices derived from the above variables: an Absolute Structural Specificity Index (ASSI) (sum of the ten internal logic elements), TSSI-1-10, DSSI, and the CSSI of the Exercise to the Session (CSSIE-Ss).

The CSSIE-Ss is calculated by multiplying its total duration by its transformed specificity score and dividing by the sum of durations for all exercises in that session. For example, if an exercise lasts 12 min and receives a transformed score of 7, and the total session time is 65 min, its contribution is 84 divided by 65. The session SSI (SsSSI) was developed as an exploratory procedure to estimate the overall structural representativeness of a training session by integrating the contribution of each exercise according to its duration and transformed specificity score. The SsSSI should be interpreted as a descriptive indicator representing the cumulative structural representativeness of the training session, whereby higher values reflect a greater proportion of exercises structurally aligned with official competition constraints. Although this proposal has not yet been empirically validated, it is intended as an operational framework to support future investigations examining the interaction between structural specificity and training load. Furthermore, the present study focused primarily on reliability outcomes rather than on empirical validation of the SsSSI itself.

Explanation of results:
1. Absolute SSI = Σ 10 elements
2. TSSI-1-10
3. CSSIE-Ss
4. Total duration of the exercise (TDex)

Example: CSSI-Ss

CSSIE-Ss = TDex × TSSI-1-10 / Σ TDex.1 to ex.5

CSSIE-Ss = (12’ × 7) / (65’)

CSSIE-Ss = 2.4

5. SsSSI

Example: Training session with five different exercises

SsSSI = Σ CSSIE-Ss (1) to (5)

SsSSI = 0.1 + 0.1 + 0.8 + 2.4 + 2.7

SsSSI = 6.1

Figure 2 illustrates the conceptual workflow of the 3D-TC tool and its structural task-classification system. The proposed indices should be interpreted as exploratory operational measures that require further validation.

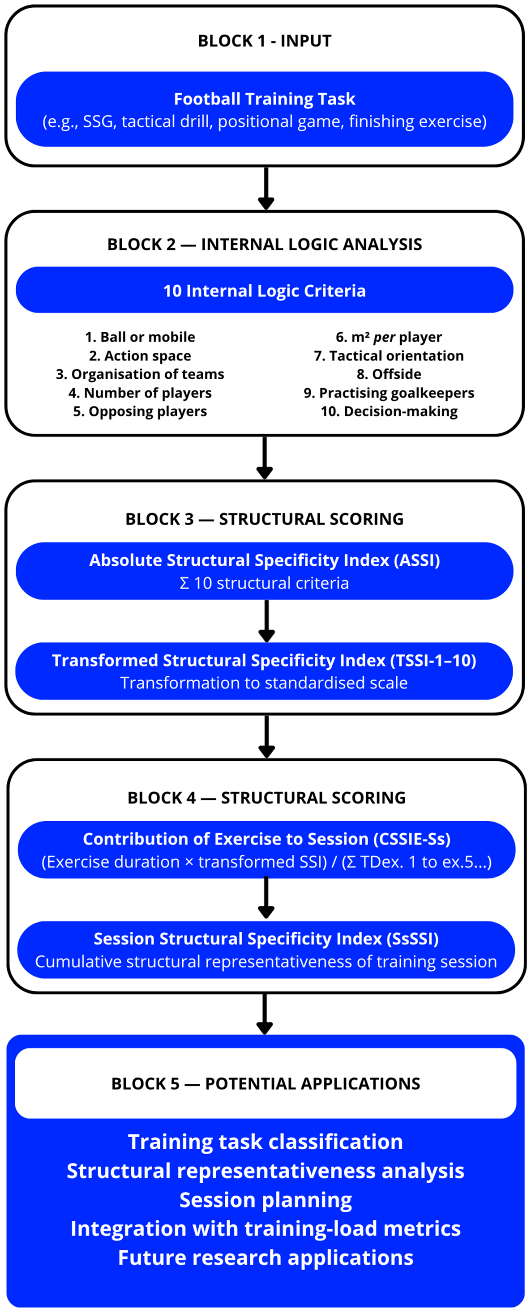


Figure 2. Conceptual framework of the 3D Training Control® tool and its structural task-classification system for deriving the Structural Specificity Index (SSI) in football training tasks

In this study, specificity is operationalised as the structural representativeness of a training task relative to competition constraints, such as space, number of players, opposition, targets, and task goals. This definition emphasises objectively observable configurations. Nevertheless, ecological factors, such as information, movement, and coupling, are influenced by these structural constraints. The 3D-TC structural task-classification system uses official competition as the reference for maximal structural similarity. Modifying any of the ten internal logic criteria makes an exercise more or less specific depending on its proximity to competitive conditions. Training tasks may be intentionally designed to depart from, or selectively represent, competitive environments in order to emphasise particular technical, tactical, physical or psychological constraints and facilitate learning [23–25]. Representative learning design highlights that the fidelity of training tasks and their cognitive and physical load should be balanced to optimise learning transfer and avoid overtraining [26]. Accordingly, the Structural Specificity Index should be understood as a pragmatic approximation of structural similarity. The decision to weight the ten criteria equally constitutes a methodological starting point, not an assertion that each criterion exerts an identical influence on the resulting Structural Specificity Index score.

