# Effectiveness of Male Handball Goalkeepers:

# A historical overview 1982-2012

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**Abstract:**

***In this article, an analysis of the historical evolution of the effectiveness of goalkeepers in high level world competitions is carried out. To this end, 32 men's handball finals have been analyzed to record and classify effectiveness rates and goalkeeping actions in relation to opponent players' throw areas and positions from 1982 to 2012. Analysis included throws from areas of 6, 7, 9 m and counterattack, performed from center or side positions. Results show no clear trend in effectiveness values registered throughout the time sample, both generally and specifically in terms of throwing position. The Kruskal-Wallis H test did not establish statistically significant differences (p>0.05) in goalkeeping effectiveness between any of the different analyzed periods, with a confidence interval of 95%. The findings of this study suggest that the ability of goalkeepers to prevent the goal from different throwing areas and positions has changed little over the past 30 years, although the game has incorporated more***

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## 2 Introduction

The handball goalkeeper is a key element in the defense system of a team as he/she is the player in charge of avoiding goals by the opposing team. For this reason, scientific literature has collected various publications in recent years where the role of handball goalkeeper has been studied, either individually or as part of the research team.

There have been studies that address different problems of injuries in goalkeepers. Research has shown the existence of a harmful pattern of goalkeeper elbow (Akgun, Karahan, Tiryaki, Erol, & Engebretsen, 2008) and his/her response in certain exercises (Hatzimanouil, Lazaridis, & Yiannakos, 2012) as a result of the impacts they receive in the goal. In fact, the physical characteristics of goalkeepers, who are subjected to responsibilities different from other players, have been addressed by the scientific literature, along with other players based on the position of play. Physical and physiological characteristics in absolute male category (Ghobadi, Rajabi, Farzad, Bayati, & Jeffreys, 2013) and in female category (Cavala & Katic, 2010; Milanese, Piscitelli, Lampis, & Zancanaro, 2011, 2012; Vila et al., 2012) have been studied. Similarly, there have been studies that have established the specific characteristics of dominate players in relation to the position in the field, either on specific selections (Sporis, Vuleta, Vuleta, Dinko, & Milanovic, 2010) or players at lower categories (Lopes, Jacobs, Travieso, & Araujo, 2014; Matthys, Fransen, Vaeyens, Lenoir, & Philippaerts, 2013; Rousanoglou, Noutsos, & Bayios, 2014; Zapartidis, Kororos, Christodoulidis, Skoufas, & Bayios, 2011). Among these studies, the physical characteristics of goalkeepers are evaluated in depth through a battery of tests where the

importance of height and size is shown as decisive features of goalkeeper performance (Justin, Vuleta, Pori, Kajtna, & Pori, 2013).

This set of studies seeks to establish an ideal profile for handball goalkeepers, which show high stop rates during actual game situations. The ultimate aim is to increase the effectiveness of goalkeepers due to their impact in better rankings in a competition team (Pascual, Lago & Casais, 2010).

However, as shown by evidence, the effectiveness of the goalkeeper should not be only a result of direct factors such as those presented in the literature, but also a combination of both direct and indirect causes to a lesser or greater degree. In this article, an analysis of the historical evolution of the effectiveness of the goalkeeper in high level world competitions is carried out. To this end, effectiveness rates in relation to opponent players' throw areas and positions are recorded and classified in an extended time span covering the last eight Olympiads. Effectiveness results and goalkeeping actions depending on the zones and launch areas are of great interest for coaches and players, given their easy incorporation into effective training methodologies.



## 3 Methods

### 3.1 Sample

For the development of the study, 32 men's handball finals have been analyzed from 1982 to 2012. The sample includes games from the first 10 European Championship finals (1994-2012), 14 World Championship finals out of 23 played (1982-2013), and 8

Olympic Games finals (from Los Angeles 1984 to London 2012) of the 11 games played so far.

For the analysis of the games, video material source was extracted from generalist and sport TV channel broadcasts. Due to TV stations technology, the first games were captured in analog standard definition (576i), whereas for the last years, digital high definition (720p) was recorded. In any case, image resolution is sufficient for the size of the proposed analysis.

With this video content, a notational analysis of 3810 game actions was performed using the software SportCode Pro v.8.5.2. To evaluate the historical development, actions were distributed in four time spans corresponding to the eight Olympiads that cover all matches of the sample.



