Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 11), Art 364, pp. 2879-2885, November 2022
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

The effects of forearm resistance band training on the throwing velocity of male handball players

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Published online: November 30, 2022
(Accepted for publication November 15, 2022)
DOI:10.7752/jpes.2022.11364

Abstract:
Introduction: Handball is a dynamic sport played in numerous countries. One of the important factors in scoring goals is throwing velocity, but training knowledge is based mostly on practical experience given the limited scientific studies devoted to this game. To fill this void, the current research investigated the influence of resistance band training for forearms on the throwing velocity of university handball players. **Materials and methods:** This study recruited 28 male university handball athletes with an average age of 20.7±0.8 years, a stature of 172.2±0.1, a body mass of 68.5 (±4.6), and a VO^2 max of 48.2 (±3.4). Of these participants, 14 were randomly assigned to an experimental group (subjected to resistance band training), and the remaining athletes served as controls. Both groups underwent pre-and post-tests, which covered throwing velocity (7 m jump shot test), hand grip, and ball accuracy tests. For eight weeks, both groups attended regular handball training sessions (three per week), but the experimental group also participated in a program specifically aimed at strengthening the forearm muscle region. The program involved two resistance band exercises after the general warm-up in each regular session. **Results:** Pre- and post-tests were carried out to analyze each player's throwing velocity and assess the effects of the strength training program. Statistically significant differences ($p \leq 0.05$) in throwing velocity were found between the experimental group, who presented an improvement of 8%, and the control group, who showed no improvement. **Conclusion:** The results suggest that an increase in the strength of the forearm muscle can contribute to an increase in throwing velocity and an enhancement in the kinetic chain that underlies throwing in handball.
Key Words: **Handball, Rubber, Training, Throwing velocity, Accuracy**

Introduction

Handball is an Olympic sport that involves seven players and is characterized by fast-paced defensive and offensive moves intended to score goals. Scoring entails finding an optimal position from which to throw the ball with quick moves over short distances, implementing strong changes in direction, facing off one on one against defenders, and passing the ball using different offensive tactics (IHF, 2005). Handball is played at two 30-minute halves on a field 40 m long and 20 m wide. The rapid pace of the game and continuous changes in direction engage players not only on a physical level but also on a mental dimension (Fieseler et al., 2017; Severino et al., 2019). It is distinguished from other sports by movements that require highly developed motor abilities, such as explosive energy, velocity, endurance, and strength, with focus on running, jumping, blocking, side-to-side chopping, quick starts and stops, and throwing (Povoas et al., 2012; Saeterbakken et al., 2011).

Handball is a complex sport wherein the overall performance of a team is determined by the individual performance of players and specific team maneuvers. Therefore, handball players are required to excellently coordinate their movements for running, jumping, pushing, changing directions, and the handball-specific moves of passing, catching, throwing, checking, and blocking. During a game, the intensity of movements constantly changes depending on whether a player needs to stand and walk, jog and run at a moderate speed, sprint, and execute fast forward, sideward, and backward movements (Wagner et al., 2014). Playing a game of handball also necessitates several basic techniques: catching the ball, passing, shooting, dribbling, feinting, executing offensive and defensive movements, and goalkeeping strategies [5]. Shooting is a form of throwing movement designed to get the ball into the opponent's goal (Gonzales et al., 2013). It is achieved through an earnest effort to assume good posture and requires the use of a number of techniques, including the jump shot. The jump shot is a powerful maneuver and the most effective and most impressive-looking way of throwing the ball into the opponent's goal. Before making a jump, however, an important aspect to note is the rhythm of steps (Hermassi et al., 2011). Jump shooting is a technique of creating numbers because scoring is achieved by jumping so that the ball is directed more precisely toward the goal (Marques et al., 2006).