Reliability tests

Two trained observers participated in the reliability assessment. After receiving approximately 90 min of instruction on how to use the 3D-TC tool and apply its structural task-classification criteria, each observer independently coded every exercise from the mesocycle, then repeated the procedure three weeks later to minimise recall effects [27]. The temporal separation helps control for memory bias and provides a conservative estimate of intra-observer consistency. This dataset comprised 19 training sessions and four official matches included as contextual elements of the analysed mesocycle. The reliability analysis was conducted exclusively on the 113 training exercises performed during the training sessions.

Statistical analysis

Intra-observer and inter-observer agreement were assessed using Cohen's kappa coefficient. Agreement was interpreted according to the following criteria: no agreement (≤ 0), no or low agreement (0.01–0.20), fair agreement (0.21–0.40), moderate agreement (0.41–0.60), substantial agreement (0.61–0.80), and almost perfect agreement (0.81–1.00) [28].

The intraclass correlation coefficient (*ICC*) was analysed to calculate intra-observer and inter-observer reliability. The *ICC* estimates and their 95% confidence intervals were analysed using a two-way mixed-effects model for the mean score, absolute agreement [29].

All information was recorded in an Excel document (Microsoft Office 365, version 2020). All analyses were carried out using the Statistical Package for Social Sciences Version 26.0 (SPSS Inc., IBM Company, Armonk, NY, USA).

Results

The intra-observer analysis of the ten indicators demonstrated very high consistency (Table 1). Observ-

Table 1. Intra-observer agreement for each criterion of the internal logic of the game

Observer	Indicator	Value	*SE*	*p*	Agreement
Intra-observer 1	ball	0.923	0.038	< 0.001	almost perfect
	action space	0.892	0.034	< 0.001	almost perfect
	organisation of teams in the exercise	0.966	0.019	< 0.001	almost perfect
	number of players *per* team	0.950	0.024	< 0.001	almost perfect
	opposing players	0.918	0.030	< 0.001	almost perfect
	m^2 *per* player inside the field	0.911	0.035	< 0.001	almost perfect
	tactical orientation	0.894	0.034	< 0.001	almost perfect
	offside	0.923	0.037	< 0.001	almost perfect
	practising goalkeepers	0.939	0.026	< 0.001	almost perfect
	decision making	0.896	0.033	< 0.001	almost perfect
Intra-observer 2	ball	1.000	0.000	< 0.001	almost perfect
	action space	0.810	0.042	< 0.001	almost perfect
	organisation of teams in the exercise	0.932	0.027	< 0.001	almost perfect
	number of players *per* team	0.842	0.040	< 0.001	almost perfect
	opposing players	0.798	0.043	< 0.001	substantial
	m^2 *per* player inside the field	0.885	0.039	< 0.001	almost perfect
	tactical orientation	0.977	0.016	< 0.001	almost perfect
	offside	0.981	0.019	< 0.001	almost perfect
	practising goalkeepers	0.905	0.033	< 0.001	almost perfect
	decision making	0.946	0.024	< 0.001	almost perfect

Table 2. Intra-observer reliability and variability for each criterion of the internal logic

Observer	Indicator	*ICC*	95% *CI*		Test *F*	
			lower limit	upper limit	value	*p*
Intra-observer 1	ball	0.939	0.914	0.958	32.326	< 0.001
	action space	0.977	0.966	0.984	87.618	< 0.001
	organisation of teams in the exercise	0.994	0.991	0.996	332.427	< 0.001
	number of players *per* team	0.993	0.991	0.995	310.476	< 0.001
	opposing players	0.987	0.982	0.991	154.369	< 0.001
	m^2 *per* player inside the field	0.992	0.988	0.994	237.956	< 0.001
	tactical orientation	0.985	0.979	0.990	142.167	< 0.001
	offside	0.954	0.934	0.968	42.967	< 0.001
	practising goalkeepers	0.975	0.964	0.983	81.000	< 0.001
	decision making	0.946	0.923	0.963	37.410	< 0.001
Intra-observer 2	ball	1.000	–	–	–	–
	action space	0.957	0.937	0.970	47.517	< 0.001
	organisation of teams in the exercise	0.994	0.991	0.996	312.930	< 0.001
	number of players *per* team	0.987	0.981	0.992	170.903	< 0.001
	opposing players	0.960	0.940	0.973	52.232	< 0.001
	m^2 *per* player inside the field	0.969	0.955	0.978	62.063	< 0.001
	tactical orientation	0.997	0.995	0.998	601.678	< 0.001
	offside	0.989	0.985	0.993	184.514	< 0.001
	practising goalkeepers	0.973	0.960	0.982	78.532	< 0.001
	decision making	0.996	0.995	0.997	532.750	< 0.001

