JHMS,2002

THE EFFECT OF HANDBALL TRAINING WITH UNDERWEIGHTED BALLS ON THE THROWING VELOCITY OF NOVICE HANDBALL PLAYERS

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SUMMARY

The throwing velocity is an important task that affects substantially the performance of a handball player. Several training methods have been suggested in order to improve this ability. The purpose of this study was to investigate the effect of training with light balls to the throwing velocity of male novice athletes and the effect of a following detraining. The subjects performed 20 weeks of handball training and were divided in two groups: one was using normal handball balls for training and the other 20% lighter ones. The first ten weeks were used for handball players to be familiar with throwing technique. The evaluation tests performed before, in the middle and the end of the specific training period and then after 4 weeks of detraining. The estimation of the throwing velocity was taken out of the mean velocity of 7 shots against a fixed target, placed 6 meters away from the subjects. A radar gun was used for measuring the ball release velocity. The results showed that training with lighter balls could improve the performance of throwing more than using normal balls. Additionally, the benefit of training was maintained 4 weeks after detraining only for the group that used the lighter ball for training. These findings are in agreement with previous studies that involve similar movements of other sports and suggest that the decreased resistance during training that involves ballistic movements can be advantageous for the player's performance, and therefore, trainers are encouraged to apply this method of training as a tool for improving the efficiency of shooting of novice handball players.

Keywords: handball, training methods, throwing velocity

INTRODUCTION

There are many factors that contribute directly or indirectly to a proficient handball performance. One of the most significant factors is the throwing velocity of the ball. The efficiency of the task is particularly important for backs that must shoot at long distances for passing and at short distances against the opponent's nest. However, despite the importance of the throwing task during a handball game, only a few studies have reported scientific findings concerning the handball throwing and the methods to improve it.

The velocity of throwing in handball is a complicate task that involves many parts of the body: from the lower extremities and the trunk, to the upper limb, until the wrist and the fingers. The result of throwing is depended on the muscular strength but a very significant role is ascribed to the successful transfer of energy from the one limb to the next one (Muller 1981, Joris et al. 1985).

There is limited information concerning the training methods that improve the throwing performance of a handball player. However, there are more studies available concerning other sports that involve ballistic movements of the upper extremities as well (Sergo and Boatwright 1993, DeRenne et al. 1994). The nature of shooting in handball is biomechanical similar to the pitching in baseball, and therefore some baseball studies will also be mentioned in the present work. Moreover, the similarities of the motor pattern of the throwing task between different sports (e.g. baseball, softball, water polo etc.) have lead many trainers in applying similar methods in order to improve the release velocity of the ball. However, it seems rather obvious that due to the different rules of the game and the variations in the used equipment, the throwing pattern is very specific and fairly differentiated for each sport. This implies that the efficiency of the methods that are used to improve the throwing velocity may vary, depending on the movement specificity.

Several training methods have been suggested for different sports to improve the performance of throwing, such as conventional weight training (Coleman 1982, Newton and McEnvoy 1994), weight training combined with explosive throwing exercises (Voigt and Klausen 1990, Hof and Almasbakk 1995, Walace and Cardinale 1997), plyometric training (Newman 1985), ballistic resistance training (Newton and Kraemer 1994) and training with over- or under-weighted balls (Egstrom et al. 1960, Brose and Hanson 1967, Straub 1968, Toyoshima and Miyashita 1973, Vasiliev 1983, van Muijen et al. 1991, DeRenne et al. 1994). More specifically, it has been reported that the training with medicine balls can primarily improve the muscle strength and secondary the release velocity of the ball (Newton and McEnvoy 1994), whereas it has been argued that the velocity component can be significantly improved when the weight training is combined with ballistic movements (Voigt and Klausen 1990, Hof and Almasbakk 1995, Walace and Cardinale 1997). Concerning the handball training, it has been reported by several investigators that the weight training with maximal resistance can be beneficial to the velocity of the ball (Muller 1981, Hof and Almasbakk 1995, Gorostiaga et al. 1999).

However, there are disagreements whether the usage of over- or under-weighted balls can be beneficial to the throwing performance (Egstrom et al. 1960, Brose and Hanson 1967, Straub 1968, Toyoshima and Miyashita 1973, Vasiliev 1983, DeRenne et al. 1990, van Muijen et al. 1991). More specifically, it has been supported that training with heavier baseballs (Egstrom et al. 1960, Brose and Hanson 1967, Straub 1968) or with lighter bats (Toyoshima and Miyashita 1973, Vasiliev 1983, Sergo and Boatwright 1993) or baseballs (DeRenne et al. 1990) increases the performance of the players. Nonetheless, in a similar investigation concerning elite handball female players, the athletes that used heavier balls for training didn’t improve their performance, whereas the ones that used the light balls did achieve better performance (van Muijen et al. 1991).

