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Original

DIFFERENCES AND RELATIONSHIP BETWEEN STANDARD AND SPECIFIC THROWING TEST IN HANDBALL ACCORDING TO THE COMPETITIVE AND PROFESSIONAL LEVEL

DIFERENCIAS Y RELACIÓN ENTRE TEST GENERALES Y ESPECÍFICOS DE LANZAMIENTO EN BALONMANO SEGÚN EL NIVEL COMPETITIVO Y PROFESIONAL

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RESUMEN

El presente estudio analizó las diferencias en la distancia de lanzamiento realizado con balón medicinal pesado y ligero y en la velocidad de lanzamiento entre jugadores de balonmano de diferente nivel competitivo y profesional. Igualmente, la relación entre los tres test de lanzamiento, de progresiva especificidad, fue analizado: lanzamiento con balón medicinal pesado (TH), lanzamiento con balón medicinal ligero (TL) y velocidad de lanzamiento (TV). Para ello, sesenta y cinco jugadores profesionales (P), semi-profesionales (S) y no-profesionales (N) fueron evaluados.

En los tres test de lanzamiento, los resultados revelaron que los valores eran significativamente mejores conforme aumentaba el nivel competitivo y profesional (TH: $F_{2, 63} = 34.399$. TL: $F_{2, 63} = 53.75$. TV: $F_{2, 63} = 70.364$). Así, en todas las situaciones de lanzamiento, el grupo profesional mostró mayores valores ($p<0.001$) que el grupo semi-profesional y no-profesional.

En todos los grupos, la correlaciones entre los test de lanzamiento fueron significativas y positivas ($p<0,01$). El valor de correlación entre TH-TV (P: r=0.469; S: r=0.619; N: r=0.687) fue menor que el valor de correlación entre TL-TV (P: r=0.652; S: r=0.818; N: r=0.891).

Por tanto, la capacidad de lanzamiento es un factor decisivo en el nivel competitivo y profesional de los jugadores. Por otra parte, los resultados sugieren que el TL predice mejor la velocidad de lanzamiento que el TH, sobre todo en jugadores no profesionales.

Palabras clave: balón medicinal, velocidad de lanzamiento, lanzamiento a portería, test de condición física.

ABSTRACT

The present study analyzed the differences in distance throwing with heavy and light medicine ball and throwing velocity between handball players of different competitive and professional level. Likewise, the relationship between the three throwing test of progressive specificity was analyzed: throwing with heavy medicinal ball (TH), throwing with light medicinal ball (TL) and throwing velocity (TV). For this purpose, sixty-five professional (P), semi-professional (S) and non-professional (N) players were evaluated.

In the three throwing test, the results revealed that the values were significantly better as the competitive and professional level increased (TH: $F_{2, 63} = 34.399$; TL: $F_{2, 63} = 53.75$; TV: $F_{2, 63} = 70.364$). Thus, in all throwing situations, the professional group showed higher values ($p<0.001$) than the semi-professional and non-professional groups.

In all groups, significant and positive correlation between the three throwing tests were observed ($p<0.01$). And the correlation value between TH-TV (P: r=0.469; S: r=0.619; N: r=0.687) was lower than the correlation value between TL-TV (P: r=0.652; S: r=0.818. N: r=0.891).

Therefore, handball players' throwing ability is a decisive factor in competitive and professional level. Moreover, the results suggest that the TL is a better predictor of throwing velocity than the TH, more so in non-professional players.

Keywords: medicine ball, throwing velocity, goal shot, fitness test.

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INTRODUCTION

Team handball is a very strenuous body-contact Olympic sport (Gorostiaga, et al., 2006) that is also played professionally in Europe (Cardoso & González-Badillo, 2006). This sport requires a high level of physical condition in the relevant actions of the game like jumping, diving, blocking, running, sprint, and throwing (Wallace & Cardinale, 1997). Of all, goal shot is considered as key to success (Hoff & Almasbakk, 1995; Wit & Eliasz, 1998). Throwing accuracy and ball velocity are considered to play an important role in goal success (Fleck et al., 1992; Van den Tillaar, R. & Ettema, 2003). Therefore, throwing capacity could be related with the competitive level of handball players (Gorostiaga et al., 2005, 2006).