Table 3. Inter-observer agreement at moment 1 and moment 2 for each criterion

Moment	Indicator	Value	*SE*	*p*	Agreement
Moment 1 inter-observers	ball	0.923	0.038	< 0.001	almost perfect
	action space	0.845	0.040	< 0.001	almost perfect
	organisation of teams in the exercise	0.797	0.043	< 0.001	substantial
	number of players *per* team	0.914	0.031	< 0.001	almost perfect
	opposing players	0.856	0.038	< 0.001	almost perfect
	m^2 *per* player inside the field	0.853	0.043	< 0.001	almost perfect
	tactical orientation	0.919	0.029	< 0.001	almost perfect
	offside	0.923	0.038	< 0.001	almost perfect
	practicing goalkeepers	0.927	0.029	< 0.001	almost perfect
	decision making	0.824	0.040	< 0.001	almost perfect
Moment 2 inter-observers	ball	1.000	0.000	< 0.001	almost perfect
	action space	0.951	0.024	< 0.001	almost perfect
	organisation of teams in the exercise	0.841	0.039	< 0.001	almost perfect
	number of players *per* team	0.853	0.039	< 0.001	almost perfect
	opposing players	0.825	0.041	< 0.001	almost perfect
	m^2 *per* player inside the field	0.971	0.020	< 0.001	almost perfect
	tactical orientation	0.894	0.034	< 0.001	almost perfect
	offside	0.963	0.026	< 0.001	almost perfect
	practising goalkeepers	0.892	0.035	< 0.001	almost perfect
	decision making	0.843	0.039	< 0.001	almost perfect

Table 4. Inter-observer reliability and variability at moment 1 and moment 2 for each criterion

Moment	Indicator	*ICC*	95% *CI*		Test *F*	
			lower limit	upper limit	value	*p*
Moment 1 Inter-observers	ball	0.939	0.914	0.958	32.326	< 0.001
	action space	0.963	0.948	0.974	53.489	< 0.001
	organisation of teams in the exercise	0.972	0.960	0.981	70.336	< 0.001
	number of players *per* team	0.994	0.991	0.995	308.328	< 0.001
	opposing players	0.984	0.977	0.989	129.911	< 0.001
	m^2 *per* player inside the field	0.966	0.952	0.976	57.756	< 0.001
	tactical orientation	0.966	0.951	0.976	57.342	< 0.001
	offside	0.939	0.914	0.958	32.326	< 0.001
	practising goalkeepers	0.972	0.959	0.980	70.525	< 0.001
	decision making	0.976	0.965	0.983	84.675	< 0.001
Moment 2 inter-observers	ball	1.000	–	–	–	–
	action space	0.990	0.986	0.993	196.769	< 0.001
	organisation of teams in the exercise	0.982	0.974	0.988	116.075	< 0.001
	number of players *per* team	0.985	0.979	0.990	134.979	< 0.001
	opposing players	0.939	0.913	0.957	32.050	< 0.001
	m^2 *per* player inside the field	0.997	0.996	0.998	704.357	< 0.001
	tactical orientation	0.967	0.952	0.977	59.359	< 0.001
	offside	0.996	0.994	0.997	456.983	< 0.001
	practising goalkeepers	0.970	0.955	0.980	70.630	< 0.001
	decision making	0.943	0.913	0.962	37.480	< 0.001

er 1 achieved almost perfect agreement across all indicators, while observer 2 reached almost perfect agreement on nine indicators and substantial agreement on the remaining one ($p < 0.001$). The intraclass correlation coefficients (ICC) calculated for intra-observer reliability are provided in Table 2 and corroborate these findings, reflecting excellent reproducibility of the repeated assessments performed by the same observer. Notably, the highest agreement values were observed for the criteria with more objective structural definitions, such as the number of players and tactical orientation, whereas slightly lower values were identified for the variables requiring greater contextual interpretation, such as opposing players.

Inter-observer results revealed similarly robust agreement (Table 3). At the initial assessment, nine of the ten indicators exhibited almost perfect agreement between observers, with one indicator showing substantial agreement. At the second assessment, agreement for all indicators was almost perfect ($p < 0.001$). The *ICC*s summarised in Table 4 confirm the high degree of inter-observer reliability. Despite minor variations between indicators, all criteria demonstrated acceptable levels of agreement, supporting the consistency of the structural task-classification system across repeated assessments.

Discussion

The primary aims of this research were to develop the 3D-TC tool as a means of quantifying the structural specificity of football training tasks, and to evaluate its reliability. The structural task-classification system embedded in the tool demonstrated high intra- and inter-observer reliability and provided a structured procedure for deriving a SSI.

