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# ORIGINAL

# DESIGN AND VALIDITY OF A BADMINTON OBSERVATION TOOL (BOT)

# DISEÑO Y VALIDACIÓN DE UNA HERRAMIENTA OBSERVACIONAL PARA EL BÁDMINTON (BOT)

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**INTEREST CONFLICT**

The authors declare that they have no interest conflict and that the work complies with all international ethical standards, as well as the current legislation on research.

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## ABSTRACT

Observational methodology allows analysing sports' specific behaviour context. The main purpose of this manuscript was to develop and validate an ad hoc observational tool for badminton singles games, which includes lunges trajectories as a non-analysed variable till this study. For that reason, the observational tool consists of 13 criteria and 47 categories mutually exclusive. 287actions of the 2015 Badminton World Championship were analysed. With the aim to assess the tool's validity Cohen's Kappa and generalizability theory were used. The outcomes for complete observational tool and for each criterion exceed 0.98, being above 0.81 proposed by literature as "almost perfect". Generalizability analysis was done by two sides model (Category/Observer = C/O) and showed an excellent reliability (1.00). It could be said that it is a reliable tool designed for recording and analyzing the behaviour of badminton singles players.

**KEY WORDS:** Racket sports; observational methodology; observational tool; performance analysis, generalizability.

## RESUMEN

La metodología observacional permite analizar deportes en contexto y dinámicas habituales. El objetivo principal fue la construcción y validación de una herramienta observacional ad hoc para analizar el bádminton individual, que incluye la trayectoria de los desplazamientos como variable no analizada anteriormente. Constituida por 13 criterios y 47 categorías mutuamente excluyentes, fueron analizadas 287 acciones del Campeonato de Mundo de Bádminton 2015. Para la validación se utilizó el coeficiente *Kappa* de Cohen y la teoría de la generalizabilidad. Se han obtenido resultados, tanto para la herramienta como para cada uno de los criterios de forma individual, superiores a 0,98 estando por encima de 0,81 que propone la literatura como "casi perfecto". El análisis de la generalizabilidad se realizó mediante un modelo de dos facetas (Categoría/Observador = C/O) y reveló que la fiabilidad era excelente (1,00). La herramienta diseñada es válida y fiable para el análisis de las conductas del bádminton individual.

**PALABRAS CLAVE:** Deportes de raqueta; metodología observacional; validación herramienta; análisis notacional, generalizabilidad.

## INTRODUCTION

To carry out an intervention program, regardless of its nature, it is necessary to develop a previous research process in order to describe the sports physical and technical-tactical characteristics. In this case, badminton is a game that

consists of passing the mobile (shuttlecock) above the net, trying to send it to the opponent's zone of greater complexity of hitting back probability (Cabello, 2000). According to the type of efforts made, it is an intervallic sport with explosive actions of short duration and high intensity between anarchic periods of recovery (Cabello, 2000; Chin et al., 1995). Players, from the defense position described by Gibbs (1988) have to move to any area of the court well in advance to hit the shuttlecock (Huber, 1999), which accounts for 15% of movements made in the individual modality of competition (Kuntze, Mansfield, and Sellers, 2010). The shots made by the players with the racket are part of the specific technical gestures of the modality, categorized in 6 types: smash, clear, drop, net, drive and lob proposed by Cabello, Serrano and García (1999) and modified by Abián-Vicén, Castanedo, Abián and Sampedro (2013).

