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Original Article

Effects of 4-week training with balls of different weights on throwing velocity in handball players

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Abstract
This study compared the effects of training programs based on the repetition of specific throws and non-specific throws with different loads to determine their relationship to throwing velocity in handball players. Twenty-four handball players (age: 21.3 ± 3.5 years; body mass: 83.7 ± 13.5 kg; height: 182 ± 8.4 cm) with experience in this sport (years of experience: 11.5 ± 4.2 years) were divided into 3 groups, each group undertaking a training program with different loads (medicine ball, specific handball ball or tennis ball). Throw velocity was assessed in standing throws from 7 m and 3-step jump throws from 9 m. The results show no significant differences in throw velocity from pretest to posttest between the different experimental groups after participating in the training programs for 4 weeks, indicating that this training period may be too short to induce significant change.
Key words: medicine ball, specific technical skills, throw, strength..

Introduction

Handball is a strenuous contact team sport in which high-intensity actions alternate with low-intensity periods or rest periods of variable duration. Handball requires that players develop a range of basic motor skills such as running, jumping, high-speed travel and multiple actions related to thrusts and blocks (Gorostiaga, Granados, Ibáñez, González-Badillo & Izquierdo, 2006). Although it is known that the technical and tactical skills of players are fundamental elements in the practice of handball sports, some authors consider that anthropometric, physical, and mechanical factors can influence sports success in elite handball competitions (Gorostiaga, Granados, Ibáñez, & Izquierdo, 2004).

Throwing is one of the most decisive technical actions in many team sports and has been studied in various sports modalities including water polo (Marques et al., 2012), cricket (Van den Tillaar & Marques, 2011) and baseball (Newton & McEvoy, 1994; Lachowetz, Evon & Pastiglione,1998). Studies have shown that the speed of throwing influences the reaction time of the opponent for intercepting the ball (Van den Tillaar & Ettema, 2003, Gutierrez-Davila, Rojas, Ortega, Campos & Párraga, 2011) and throwing at the fastest possible speed is a factor that determines sporting success in attack situations (Vila et al., 2009). Another factor influencing the efficiency of throwing in handball is accuracy (Fleck et al., 1992). Gorostiaga, Granados, Ibáñez and Izquierdo, (2005) and Ortega-Becerra, Pareja-Blanco, Jiménez-Reyes, Cuadrado-Peñafiel and Gonzalez-Badillo (2018) indicate that throwing mechanics, strength and muscular power in the upper and lower body segments are factors that increase speed rates in specific handball throws. To improve throw velocity, different training programs have been carried out focused on both strength and velocity (Potteiger, Williford, Blessing & Smidt, 1992) based on the principle of overloading of the upper body segments (Gorostiaga, Izquierdo, Itralde, Ruasta & Ibáñez, 1999; Marques et al., 2012), and on the principle of specificity with regard to throws in this sport (Lachowetz et al., 1998; van der Tillaar & Ettema, 2003, 2011; van der Tillar, 2004; van der Tillar & Marques, 2009).

Several studies have analysed throw velocity in handball from different perspectives. Some studies have related the anthropometric characteristics of the players to their throw velocity performance (Chaouachi et al., 2009; Debanne & Laffaye, 2011; Mohamed et al., 2009). In other investigations, throw velocity was investigated in relation to physical conditioning programs using strength and power exercises at different levels of performance (Bayios, Anastasopulou, Sioduris & Bodoulus, 2001; Gorostiaga et al., 2005; Marques, van der Tillar, Vescovi & Gonzalez-Badillo, 2007; Van den Tillaar & Marques, 2011). Rivilla (2009) studied the influence of the action of the goalkeeper on the throw velocity to goal. Chelly, Hermassi and Shepard (2010) analyzed the relationship between the throw velocity and the strength of the lower and upper limbs, Van den Tillaar and Marques (2011) compared the effect of three throw training programs with medicine balls, soccer balls and the combination of both to determine the relationship with the throw velocity in young students.

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The studies published show a great diversity in methodology in terms of materials, samples, and protocols. It is therefore necessary to carry out more studies to estimate and check the variables that most influence these sport skills. Standing throws and 3-step throws are the most analyzed technical skills in the different methodologies; however, these actions are less demanded in real game situations than the 3-step jump throw, which is more frequently used during matches. This justifies the need to analyze the technical action of throwing in real, dynamic playing situations. The objective of this study was to check the effect of three different strength training programs on throwing velocity using repeating throws with balls of different weights.