Improving the throwing technique through the successive action of strong arm muscles and bodily segments is expected to increase ball speed. In the act of throwing, muscular activity in the forearm is a very dominant component of the arm acceleration phase (Clements et al., 2001). The most specific exercise for upper-arm throwing is the technique exercise, which can be achieved in two ways: by increasing duration through

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variations in repetition or by imposing additional weight on the forearm (Ettema et al., 2008; van Edwards Muijen et al., 1991). Previous studies proposed forearm strengthening programs for achieving or maintaining balance and strengthening arm muscles (Page et al., 1993). These programs typically entail the use of exercise equipment, such as external weights or machines, but elastic rubber bands are more popular because of their versatility, simplicity, and low cost. In addition, the resistance achieved by stretching these bands is affected by the force of gravity. Such resistance in training loads that consist of elastic bands also depends on the tensile properties of latex or elastic polymers (Hughes, 1999). Numerous studies have been conducted to confirm the efficacy of this type of muscle strengthening because elastic band resistance programs are widely implemented and appreciated by athletes, coaches, and sports medicine specialists. Their findings demonstrated that elastic band training effectively enhances the strength of shoulder and arm muscles (Hibberd et al., 2012; Niederbracht et al., 2008).

In the context of handball, a necessary task is for players to perform exercises that start with light loads before gradually transitioning to actual training loads so that athletes are not overwhelmed by the weight imposed on their bodies and prevented from carrying on exercising. In this regard, resistance bands are suitable training tools. Correspondingly, our main objective was to identify the effects of forearm muscle training using an elastic band on throwing velocity. We hypothesized that such an intervention would effectively improve the muscle strength and throwing performance of male handball players.

Materials and methods

Experimental research involves implementing treatment to determine changes that occur before and after the intervention (e.g., an increase or no increase) (Bompa, 1999). This type of research can therefore count as a method for comparing certain treatments under controlled conditions. In this work, all the participants consented to participating in observational studies and experimental procedures, which were all approved by the ethics committee of Universitas Islam 45.

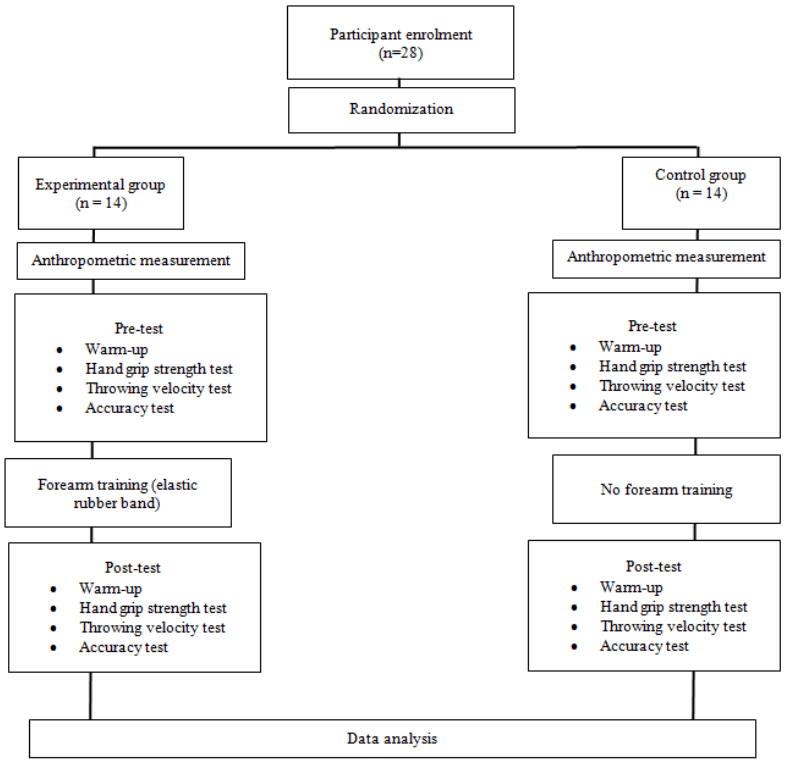

Figure 1. Research design

Participants

The target population consisted of members of the Handball Community of Unisma Bekasi. From this population, we recruited 28 male university players on the basis of the following criteria: a minimum of three years' continuous handball training as a men's team athlete, participation in national tournaments, participation in 10 or more hours of training per week, no concomitant diseases, non-smoker, and no use of anti-oxidant or anti-inflammatory drugs during the experimental period. The athletes were then divided into two groups (experimental and controls). To increase strength and power, we subjected the participants to different dynamic strength and strength training programs over a period between six and 12 weeks, consistent with previous training studies (Florin et al., 2022; Gonzales, 2013; Hermassi, 2011; Marques 2006, 2007). This decision is also supported by the results derived by Ortega (2019), who showed that four weeks or shorter periods of exercise have no effect on increasing strength.

