International Journal of Sports Physiology and Performance, 2009, 4, 474-484

Effect of Two Different Training Programs with the Same Workload on Soccer Overhead Throwing Velocity

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Purpose: The purpose of this study was to determine whether two throwing programs, based upon velocity or resistance with the same workload, would enhance soccer overhead throwing velocity. ***Methods:*** Sports science students (n = 64, age 21.1 ± 2.1 y, mass 71.1 ± 11 kg, height 1.75 ± 0.09 m; mean ± SD) divided into two groups matched on performance, participated in the study. The resistance-training group trained overhead throwing with a 5-kg medicine ball for two sets of 8 reps per session, whereas a velocity training group threw four sets of 16 reps with a regular soccer ball. These training programs were matched on workload. Throwing performance with a soccer ball and a 5-kg medicine ball were tested before and after a training period of 6 wk with two sessions per week. ***Results:*** Both groups significantly increased the throwing velocity with the soccer ball (resistance-training group: 3.2% [1.0–5.5%)]; $P = .003$ and velocity-training group: 5.1% [2.6–7.7%]; $P < .001$), whereas no substantial changes were found for throwing with the 5-kg medicine ball after the training period. No substantial differences between the groups were found, which indicates that both forms of training increased the throwing velocity. ***Conclusions:*** It is concluded that both velocity and resistance throwing training programs after a short period of training with the same workload can increase throwing velocity and that workload is of importance in designing training programs and comparing them with each other.

Keywords: specificity, resistance training, velocity training, soccer ball throwing

Maximum velocity is a dominant factor in the performance of overarm throwing.[1] To improve this characteristic, different training programs based on the principles of overload, either by resistance or by velocity of the exercise, can be employed.[2] In overarm throwing sports, such as cricket, baseball, and team handball, resistance training appears to have a positive effect on throwing velocity.[3–14] The basic principle behind this is thought to lie in the force-velocity relationship of

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muscles: if an athlete becomes stronger, they should become faster at the same level of force or resistance.[15] However, in many training studies in throwing, resistance training was introduced in addition to regular training and compared with controls that did not receive any form of additional training.[3,5,7–9,11,16] This shortcoming makes it difficult to identify which aspect of resistance training elicits enhanced performance: is it the training form or added training load?[15]

To our knowledge, only Ettema et al[15] conducted a study on throwing in which the training load was equal for each training group as measured by the total workload (impulse) during training. They showed, in experienced female handball players, that throwing velocity in both groups significantly increased by 1.4 to 6.1% after a training period of 8 wk with no significant differences between the groups. The authors concluded that after specific resistance training, mimicking the kinematics of the overarm throw, did not surpass standard throwing training for improvement of throwing velocity. However, this study had few participants in each group (six and seven in each group) on which the findings were based.

Two-hand overhead medicine ball throwing is often used in resistance training for throwing athletes.[12] However, Newton and McEvoy[12] did not find a positive effect of medicine ball throwing after a training period of 8 wk in experienced baseball players. Possible reasons could be that medicine ball throwing with two hands does not adequately mimic overarm throwing required for handball and baseball. In addition to their medicine ball throwing, these participants trained on regular throwing in training and competition. This shortcoming makes it difficult to control the total workload on throwing. However, it is difficult to ask throwing athletes to only conduct a controlled throwing training program, without any extra throwing activities. Most people have had experience with two-handed overhead throwing with medicine and soccer balls during physical education at school and in football (soccer). However, most of them do not train using regular throwing activities. This scenario makes it easier to control the workload for these subjects.

The aim of this study was to compare the effect of specific throwing training based upon resistance (throwing with heavy medicine balls) with training based upon velocity (throwing with a regular sized soccer balls). It was hypothesized that both groups would improve their throwing velocity as a result of the additional training with the same workload. A substantial difference between the groups would indicate the influence of the training content. Furthermore, we were interested to see whether the effect of the training form with the same workload is independent of gender.

Methods

Subjects

Sixty-four (46 men and 18 women) students in sport science (age 21.1 ± 2.1 y, mass 71.1 ± 11 kg, height 1.75 ± 0.09 m) participated in this study. None of the participants had extensive experience with this type of training. Before participating in this study, the subjects were fully informed about the protocol. Informed consent was obtained before all testing, in accordance with the recommendations of the local ethical committee and current Portuguese law and regulations.