### 3.2 Procedure

Analysis of video recordings was made by an experimenter observer. To ensure reliability of observation during the study, two intra-operator views (Davis, James, & Rees, 2008) were performed. For each of the variables under analysis, relative difference was calculated by means of the following expression (Hughes, 2004):

$$\text{Diff}\ (\%) = (\Sigma(\text{mod}[V_1 - V_2])/V_{mean})*100\%,$$

where $V_1$ and $V_2$ are variables, $V_{mean}$ is their mean value, mod is short for modulus and $\sum$ means "sum of". Results of the inter-operator analysis reliability are less than 5%

(James, Taylor, & Stanley, 2007), being within acceptable margins of error in observation and analysis.

As discussed in the introduction, the analysis of the games was focused on the handball goalkeeper, sorting the stops according to the position of offensive player. To this end, observation variables were established in notational analysis that allowed studying the influence of the goalkeeper in the development of games. Next, these variables are presented with their definition.

First, four throwing areas were established, which are representative of the offensive play: 6-meter throw (6 m), 9-meter throw (9 m), 7-meter throw (7 m) and counterattack throw (CA). Table 1 shows the observation protocol for these variables.

Table 1: Throwing Area Analysis Matrix

| **Operation** | **Definition** |
|---|---|
| 6-meter throw (6 m) | Throws conducted in the area between the 6 m line and 9 m line, that is, the free-throw area. In throws where the player is in the air, the throwing area will be taken considering the jump position previous to the fly. |
| 9-meter throw (9 m) | Throws conducted behind the 9 m line, which is marked as the free-throw line. In throws where the player is in the air, the throwing area will be taken considering the jump position previous to the fly. |
| 7-meter throw (7 m) | Throws at 7-m distance as a result of a penalty called for the attacking team. |
| Counterattack | Throws made by an attacker that is situated just in front of |

| | |
|---|---|
| (CA) | the goalkeeper for having excelled in speed defenders in the defensive withdrawal. |

Figure 1 shows the throwing positions of the observation protocol in a typical handball court.

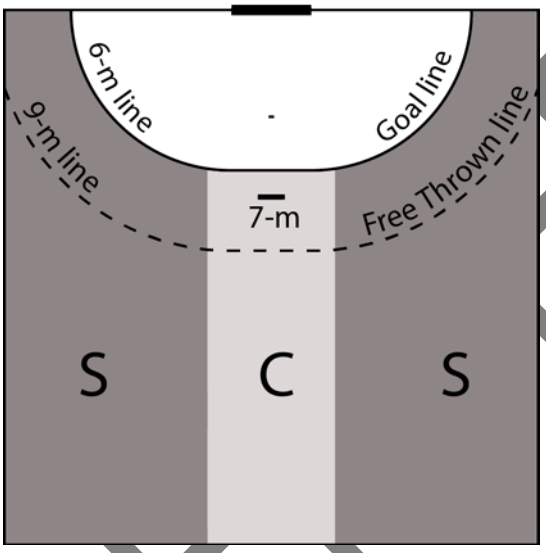



Figure 1. Half handball court with references for the throwing area and position variables.

In handball, it is of particular interest to know if throws were performed from central or lateral position. To account for this information in the analysis, the throwing position was also coded along with throwing areas of the above matrix: from center (C) or from side (S) positions. Table 2 shows the observation protocol for the throwing position.

Table 2: Throwing Position Analysis Matrix

| **Operation** | **Definition** |
|---|---|
| Side | Throws carried out by the curved zone of the 6-meter and |

| | |
|---|---|
| | 9-meter areas. This zone corresponds to the right and left side of the court. |
| Center | Throws carried out by the straight part of the 6-meter and 9-meter areas. |

Finally, the outcome variables as a result of the throw were established whether scoring (GOAL) and not scoring (NGOAL). The goalkeeper participation in the action was also recorded for the not scoring case. Thus, the goalkeeper may have direct intervention (DI) on the throw resulting in stop (STOP) or indirect intervention (II) on the failed throw (OUT). These variables are coded according to the observation matrix protocol described in Table 3.