On the other hand, knowing the sport's tactical-strategic elements allows the coach to analyze the "behavioral patterns" of players, thus achieving a better adaptation to the game's real context, adjusting the efforts to carry out technical actions that allow a greater number of points and even improve the less effective aspects of each player (Losada, Casal, and Ardá, 2015). Having identified the factors to be analyzed, the observational methodology is adapted to the proposed objective because it is carried out in a natural context, habitual or not prepared, typical of the competition that we are going to observe, focusing on spontaneous and habitual behavior of the players (Anguera, 1990, Sánchez-Algarra and Anguera, 2013), without any intervention in the development of the game, nor in the decisions of the same ones and in the behaviors perceptivity, that are the movements that players make during real competition (Anguera, Blanco, and Losada, 2001). The use of this methodology allows the knowledge of the game actions and the context in which they are produced, something very used in the study of different sports specialties (e.g. Alonso y Argudo, 2011; Arbulu, Usabiaga, y Castellano, 2016; Castañer, Torrents, Anguera, Dinušová, y Jonsson, 2009; Cuadrado et al., 2010; Fernández, Camerino, Anguera, y Jonsson, 2009; Losada et al., 2015; Menescardi, López-López, Falcó, Hernández-Mendo, y Estevan, 2015; Pradas, Floría, González-Jurado, Carrasco, y Bataller, 2012). This requires a rigorous observer when designing the model, as well as in the following phases of the observation or analysis process (Etxeazarra, Castellano, and Usabiaga, 2013).

Taking into account the previously mentioned, the aim of this study was to design and validate an ad hoc observational instrument called "Badminton Observational Tool" (BOT), which allows us to identify and describe game actions in badminton, as well as assess the tool's data quality applied in the individual modality.

## METHODS

### Participants

Systematic observations were made of 287 records corresponding to the men's singles quarter-final match of the 2015 World Championship Jakarta. Sample selection answers to the need to control the situational variable "player level" ensuring that players show a similar play level and are within the world's TOP 15 (Badminton World Federation, 2015). Images were taken from official recordings provided by the World Badminton Federation (WBF) television channel and are available on their website. According to the Belmont Report (1978) in the field of research, public images do not need informed consent.

### Material

Data recording was done through the use of different programs: LINCE (Gabin, Camerino, Anguera, and Castañer, 2012) for data registration defined by the BOT tool, KINOVEA for court footwork and SAGT (Hernández-Mendo, Blanco-Villaseñor, Pastrana, Morales-Sánchez, and Ramos-Pérez, 2016) to carry out the generalizability analysis. Statistical treatment was performed using the IBM SPSS Statistics v.23 statistical package (SPSS Inc., Chicago IL).

### Procedure

For the construction of the *ad hoc* tool, a system of field categories and formats has been chosen (Anguera, Blanco, Losada, and Hernández-Mendo, 2000; Castellano, 2005; Hernández-Mendo, 1996). Several situations produced in a natural environment, opting for closed systems, in a way that forces unidimensionality and is exhaustive and mutually exclusive (E / ME). 5 sessions with 3 experts were conducted (national badminton coaches with at least 10 years of experience in training and training of players) where 409 non-systematic observations were made, in order to define the categories final configuration that the tool includes.

The situations described by BOT, meet the observational designs criteria for classification, responding to nomothetic, follow-up and multidimensional designs (Anguera et al., 2000).

To guarantee the recorded data reliability, observers received training sessions, following the instructions of Losada and Manolov (2015). Subsequently the observer, following previously criteria defined by experts, perform the analysis of the same match twice with 10 days between following Lupo et al. (2011); Lupo, Condello and Tessitore (2012); Menescardi et al. (2015); Tornello et al. (2014); Tornello, Capranica, Chiodo, Minganti and Tessitore (2013).

Following Anguera's indications (1990), to guarantee intra-intersessional constancy, each match to be analyzed was selected, so that there were no

exceptional circumstances that would break the behavioral flow, such as injuries, accidents, outages, material rupture, etc. Registration was made on a continuous basis (Hernández-Mendo, 1996) by means of direct coding, where the periods of non-observability were not taken into account, since in no case they exceeded 10% of the total registry (Anguera, 1990).