There are several studies that confirm differences in general physical condition depending on the competitive player level. So, in handball, Gorostiaga, Granados et al. (2005) and Granados et al. (2007) obtained significant differences between elite and amateur players in physical capacities like maximal strength and muscle power. Similarly, Mohamed et al. (2009) obtained differences in standard strength, velocity and agility tests among elite, non-elite and under-16 players. In baseball, Grove (2001) obtained significant differences between members of professional, first division and junior category teams in upper and lower body muscle power tests. In ice hockey, Hoff et al. (2005) found differences between elite and junior players in strength and endurance ability. In volleyball, Forthomme et al. (2005) obtained significant differences between first and second division players in general jumping tests. Smith et al. (1992) indicated physical and physiological differences between elite and university players in several standard tests (VO_2 max and 20 m maximum velocity). In football, as well as in rugby, there are several studies that confirm the same line (Baker & Nance, 1999; Baker, 1999; Baker, 2001; Baker, 2002; Gabbett, 2002; Ostojic, 2003), showing better values in general physical condition when the competitive level of the player is higher.

The results of studies that analyzed throwing velocity according to the competitive level were similar to those obtained in the standars tests. So, Gorostiaga et al. (2005) and Granados et al. (2007) found higher values in standing throw and three steps throw velocity in elite than in amateur players. Bayios et al. (2001) obtained significant differences among first, second division players and students in velocity among standing position, run or jump throw. Likewise, in baseball (Grove, 2001) and cricket (Freeston et al. 2007), studies showed that players with higher competitive level achieved better values in throwing velocity.

Although, it is surprising the few studies that examined the differences between groups of players using throwing tests with medicine ball. Although, these tests are widely used in sport training and fitness evaluation for sport talent identification (Cercel, 1990; Torres et al. 2004; Torrescusa, 1986; van den Tillaar & Marques, 2009).

On the other hand, several studies in handball observed a significant positive correlation between throwing velocity and general fitness abilities such as strength or muscle power (Fleck et al., 1992; Gorostiaga et al., 2005; Granados et al., 2007; Hoff & Almasbakk, 1995; Marques et al., 2007). Similar and higher correlation values were found in other sports like baseball (Kane, 2003), cricket (Pyne et al. 2006) and soccer (Anthrakidis et al. 2008). However, some studies found no significant correlations between throwing velocity and muscular strength (Bayios et al. 2001; Dauty et al. 2005). Few studies have examined the correlation between handball throwing velocity and medicine ball throwing, although there is evidence that light medicine ball training significantly improves the handball throwing velocity (Barata, 1992; DeRenne et al., 1994; DeRenne et al., 1990). Curiously, this improvement was lower in female students (Brylinsky et al., 1992).

The aims of this study were assessed the relationship between throwing tests (Standard throwing tests: throwing with heavy medicine ball (TH) and throwing with light medicine ball (TL); Specific test: throwing velocity test (TV)) with different degrees of specificity. For this purpose, sixty-five professional (P), semiprofessional (S) and non-professional (N) players were evaluated.

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METHODS

Sample

The sample consisted of sixty-six handball players from four different teams (Table 1). It was divided into three groups depending on their professional and competitive level: professional (P), semi-professional (S) and non-professional (N) players.

The professional group (P) was representative of the highest international level because players were playing in top level Spanish handball league (Asobal League) and participated in the highest level international league (Champions League). All players of this group were professionals sportsmen. The semi-professional players competed in second level Spanish handball league (Silver Division) and half of the players from each team were professional sportsmen. The non-professional group (N) was composed of two senior teams that compete in third and fourth category of Spanish handball leagues (1st and 2nd Division), its members are amateur players.

Table 1. General characteristics of the sample. Group P: professional, group S= semi-professional, group N: non-professional.