Material & methods

Participants

Twenty-four male handball players (age: 21.3 ± 3.5 years; body mass: 83.7 ± 13.5 kg; height: 182.1 ± 8.4 cm) participated in this study. All participants were experienced handball players (years of experience: 11.5 ± 4.2 years). The present investigation was approved by the Research Ethics Committee of Pablo de Olavide University and complied with the Declaration of Helsinki. All the participants signed an informed consent agreement after being informed of the aims of the study and the procedures that were to be carried out. The following criteria for participation in the study were established: a) agreeing to participate voluntarily in the experiment; and b) not having suffered any injury in the last year or at any other time that could influence the results or present a potential risk.

Procedure

Eight training sessions were performed over 4 weeks, involving two sessions weekly on alternate days with at least 48 hours between them to allow for rest. All the training sessions were conducted during the last month of the regular championship. One week before the beginning of the training programs all subjects undertook a pretest and one week after finishing the last training session of the program, a posttest was completed by all participants to assess their throwing velocity. Throwing velocity was evaluated with a Stalker Sports Radar Gun (Applied Concepts, Inc., Texas, USA) located 2 m behind the goal at a height of 1.25 m. All the sessions were held in the same indoor sports hall. Before the evaluation of throwing velocity, subjects performed a 15-minute warm-up consisting of movements, passes and throws. Each player performed three throws in both situations, standing throw from the 7 m line and 3-step jump throw from the 9 m line, with a regulation handball ball (diameter 58-60 cm; weight 452-475 g), as fast as possible, directly at the goal using his personal throwing technique, without a goalkeeper present. The best result was used for the subsequent analysis. Throws were considered valid when the ball entered directly into the goal without touching the ground. In order to avoid fatigue, throws were made with 3-min rests between attempts. The players were immediately informed of the result of their throw in order to maintain motivation. The sequence of throws was as follows: standing throw (static) from the 7 m line, and 3-step jump throw from the 9 m line. A line placed 2 m before the 9 m line was used as a reference for the last step of the cycle before throwing so that the throw was made 9 m from the goal.

After the pretest, players (N = 24) were divided into 3 experimental groups of 8 players each, depending on their level of performance, using a random order system (ABC-CBA): Group 1, Medicine ball - non-specific throw using two hands (from the plane posterior to the anterior plane, above the head, with a medicine ball weighing 1 kg); Group 2, Specific ball - one-hand specific handball throw with a size 3 handball (weight 425-475 g); and Group 3, Tennis ball - one-hand specific handball throw with a tennis ball (weight 56.7-58.5 g).

All the training sessions started with the same warm-up that was performed during the pretest and posttest. Following the warmup, players executed the specific training program as specified in Table 1. All players in each experimental group were instructed to perform the throws at the maximum speed possible and with a straight trajectory at the height of the shoulders, parallel with respect to the ground.

Table 1. Program training for all the groups

WEEK	(Sets x Repetitions)			
1	*TS 1*	3 x 6	*TS 2*	3 x 6
2	*TS 3*	3 x 8	*TS 4*	3 x 8
3	*TS 5*	3 x 8	*TS 6*	3 x 8
4	*TS 7*	3 x 6	*TS 8*	3 x 6

TS Training Session

After performing all the repetitions in each set, participants took a 2-minute break to avoid the emergence of neuromuscular fatigue (Ronglan, Raastad & Borgesen, 2006). After completing the training scheduled for the improvement of the throw velocity the participants continued with the training session programmed.

Statistical analysis

An ANCOVA was performed to determine whether there was a difference between groups, along with an ANOVA to analyze intra-group differences, following the method of Hopkins (2006) and Hopkins, Marshall, Batterman and Aughey (2009), using a 90% confidence interval. The results are shown as mean ± standard deviation. In addition, the differences between variables were evaluated qualitatively following the method of Hopkins, Marshall, Batterham & Hanin (2009) <1%: Almost Certainly Not; <5%: Very Unlikely; <25%: Unlikely; 25-75%: Probably Not; > 75%: Probably; > 95%: Very Likely; > 99%: Almost Certainly. If the difference between variables is > 75%, it is considered that there are substantial differences (Aughey, 2011; Jennings, Cormack, Coutts & Aughey, 2012).