Experimental Design

A randomized controlled study was conducted in which two groups of sport science students, matched on throwing velocity with the soccer ball at the pretest (Table 1), received different training programs (soccer ball throwing or medicine ball throwing) with the same training load (ie, total impulse). The training programs were based upon either high resistance or high velocity. Two-handed soccer ball throwing was used instead of overarm throwing with one hand because most participants had some experience with two-handed overhead throwing with medicine and soccer balls. Furthermore, two-handed medicine ball and soccer ball throwing are the same throwing movements, with only a weight difference. This makes it easier to compare the influence of the different training types. Moreover, the two-handed overhead throwing technique limits the degrees of freedom that are possible to use, that is, trivial rotation along the longitudinal axis. Thereby, the performance is less dependent on technique differences among participants. Given that the aim of this study was to compare effects of specific resistance training with velocity training, and not the absolute effect of training, we did not include a nontraining control group.[14]

Methodology

Before the pretest, the participants were familiarized in throwing with differently weighted balls. This activity was undertaken to avoid a learning effect. Pre- and posttests were performed on maximal throwing velocity with a soccer ball (circumference 0.68 m; regular weight 0.45 kg) and a 5-kg medicine ball (circumference 0.85 m). After a general warm-up of 10 min, which included throwing with balls of differing weight to warm up the shoulders, throwing with the soccer and 5-kg medicine ball was tested. The participant stood with each foot parallel to the other while throwing the balls. All participants started with holding the ball in front of them with both hands. They were instructed to throw the medicine ball as far and fast as possible with both hands over their head and hyperextending their back and shoulders (soccer throw-in movement). Both feet were kept in contact with the ground at all times during and after the throw, and no preliminary steps were allowed. Torso and hip rotation was also prohibited. When a participant did not keep both feet on the ground during the throw, the attempt was not approved and a new attempt was performed. An expert in throwing controlled this aspect of the study.

Three approved attempts were made with each ball with 1 min of rest between each attempt. The sequence of ball type was randomized for each participant to ensure that fatigue or learning effects did not alter the performance. The maximal velocity with the soccer ball was determined using a Doppler radar gun (Sports Radar 3300, Sports Electronics Inc.), with ±0.03 m/s accuracy within a field of 10° from the gun. The radar gun was located 1 m behind the participant at ball height during the throw. Throwing distance with an accuracy of 0.1m was measured for the medicine ball. Only the best attempts with each ball were used for further analysis.

After the test, the participants were matched on throwing velocity and allocated to either the medicine ball throwing group (resistance-training group, n = 32) or soccer ball group (velocity-training group, n = 32). Both groups conducted throwing training, standing with both feet on the ground while throwing the ball (either a soccer or medicine ball) as hard as possible to the wall over a 3- to 5-m distance (dependent on their throwing ability). The participants performed these exercises twice a week for six consecutive weeks. The participants did not undertake any additional resistance training activities during the testing or training period. Every training session was supervised by an expert to ensure that the participants threw correctly and followed the experimental protocol.

The training load was calculated by the impulse generated per throwing attempt according to the same methods used by Ettema et al.[15] Impulse ($\int F dt$) was considered a highly relevant measure for resistance training as it measures the total amount of force produced during the throwing movement. In ball throwing, momentum of the ball at release (mv_{rel}) was used to indicate impulse, as initial momentum was equal to zero ($\int F dt = \Delta mv = mv_{rel}$). The comparison of the pretests indicated a mean impulse for throwing with the 5-kg medicine ball of 29.4 N·s, and 5.7 N·s for throwing the football. Thus, four repetitions with the medicine ball were matched by 21 throws with the soccer ball. One training session for the resistance-training group consisted of two series of eight throws with the 5-kg medicine ball. Thus, the velocity-training group had to perform 84 throws (six sets of 14 reps) per session with soccer balls. A pause of approximately 3 min was used between the series to avoid fatigue.