	Group P (n=16)	**Group S** (n=15)	**Group N** (n=35)
Age (years ± SD)	27.9±2.82	25.8±3.13	24.7±4.91
Mass (kg ± SD)	93.6±8.22	95.3±9.33	90.2±10.23
Height (cm ± SD)	197±5.10	192±7.56	186±5.80
Level of playing	*Asobal and Champions League*	*Silver Division*	*1st and 2nd National Division*

Procedure

All participants were assessed in three throwing situations: 1) throwing with heavy medicinal ball (TH), 2) throwing with light medicinal ball (TL) and 3) throwing velocity (TV). In order to decrease interferences with environment and external constraints, all teams were tested the same day and during the same session. Each subject followed the same order during the tests session.

Subjects were properly informed about the procedure to be followed and gave their voluntary consent to form part of the study after warming up. A 10 m standard warm up was performed including specific displacements. Special emphasis was focused on acceleration and brake actions that are characteristic of the prior steps before throwing. It was also included during the warm up specific mobility exercises; shoulder throws with different weight balls and finally throws with the balls to be used in the tests.

The heavy medicinal ball test (TH) protocol was: From standing position, with a 3 kilograms ball, feet shoulder width apart, body towards throwing direction and ball symmetrically adapted with both hands under hips, (Martínez, 2002) raisie the medicinal ball with both hands over and behind the head, extending trunk, flexing elbows and knees, and, finally, do an explosive throw movement to raise the maximum horizontal distance. Raising heels from the floor was allowed but not taking toes off from the floor. The thrower was not allowed to move in front of the throwing line.

Subjects were allowed to use resin in light medicinal ball throwing test (TL). Three steps preceded the throw that was performed with ball adapted to one hand. The purpose was to perform the throw with ball properly adapted to hand like it happens in real game. Thus, players began the test placed in standing position after the throwing line in any desired distance (with 3 previous steps), with feet flat on the floor, and with body oriented to the throwing direction. The movement description (Torrescusa, 1986) is as follows: execution of 3 specific approach steps to throw ending with the opposite foot to the executor arm in front, and throw with the ball completely adapted to one hand. Throwers were not allowed to move in front of the throwing line.

The throwing velocity test (TV) was subject to the following instructions: throw the ball at the highest possible speed, using only one hand and an appropiate technique for a throw at the goal; make a maximum of three steps prior throwing and execute it from behind the free-throw line, at 9 m from the goal.

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As the aim of the test was a real game simulation, the use of resin on the hands was allowed. The subjects were also instructed to make precise shots according to the criterion for goalkeeper's intervention difficulty, stated by Zeier (1987): the throws had to aim at the goal corners.

Coaches supervised the throws to ensure the correct application of the technique. All throws were recorded by a video camera to check players' intervention.

Each participant in the tests made several shots until three values were obtained. The two best throws were registered in each test. The procedure was the following (Gorostiaga et al., 2005; Granados et al., 2007): each subject made a series of continuous shots with a pause of 10-15 s between them. If the throw requirements concerning distance or velocity were not met, a second series of throws was performed, with a 1-2 min break. The maximum number of series was three.

In order to encourage the participants, they were informed about throw distance and velocity of each repetition immediately after shot. A further analysis of the fastest shots made by each player was carried out. The Interclass Correlation Coefficient (ICC) was 0.98 (TH), 0.96 (TL) and 0.96 (TV). The Coefficient of Variation was 4.1% (TH), 4.7% (TL) and 3.2% (TV).

Material

The tests were carried out in an indoor handball court. In the case of the medicine ball tests, two balls "Salter" were used (Heavy medicine ball: 3kg weiht and 72.22 cm circumference; Light medicine ball: 0.8kg weight and 58 cm circumference). Throw horizontal distance was measured with a tape measure with a 0.01 resolution. The exact spot of the medicine ball fall was measured using a black flat tarpaulin (20 x 3m) which reflected the ball mark.