Results

The data obtained in standing throws from 7m show that there were no significant Intra-group differences in the data obtained in the pretest and posttest, with a low ratio of 5%-75% (QA = Very Unlikely to Probably Not). The throw velocities ($m \cdot s^{-1}$) after completing a 4-week training program are shown in

Table 2. Intra-Group throw velocity differences in stand throw from 7 m (Mean ± SD)

	Pretest	Posttest	Standardized differences (90% CL)	QA
Group 1 **($m \cdot s^{-1}$)**	23.4 ± 1.9	23.2 ± 1.9	-0.0 ± 0.4	Very Unlikely
Group 2 **($m \cdot s^{-1}$)**	23.0 ± 1.8	23.3 ± 1.6	0.1 ± 0.45	Probably Not
Group 3 **($m \cdot s^{-1}$)**	23.5 ± 1.6	23.8 ± 1.5	0.1 ± 0.2	Probably Not

SD, Standard Deviation; QA, Qualitative assessment

Table 3 shows the results obtained by comparing the data from the three experimental groups in the pretest and the posttest. The results show little relationship between the throwing speeds for the three groups. Group 1 (medicine ball), showed a relationship of 25% – 75% with Group 2 (specific handball throw) (QA = Probably Not), and the same outcome was found when Group 1 was compared with Group 3 (tennis ball) (QA = Probably Not). This ratio decreased further in the comparison of Group 2 with Group 3, with a value of 5%-25% (QA = Unlikely) for throwing velocity in the static situation. Therefore, there were no statistically significant differences between any of the training groups.

Table 3. Comparison throw velocity Inter-Groups in stand throw from 7 m (Mean ± SD)

	Group 1		***Group 2***		***Differences***	
	Pretest	**Posttest**	**Pretest**	**Posttest**	**ES**	**QA**
Throw Velocity ($m \cdot s^{-1}$)	23.4 ± 1.9	23.2 ± 1.9	23.0 ± 1.8	23.3 ± 1.6	0.2 ± 0.5	Probably Not / Probably
	Group 1		***Group 3***		***Differences***	
	Pretest	**Posttest**	**Pretest**	**Posttest**	**ES**	**QA**
Throw Velocity ($m \cdot s^{-1}$)	23.4 ± 1.9	23.2 ± 1.9	23.5 ± 1.6	23.8 ± 1.5	0.2 ± 0.5	Probably Not / Probably
	Group 2		***Group 3***		***Differences***	
	Pretest	**Posttest**	**Pretest**	**Posttest**	**ES**	**QA**
Throw Velocity ($m \cdot s^{-1}$)	23.0 ± 1.8	23.3 ± 1.6	23.5 ± 1.6	23.8 ± 1.5	-0.0 ± 0.6	Unlikely

SD, Standard Deviation; QA, Qualitative assessment *ES,* Standardized differences (90 % CL)

For the 3-step jump throw from 9 m, there were no significant differences between the pretest and the posttest, with a low ratio of 5%-75% (QA = Unlikely to Probably Not) for the speed of throw ($m \cdot s^{-1}$) in the three groups, as shown in Table 4.

Table 4. Intra-Group throw velocity differences in 3-steps throw from 9 m (Mean ± SD)

	Pretest	Posttest	ES	QA
Group 1 **($m \cdot s^{-1}$)**	24.9 ± 1.2	24.8 ± 1.1	-0.0 ± 0.5	Unlikely
Group 2 **($m \cdot s^{-1}$)**	23.8 ± 2.0	24.2 ± 2.5	0.1 ± 0.2	Probably Not / Probably
Group 3 **($m \cdot s^{-1}$)**	25.6 ± 1.6	25.7 ± 1.5	0.0 ± 0.1	Unlikely

SD, Standard Deviation; QA, Qualitative assessment

As shown in Table 5, when comparing the pretest and posttest for the different groups, the results show little relationship between the throwing speeds. Group 1 (medicine ball,) showed a relationship of 25%-75% with respect to group 2 (specific handball throw) (QA = Probably Not) and this decreased notably with respect to Group 3 (tennis ball) with a ratio of 5%-25% (QA = Very Unlikely). In the comparison of Group 2, (specific handball) with Group 3 (tennis ball) the relationship was almost non-existent, with a value of 1%-5% (QA = very unlikely) for throwing speed in the dynamic situation. Therefore, there were no statistically significant differences between any of the experimental groups.