Reliability as a foundation for future research

Before any assessment tool can be deployed for scientific or applied purposes, its reliability must first be established [30]. In this study, the structural task-classification system embedded in the 3D-TC tool exhibited near-perfect intra- and inter-observer agreement, with values of kappa and *ICC* exceeding thresholds, indicative of excellent reliability [29, 31]. Such high reliability is critical because, as it indicates that different observers will obtain consistent SSI scores when analysing the same training exercise, and that repeated analyses by the same observer will yield stable results [32, 33]. Establishing reliability represents an essential preliminary step towards examining the validity of the SSI. It further provides coaches and researchers with the confidence to apply the tool in practice and to build upon its framework in future studies. Without a reliable structural task-classification system, subsequent attempts to assess structural specificity, evaluate training programmes or integrate the tool into monitoring systems would lack a sound evidential basis. The consistency demonstrated by the 3D-TC tool provides an initial methodological foundation for its further development and for comparative research across teams and contexts.

Rationale for equal weighting of structural criteria

The structural task-classification system embedded in the 3D-TC tool assigns equal weight to each of the ten internal-logic criteria (*e.g.*, action space, number of players, opposing players, tactical orientation, *etc.*). This choice reflects a pragmatic methodological decision [34]. In the absence of empirical evidence about the relative importance of each criterion, equal weighting provides a simple and transparent way to aggregate the structural components into a single SSI [34, 35]. This simplicity is valuable for practitioners, allowing them to compute the index quickly and to interpret it intuitively [36]. However, equal weighting does not imply that each structural element contributes equally to the representativeness of a task, rather, it represents an initial assumption [34]. Future research should examine the empirical contribution of each criterion to structural specificity, potentially using statistical approaches (*e.g.*, factor analysis or regression models) to derive data-driven weighting schemes based on the association of each criterion with performance or load variables. Nevertheless, the current proposal provides an initial operational framework that may support future investigations and applied practice aimed at advancing the understanding of structural specificity in football training tasks.

Representativeness and the SSI

The concept of representativeness stems from representative learning design, which proposes that skill transfer is optimised when practice tasks preserve the key informational constraints of competition [23, 25, 37, 38]. Under this view, the closer the resemblance between the perceptual–motor environment in training and the competitive game, the greater the opportunity for players to attune to game-relevant information and calibrate their actions accordingly [23, 39]. However, representativeness exists on a continuum and must be balanced against the physical and cognitive loads imposed by each exercise [26]. Highly representative tasks may enhance skill transfer, although they may also increase physical and cognitive demands. Conversely, less representative drills may fail to stimulate the perception–action coupling required in matches [26]. The SSI operationalises representativeness by quantifying how closely the structural elements of a training task (*e.g.*, space, player numbers, opposition, and goals) mirror the internal logic of football [21, 22]. By scoring exercises on ten criteria and transforming these scores to a common scale, coaches can compare the relative representativeness of different drills, design sessions that progressively approximate match conditions, and monitor how structural fidelity interacts with other load metrics.

Ecological dynamics and non-linear training design

The ecological dynamics framework proposes that skilled behaviour emerges from the interaction between performer, task, and environmental constraints, rather than from pre-programmed actions [40, 41]. This perspective emphasises how athletes continuously adapt their behaviour through interactions with constraints, enabling them to perceive and exploit relevant affordances. It is closely aligned with the constraints-led approach, which advocates the systematic manipulation of constraints to promote functional and adaptable movement solutions [38, 41]. Manipulating variables such as pitch dimensions, rules, or opposition allows coaches to shape desired behaviours and guide players' actions [37]. In football, the internal logic of the game reflects the interaction between players, space, time, and rules [21, 22]. By modifying these elements, practitioners can create learning environments that encourage self-organisation and non-linear adaptation [42]. Within this framework, 3D-TC's SSI provides a practical method for characterising the structural constraints of exercises and positioning training tasks along a continuum from highly representative to more exploratory settings. Consequently, integrating structural specificity with ecological dynamics may support the design of training sessions that are both representative and adaptable.

Study limitations and future research avenues

While the structural task-classification system embedded in the 3D-TC tool provides a novel, reliable procedure for assessing the structural specificity of football training tasks, several limitations should be acknowledged. First, the reliability assessment was conducted on a single professional club's mesocycle using two trained observers, limiting the generalisability of the findings across different teams, playing levels, age groups, and cultural contexts. Furthermore, the present study focused exclusively on reliability outcomes and did not examine construct validity, criterion validity, or associations between SSI scores and performance-related variables. The equal weighting of the ten structural criteria represents a pragmatic starting point, not an empirically derived model; as such, the current SSI may oversimplify the relative influence of individual constraints on representativeness and learning.

