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Combined Strength Training on Throwing Ball Velocity in Softball

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ABSTRACT

One of the most important skills in softball is throwing. Various methods of training were tested to determine an alternative approach that can improve throwing ball velocity. Combined training is one method that recently gained attention among sports practitioners. However, most training focuses only on the major muscles and neglects supporting muscles such as handgrip and trunk rotation muscles that are also critical in the execution of throwing. Therefore, this study seeks to determine the effect of handgrip, trunk rotation, and combination of handgrip and trunk rotation training on the throwing ball velocity of collegiate female softball players. A total of 72 collegiate female softball players were assigned into 4 strength training groups namely handgrip (HG), trunk rotation (TR), combination (HG&TR) group (CB) and control group (CG). All participants had undergone a training program, 3 days per week for 6 weeks. All groups were instructed to perform the same basic strength training program (training on major muscles) with different additional strength training (handgrip strength or trunk rotation strength) according to the group`s assigned exercises. Participants were assessed on their throwing ball velocity before the intervention (pretest) and after the 6-week training program (posttest). After 6 weeks of

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training, the result showed that throwing ball velocity significantly increased in the HG (1.45 m/s), TR (1.62 m/s), CB (2.08 m/s) and CG (0.93 m/s) groups. The post-hoc test indicated that all groups were significantly different compared to each other except the comparison between HG and TR groups. This study also demonstrated that the combination training (CB) approach was more effective in improving throwing ball velocity compared to a single mode approach (HG and TR).

Keywords: Handgrip, throwing ball velocity, trunk rotation, softball

INTRODUCTION

Throwing is one of the most vital skills in softball. This skill requires more attention during training to enhance performance since all softball players are required to use this skill regardless of their position on the field. Primarily, one of the variables that can improve throwing performance is throwing ball velocity (Escamilla et al., 2012). To gain an advantage over the opponent, throwing ball velocity is crucial to prevent the opposing runner from achieving more runs (Potter & Johnson, 2007).

Throwing velocity has been studied in various sports and in various training programs in order to look for an alternative exercise to improve throwing performance (Szymanski, 2012). However, Szymanski (2012) also emphasised that it was not clear as to which type of training could best improve throwing ball velocity. Strength training is one of the approaches that is commonly used to develop the performance of throwing ball velocity (Escamilla et al., 2010; Szymanski, 2012). This training develops selective muscle groups that are specifically engaged during throwing (Zawrotny, 2005). Development of certain muscle groups that are particularly involved in throwing will enhance the execution process of the overhead throw by maximising the efficiency of the kinetic chain (McDaniel et al., 2009; Moynes et al., 1986). The full throwing execution begins with the process of energy transfer from the lower body towards the trunk, shoulder, elbow, wrist, and fingers (McDaniel et al., 2009; Moynes et al., 1986). Each body part has their own function during throwing which defined the throwing performance itself. Szymanski (2012) reviewed 39 journal articles about training on overhand throw and found inadequate studies that emphasised the significance of handgrip strength, body rotation strength, or the combination of both handgrip and body rotation training.

Handgrip Strength and Throwing Ball Velocity

In general, throwing involves movement of the upper body which affects the whole arm segment including handgrip motion (Koley & Kumaar, 2012). According to Shea (2007), players' grip strength is an essential aspect in sports that require upper body movement and those that require holding an object such as basketball, baseball, handball, softball and so on. In addition, McDaniel et al. (2009) supported the argument where an improvement in handgrip strength not only improved the skill of gripping the object but also improved force production in throwing. Basically, grip strength can increase the ability of the hand to grip the ball and generate control over the ball during throwing (Ferragut et al., 2010). The amount of force generated in the handgrip, indirectly enhances the spin of the ball that leads to the improvement in throwing velocity (Takahashi et al., 2001).

The power of handgrip motion is the result of a forceful flexion of the whole finger joint with maximum voluntary force (Goswami et al., 2016; Shea, 2007). Shea (2007) emphasised that gripping involved most of the muscles in the forearm and hand which totaled to 35 muscles. The composition of the gripping action comprised flexion and extension. The study claimed that the flexor mechanism of the fingers was 62% higher than the extensor mechanism. Hence, a proper training program which emphasises on flexion and extension movement is crucial in handgrip strength development.