**Observational instrument**

Tool used for match analysis is grouped into 3 response macrolevels, which are: contextual (gender, round, match, player number and set number), behavioural (shot type and movement type) and result (shot result, times and points). Criteria "shot", "time" and "point" are based on previous works by Christmass, Richmond, Cable and Hartmann (1995); Galiano, Escoda and Pruna (1996); Cabello, Carazo, Ferro, Oña and Rivas (2004); Pradas, Floría, González-Jurado, Carrasco and Bataller (2012); Abián-Vicén et al. (2013) and Abián, Castanedo, Feng, Sampedro and Abián-Vicén (2014). The "footwork" criteria make up the main contribution of this work, which will be detailed below.

"Play" is the unit of analysis, understood as the action performed by the observed player that results from the possible combination of the categories "footwork" and "shot". Exclusion criterion for play analysis will be the incomplete filming of both. We defined "shot" as a technical gesture performed with the racket to the shuttlecock, with the different variants (Cabello et al., 1999; Hernández and Moreno, 1984). Criterion "footwork" (movements made by the player to hit the shuttlecock) is defined as the trajectory the player realize from the position where he is when the opponent hits the shuttlecock, to the place where he hits the shuttlecock back. The construction of this criterion results from dividing the court into 12 zones or quadrants (Z1, ..., Z12) of identical dimensions, which arise from extending the longitudinal line to the grid and in turn dividing the 2 resulting zones into 6 (Figure 1). In addition, the "start" and "end of footwork" levels are defined, specifying where and how the footwork trajectory occurs. These actions are classified according to the direction they take: "longitudinal" (parallel to the longitudinal axis of the court), "transversal" (perpendicular to the longitudinal axis of the court) and "diagonal" (neither longitudinal nor transversal). Depending on the distance traveled: "short" (to the adjacent quadrant) and "long" (to a noncontiguous quadrant). And according to the footwork direction, taking as a reference the starting position in respect to the net: "left", "right", "forward" and "backwards".

Finally, movement will be coded by using the combination of the 3 terms of court movement (trajectory, length or direction), for example: "short longitudinal forward footwork " (from zone 7 to zone 8), "short transversal left footwork" (From zone 3 to zone 6) or "long diagonal forward right footwork " (zone 11 to zone 6). Player's permanence in the same quadrant for hitting will be considered as "without footwork (NM)".