Since the only study that has been done about the effect of training with lighter handballs is concerning elite female handball players (van Muijen et al. 1991), the current study has been designed to get additional information about the effect of training and detraining with light balls on the development of the throwing velocity of male subjects with no former handball experience. A comparison of the results of the present study with others that took place in the past, and involved throwing movements of different sports, can provide useful information about the training adaptations that occur.

METHODS

Forty-three male students of physical education with no previous experience of handball playing, or other sports involving ballistic tasks of the upper arm (i.e. baseball, javelin, volleyball etc.) participated voluntarily in the present study. None of the participants suffered from any kind of neuromuscular diseases, neither during the experiment nor in the past years. All subjects were informed about the content of the study before their acceptance for participation.

The subjects were divided randomly in two groups: The first (experimental group: n=22) used for training 20% lighter balls (weight: 340 gr), whereas the second (control group: n=21) used normal balls (weight: 425 gr). The components of the training programs were common for the two groups and consisted of 9-16 sets of 6 maximal throws during each training session. The interval between the sets was 1 minute and the duration of each training session was 45 to 70 minutes. The training contents of the trainees are presented in detail in Table 2.

A special synthetic material was used to achieve reduction of the ball weight. The surface of the balls had been specially treated to develop a rough surface that was efficient to let the ball be easily grasped from the trainees. The modified balls had the same size (circumference: 56 cm) and very similar texture with the normal balls that are used in official handball games.

The performance of throwing was evaluated by measuring the velocity of the ball, using a radar gun (Sports Radar 3300, Sports Electronics Inc.). The principle for measuring the ball’s velocity was based on the Doppler phenomenon effect. The accuracy of the device, as defined by the manufacturer, was ±0.1 km/h, within a field of 10 degrees. As shown in Figure 1, the radar gun was placed on a tripod, behind a wooden target, which had had a hole in the center to permit the optical contact of the radar gun with the ball. The subjects were standing 6 meters away from the target. This setup was preferred, because as suggested by the manufacturer of the radar gun, the reliability of the device is higher when the measured object is moving towards the radar gun.

The target was round with a diameter of 50 cm and was placed facing the player with its center 170 cm over the ground and centered horizontally in the middle of the nest. Two pairs of vertical and horizontal bars fixed firmly the target to the nest, preserved the stability of the target. The diameter of the target was sufficient to preserve the accuracy of the radar gun, which is limited to 10 degrees.

The training program lasted 20 weeks and the training sessions took place 3 times per week in a handball hall. As it is recommended from previous studies that concern novice players (Brylinsky et al. 1992), during the first 10 weeks, the training components where focused to learn, improve and standardize the handball throwing ability of all the subjects. Following this period, the subjects were trained for 10 additional weeks, using balls of different weight, depending on the group that they belong to. The components of the training programs were common for the two groups and consisted of 9-16 sets of 6 maximal throws during each training session. The interval between the sets was 1 minute and the duration of each training session was 45 to 70 minutes. The training contents of the trainees are presented in detail in Table 2.

Four tests of the throwing velocity were administered before, in the middle and the end of the specific training period and after 4 weeks of detraining. Both right- and left-handed subjects were tested using their hand of preference. Prior testing (and during a normal training session as well) the subjects performed a 20 minutes of warming-up (jogging and stretching) to prevent potential injuries and maximize their performance. The shots were made from the stance position, without preparatory steps, using normal balls (Figure 1). The mean of 7 trials for each subject was evaluated on each day of the test. The interval given between the trials was individual dependent, and was enough to prohibit the appearance of fatigue indications (i.e. reduced performance). The shots that didn't reach the target were omitted and repeated, after the appropriate rest interval was given. Before the measurement, it was clearly stated to the participants that their primal purpose should be to perform their maximal throwing velocity, and that they should avoid throwing the ball with submaximal effort in order to reach the target.

The results are presented as means and standard error of the mean. The statistical analysis was performed using the STASTICA statistical package. A two-way Analysis of Variance (2X4 for GROUP and TIME factors respectively) was applied to the data to calculate the mean differences between the two groups and between the four different tests (repeated measurements). The Sheffé post-hoc test was used to detect the existence of differences between the groups or between the measurements. The level of significance was set at 0.05.