Procedures

The study was performed from January to March (an eight-week period) in the middle of the playing season. Before the experiment was initiated, all the participants took preliminary tests consisting of anthropometric, hand grip, throwing velocity, and accuracy tests in a single period. The experimental group engaged in a light resistance training program for the forearm using elastic rubber bands and exercises using body weight as resistance three times a week. The control group performed exercises in accordance with a predetermined schedule that did not involve elastic rubber band exercises. After eight weeks, a post-test was conducted to evaluate the treatments.

Figure 2. Elastic band training

Instrumentation and Measured Parameters

Anthropometry

Anthropometric and cardiorespiratory tests were carried out at a constant normal temperature (27°C–29°C). The participants' body weights, body fat, and body mass indices (BMIs) were measured using an Omron Karada Body Scan (HBF 375), and their heights were measured using a stadiometer with a readability of 0.1 cm (Seca 214 Portable).

Table 1. Anthropometric information of the participants

Variable	Exp (n = 14) $\bar{x}$(SD)	Con (n = 14) $\bar{x}$(SD)
Age (years)	20.7 (± 0.8)	19.9 (± 1.3)
Height (cm)	172.2 (± 0.1)	169.3(± 0.7)
Weight (kg)	68.5 (± 4.6)	68.2 (± 7.6)
BMI (kg/M2)	23.1 (± 1.6)	23.6 (± 3.5)
Fat (%)	19.8 (± 1.7)	19.2 (± 1.3)
VO^2max (ml/kg/min)	48.2 (± 3.4)	48.7 (± 4.1)

Note: Exp = experimental group, Con = control group, BMI = body mass index

Throwing Velocity

The participants were instructed to warm up before testing, after which they performed five-time trials of throwing using a 7 m jump shot technique. After five attempts, the throw with the highest velocity was chosen as the representative indicator. Ball velocity was measured using a radar gun (Speed Gun Bushnell Velocity 101911 range for baseball/softball/tennis: 10–110 km/h, or up to 90 ft).

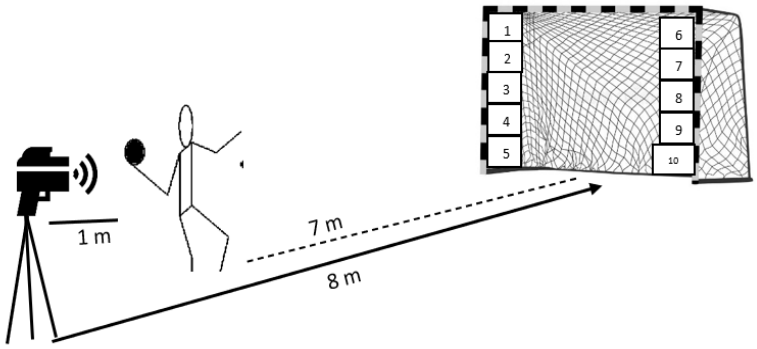

Figure 3. Experimental setup

Hand grip

A hand dynamometer was used for this test (TKK 5401 Takei Scientific Instruments, Tokyo, Japan). In a seated position, an athlete was asked to hold the hand dynamometer in his dominant hand, with his elbow fully extended and his arm close to his body. The athlete was instructed to gradually increase pressure to the maximum level and hold this intensity for at least 2 seconds.

Accuracy

The participants were directed to randomly throw a standard handball at five targets (40 cm square-shaped targets), which were then classified as goals (Figure 1) [22]. To avoid the effects of fatigue on speed and accuracy, they were asked to throw the ball five times, with a rest period of 5 seconds applied between each throw.

Statistical Analyses

Statistical analysis was performed with the Statistical Package for the Social Sciences (v. 26.0), and the normal distribution of the sample was verified via the Shapiro–Wilk test. A 2 × 2 (group: exp and con × time: pre, post) repeated-measures analysis of variance (ANOVA) was carried out for each parameter. To determine the differences between the results before and after supplementation in each group, we performed an independent t-test. Statistical significance was set at $p < 0.05$.

Results

Table 2 displays the mean and SD values, as well as percentage changes for hand grip, throwing velocity, and accuracy, of the experimental and control groups before and after supplementation.