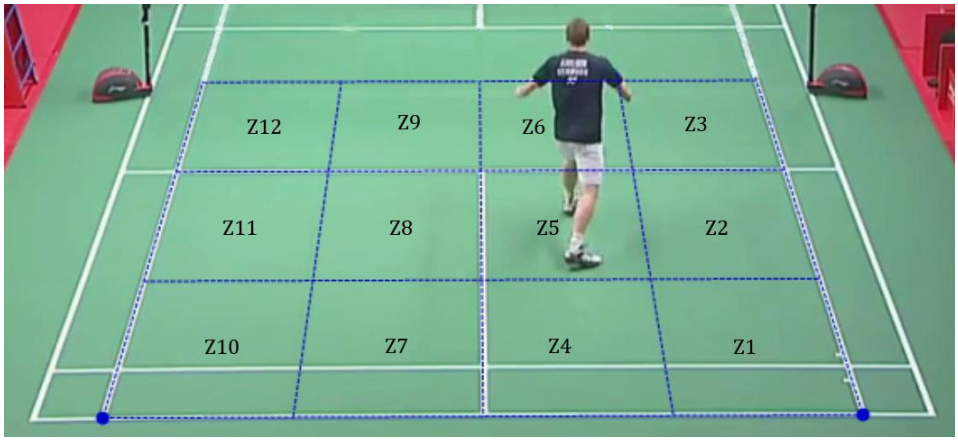


**Figure 1.** Court distribution in 12 zones.

## Statistical analysis

Data quality analysis has been approached from two perspectives: qualitative through consensual agreement (Anguera, 1990) between experts in badminton, and quantitative, through intra-observer reliability calculation, for which Cohen's *Kappa* was used (Cohen, 1960), taking into account both the chance effect correction and commission and omission errors (Robinson and O'Donoghue, 2007). This index has been calculated for each criteria that constitute the BOT, and for the general session (Castellano et al., 2000; Hernández-Mendo, Montoro, Reina, and Fernández, 2012). This index is considered the only valid statistic to verify tool reliability for the analysis of temporal parameters according to Choi, O'Donoghue and Hughes (2007). Results are also contrasted by a generalizability analysis with a two-facet model (categories/observers=C/O), which also allows to verify the categories reliability that make up the BOT tool.

Observational data quality verification allows us to carry out subsequent objective studies on the diachronic dynamics of the interaction developed in the game and thus adopt original strategies for training application (Castellano, Hernández-Mendo, Gómez de Segura, Fontetxa, and Bueno, 2000).

## RESULTS

Intra-observer reliability analysis yields a Cohen's Kappa result for the total BOT tool of 0.994 being above the 0.81 considered by Landis and Koch (1977) as "almost perfect". Analysing criteria independently, the results obtained, shown in Table 1, also presented values above 0.81.

**Table 1.** *Intra-observer Cohen Kappa coefficient for the tool's each criterion frequencies.*

| *BOT Criteria* | Value |
|---|---|
| Shot | 0.980 |
| Footwork | 0.983 |
| Result | 1.000 |
| Time | 1.000 |

This perspective of data control is complemented by the generalizability study of data (Blanco and Anguera, 2003), which assume that there are other variation sources, in addition to the intra, inter and error of the observer differences, and integrating each one of these variation sources in a global structure that allows particular applications of the statistical sampling theory (Blanco, 1989, 1992, 1997).

The generalizability theory analysis (Table 2) was performed using a two-facet design (categories/observer=C/O). Determination of variance sources reveals that most of the variability (99.984%) is associated to the category facet, presenting a 0.008% variability for the observer facet and 0.016% for the interaction of both (C/O). Generalizability coefficients overall analysis revealed that results generalization precision reliability was excellent (1.00).

**Table 2.** *Generalizability analysis of BOT tool*

| | SS | DF | RMS | Random | Mixt | Corrected | % | SD | $\eta^2$ | $\eta^2_p$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Model | 276050.98 | 59 | 4678.83 | | | | | | 0.691394 | 1.00 |
| Intersection | 123216.02 | 1 | 123216.01 | | | | | | 0.308606 | 1.00 |
| C | 276028.48 | 29 | 951822 | 4758.73 | 4758.73 | 4758.73 | 99.98 | 1208.8 | 0.691338 | 1.00 |
| O | 0.15 | 1 | 0.15 | -0.02 | -0.02 | -0.02 | 0.00 | 0.01 | | 1.00 |
| C*O | 22.35 | 29 | 0.77 | 0.77 | 0.77 | 0.77 | 0.02 | 0.20 | | 1.00 |
| Total | 399267.00 | 60 | | | | | | | | |

SS= sum of squares; DF=Degrees of Freedom; RMS=root mean square; SD=standard deviation; $\eta^2$= Eta squared; $\eta^2_p$=partial Eta squared.

Finally, with the analysis of factors determined by the experts, the BOT tool emerges. With the combination of the 13 criteria and 47 categories, the following possibilities result (Tables 3, 4, 5 and 6):

**Table 3.** *Contextual macrolevel and observation instrument codes (BOT)*

| MACROLEVEL | CRITERIA | CATEGORY | DESCRIPTION | CODE |
|---|---|---|---|---|
| CONTEXTUAL | GENDER | MALE | Game modality | MA |
| | | FEMALE | | FE |
| | ROUND | ROUND 1/64 | Competition round where he/she belongs | R64 |
| | | ROUND 1/32 | | R32 |
| | | ROUND 1/16 | | R16 |
| | | ROUND 1/8 | | R8 |
| | | ROUND ¼ | | R4 |
| | | ROUND ½ | | R1/2 |
| | | FINAL | | RF |
| | MATCH | MATCH Nº | Match analysed number | N |
| | PLAYER | PLAYER | Player analysed number | P |
| | SET | SET 1 | Set that is being analysed | S1 |
| | | SET 2 | | S2 |
| | | SET 3 | | S3 |