Table 3: Result Analysis Matrix

| **Operation** | **Definition** |
|---|---|
| Goal | Throws in which the goalkeeper does not stop the ball so it ends up going in goal. |
| No Goal | Throws in which the goalkeeper, either by direct intervention (DI) or indirect intervention (II) of the goalkeeper, the ball goes into the goal. |
| Stop | Actions in which the goalkeeper intercepts the trajectory of the ball that goes to the goal preventing it from scoring. Therefore, it is a direct intervention of the goalkeeper (DI). |
| Out | Actions in which the goalkeeper does not carry out any contact with the ball and still, it does not go into the goal |

| | |
|---|---|
| | due to its deflected path. Therefore, it is an indirect intervention of the goalkeeper (II). |

Finally, game results were grouped into four time spans of eight year each, which matches groups of two consecutive Olympiads comprising the analyzed sample in order to observe the evolution of the effectiveness of the goalkeeper (Table 4). This eight-year period of time will be referred to as Grand Olympiad (G.O.) in the following.

Table 4: Classification of game finals for each Grand Olympiad

| **G.O.** | **Finals between** |
|---|---|
| 1 | 1982 - 1988 |
| 2 | 1989 - 1996 |
| 3 | 1997 - 2004 |
| 4 | 2005 - 2012 |

As a result, full analysis procedure includes the elements described above in the following order:

- Capture and digitalization of analogue recordings.
- Video normalization of all games, regardless of their source.
- Creation of code matrices containing analysis variables.
- Notational analysis coding of videos with the code matrices.
- Combination of frequency results to obtain a proper quantification of analyzed actions.
- Grouping of results by Grand Olympiads.

### 3.3 Statistical Analysis

Data were analyzed using SPSS v.19 to perform descriptive statistics. The significance of the analysis of the goalkeeper effectiveness and goalkeeping actions was computed using the Kruskal-Wallis H test to compare proportions, with a confidence interval of 95%. The test evaluated the comparison between each Grand Olympiad as a function on the area and throwing position.

## 4 Results

### 4.1 Effectiveness

The results of the analysis performed on the study sample will be displayed. First, the coefficients of stop effectiveness in percentage for each throwing area were settled. For 6-m and 9-m areas, stop coefficients are also shown in percentage as a function of the throwing position (Table 5).



Table 5: Stop Effectiveness Coefficients

| | 6 m | | | 9 m | | | 7 m | CA |
|---|---|---|---|---|---|---|---|---|
| **G.O.** | **General** | **Center** | **Side** | **General** | **Center** | **Side** | **General** | **General** |
| 1 | 26.3 | 29.1 | 23.9 | 32.4 | 33.3 | 28.6 | 32.4 | 26.2 |
| 2 | 32.2 | 27.3 | 36.0 | 39.4 | 42.3 | 32.3 | 20.5 | 24.1 |
| 3 | 29.3 | 26.1 | 31.6 | 38.3 | 36.3 | 44.9 | 24.0 | 28.4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 31.5 | 27.7 | 34.4 | 35.6 | 36.2 | 32.5 | 20.0 | 19.6 |

Results show no clear trend in effectiveness values registered throughout the different Grand Olympiads, both generally and specifically in terms of the throwing position (side or center). Table 6 shows that there were no statistically significant differences between the different Grand Olympiad periods since all *p*-values are above 0.05.

Table 6: Statistical significance of the Kruskal-Wallis H test between G.O. periods

| G.O. | 1 vs 2 | 1 vs 3 | 1 vs 4 | 2 vs 3 | 2 vs 4 | 3 vs 4 |
|---|---|---|---|---|---|---|
| **6 m General** | 0.271 | 0.430 | 0.580 | 0.859 | 0.157 | 0.107 |
| **6 m Center** | 0.972 | 0.999 | 0.955 | 1.000 | 0.865 | 0.650 |
| **6 m Side** | 0.105 | 0.176 | 0.285 | 0.958 | 0.946 | 0.785 |
| **9 m General** | 0.668 | 0.869 | 0.917 | 0.628 | 0.761 | 0.755 |
| **9 m Center** | 0.782 | 0.601 | 0.370 | 0.467 | 0.331 | 0.382 |
| **9 m Side** | 0.545 | 0.567 | 0.725 | 0.586 | 0.720 | 0.440 |
| **7 m** | 0.088 | 0.220 | 0.314 | 0.404 | 0.684 | 0.580 |
| **CA** | 0.943 | 0.920 | 0.591 | 0.715 | 0.446 | 0.395 |



### 4.2 Goalkeeping actions

In the following, the evolution over time of the goalkeeping actions has been analyzed. Figure 2 depicts the number of goalkeeping actions as a function of time over Grand Olympiads for the general throws. As shown in Figure 2, no conclusive trend in stops of the goalkeeper is found, only some specific behaviors at some distances.