RESULTS

Due to injuries (one case), or insufficient number of training sessions (more than 8 training sessions missed) 3 subjects of the control group were not included to the evaluation process in the overall results. The age, body mass, height and percentage of body fat (Durnin and Womersley 1974) of the subjects that didn't drop out are shown in the Table 1. There was no significant difference ($p>0.05$) between the groups for the above-mentioned variables.

The statistical analysis revealed significant main effects for the factor TIME ($F_{(3,39)}=30.0$, $p<0.05$), but not for the factor GROUP ($F_{(1,39)}=2.17$, $p=0.15$), whereas the interaction between the depended variables was significant ($F_{(3,39)}=8.57$, $p<0.05$). The mean values and the standard error of mean for the throwing velocity for each group and each test are shown in Figure 2.

For the experimental group, as shown in Figure 3, the throwing velocity increased significantly ($p<0.05$) by 6.6% during the first 5 weeks after the first test and at the end of the training period 4.3% additional was gained ($p>0.05$). A minor and not significant ($p>0.05$) decrease of 0.9% was shown after 4 weeks of detraining.

Concerning the control group, the effect of training had less significant effects. More specifically, the throwing velocity was differentiated from the first measurement at the end of the training period, and it was significantly lower ($p<0.05$) compared to the results of the experimental group. The total increase of the throwing velocity at the end of training was 6.5% and 11.2% for the control and experimental group, respectively. During the 4 week detraining period the values of the ball velocity for the control group reached the level of the respective values of the pre-training. As a result, the two groups had significantly different scores after the detraining period ($p<0.05$).

DISCUSSION

The analysis of the results showed that the throwing velocity of the ball increased significantly after 10 weeks of handball training for both groups, but the benefit was significantly greater for the experimental group that was trained lighter balls. Furthermore, the effects of training were retained for the experimental group only, after 4 weeks of detraining.

Previous studies have shown that the throwing velocity is affected from age and gender (Sakurai and Miyashita 1983). For this reason special care was taken so that the two groups were homogenous concerning the above mentioned factors. Regarding the skill level, which is also crucial factor that affects the throwing performance (Winkstrom 1975), all subjects had no previous experience with ballistic training for the upper extremities. Therefore, it can be argued that the differences found in the increase of the throwing velocity between the two groups could not be attributed to their previous training background, because the only training that they had prior testing, was the 10 week handball training, in order to learn the movement of throwing. This training program was common for both groups. As a result, the pretraining values of the two groups for the throwing velocity did not have significant differences.

The findings of the current study are similar to other studies concerning training of baseball players with normal and light balls (DeRenne et al. 1990). Concerning handball, the results are also in agreement with the results reported (van Muijen et al. 1991), although the increase in the throwing velocity was much higher in the current study (11% vs. 2%). This can be attributed to gender specific differences but it is more likely that the difference is due to the previous handball experience that the participants had, when comparing the two studies (novice vs. national Dutch team). Moreover, in the current study the trainees performed more throws per training session (54-96 vs. 60) and they were all carried out with the light balls. Additionally, the training program of the control group of the present study was differentiated only in the ball weight, and no additional training sessions were performed for the experimental group. On the contrary, in the study of van Muijen et al. (1991) the control group performed 2 sessions per week less and probably this is the reason that they didn't have any significant improvement in the throwing velocity, whereas this was the case in the current study.

It is well known that according to the principle of training specificity, the best improvement of performance that occurs after a training program is achieved for the movements that have biomechanical the most similar pattern to the training movement. It could be argued, therefore, that the usage of lighter balls can have interference in the pattern of throwing. Nevertheless, this seems not to be the case in the current study, since it has been supported that an addition or reduction of 20% of the ball weight does not affect the performance range of motion (DeRenne et al. 1994).

The group that used the light balls for training can be assumed that it had a greater overload of the velocity component, comparing with the group that used the normal balls. Reversely, using heavier balls for training induces a greater overload on the force components. It is commonly accepted that the training adaptations that occur are velocity specific (Behm and Sale 1993). However, there are studies that support that training with high angular velocities results a carryover to the lower velocities as well, nevertheless the opposite seems not to be true (MacDougal et al. 1977, Sale and MacDougal 1981). This is in agreement with the current results, considering that using 20% lighter balls, the throwing velocity increases approximately 10% (Toyoshima and Miyashita 1973, Kunz 1974). Hence, using a higher velocity for training, there was a transfer of the training result to the lower velocity, i.e. to the throwing of a normal ball.