**Table 4.** *Behavioural macrolevel and observation instrument codes (BOT) I*

| MACROLEVEL | CRITERIA | CATEGORY | DESCRIPTION | CODE |
|---|---|---|---|---|
| BEHAVIOURAL | SHOT | SHORT SERVE | Shot the nearest allowed zone to the net (Z3, Z6, Z9 and Z12) | SS |
| | | DEEP SERVE | Shot to the bottom of the court (corridor zone that limits the serve of doubles, Z1, Z4, Z7 and Z10) | DS |
| | | SMASH | Shot made from the bottom or half of the court with a hand above the head. Trajectory of shuttlecock is descending, rectilinear and high speed. | SM |
| | | CLEAR | Shot made from own's court bottom to opponent's court bottom, above head and flat trajectory. | CL |
| | | DROP | Soft shot, from the bottom with hand above head with downward trajectory to fall close to serve line | DP |
| | | NET | Shot from a position close to the net. Shuttlecock describes trajectory as close as possible to the net in height and distance. It can be hit at half height and even at low hand. Includes *kill, brush* and *push.* | NE |
| | | DRIVE | Shot made at body height (between head and waist) shuttlecock makes a tense, parallel-downward trajectory to the ground, passing as close as possible to the net | DR |
| | | LOB | Shot near the net to throw shuttlecock to the bottom of opposite court as high as possible in tense trajectory. It is hit by hand at medium or low height | LB |

**Table 5.** *Behavioural macrolevel and observation instrument codes (BOT) II*

| MACROLEVEL | CRITERIA | CATEGORY | DESCRIPTION | CODE |
|---|---|---|---|---|
| BEHAVIOURAL | LONGITUDINAL FOOTWORK | SHORT FORWARD | Parallel footwork to the court's longitudinal axis, to adjacent quadrant and approaching net | LSF |
| | | SHORT BACKWARDS | Parallel footwork to the court's longitudinal axis, to adjacent quadrant and approaching own's back boundary line | LSB |
| | | LONG FORWARD | Parallel footwork to the court's longitudinal axis, to non-adjacent quadrant and approaching net | LLF |
| | | LONG BACKWARDS | Parallel footwork to the court's longitudinal axis, to non-adjacent quadrant and approaching own's back boundary line | LLB |
| | TRANSVERSAL FOOTWORK | SHORT RIGHT | Perpendicular footwork to the court's longitudinal axis, to right adjacent quadrant | TSR |
| | | SHORT LEFT | Perpendicular footwork to the court's longitudinal axis, to left adjacent quadrant | TSL |
| | | LONG RIGHT | Perpendicular footwork to the court's longitudinal axis, to right non-adjacent quadrant | TLR |
| | | LONG LEFT | Perpendicular footwork to the court's longitudinal axis, to left non-adjacent quadrant | TLL |
| | DIAGONAL FOOTWORK | SHORT RIGHT FORWARD | Non-longitudinal nor transversal footwork, to adjacent quadrant, approaching net, right | DSFR |
| | | SHORT LEFT FORWARD | Non-longitudinal nor transversal footwork, to adjacent quadrant, approaching net, left | DSFL |
| | | SHORT RIGHT BACKWARDS | Non-longitudinal nor transversal footwork, to adjacent quadrant, approaching own's back boundary line, right | DSBR |
| | | SHORT LEFT BACKWARDS | Non-longitudinal nor transversal footwork, to adjacent quadrant, approaching own's back boundary line, left | DSBL |
| | | LONG RIGHT FORWARD | Non-longitudinal nor transversal footwork, to non-adjacent quadrant, approaching net, right | DLFR |
| | | LONG LEFT FORWARD | Non-longitudinal nor transversal footwork, to non-adjacent quadrant, approaching net, left | DLFL |
| | | LONG RIGHT BACKWARDS | Non-longitudinal nor transversal footwork, to non-adjacent quadrant, approaching own's back boundary line, right | DLBR |
| | | LONG LEFT BACKWARDS | Non-longitudinal nor transversal footwork, to non-adjacent quadrant, approaching own's back boundary line, left | DLBL |
| | NO MOVEMENT | | Quadrant permanence | NM |