Tabla 5. Comparison throw velocity Inter-Groups in 3-steps throw from 9 m (Mean ± SD)

	Group 1		***Group 2***		***Differences***	
	Pretest	**Posttest**	**Pretest**	**Posttest**	**ES**	**QA**
Throw Velocity ($m \cdot s^{-1}$)	24.9 ± 1.2	24.8 ± 1.1	23.8 ± 2.0	24.2 ± 2.5	0.1 ± 0.4	Probably Not / Probably
	Group 1		***Group 3***		***Differences***	
	Pretest	**Posttest**	**Pretest**	**Posttest**	**ES**	**QA**
Throw Velocity ($m \cdot s^{-1}$)	24.9 ± 1.2	24.8 ± 1.1	25.6 ± 1.6	25.7 ± 1.5	0.1 ± 0.5	Probably Not / Probably
	Group 2		***Group 3***		***Differences***	
	Pretest	**Posttest**	**Pretest**	**Posttest**	**ES**	**QA**
Throw Velocity ($m \cdot s^{-1}$)	23.8 ± 2.0	24.2 ± 2.5	25.6 ± 1.6	25.7 ± 1.5	-0.0 ± 0.3	Very unlikely

SD, Standard Deviation; QA, Qualitative assessment *ES,* Standardized differences (90 % CL)

Discussion

The present study was designed to compare the effect of a training program based on the repetition of specific and non-specific throws with different loads in handball (using a specific handball, a medicine ball and a tennis ball) with the same volume of training in the three experimental groups, in an attempt to determine a relationship between the type of training load and improvement in throwing velocity in static and dynamic situations.

The results obtained in this research indicate that there were no differences between the different groups regardless of the training program used when we compared the mean speed of the throws. By contrasting the results of the 3 groups, the results showed no differences between any of the groups. Within individual groups, the data confirm that there was no improvement in any of the three training programs. Other training programs based on strength and power overload, with the aim of improving throwing speed by strengthening upper body segments (Marques et al., 2007; Chelly, Hermassi & Shepard, 2010), obtained significant improvements in throwing velocity and increased force rates, measured by the peak force in a maximum repetition (1RM). The training programs used in these studies were carried out for longer periods of time and with weekly training frequencies higher than those in this study, which may help to explain the differences in the results obtained.

In the training program used in this study involving non-specific throws using medicine balls, players showed no significant improvements in throwing velocity in either the standing throw or the 3-step jump throw. However, in a similar study, Van den Tillaar and Marques (2011), with student participants, obtained increases in throwing velocity of 2.8% when using 1kg medicine balls during training and 6.9% using soccer balls. These significant improvements may be due to the inexperience of the subjects or to biomechanical changes in their skills by improving the technique of execution and working with loads that produced increases in the relative

indices of force. In this research, which involved working with experienced subjects with probably higher force rates, it was more difficult to provoke significant improvements in technique, which dominated the analyzed skills, in combination with low relative loads. Van den Tillaar and Ettema (2011), training with different loads, obtained significant improvements in throwing velocity in female elite handball players. They focused on throwing with different articular ranges presented by the players in a static position, using only a specific handball throw. Using another, non-specific, throw in the present study may be another reason for not finding improvements in velocity in the pre and posttests.

Conclusions

The training program used in this study, involving the repeated execution of throws with different ball weights and throwing techniques, did not produce significant improvements in either standing throws or 3-step handball throws after completing a 4-week training program with different loads and the same training volume. This finding indicates that training programs aimed at improving throwing velocity in experienced subjects should be conducted for longer periods and with training loads requiring greater strength.

It must be noted that at elite levels, sporting and competitive demands require specific training programs focused on throwing, over short periods of time, in order to improve speed and increase the odds of scoring a goal. Although at the highest level of sports performance, short-term improvements are required, a 4-week program seems insufficient to cause significant improvements in specific handball throws in experienced subjects.

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