Future studies should replicate the reliability tests across diverse samples, explore alternative weighting schemes, and examine the predictive validity of the SSI by linking it to performance outcomes, player development, and injury incidence. Investigations that integrate structural measures with internal load metrics (*e.g.*, rating of perceived exertion) and explore how representativeness interacts with ecological dynamics variables (*e.g.*, affordance perception, decision-making accuracy) could provide a more holistic understanding of training design. Finally, the proposed three-dimensional load equation (volume × intensity × specificity) remains conceptual; its utility and relationship with player health and performance should be tested empirically in longitudinal studies.

Conceptual examples illustrating the integration of structural specificity into three- and four-dimensional load estimations were developed as supplementary exploratory models (Figures S1 and S2 in Supplementary material). These examples are intended solely to illustrate potential future applications of the SSI within integrated training-load frameworks and should not be interpreted as validated monitoring procedures.

Practical applications

By translating qualitative judgements about drills into a single SSI, the 3D-TC tool may assist coaches in designing training sessions that more closely reflect selected structural characteristics of match play. The SSI can be integrated with standard load metrics to capture the volume, intensity, and specificity of each exercise, thereby potentially contributing to a broader understanding of training demands. Because the structural classification criteria and scoring procedures are transparent, practitioners can quickly adjust variables such as pitch size, player numbers, and opposition to achieve the desired level of representativeness. Using the SSI across micro-cycles and age groups may improve session planning, align practice with club philosophy, and help manage fatigue and injury risk.

Conclusions

The 3D-TC tool demonstrated high intra- and inter-observer reliability for classifying the structural characteristics of football training tasks and deriving SSI at both the exercise and session levels. These findings provide initial support for the consistency of the structural task-classification system and establish a methodological foundation for its application in research and practice.

By focusing on objectively observable structural constraints rather than subjective judgements, 3D-TC offers a transparent and flexible framework for quantifying the representativeness of football training tasks relative to competition constraints. The tool may provide practitioners with a structured framework for examining the structural characteristics of football training tasks and for supporting the systematic organisation of exercise design according to specific contextual and tactical objectives. Furthermore, the structural task-classification system may be adapted to other invasion sports that share comparable internal-logic structures.

Although the present study was limited to reliability testing, integrating structural specificity into broader monitoring systems that include volume and intensity metrics may contribute to a more comprehensive understanding of training processes. Future research should examine the validity of the SSI and explore its relationships with performance, development, and injury-related outcomes. In this regard, 3D-TC provides an initial methodological framework for advancing the analysis of football training design.

Ethical approval

The research related to human use complied with all the relevant national regulations and institutional policies, followed the tenets of the Declaration of Helsinki, and was approved by the Scientific Council and the Ethics Committee of the University of Coimbra, Portugal (approval No.: CE/FCDEF-UC/00172024).

Informed consent

Informed consent was obtained from all individuals included in this study.

Conflict of interest

The authors state no conflict of interest.

Disclosure statement

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Supplementary material

Table S1. Description of each macro-criterion and detailed explanation of the elements that comprise it

1. Macrocriteria elements of temporality	Detailed description
Temporality of planning: General information regarding the micro-cycle	1. Date: Temporal identifier in a chronological year. 2. Micro-cycle (MC): Weekly time unit. It can include one or two official competitions and several training sessions. 3. Number of competitions *per* micro-cycle (NCMC): considers the number of competitions that take place within a period of seven days. 4. Session (Ss): Corresponds to the specific work of training on-site. A weekly micro-cycle usually comprises five sessions, in addition to the competition. This structure usually changes if two competitions take place in the same weekly micro-cycle. 5. Exercise number (EN): It is the minimum time unit within the training session that enables the trainer to convey his ideas. It is made up of the technical, tactical, physical, and psychological behaviours of the coach related to team development.
2. Macrocriteria technical-tactical and physical elements	Detailed description
Phase or moment of the game to develop in the exercise: Elements that determine the goals to be achieved with the exercise	1. General bases of orientation of the exercises: Refers to the phases of play or moments (offensive organisation, defensive organisation, and transitions from defence, attack, or attack to defence, and fixed offensive or defensive tactics). Finally, physical elements have been incorporated, preferably to be performed at the beginning or end of each session. 2. Reference game situations and others: Different situations occur during the game in its different phases and moments, which serve to clearly define what is to be worked on in each exercise. Elements of a more mixed nature are also included. Finally, physical elements have also been included, preferably to be performed at the beginning or end of each session. 3. Game principles to develop in the exercise and others: These are the principles that the coach most frequently wants to develop in the exercises performed. A distinction is made between offence and defence. Official and friendly competitions are also considered elements in which all the principles of the game should be present. Finally, physical elements have been included that can preferably be performed at the beginning or end of each session.
3. Macrocriteria density	Detailed description
Exercise density: Relationship between execution time and recovery time during exercise	1. Number of repetitions (NR): number of repetitions of an exercise during the training session. 2. Duration time *per* repetition (DTR): It is the unit of time (minutes or seconds) that each repetition of a particular exercise takes. 3. Pause time (PT): This is the unit of time (minutes or seconds) the player has to recover from the previous effort. 4. Total duration of the exercise (TDex): It is the sum of the multiplication of (NR × DTR) + (NR × PT). 5. Density or % effective working time (D%-ewt): It is the percentage of player action that results from the equation [(NR × DTR) × 100] / TDex.
4. Macrocriteria structural elements of the game's internal logic	Detailed description
1. Ball or mobile (BoM): Interaction that the player can have with the ball during the exercise	0. Not applicable (N/A): The exercise is performed without a ball and focusses analytically on purely physical or tactical elements as a warm-up training. 1. Ball-in-hand games: The exercise is performed as a playful element or as an introduction to other concepts in the main part of the training. 2. Hand and foot: The exercise combines actions with hand and foot or other body parts that are permitted in the official competition. 3. Ball in the foot: The exercise takes place exclusively with the ball on the foot and on parts of the body that can be used in accordance with the football rules.