Trunk Rotation Strength and Throwing Ball Velocity

Apart from handgrip strength, trunk rotation strength is also involved in the energy transfer process and force production during throwing and this may help to maximise throwing ball velocity. According to Robb et al. (2010), in developing necessary torque and velocity for an overhead activity such as throwing, the important element is the hip motion and trunk rotation. A successful throwing technique with the presence of throwing velocity is derived from the effectiveness of the energy transfer process from the lower body, facilitated by the trunk, and forward to the upper body (Aragon, 2010). Study of the overhand throw showed that 46.9% of throwing ball velocity was generated during the stride and trunk rotation, and 53.1% by the arm action (Zawrotny, 2005). In other words, the lower extremities which includes hip and trunk rotation produced almost as much energy as the arm itself in during throwing.

The role of trunk rotation strength in throwing velocity was supported by Stodden et al. (2008). They noted that the increase of pelvis and trunk rotation velocity intensified throwing ball velocity which maximised performance. The increase of pelvis and trunk rotation velocity created higher force production to the throwing arm which leaded to an improvement in throwing velocity. Stodden et al. (2008) also noted that improvement in trunk rotation strength was important to increase dynamic stabilisation during throwing which was useful during the follow-through phase. Therefore, the risk of injury such as muscle imbalance could be reduced if the muscular strength of trunk rotation is properly developed by the athletes.

Generally, training exercises should focus on every muscle that is involved in the execution of a specific movement or skill. However, most training programs are designed to only focused on the main muscles that generate energy in a throwing process such as arm and legs (McDaniel et al., 2009; Park et al., 2014; Pedegana et al., 1982; Zawrotny, 2006). The significance of the supporting muscles that also contribute in a throwing process tends to be ignored. Handgrip and trunk rotation strength are the supporting muscles that assist in the accomplishment of a throwing process and these muscles have been neglected in training. In addition, the combined effect of both strength training (handgrip and trunk rotation) has not been investigated and discussed since there are inadequate studies that focus them together. In response to the current problem, the purpose of this study is to identify the effect of handgrip, trunk rotation, and combination of both strength training in improving the throwing velocity of collegiate female softball players.

METHODOLOGY

Subject

A total of 72 healthy female softball players participated in this study. The participants were from University Technology Mara, Malaysia and were all right-handed collegiate female softball players. The participants were assigned into 4 groups with each group having 18 participants. Prior to the study, all participants were screened and only those who were free from current or prior injuries and illnesses were included from the study. Written consent was obtained from all the participants prior to the beginning of the study.

Instrumentation

The ball velocity during throwing was measured using a radar gun (Bushnell Speedster Speed Gun; Bushnell Inc, Lenexa, KS) with an accuracy of 1.61 kph (1 mph) (Bowman et al., 2006). The intraclass correlation coefficient (ICC) reported a 0.95 during the pre-study reliability test indicating it had high reliability.

Procedure

Throwing Velocity Assessment. Based on the procedure guidelines by Tilaar and Marques (2013), the position of the radar gun (Bushnell Speedster Speed Gun) was placed around 1 meter behind the target. A target was provided to control the projectile of the travelling ball and was placed parallel to the ball direction. The participants were given a maximum of 5 throwing trials and recording was made for each trial. The distance between the participant's position and the throwing target was 10 meters. Following a pre-investigation trial session, it was identified that the ball projectile is minimum within this distance. Hence a 10-meter distance had been set in this study to measure the throwing ball velocity. This had been supported by Escamilla et al. (2010) which indicated that the critical peak velocity in throwing occurred within the middle distance between bases. In addition, to prevent muscular fatigue during the throwing test, 30 seconds of rest was given to all participants between throwing trials. The throwing ball velocity was measured twice, before (pretest) and after (posttest) the 6-week training intervention program.

Training Description

All experimental training groups participated in 3 sessions of resistance training for 6 weeks. The training sessions were conducted in an indoor environment (gymnasium) and performed on 3 separate days in a week with at least 1 day of rest between sessions. Each session (50 min) began with a warm-up of slow stretching and movement exercises (10 min) and ended with cool-down exercises (10 min). After the warm-up, the participants start the basic strength training for all groups. The basic strength training program comprised 2 categories which were core exercises and assistance exercises. Table 1 below shows the training program for the 6-week intervention.