Table 2. Effects of resistance band exercises on hand grip, throwing velocity, and accuracy

Variable	Experimental group				Control group				P^2		
	pre	post	Δ%	p^a	pre	post	Δ%	p^a	group	time	group × time
HG (kg)	43,57 ± 2,65	47,21 ± 3,84	8	0.007*	45,21 ± 3,76	45,69 ± 3,82	1	0.741	0.949	0.035*	0.102
TV (km/h)	60,21 ± 5,63	65,07 ± 6,05	8	0.037*	55,78 ± 5,56	56,71 ± 5,23	2	0.653	0.001*	0.006*	0.198
ACC (n)	19,85 ± 3,00	21,50 ± 2,76	28	0.035*	22,28 ± 3,24	24,85 ± 2,50	21	0.001*	0.018*	0.001*	0.492

Notes: HG = hand grip, TV = throwing velocity, ACC = accuracy, SD = standard deviation
[a] Independent t-test, [b] 2 × 2 repeated-measures ANOVA
* Values significantly different between the groups ($p < 0.05$)

Table 3. Specific changes in hand grip, throwing velocity, and accuracy in the experimental and control groups

Groups	Variables	Mean	Std. deviation	Std. error mean	95% Confidence interval of the difference		t	df	Significance (2-tailed)
					Lower	Upper			
Exp - hand grip strength (kg)	Pre–Post	–3.642857	1.780542	.475870	–4.670911	–2.614803	–7.655	13	.007*
Con - hand grip strength (kg)	Pre–Post	.064286	1.05218	.281208	–.543226	.671798	.229	13	.741
Exp - throwing velocity (km/h)	Pre–Post	–4.857143	4.521013	1.208292	–7.467498	–2.246788	–4.020	13	.037*
Con - throwing velocity (km/h)	Pre–Post	.978571	2.943619	.786715	–.721023	. 2.678166	–1.244	13	.653
Exp - accuracy (n)	Pre–Post	–5.642857	3.499608	.935309	–7.663470	–3.622244	–6.033	13	.001*
Con - accuracy (n)	Pre–Post	–4.571429	1.452546	.388209	–5.410104	–3.732753	–11.776	13	.001*

Notes: Exp = experimental group, Con = control group
* Significant difference between pre- and post-test values ($p < 0.05$)

Hand Grip

The independent t-test for hand grip revealed significant differences between the pre- and post-test values in the experimental group ($p = 0.007$), but no such variances were found in the control group ($p = 0.741$) (Table 3). The ANOVA showed a significant main effect of time ($p = 0.035$), but no significant main effect was detected with respect to the group ($p = 0.949$) or time × group interactions ($p = 0.102$). Figure 2 shows a significant increase in hand grip results following eight weeks of resistance band training.

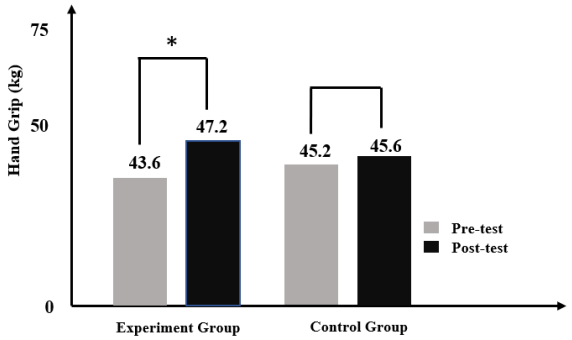

Figure 4. Hand grip

Throwing Velocity

The independent t-test for throwing velocity uncovered a significant increase between the pre- and post-test values in the experimental group ($p = 0.037$), but no such result was found in the controls ($p = 0.653$). The ANOVA revealed significant main effects of time and group interactions ($p = 0.006$ and $p = 0.001$, respectively) despite the suggestion in the statistical analysis that no significant main effect occurred with regard to the time × group interactions ($p = 0.198$).

Accuracy

The independent t-test for accuracy pointed to significant changes between the pre-and post-test values in the experimental and control groups ($p = 0.001$ and $p = 0.001$, respectively). The ANOVA results indicated no significant time × group interactions ($p = 0.492$), but the statistical analysis established a significant main effect of grouping ($p = 0.018$) and timing ($p = 0.001$).