2. Action space (AS): Delimitation of the space in which the players must act during the exercise	0. Not applicable (N/A): The exercise is performed in a defined space but is based on purely physical elements. 1. Segmented space: Space that includes different action zones in which groups of players can be restricted in their participation by the rules or instructions of the coach and participate intermittently (*e.g.*, practice of passes in figure, without tactical orientation, or passes with completion and tactical orientation, but with different zones). 2. Segmented and common space: This corresponds to exercises in which a group of players initially stay in a certain area and, after achieving a certain goal (*e.g.*, number of passes, recovery, *etc.*), move to a common area that could correspond to the previous structure or be open. 3. Common space: A space without subdivision and segmentation, in which teams interact simultaneously, in co-operation and opposition as in the official game.
3. Organisation of teams in the exercise (OTE): Organisation of teams for the execution of the exercise	0. Not applicable (N/A): The exercise executed does not correspond to this criterion. 1. Individual: The exercise is performed individually and without the involvement of other players, focusing on technical-tactical or physical elements of warm-up, opposition or recovery. 2. Group: The exercise is performed by several players (two or more), regardless of their position on the pitch, and focused on technical-tactical or physical elements of warm-up, opposition or recovery. 3. Sectorial: The exercise is performed by the players according to their sector on the pitch. 3.1 Defensive sector. 3.2 Midfield sector. 3.3 Offensive sector. 4. Intersectoral: The exercise is executed by players from two different and adjacent lines of play. The sectors do not need to be completed according to the game system adopted. 4.1 Defensive line + midfield line 4.2 Midfield line + offensive line 5. Collective: Incorporates all three player lines into the official game (*e.g.*, defensive, midfield, and offensive line).
4. Number of players *per* team (NPT): Number of players that make up the teams	0. Not applicable (N/A): Exercises carried out individually or in groups but focused on physical elements of activation, opposition or recovery, and not corresponding to this criterion. 1. 1 player: Minimal interaction with no involvement of a partner in achieving a specific objective. 2. 2 to 4 players (small-sided games): Small teams that allow the emergence of some more specific principles. 3. 5 to 7 players (medium-sided games): Teams with an intermediate number of players that allow more specific behaviours to emerge. 4. 8 to 10 players (large-sided games): Teams with Teams that that most closely resemble the number of players in an official competition. This structure allows several game principles to occur simultaneously. 5. 11 players: The maximum number of players permitted by the rules of the official game, allowing all principles of play to emerge.
5. Opposing players: Numerical condition of the opposing team	0. Not applicable (N/A): Exercises that do not fulfil this criterion and are performed outside the field context. 1. No opposition: Exercises that are performed individually or in a group without opposition and focus on technical-tactical elements or physical activation, optimisation, and recovery. 2. Numerical inferiority: Exercises involving opposition in which the opposing team has fewer players than the team working towards the main objective, facilitating the achievement of the exercise objective. 3. Numerical superiority: Exercises involving opposition in which the opposing team has more players than the team working towards the main objective, making the achievement of the exercise objective more difficult. 4. Numerical equality + Mixed Joker: Both teams have the same number of players; however, the team in possession of the ball has an additional advantage through the presence of a joker who can support play both inside and outside the field. 5. Numerical equality + Outside Joker: Both teams have the same number of players; however, the team in possession of the ball receives additional support from an external joker positioned outside the playing area (outside the field). 6. Numerical equality + Interior Joker: Both teams have the same number of players; however, the team in possession of the ball receives additional support from an interior joker who operates within the playing area. 7. Numerical equality: The opposition is organised with numerical equality, following the rules of the game and replicating the conditions of the official competition.