In addition to basic strength training (core and assistance exercises), each experimental group was given a specific training program which was different according to the specifics of each group. For the handgrip group (HG), besides the basic resistance-training program, an additional 6 specific handgrip exercises were assigned to this group. For the trunk rotation group (TR), an additional 6 specific trunk rotation exercises were assigned. As for the combined training group (CB), an additional 6 combination specific exercises (3 specific handgrip exercises and 3 specific trunk rotation exercises) were assigned. Lastly, the control group (CG) only performed the basic strength training without any additional specific exercises given. Table 2 shows the list of exercises for each group.

The exercises in the basic strength training program utilised the intensities based on the core and assisted exercise training program (Table 1). All the exercises in the specific training program consisted of assistance exercises as indicated in Table 2.

Table 1

Training program

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
	Warm-up					
Sets	2	2	2	2	2	2
Repetition	10	10	10	10	10	10
% 1RM	40	40	45	45	50	50
	Core exercise					
Sets	2	3	3	3	3	3
Repetition	4-6	4-6	2-4	4-6	1-2	2-4
% 1RM	80	80	85	85	90	90
	Assistance exercise					
Sets	2	3	3	3	3	3
Repetition	8-10	8-10	6-8	8-10	6-8	8-10
% 1RM	65	65	70	70	75	75

% 1RM = Percentage of Estimated One Repetition Maximum

Table 2
List of exercises

Category/ groups		Handgrip strength training group	Trunk rotation strength training group	Combination strength training group	Control group
Basic strength training	Core exercises	Chest press	Chest press	Chest press	Chest press
		Squat	Squat	Squat	Squat
		Stiff-leg deadlift	Stiff-leg deadlift	Stiff-leg deadlift	Stiff-leg deadlift
		Abdominal crunch	Abdominal crunch	Abdominal crunch	Abdominal crunch
		Biceps curl	Biceps curl	Biceps curl	Biceps curl
		Seated row	Seated row	Seated row	Seated row
		Dumbbell press	Dumbbell press	Dumbbell press	Dumbbell press
		Triceps extension	Triceps extension	Triceps extension	Triceps extension
Specific training	Assistance exercises	Barbell reverse wrist curl	Kneeling cable lift	Barbell reverse wrist curl	
		Barbell wrist curl	Kneeling cable chop	Barbell wrist curl	
		Hammer cable wrist curl	Woodchop cable	Hammer cable wrist curl	
		Hammer cable reverse wrist curl	Seated cable core rotation	Kneeling cable lift	
		Cable wrist curl	Standing cable core rotation	Kneeling cable chop	
		Cable reverse wrist curl	Torso rotation	Torso rotation	

The exercise order in this study followed the sequence of exercises by alternating the agonist and antagonist, and the upper and lower body exercises when it seemed appropriate in each session. The training exercise was based on Zawrotny (2005) and the training guidelines were adopted from Baechle and Earle (2008).

Data Analysis

Data from the study was analysed using the Statistical Package of Social Sciences (SPSS) program software version 20.0. A one-way ANOVA on pretest data and mean gained score was conducted. Firstly, the pretest data was analysed for homogeneity between groups. Then, the mean gained was calculated (posttest–pretest) to determine the treatment effect prior to the main analysis. Finally, the significant difference on throwing ball velocity between the 4 groups was identified.

RESULT

The results of the pretest indicated that there was no significant difference for throwing ball velocity between the 4 groups (HG, TR, CB and CG): $F(3, 68) = 0.018$, $p = 0.997$. This shows that all groups were homogeneous prior to the experiment. Table 3 below presents the mean and mean gained score of the pretest and posttest result of all groups.

Based on Table 3, the CB group showed the highest change with a mean difference of 2.08 m/s, followed by the TR group with 1.62 m/s and the HG group with 1.45 m/s. Concurrently, the CG group displayed the least improvement with a mean difference of 0.93 m/s.