Statistical Analysis

To compare the effects of the training protocols, a 2-way ANOVA (test occasion: pretest–posttest × group: resistance-velocity training) for repeated measures was used. The test–retest reliability was calculated according to the procedures of Weir[17] and measured on 11 participants with 2 d between the measurements (two women and nine men; five from the resistance-training group and six from the velocity-training group). The intraclass correlations (3,1 ICC) were 0.96 for throwing velocity with the soccer ball, and 0.94 for throwing distance with the medicine ball. A paired *t* test between test and retest revealed no systematic errors (throwing distance: P = .422; throwing velocity: P = .949). The SEM on test–retest data for velocity was 0.35 m/s and for distance 0.30 m. Ninety-five percent confidence intervals (CI) were calculated for the changes in throwing distance and velocity. To show whether there are differences in anthropometrics, a *t* test between the training groups was performed for each parameter. The level of significance was set at $P < .05$, and all data are expressed as mean ± SD.

Results

No significant differences in anthropometrics between the groups ($P \geq .454$) were found (Table 1). A significant increase in throwing velocity with the soccer ball of 3.2% (1.0–5.5%) for the resistance-training group and 5.1% (2.6–7.7%) for the velocity-training group was found after the 6-wk intervention programs (Figure 1; $P < .001$). In contrast, no main effect of the training group in throwing velocity was found (P = .463; Table 2).

The throwing distance with the 5-kg medicine ball decreased significantly after the training period with 2.7% (0.2–5.1%) (Figure 2; Table 2; P = .013) with no significant difference of change between the two intervention groups (Table 2;

Table 1 Anthropometrics and throwing characteristics of both groups at the pretest (mean ± SD)

	Velocity Training		Resistance Training	
Group	Men (n = 23)	Women (n = 9)	Men (n = 23)	Women (n = 9)
Weight (kg)	74.5 ± 9.5	58.3 ± 9.8	76.0 ± 10.0	60.6 ± 3.8
Height (m)	1.78 ± 0.07	1.64 ± 0.05	1.78 ± 0.06	1.64 ± 0.03
Age (y)	22.0 ± 2.4	21.4 ± 2.1	21.6 ± 1.8	20.7 ± 1.5
Throwing velocity soccer ball (m/s)	13.3 ± 0.9	9.9 ± 1.4	13.3 ± 1.0	10.1 ± 1.0
Throwing distance 5-kg ball (m)	5.7 ± 0.7	3.9 ± 1.0	5.8 ± 0.7	3.7 ± 0.6

Table 2 Statistical analysis of the effect of resistance- and velocity-based training on throwing velocity of the soccer ball and distance of the 5-kg ball

Ball	Training Effect on All Subjects				Effect Between Groups		
	Percent Change (95% CI)	*P*	Effect Size	Statistical Power	*P*	Effect Size	Statistical Power
5-kg medicine ball	−2.7 (−0.2 to −5.1)	0.013	0.093	0.709	0.201	0.026	0.246
Soccer ball	4.2 (2.6 to 5.9)	<0.001	0.291	0.999	0.463	0.009	0.112
	Training Effect on All Men				Effect Between Groups		
5-kg medicine ball	−1.9 (−0.5 to −4.3)	0.122	0.054	0.338	0.262	0.028	0.199
Soccer ball	2.1 (0.3 to 3.9)	0.020	0.116	0.645	0.577	0.007	0.085
	Training Effect on All Women				Effect Between Groups		
5-kg medicine ball	−5.7 (−13.8 to −2.5)	0.160	0.113	0.283	0.976	0.001	0.050
Soccer ball	11.1 (8.4 to 13.9)	<0.001	0.807	1.000	0.061	0.191	0.472

Note. Overall effect is based on the ANOVA's main training effect and effect between groups on training × group interaction. Effect size was partial eta squared.