6. m^2 *per* player inside the field: Number of square metres each player must cover. (Calculated by dividing the total area/number of players on the pitch)	0. Not applicable (N/A): The exercise does not correspond to this criterion. 1. ≤ 67 m^2 × player: The minimum playing area to be covered *per* player during the exercise, which may involve physical or technical-tactical demands. 2. 68–134 m^2 × player: A small playing area to be covered *per* player during the exercise, which may involve physical or technical-tactical demands. 3. 135–201 m^2 × player: A average playing area that must be covered *per* player during the exercise, which may involve physical or technical-tactical demands. 4. 202–268 m^2 × player: A large playing area to be covered *per* player during the exercise, which may involve physical or technical-tactical demands. 5. 269 or more m^2 × player: The maximum field area to be covered *per* player, corresponding to the dimensions of a standard pitch during an official match (approx. 100–110 m long × 64–75 m wide).
7. Tactical orientation: It corresponds to a clear division of objectives into attack and defence	0. Not applicable (N/A): The exercise does not correspond to this criterion. 1. Without tactical orientation: The main objective of the exercise is based on specific requirements that do not necessarily involve tactical orientation (*e.g.*, transition, ball possession, or passing exercises, *etc.*). 2. Single tactical orientation: The objective of the exercise focuses on performing one or more actions in a single direction (*e.g.*, a finishing exercise). 3. Multiple tactical orientations: The objective of the exercise involves several structural goals, allowing players to attack and defend in multiple directions, unlike the two-directional structure of an official match (*e.g.*, four goals placed on each side of a 20×20m pitch, multiple goals within a defined area or one official goal combined with additional goals in different corridors, *etc.*). 4. Two tactical orientations: The objective of the exercise is centred on finishing moves toward the opposing team's goal while preventing the opponent from scoring in their own goal. For this reason, the exercise structure is set to one direction of attack and one direction of defence, as stipulated in the rules of the official game.
8. Offside: This dimension concerns the degree to which the offside rule is preserved, modified, or removed within the structural configuration of the task	0. Not applicable (N/A): The exercise does not correspond to this criterion. 1. No offside: The exercise is performed without applying the offside rule. No offside-related spatial or regulatory constraints are incorporated, and the exercise focuses on specific performance components (*e.g.*, possession, pressing, coordination, technical–tactical sub-principles). 2. Offside for a team: The offside rule is applied to only one team, depending on the structural organisation of the exercise or the targeted phase of play. Typically, the initiating team may be exempt from the offside rule [*e.g.*, during the build-up phase), while the opposing team becomes subject to the offside rule when transitioning to attack. 3. Offside for both teams: The offside rule is applied equally to both teams throughout the exercise. The exercise is structured to include defined attacking and defending phases, with both teams required to comply with the offside rule when attacking.
9. Practising goalkeepers (PGK): Corresponds to the use or not of goalkeepers	0. Not applicable (N/A): The exercise does not correspond to this criterion. 1. Without a goalkeeper: The exercise does not require goalkeepers nor official goals to be executed. 2. One goalkeeper: The exercise includes one goal defended by a goalkeeper during its execution. 3. Two goalkeepers: The exercise includes two goals, each defended by a goalkeeper during execution. This structure separates the exercise into attacking and defending zones.
10. Decision-making (DM): This corresponds to the autonomy that the player has to find the best solution to the problems that arise during the exercise	0. Not applicable (N/A): The exercise does not correspond to this criterion. 1. Perception and execution without tactical orientation: The exercise focuses on performing a repeated and predetermine action with a fixed sequence of movements, in which the beginning and end occur in the same location (*e.g.*, working passes performed in a square format or similar). 2. Tactically oriented perception and execution: The exercise focuses on the execution of a repeated and predetermined action with different starting and finishing points (*e.g.*, a tactical scheme for an unopposed finish, a pass with a precise end goal). 3. Perception, analysis, decision, and execution without tactical orientation: These exercises differ in the instability and variability of responses that contribute to achieving the defined objective (stimulation of spontaneous decision-making). They do not include physical target for scoring (goals or portals), and points are awarded for other elements (*e.g.*, number of passes made or number of recoveries). 4. Perception, analysis, decision, and execution with a single tactical orientation: Exercises that entail a certain degree of instability and variability of responses that can encourage spontaneous decision-making. There is a clearly defined goal or objective (*e.g.*, an intersectoral work with medium offence, in which a team attempts to score a goal against a numerically inferior defending team whose objective is to stop the opponent's attack (6vs3+ GK). 5. Perception, analysis, decision, and execution with more than two tactical orientations: Exercises that involve instability and variability of responses that can help achieve the defined objective (promoting spontaneous decision-making). They include more than two physical targets for scoring (*e.g.*, an official goal and three portals in different areas of the pitch, or a passing exercise (5vs5) with four small precision goals). 6. Perception, analysis, decision, and execution with two tactical orientations: Exercises in which two tactical orientations are clearly defined (attack and defence), so that this polarisation facilitates offensive and defensive organisation in order to achieve the established objectives (which encourages spontaneous decision-making). This orientation structure replicates the organisation of the official competition.