A regulation handball, 480 g of weight and 58 cm circumference, was used in the throwing velocity test.

Procedure

The velocity was calculated considering the ball fly time measured from the moment it crossed the 6 m line (pace sensor) to the moment it contact with a metal panel placed in the goal (sound sensor).

Time measurement was carried out with a precision of 0.001 s, using a chronometer system (Sportmetrics, Valencia, Spain) consisting in a photoelectric cells pace sensor and a sound sensor. The pace sensors was situated at 2 m away from the 6 m line. It consisted in eight photoelectric cells vertically and uniformly distributed, with a distance of 15 cm between them (at a range of 1.40-2.50 m over the floor). The sound sensor, of gradable intensity, was situated in the inner central part of the goal crossbar. The chronometer turned on automatically any time the ball crossed the photocells and switched off when the sound sensor detected the impact between the ball and the metal panel placed in the goal. Since the distance between the ball impact and the sound sensor is never longer than 2.5 m and given that the sound generates a delay of 0.001 s every 30 cm approximately, a measuring mistake not higher than 0.008 s has been estimated.

Statistical analysis

The mean values and the standar deviations of the variables were calculated. One way anova was calculated to analyze the differences between groups. A further in-depth *post hoc* analysis of the variation was carried out using Bonferroni method. The study of correlations between the three tests was analyzed by applying the Pearson correlation coefficient. Statistical calculation was done by means of the Statistics software SPSS 19.0. Results were considered significant at $p<0.05$.

RESULTS

The data gathered in the three throwing tests is given in continuation (Table 2).

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*Table 2. Mean ± SD of distance (m) and velocity ($m \cdot s^{-1}$) in the throwing tests: heavy medicine ball test (TH), light medicine ball test (TL) and throwing velocity test (TV) (differences: **: p<0.01; ***: p<0.001).*

Groups	N	TH (m)	TL (m)	TV ($m.s^{-1}$)
P	16	12.93±1.20	43.41±2.51	28.11±1.90
S	15	11.45±1.68	39.26±2.74	25.08±1.45
N	35	10.15±2.25	35.17±3.03	22.45±1.86
All	66	10.41±1.71	35.75±4.50	22.94±2.82
Differences	P-S	**	**	**
	P-N	***	***	**
	S-N	**	**	***

The professional group obtained the highest values in all tests, followed by the semi-professional and non-professional group (Table 2). The differences between the three groups were significant (p<0.001; $F_{2, 63} = 34.399$). The differences were higher in the TL test, with significant differences between the three groups (p<0.001; $F_{2, 63} = 53.75$). Similar to what occurred in the medicine ball throwing tests, the higher the competitive and professional level rose, the higher the throwing velocity values went. The differences between groups were the highest and significant (p<0.001; $F_{2, 63} = 70.364$).

On the other hand, the results showed significant correlations in all cases (Table 3).

*Table 3. Correlation between the three throwing tests: heavy medicine ball test (TH), light medicine ball test (TL) and throwing velocity test (TV) (significant correlation: *: p<0.05; **: p<0.01). Group P: professional, group S= semi-professional, group N: non-professional.*

	TH – TL (r)	TH–TV (r)	TL–TV (r)
Group P	0.622*	0.469**	0.652*
Group S	0.724**	0.613*	0.818*
Group N	0.695**	0.687**	0.891**
All	0.667*	0.602**	0.863**

The correlation between TL and TV was highest in all groups. In contrast, the correlation between the most standard test (TH) and most specific test (TV) was the lowest. In both cases, TL-TV and TH-TV, the values were higher in the less competitive and non-professional groups.

DISCUSION

Scientific literature showed that few studies have analyzed the relationship between standard (medicine ball throwing test) and specific throwing tests (velocity throwing test). Likewise, the differences between handball players according to the professional level, in these tests, have rarely been studied.