The results of the one-way ANOVA on the mean difference (mean gained) showed that there were differences in the throwing ball velocity among the 4 groups: $F(3, 68) = 26.174$, $p = 0.000$. Subsequently, the Tukey HSD test analysis to compare the 4 groups (HG, TR, CB and CG) showed that there were significant differences between all groups ($p < 0.05$) except between HG and TR ($p = 0.557$). Among all the groups, CB had the highest mean difference compared to CG with a mean gained of 1.15 m/s.-

DISCUSSION

The results of this study showed significant differences among all the groups except for the comparison between HG and TR groups. However, among all the groups, the CB group displayed the greatest improvement in throwing ball velocity. The findings showed that the combination of specific training approach has a synergy effect towards the improvement of throwing ball velocity compared to the single specific training approach. Handgrip and trunk rotation strength are important factors in the development of throwing velocity since both of these strengths play an important role during throwing where the movement contributes in producing greater force which increase its maximum velocity.

Similarly, trunk rotation strength also generates the same effect as handgrip strength. Trunk rotation does not only act as a medium to forward energy from the

Table 3

Mean score and mean gained score for throwing ball velocity

Group	N	PRE-TEST Mean (*SD*) m/s	POST-TEST Mean (*SD*) m/s	Mean gained (*SD*) m/s
HG	18	17.70 (2.41)	19.15 (2.40)	1.45 (0.38)
TR	18	17.74 (2.10)	19.37 (1.81)	1.62 (0.47)
CB	18	17.66 (2.08)	19.74 (2.02)	2.08 (0.37)
CG	18	17.82 (2.08)	18.75 (2.06)	0.93 (0.35)

HG = Handgrip strength training group, TR = Trunk rotation strength training group, CB = Combination strength training group and CG = Control group lower to the upper body, but it also can be used in force production to increase throwing velocity. Trunk rotation strength could increase force to the throwing arm and indirectly improve throwing ball velocity (Stodden et al., 2008). Fleisig et al. (2013) biomechanically explained how trunk axial rotation could increase throwing velocity. Trunk rotation begins during the wind-up phase. The athlete starts to rotate the pelvis to face the target while ensuring that the upper trunk is parallel to the direction of throwing. Immediately after the foot touches the ground, maximal trunk rotation occurs, and trunk axial acceleration is at its peak at this point. The throwing arm is externally rotated as the pelvis and upper trunk rotates, and the acceleration of the movement increases in accordance with the force production created by the muscle contraction (Fleisig et al., 2013). This is where trunk rotation strength can produce a greater force to improve throwing ball velocity. Moreover, Sakurai (2000) stated that the ball could only be accelerated to 50% of that attained in the normal throwing motion without trunk rotation.

Among the 4 groups, the CB group had shown the greatest improvement with a change of 2.08 m/s. Furthermore, the CB group also showed a significant improvement compared to the other groups where the mean difference between CB and HG is 0.63m/s, CB and TR is 0.46 m/s, and CB with CG is 1.15 m/s. This study revealed that combination training (CB) was far more effective to a single mode approach (HG and TR) in improving throwing ball velocity. As mentioned earlier, handgrip strength is effective to increase the backspin of the ball during throwing (Kinoshita et al., 2017; Takahashi et al., 2001) while trunk rotation strength can maximise trunk rotation acceleration on the overhead throw movement (Fleisig et al., 2013; Prieske et al., 2016). Therefore, it is not surprising that the combination training approach involving handgrip and trunk rotation exercises has created the synergy effect on the throwing performance.

The CB group had benefited from both strength training exercises whereby this training intervention group comprised both movements (handgrip and trunk rotation) which involves the usage of different muscles. The number of muscle unit development also plays an important role that leads to this significant finding. The CB group had the advantage of using different type of muscles and this technically led to an increase in multiple muscular strengths. A significant improvement in maximum muscular strength can significantly increase force production in the throwing process (Hong et al., 2001; Moynes et al., 1986). The development of muscles also contributed to the successful synergy process which is crucial in the energy transfer process. It can be concluded that the improvement that occurs in the CB group is technically due to the advantage of both strength training.

CONCLUSIONS

A complete throwing process involved various muscular strengths. However, this study demonstrated that the throwing velocity was affected by the handgrip and trunk rotation strength which influenced softball performance. This study also emphasised that the combination of handgrip and trunk rotation strength (CB) was more effective compared to the training program that only used a single specific training approach (HG, TR, and CG). Therefore, athletes should include a combination of various training approaches that utilise different muscle groups in their training program to maximise throwing ball velocity and improve their softball throwing performance. Since there are other throwing sports such as javelin throw, handball, cricket, tennis, water polo, and baseball which also utilise handgrip and trunk rotation strength, more studies are needed to determine their specific roles.

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