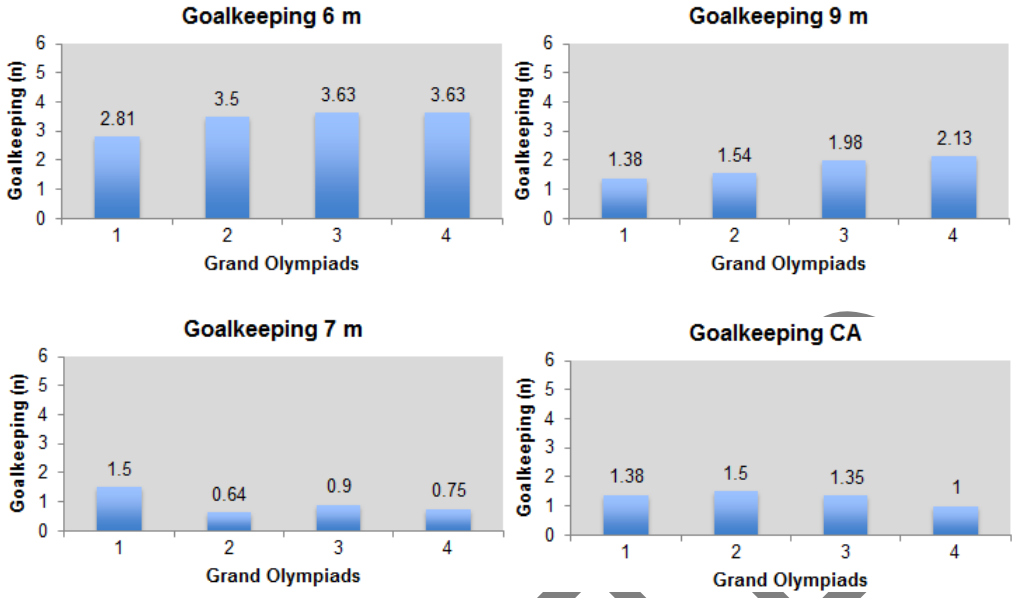
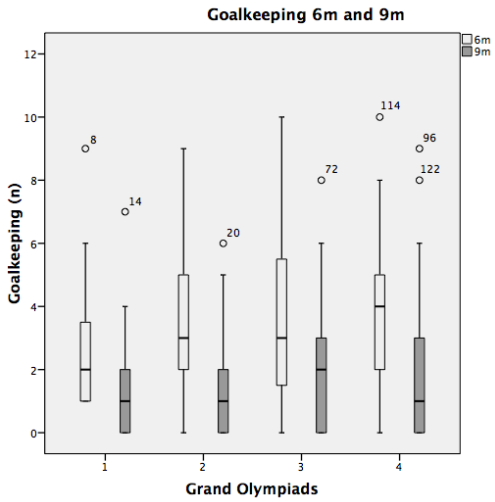



Figure 2. Time evolution of goalkeeping actions as a function of the throwing area.

Of the four goalkeeping action records, the ones corresponding to 6-m and 9-m areas refer to positional attacks, which are consequence of technical-tactical practices by the attacking team. By contrast, the 7-m area throws occur as a result of disciplinary



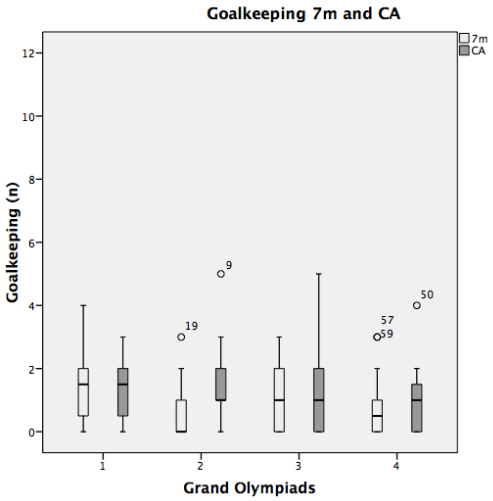

actions, while the counterattack area is due to the loss, interception or foul resulting in the loss of the ball by the attacking team. Therefore, positional attacks of 6-m and 9-m

areas are analyzed in detail in Figure 3, where box plots are shown for both areas that provide an overview of the symmetry of the data distribution.