**Table 6.** *Results macrolevel and observation instrument codes (BOT)*

| MACROLEVEL | CRITERIA | CATEGORY | DESCRIPTION | CODE |
|---|---|---|---|---|
| RESULTS | RESULT | SUCCESS | Shot made by observed player ends in point gained | SU |
| | | NO SUCCESS | Shot made by observed player does not end in point gained (it goes out or game continues) | NS |
| | TIME | MATCH DURATION | Time past from first service until shuttlecock ceases to be playable at match's last point | MD |
| | | REAL TIME PLAYED | Sum of times in which shuttlecock can be playable | RTP |
| | | RALLY TIME | Time past between racquet touching the shuttlecock in the service until shuttlecock stops being playable | RT |
| | | REST TIME | Time past between shuttlecock touching the ground until next service | ReT |
| | POINT | PLAYED POINTS | Match's number of disputed points | PP |
| | | SHOTS PER POINT | Number of times that shuttlecock is hit in each point | SPP |

## DISCUSSION

The main novelty that this work contributes is the construction of an ad hoc tool (BOT) that includes the variable "footwork" to the rest of technical actions developed by badminton players during a match, allowing a more complete and detailed study of this sport. Previously studies as those carried out by Abián et al. (2014), Abián-Vicén et al. (2013), Cabello et al. (1999), Cabello et al. (2004), Cabello and Serrano (1997) provide data regarding the time relation (work/rest) and frequency and shot type performed, but nothing in respect to the variable "footwork", its trajectory, length or direction.

In badminton, the behavior specificity of players, coupled with the high speed played in matches, makes it very difficult to register actions without digital media, as well as in other sports such as tennis (Gorospe, Hernández-Mendo, Anguera, and Martínez, 2005) and table tennis (Pradas et al., 2012).

Data obtained on Cohen's *Kappa* indexes were optimal, similar to those found in other studies by Garay, Hernández-Mendo and Morales (2006) and Gorospe et al. (2005) in tennis; Pradas et al. (2012) in table tennis; Hernández-Mendo et al. (2012) and Hileno y Buscà (2012) in volleyball; Castellano et al. (2000) in soccer and Arbulu et al. (2016) and De Benito et al. (2011) in climbing. In addition, estimated values on variability percentage contributed by the generalizability analysis are similar to those obtained by other authors in other sports disciplines, such as Gorospe et al. (2005) in tennis.

As a practical application and future lines in the field of observational research, innovative statistical techniques could be applied in this sport modality, such as predictive analysis through logistic regression, identification of motor patterns

through multiple correspondence analysis, decision tree, temporary patterns (*T-Patterns*), etc.

## CONCLUSIONS

The tool presented here and its data quality results (reliability indexes and generalizability) allow us to consider the proposed category system as "excellent", fulfilling with good measure the methodological requirements of goodness of fit, reliability and generalizability required.

BOT allows the coding of frequency, order and duration of actions (understood as "shots with or without footwork") that are given in the individual mode of badminton, so it could be used in future research to assess the performance of players and/or to design intervention proposals adjusted to the competitive context reality.

Finally, results showed that BOT observational tool could be used to describe singles badminton players behaviours.

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