Biomechanical studies that concern the analysis of the throwing task, reveal that the main factor which affects the velocity of the ball release is the effectiveness of the energy transfer from the lower to the upper extremities and from there distally until the finger tips (Muller 1981, Joris et al. 1985). Although no biomechanical data is available in the current study, it can be argued that the improved performance of both groups was due to a better coordination of the movement, since no strength training was applied. Furthermore, the better scores of the experimental group and the retaining of their values after 4 weeks of detraining, reveals that it is likely that training with underweight balls is especially beneficial for the neuromuscular coordination.

It is rather difficult to identify the neuromuscular mechanisms that are responsible for the adaptations that took place in the current study. However, it has been shown that during ballistic movements the fast-twitch motor units are recruited (Smith et al. 1980). Therefore it can be argued, that using higher velocities for training (i.e. decreased ball weight), enhances the recruitment of the fast motor units, and as a result, the overall mechanical output is increased.

The rising question after considering the results of the present study is whether there is an optimal percentage of weight that should be used depending on the background training level of the athlete. Additionally, it is still unknown whether combination of lighter and heavier balls could have an even better effect, although a relative study for baseball has shown that 2 different combinations of using light or heavy balls (±20% of normal weight) can result the same improvement in the throw of the baseball (DeRenne et al. 1994), nevertheless, this was not the case for using weighted bats (DeRenne et al. 1995).

In conclusion, the improvement of the throwing velocity of handball players is rather important for a handball game, and more sophisticated methods have to be developed to achieve this goal. Training with lighter balls seems to be more beneficial for novice athletes in comparison to training with conventional balls and therefore trainers are encouraged to use this training. This could be attributed to a better energy transfer through the kinematical chain, though further investigation is required to reveal the responsible mechanisms behind it. Eventually, it seems probable that the training with lighter balls increases the performance of the throwing velocity due to neuromuscular adaptations that take place and have as result a better coordination of the motor centers of the central nervous system.

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Table 1: Mean values ± standard error of mean (range of values) for biometric data for both training groups.

	Experimental Group (n=22)	**Control Group** (n=18)
Age (years)	19.2±0.2 (18.0-21.0)	18.8±0.2 (18.2-20.3)
Weight (kg)	78.2± 12.1 (60-103)	81.4±13.0 (60-106)
Height (cm)	180.5±5.0 (168-192)	182.0±5.3 (166-191)
Body fat (% of Body weight)	14.5±1.3 (6.9-28.0)	14.5±1.5 (5.9-25.5)

Table 2: Contents of the training protocol for the participants. Symbols (§n) indicate the period that the 4 evaluation tests took place (n=1-4).

No. of training week	No. of sets	No. of throws	Total no. of throws
1-10	Technique learning – familiarization		
11-12 §1	9	6	54
13-14	10	6	60
15-16 §2	12	6	72
17-18	14	6	84
19-20 §3	16	6	96
24 §4	Detraining		