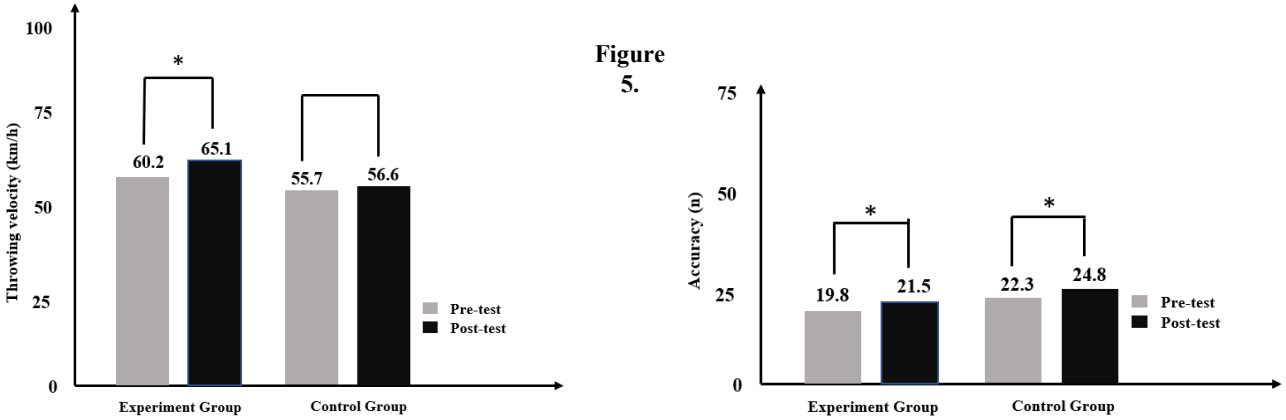

Figure 5. Throwing velocity and accuracy

Discussion

The study was aimed at examining whether exposure to eight weeks of forearm strength exercises with a resistance band effectively aids muscle strengthening among male university handball players and correspondingly increases muscle strength, throwing velocity, and accuracy. To the best of our knowledge, this study is the first to investigate the effects of forearm-specific elastic band muscle training for handball players. The main findings were as follows: (1) Forearm strength training using a resistance band significantly enhanced the strength of the players' forearm muscles. (2) Forearm strength training using a resistance band increased the players' throwing velocity, and (3) forearm strength training using a resistance band increased ball throwing accuracy.

Increased strength in forearm muscles affects the results of throwing velocity. Previous studies showed that such muscles tremendously advance throwing in the acceleration phase (Fleishig, 1996). For example, Canli Age and Cem Kurt (2022) reported a relationship between hand grip strength and throwing velocity, and Mascarin's (2017) research on the effects of upper limb exercises using a resistant band indicated that six weeks of exercise were found to increase throwing velocity. Consistent with these works, the current research showed that muscle strength training using a resistant band, specifically for forearm muscles, has a positive effect on throwing performance. The results related to the control group reflected no significant difference in hand grip strength and throwing velocity, but ball throwing accuracy increased. The increase in ball throwing accuracy in the control and experimental groups could have stemmed from the athletes' levels of expertise. This aligns with

the explanation of García (2013), who observed that speeds close to the maximum do not seem to have a significant effect on throw accuracy. This phenomenon very likely happened in the present study because the athletes in the control group performed repetitive throwing movements during the training period, thereby indirectly elevating the accuracy with which they threw the ball. This observation is supported by the results of previous studies on ball throwing accuracy (García, 2013; Van den Tillaar, 2003) and that of Papanikolaoy et al. (2021), who discovered that throwing accuracy is affected by many factors, including chronological age, APHV, standing height, mesomorphy, forearm length, hand width, and self-efficacy.

Conclusion

The research hypothesis was confirmed—that is, eight-week forearm strength training using an elastic band at three workouts per week can derive effective results with regard to hand grip strength and throwing velocity. Note, however, that increased accuracy occurred in both the control and experimental groups, indicating that factors other than elastic band training can improve throwing accuracy. The findings also showed that although forearm strength training using an elastic band increased muscle strength, thereby favorably affecting the increase in throwing velocity, it did not generate positive results on increasing accuracy. It is necessary to conduct an in-depth study of another training method that can considerably affect accuracy.

Conflicts of interest.

The authors declare that there are no conflicts of interest.

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