Figure 3. Box plot diagram of the temporal evolution
of the goalkeeping actions for 6-m and 9-m areas.

Distribution analysis of the goalkeeping data shows that the interquartile range for stops from 6 and 9 m remain fairly constant throughout all Grand Olympiads. This behavior suggests that goalkeepers are stopping in the same way as the evolution of the sport itself and the specific preparation work has not greatly affected the effectiveness from that distance. Notice also that the evolution of median values for these areas shows little variation over the sample period.

As discussed above, the 7-m and counterattack areas are produced by disciplinary decisions as a result of the game development, which are applied by refereeing corps.




This means that for 7-m shots, the goalkeeper is alone with the thrower, and a similar

situation occurs in counterattack since no defense is often present to avoid scoring. Figure 4 shows the distribution of the goalkeeping data for these two areas.

Figure 4. Box plot diagram of the temporal evolution
of the goalkeeping actions for 7-m and counterattack areas.

As it can be seen, there is a consistent pattern in median values and in interquartile range size due to the fact that these actions are derived from an unnatural attack situation. For 7 m throwing, goalkeepers intercept the ball carrying out a series of decisions prior to the shot, covering spaces with different body segments. In this way, goalkeepers try to block the ball as the thrower would seek those same places. This type of situations is produced almost equally in counterattack actions, where goalkeepers have no defense on many occasions. Therefore, as observed in 7 m throwing, the goalkeeper interception is made by taking previous decisions aiming at blocking the path of the ball.

It has been argued that the 6 m and 9 m throws are the result of technical-tactical practices by the attacking team. In many cases, these attacks do not only occur from the center, but also from sides, in an attack strategy that aims to tilt the defense and thus to clear wings to attack without opposition. In order to analyze the influence of the throwing position, Figure 5 shows goalkeeping actions analysis in terms of the central and side position for 6 m and 9 m areas.

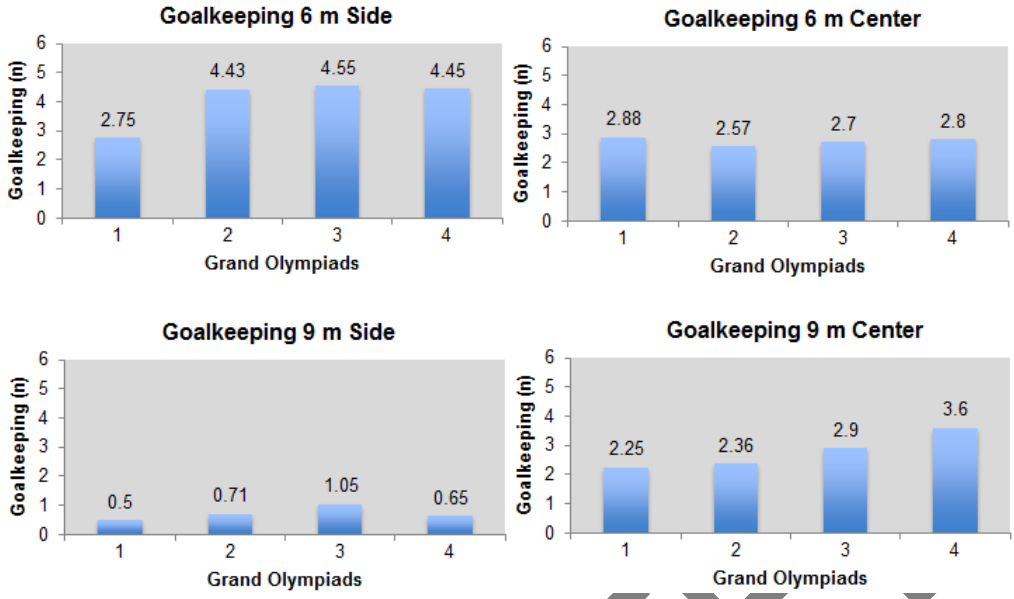



Figure 5. Time evolution of the 6 m and 9 m goalkeeping actions as a function of the throwing position.