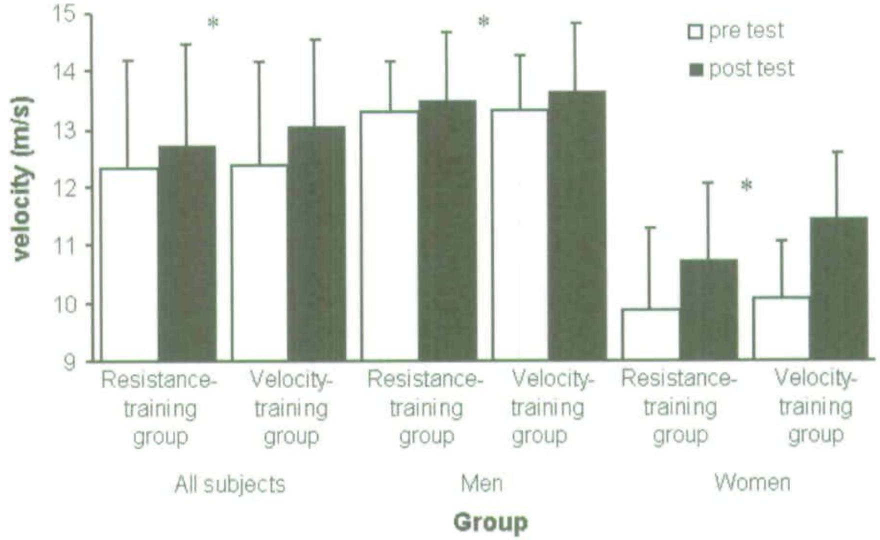

Figure 1 — Throwing velocity (mean ± SD) with the soccer ball before and after the training period, averaged per training group (resistance-training group and velocity-training group) for all participants, men and women. *Indicates a significant difference ($P < .05$) from the pretest to the posttest for both groups.

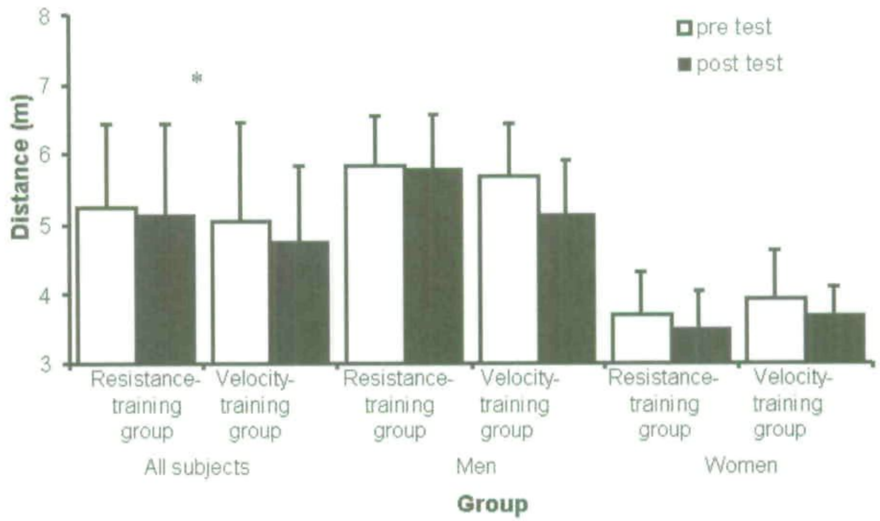

Figure 2 — Throwing distance (mean ± SD) with the 5-kg medicine ball before and after the training period, averaged per training group (resistance-training group and velocity-training group) for all participants, men and women. *Indicates a significant difference ($P < .05$) from the pretest to the posttest for both groups.

$P = .201$). In Table 2, a summary was given of the statistical analysis of the 2-way ANOVA for repeated measures for all participants, all men and women.

When evaluating the performance per gender it was found that both women ($P < .001$) and men ($P = .020$) significantly increased their throwing velocity with the soccer ball (Figure 1; Table 2). However, no significant changes were observed for the throwing distance with the 5-kg medicine ball for men ($P = .122$) or women ($P = .160$; Figure 2). No training group effects were found when evaluated per gender ($P \geq .061$; Figure 1 and 2; Table 2). The throwing velocity of the women (Figure 1) in the velocity-training group showed an increase of 13.6% (10.3–16.9%) compared with the velocity of women from the resistance-training group that showed an increase of 8.8% (3.3–14.3%). When the change in throwing distance and throwing velocity was calculated for each gender, it showed that only the throwing velocity with the soccer ball increased significantly ($P < .001$) more for women (1.1 ± 0.6 m/s) than for men (0.3 ± 0.9 m/s). No substantial gender effects were found for the throwing distance with the 5-kg medicine ball ($P = .482$).