First focus on the relationship between the applied test, it should be highlighted that correlation between the most specific test (TV) and the standard test (TH) was moderate (r: 0.602, p<0.01), not high in any group, with lower values with increasing professional level players (r: 0.469, p<0.01). One possible reason could be the large differences in throwing performance technique. These data coincided with those found in other studies examining the relationship standard tests and throwing velocity test in handball (Fleck et al., 1992; Gorostiaga et al., 2005; Granados et al., 2007; Hoff & Almasbakk, 1995; Marques et al., 2007) and other sports (Anthrakidis et al., 2008; Kane, 2003; Pyne et al., 2006). By contrast, several studies found no relation between throwing velocity and muscular strength (Bayios et al., 2001; Dauty et al., 2005).

Given the moderate relation between the throwing test with heavy medicine ball (TH) and the throwing velocity test (TV) and references that indicate the lack of relationship with players' muscular strength (Bayios et al., 2001; Dauty et al., 2005) the performing of TH has little application to know the specific capacities of strength or throwing velocity of handball players.

Results obtained in the standard throwing test (TH), concerning other team sports, were similar to those obtained in other sports, such as baseball (Grove, 2001), ice hockey (Hoff et al., 2005), volleyball (Smith et al., 1992), football (Ostojic, 2003) and rugby (Baker, 1999; Baker, 2001; Baker & Nance, 1999; Gabbett, 2002). All these studies confirmed

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that physical capacities values achieved in high level players were higher than those obtained in lower level players. Forthomme at al. (2005) obtained significant differences between elite and amateur players, in rebound speed in volleyball.

The TH test can help us to understand the performance level of our players but does not help us know other more specific aspects.

On the other hand correlation between TL and TV test was very high in all groups (Table 3), with higher values in non-professional players (r: 0.891, $p<0.01$). This could be due to the very similar throwing technical of both tests. These results allow saying that TL test could be a good predictor of the throwing velocity (TV), especially in non-professional players.

There were no studies that examine this relationship but these data seem to corroborate the efficacy of light medicine ball training to improve throwing velocity, an assertion that has been confirmed in several studies (Barata, 1992; DeRenne, Buxton et al., 1994; DeRenne et al., 1990; DeRenne et al., 2001).

To perform a TV test requires a highly specialized and generally expensive material (photoelectric cells or radar system). The certification of the relationship between TV and TL test, which requires a more accessible and cheaper material to all competitive levels, ensures the utility of performing TL test with handball players. The TL results could show indirectly the throwing velocity level of the evaluated players.

Performing an analysis of the results according to performance level showed that professional players obtained substantially higher values than the other players. So, in the three throwing tests, the results order between groups was as follows: professional, semi-professional and non-professional. These results have been ratified in others handball studies. In the same manner, Gorostiaga et al. (2005) and Granados et al. (2007) found similar significant differences between two groups: elite and amateur players in standard tests. Likewise, Mohamed et al. (2009) observed differences between elite, non-elite and under 16 players in standard fitness tests (strength, speed and agility).

The findings of our study concerning throwing velocity (Table 2) are similar to results found in other researches which compare high level and amateurs players (Bayios et al., 2001; Gorostiaga et al., 2005; Granados et al.; 2007). Throwing velocity results obtained by the professional group (28.11 ± 1.90 $m \cdot s^{-1}$) is higher than the values shown in other studies which involve high level players (Bayios & Boudolos, 1998; Gorostiaga et al., 2005; Marques et al., 2007), obtaining a maximum value of 30 $m \cdot s^{-1}$. This could be due to the very high level of the professional players assessed. However, comparison of results between studies is complicated because there are marked differences between the evaluation process and instruments used to measure the throwing velocity. Therefore, results should be interpreted very cautiously.

CONCLUSIONS

The heavy medicine ball throwing test can help us to understand the performance level of our players but does not help us know other more specific aspects of handball players.

The light medicine ball throwing test, which requires more accessible and cheaper material than velocity throwing test, is useful for assessing specific throw ability of handball players. However, the standard throwing test seems to be a poor predictor of this specific capacity.

The competitive and professional level seems to have a profound effect on the throwing capacity, greater in specific than in standar tests.

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