Figure 5 depicts a steady evolution in center 6 m goalkeeping actions with almost null variation during the four Grand Olympic periods. For side throws at the same distance, the number of goalkeeping actions is also maintained fairly constant during the last three periods. Consequently, there has been no change in the goalkeeping actions from 6 m throws, regardless of the throwing area. This kind of throws is performed at high speed near the goal, so there is an intrinsic difficulty for goalkeepers to save them. However, for side actions, goalkeepers have an advantageous position due to covered angle, which force throwers to make more mistakes as trying to perform parabolic-type shots. A similar behavior is also observed for shots from 9 m. Goalkeeping actions from side shots at this distance are constant throughout the sample period and of very low values. This low score is consistent with the low frequency of these shots since throwers try to avoid low angle and high distance shots in order to increase their goal chances. Regarding center shots, goalkeeping actions show no significant change between the

first two Grand Olympic periods and a slight tendency to grow onwards. It must be noted that defensive 3:3 systems were used mostly during the first Grand Olympic aiming at blocking shots from that distance but throwers were progressively enhancing their power and speed of shots to overcome that defense.

As with general shots by area, an analysis of the symmetry of data distribution in these side and center registered positions can reveal the behavior and evolution of goalkeeping actions. Figure 6 shows the box plot diagram of 6-m throws from center and side positions.

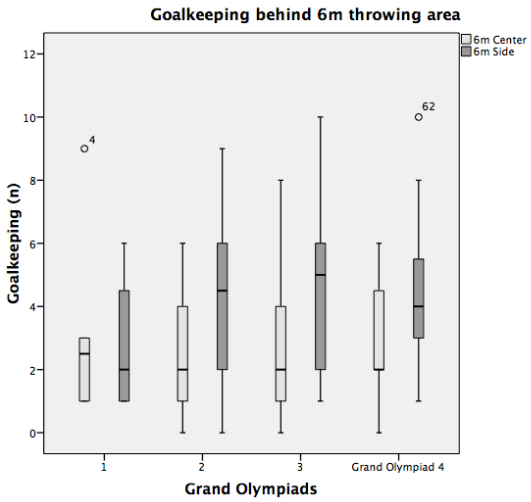



Figure 6. Box plot diagram of the temporal evolution

of the goalkeeping actions for side and center throws in the 6-m area.

For center 6-m throws, dispersion of goalkeeping actions has similar values, according to the width of boxes, which are proportional to the interquartile range. Their median

values are also fairly constant for the sample period. On the other hand, goalkeeping actions from side 6-m throws have experienced a steady dispersion for the three initial Grand Olympic periods, whereas the median value reached a steady value from period two onwards. This may be due to the fact that lateral shots may be easier for goalkeepers to save since their bodies can block a larger area and that behavior has been maintained without changes since the beginning of the sample.

Figure 7 describes the same analysis for 9-m throws from center and side positions. As in 6-m throws, a slight decrease is observed for median values of center shots with no significance ($p$=0.955) with moderate dispersion. Regarding side shots, a fairly constant median value is observed, together with low dispersion, according to the interquartile range. Notice also the low frequency of goalkeeping actions for side 9-m shots, which can be explained by the nature of long-distance shots, in which throwers must perform powerful shots with no score guarantee.

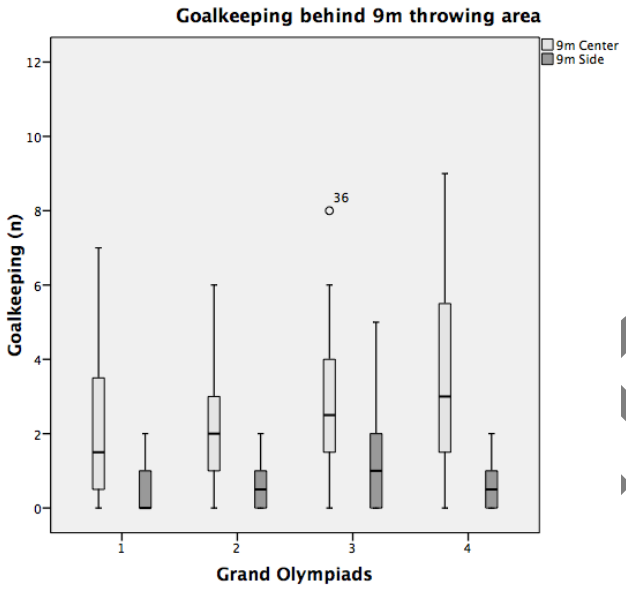



Figure 7. Box plot diagram of the temporal evolution

of the goalkeeping actions for side and center throws in the 9-m area.