5. Macrocriteria result elements	Detailed description
Absolute Structural Specificity Index (ASSI)	1. The ASSI corresponds to the sum of the ten specificity indicators, according to the elements of the internal logic it contains.
Transformed Structural Specificity Index (TSSI-1-10)	1. The TSSI-1-10 is the value obtained from the ASSI, which is subsequently transformed for classification.
Descriptive Structural Specificity Index (DSSI)	1. The DSSI provides a descriptive classification of the TSSI-1-10. Values 1 and 2 correspond to an exercise with a very low Structural Specificity (SS); values 3 and 4 correspond to an exercise with a low SS; values 5 and 6 correspond to an exercise with an average SS; values 6 and 8 corresponds to an exercise with a high ; and values 9 and 10 corresponds to an exercise with a very high SS.
Contribution of Structural Specificity Index of the Exercise to the Session (CSSIE-Ss)	1. Exercises may have different SSI values and different durations; therefore, it is necessary to determine the contribution of each exercise to the total training session. For this purpose, the equation proposed by Solé (15) is applied: CSSIE-Ss = [total duration time (TDex) × TSSI-CR10] / Σ ex.1 to e.8.

Conceptual illustration (not validated)

On the other hand, obtaining a transformed value from 1 to 10 allows us to move from a two-dimensional (2D) equation [volume (time) × intensity (session Rating of Perceived Exertion – s-RPE)] for determining training load to a more complete and more transformed three-dimensional (3D) equation [volume (time) × intensity (s-RPE) × Session Structural Specificity Index (SsSSI) / 3] (Figure S1):

1. Example: Estimation of arbitrary units (AU) in 3D

$$AU3D = (Volume \times s\text{-}RPE \times SsSSI) / 3$$
$$AU3D = (65' \times 7 \times 6.1) / 3$$
$$AU3D = 925$$

Furthermore, applying a similar estimation of percentage density on a scale ranging from 1 to 10, considering both the execution time and the total rest time of each exercise within the overall training session, would allow the incorporation of a four-dimensional (4D) estimate (volume × intensity × specificity × density / 30) (Figure S2):

2. Example: Estimation of arbitrary units (AU) in 4D

$$AU4D = (Volume \times s\text{-}RPE \times SsSSI \times Density) / 30$$
$$AU4D = (65' \times 7 \times 6.1 \times 7) / 30$$
$$AU4D = 648$$

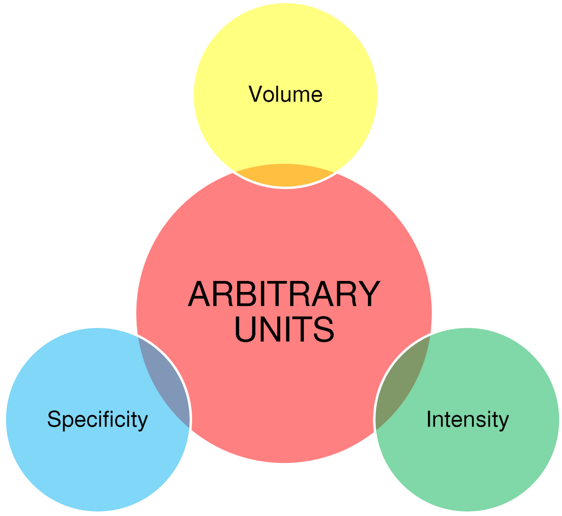

Figure S1. Elements that make up the load unit in 3D

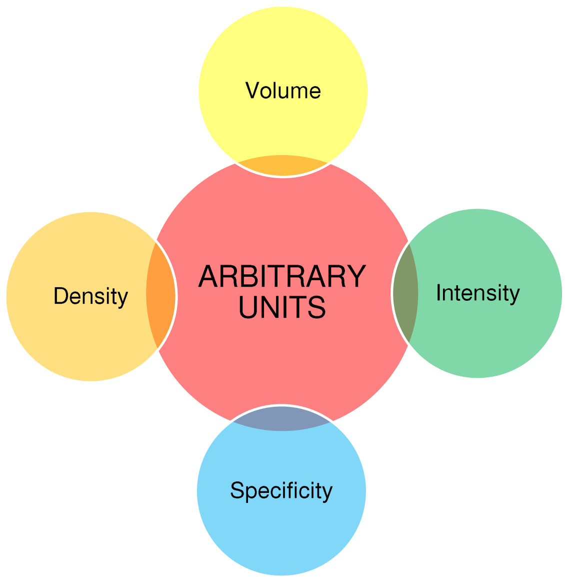

Figure S2. Elements that make up the load unit in 4D