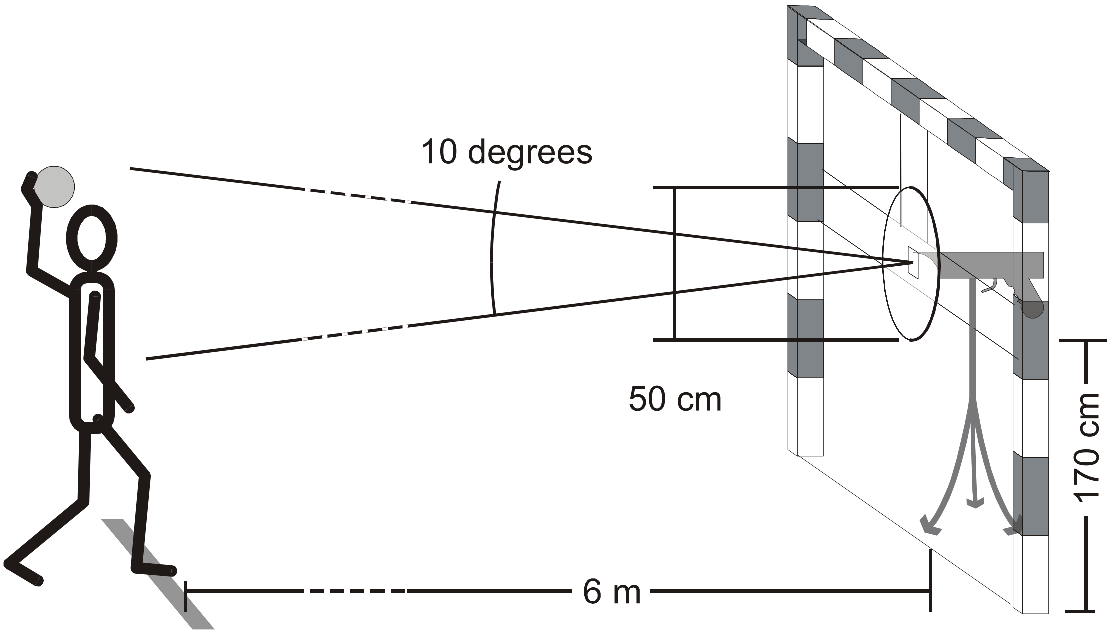

Figure 1: Schematic representation of the experimental setup for the assessment of the throwing velocity.

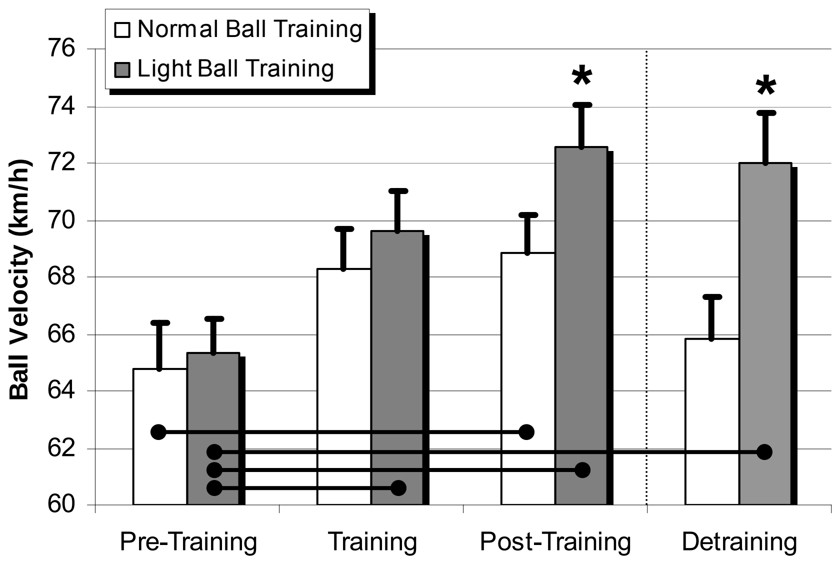

Figure 2. Mean throwing velocity of the handball towards the target for the experimental and control group, before, during, at the end of the training period and after detraining. Vertical bars represent the standard error of mean. The asterisks indicate significant differences between the groups, and the horizontal lines represent significant differences for the time factor ($p<0.05$).

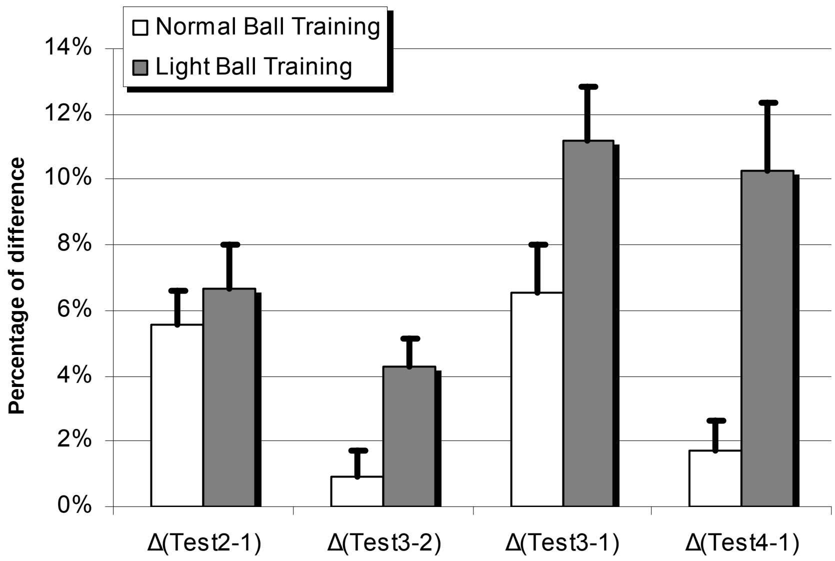

Figure 3: Mean alterations (in %) of the experimental and control group, comparing the throwing velocity between the 4 different tests. The vertical lines represent the standard error of mean.