Discussion

Both strength and velocity training programs increased the throwing velocity with soccer balls, with no differences between the two training groups. A small decrease in throwing distance with the medicine ball was found after the training period. The findings of this study are in line with those of Ettema et al,[15] who also used two training programs with the same workload. Ettema et al[15] used around 500 N·s as workload, which elicited increases of 6.1% and 1.4% for the velocity-training group and resistance-training group, respectively. In our study, only 470 N·s of work per session was conducted with similar mean increases of 5.1% (velocity training) and 3.2% (resistance training). The resistance-training group (5-kg ball) in the current study had more than twice the increase (3.2% vs 1.4%) than the study of Ettema et al.[15] In the study of Ettema et al,[15] the participants had to simulate throws with around 18 kg using a pulley system, which demands more force than with 5-kg medicine balls. These weights presumably stimulate the lower part of the force-velocity curve,[18] and improvements may not transfer substantially to throwing with lighter weights. Throwing with 5-kg medicine balls lies probably in the middle part of the force-velocity curve, and presumably better transfer to throwing velocity with the soccer ball.

The 3.2% increase of throwing velocity after the resistance-training program was similar to earlier studies that used resistance training for the upper body with an intensity of 10 RM or bench throws.[9,11] In addition, Newton and McEvoy[12] showed that heavy resistance training for the upper-body extremities improved throwing velocity, but that more specific resistance training, that is, medicine ball throwing, had no such effect. Newton and McEvoy[12] concluded that heavy resistance training produces greater force output and rate of force development than medicine ball throwing. They stated that in medicine ball throwing, this force output is not large enough to increase the throwing velocity when using regular balls. Furthermore, these investigators suggested that medicine ball throwing was not sufficiently specific to the movement patterns of baseball throwing. The lack of movement specificity might explain the positive effect of medicine ball throwing on soccer ball throwing performance because the participants trained with similar movement patterns and higher force output with the heavier medicine balls. It is difficult to compare the results of earlier studies that have investigated the effects of medicine ball throwing performance velocities because of methodological differences, including the method of measurement, training experience, and lack of controlled workload.

A decrease in throwing distance with the medicine ball was observed, probably caused by the training setup and measuring method. In the test procedure, only the distance was measured, which could be negatively influenced by the throwing angle and throwing height even when the throwing velocity was increased after the training period. Furthermore, the measurement of distance was performed with an accuracy of 0.1 m. The mean change in ball distance was also just 0.17 m. Thus, the decrease could be the result of the inaccuracy of the measurement as shown by the SEM of 0.3 m found in the test–retest comparison.

Differences in the magnitude of the increase between men and women were found in throwing with soccer balls after the training period. This gender difference could be caused by the throwing experience of the women. However, no ceiling effects were found for the men ($r = -0.17$) and women ($r = -0.10$), indicating that an increase in throwing velocity was independent of their possible previous throwing experience, before the start of the study. The total workload was based upon the mean workload for the whole group. This methodological requirement influenced the workload per participant, especially between men and women. Since women threw with less velocity than men, the workload they had was lower than that of men. However, no substantial mean difference between the groups in workload was evident because participants were matched before dividing them in the two groups, which was shown by the same results of the two groups at the pretest. Thus, when using mean workload make sure that the participants were matched before dividing them into different training groups.

The workload between the two training groups was equal and elicited a similar increase in throwing velocity. Perhaps the results should be different when the workload of the resistance-training group was double that of the velocity-training group. It is easy for the resistance-training group to increase the amount of throws from two sets of eight times, to four sets of eight times during the training period, without losing the quality of throws during the training due to fatigue. For the velocity-training group, this is more difficult to achieve, since increasing from 84 to 168 throws per training session with maximal effort would surely be altered by fatigue. Thus, throwing with 5-kg medicine balls could be a good alternative for enhancing throwing performance via increases in the total workload. Still, the velocity-training group tended to increase more than the resistance-training group, indicating the importance of specificity training. Combining the two training methods could be useful to limit fatigue related to the total amount of throws. Further studies comparing different workloads and/or combinations between training based upon velocity and strength should be conducted.

Practical Applications

Two specific throwing training programs with the same workload, one based upon velocity and the other on strength, can increase throwing velocity by 3 to 5% after 6 wk of training in a group of sports science students with little soccer ball throwing experience. This outcome indicates that workload is of importance for designing training programs. Throwing with 5-kg medicine balls can be used as alternative training for throwing with soccer balls, as the time demands are less. It is also easy to increase the total workload with this form of throwing training and limit fatigue with a smaller number of total throws.

Conclusion

Both velocity and resistance throwing training programs with the same workload, after a short period of training, increase the throwing velocity. It appears that workload is of importance in designing training programs and comparing different forms or types of throwing training with each other.

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