## 5 Discussion

In this study, only finals have been analyzed, which can pose a limitation since those teams reaching the finals do not always have the best goalkeepers. It should also be noted that the sample analyzed in this study is developed in a temporary period of thirty years, so preparation, training and development of the game has been modified to an extent by various reasons. One reason would be the accelerated speed of game, which has caused the number of offensive actions of equipment to augment (Pascual, Lago & Casais, 2010). The increasing intensity of play and the number of shares have forced teams to carry out a better preparation of players, adapting their training to the demands of distance and intensity that current handball requires (Michalsik, Aagaard, & Madsen,

2013). This results in a greater preparation and conditioning of the players to perform more actions and of greater intensity, in terms of displacement actions, both offensive and defensive.

However, although the game is faster with more offensive actions and therefore more attacks, the number of goalkeeping actions has proportionally changed little over the different Grand Olympic periods. Not only the increase in game speed is crucial, but also the level of opposition to attackers, since a higher level of opposition in offence actions play a role in throwing speed (Rivilla-Garcia, Grande, Sampedro, & van den Tillaar, 2011). Therefore, in central positions, throws are performed at more speed than those at wings (Rivilla-Garcia, Navarro Valdivielso, Grande Rodriguez, & Sampedro Molinuevo, 2012). This would explain the decline of effectiveness from center 6-m throws maintaining the same number of goalkeeping actions, and the increase of effectiveness and goalkeeping actions from side 6-m throws, as the goalkeeper has a longer preparation and accommodation time for stopping the shot against these throws.

On the other hand, for 9-m throws, goalkeepers have more time to react and intercept the ball, which has resulted in a slight increase in general effectiveness and goalkeeping actions along periods. In addition, studies of skilled goalkeepers have determined that for long distance shots, experienced goalkeepers showed a better anticipation to shots than inexperienced goalkeepers (Rojas et al., 2012).

Moreover, the anticipation work and training of goalkeepers regarding recognition of game intentions of attackers (Bideau et al., 2004. Vignais et al, 2009, 2010) have been of interest by the scientific community in order to practice these situations to improve stop effectivities of goalkeepers. Despite anticipatory skills training (Loffing & Hagemann, 2014), there have been no improvements in stop effectiveness from 7 m.

Indeed, effectiveness at this distance is determined by the technical quality of throwers, the short distance between the throwing point and goal, and the throwing speed, getting better and faster. All these elements may have affected negatively to the stop effectiveness at this distance, even though goalkeeping actions declined steadily over analyzed periods.

Finally, it should be noted that several factors play a role in goalkeepers' behavior, such as age (Kajtna, Vuleta, Pori, Justin, & Pori, 2012; Karcher & Buchheit, 2014) weight, height (Justin et al, 2013) and other subtle anthropometric characteristics, such as foot dimensions (Ghobadi et al, 2013). Therefore, goalkeepers' effectiveness can be understood as a result of multiple factors that determine their best or worst predisposition to play a good job in such a position.

## 6 Conclusions

This paper has presented a study of performance of handball goalkeepers in an extended time span in order to observe their evolution over the last eight Olympiads. Results indicate that goalkeeper effectiveness, as a measure of the ability to prevent the goal from different throwing areas and positions, and the total number of goalkeeping actions, have presented moderated variations over the 30 years covered by the sample with no significant trend. Therefore, there is no asymptotic temporal behavior that reveals an increase or decrease of effectiveness and goalkeeping actions, as observed in other sports. Indeed, the Kruskal-Wallis H test did not establish statistically significant differences ($p$>0.05) in goalkeeping effectiveness between the different Grand Olympiad periods.

Contrary to other sports, in which game rules have changed during time to address the number of players, the court dimensions and areas or substitutions, handball did not improved major game rules during the last 32 years, resulting in a lack of evolution to some specific players, for instance, goalkeepers. By only limiting the attack times by a certain time, attack patterns would be restructured in such a way that handball would become faster and more spectacular, expanding the range of attacks and throws.

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