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Investigating the Effectiveness of Six-Week Plyometric Training Intervention on Speed-Strength Fitness Abilities of Male Team Handball Players

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Abstract

Background and study aim: Plyometric training is widely acknowledged as an effective option for athletes to attain improved physical performance. A variety of exercises involving the lower limb's stretch-shortening cycle can be used for plyometric training. Numerous studies have examined the impact of plyometric training on various outcomes in various populations over the past few decades.

Objective: This study set out to ascertain how a six-week plyometric training programme affected the development of speed-strength fitness measurements in male team handball athletes.

Material and methods: Total of thirty intercollegiate level team handball athletes were randomly assigned to 2 groups i.e. plyometric training group with an average age of 20.7 ± 0.7 years, height of 175.3 ±4.2, weight of 75.1 ± 4.1 and BMI of 24.43 ± 0.97; control group with an average age of 20.8 ± 0.7, height of 175.1 ± 4., weight of 74.9 ± 3.1 and BMI of 24.47 ± 1.37. The linear sprint (10 m and 30 m), standing long jump (SLJ), and change of direction sprint (CODS) were evaluated before and after the intervention for thirty male team handball athletes who were randomly assigned to either the plyometric training group (PTG) (n = 15) or the control group (CG) (n = 15).

Results: Within group changes were analyzed using paired t-test. The significant differences obtained between the tests in all dependent variables.

Conclusion: When it comes to linear sprints, standing long jumps, and change of direction sprints, plyometric training works better than CG. Consequently, adding either plyometric training or sport-specific training to an athlete's regimen may help male team handball players achieve greater speed-strength fitness.

Keywords: plyometric training, team handball, speed, lower limb muscle power and change of direction speed.

Анотація. Дослідження ефективності шеститижневого пліометричного тренування на швидкісно-силову підготовленість гандболістів чоловічих команд. Баладжі Етірадж, Муругавел Каматчі, Раджкумар Маріяппан, Логесваран Суббрамані, Віджаясанкар Велучамі, Деварадж Чіннатхамбі. *Передісторія та мета дослідження:* пліометричне тренування широко визнане як ефективний варіант для спортсменів, що дозволяє покращити фізичну працездатність. Для пліометричного тренування можна використовувати різні вправи, що включають цикл розтягування-скорочення нижніх кінцівок. Останні кілька десятиліть у численних дослідженнях вивчалося вплив пліометричних тренувань на різні результати у різних групах населення. *Мета:* з'ясувати як шеститижнева програма пліометричних тренувань вплинула на розвиток показників швидкісно-силової підготовки у спортсменів чоловічих команд з гандболу. *Матеріали та методи.* Усього тридцять спортсменів-гандболістів міжвузівської команди були випадковим чином розподілені на 2 групи, а саме групу пліометричної підготовки із середнім віком 20,7±0,7 років, зі зростом 175,3±4,2, вагою 75,1±4,1 та ІМТ 24,43±0,97; контрольна група із середнім віком 20,8±0,7 років, зі зростом 175,1±4, вагою 74,9±3,1 та ІМТ 24,47±1,37. Спринт (10 м та 30 м), стрибок у довжину з місця (SLJ) та спринт зі зміною напряму (CODS) оцінювалися до та після втручання для тридцяти спортсменів-гандболістів чоловічої команди, які випадково були розподілені в одну з груп пліометричної підготовки (ПТГ) (n=15) або контрольну групу (КГ) (n=15). *Результати:* внутрішньогрупові зміни проаналізовано з використанням парного t-критерію. Достовірні відмінності отримані між тестами за всіма залежними змінними. *Висновки:* коли справа доходить до спринту, стрибків у довжину з місця та спринту зі зміною напряму, пліометричне тренування працює краще, ніж звичайне у контрольній групі. Отже, додавання до режиму спортсмена або пліометричного тренування, або спеціального спортивного тренування може допомогти гандболістам чоловічих команд досягти кращих показників швидкісно-силової підготовки.

Ключові слова: пліометричне тренування, командний гандбол, швидкість, сила м'язів нижніх кінцівок та швидкість зміни напрямку.

Introduction

The development of outstanding sports performance is the ultimate goal of sports training in competitive sports, and the most important factor in enhancing athletic ability is an athlete's physical fitness [1]. To properly execute tasks specific to a sport, a better physical fitness is needed [2]. However, athletes who are exceptionally physically fit can improve their own athletic ability and prevent injuries [3] and be conscious of their own ability to tolerate more rigorous sports training or competition [4].

The Russian researcher Zaciorski used the term "plyometric" for the first time in his work in 1966 [5]. Zaciorski coined the term "plyometric" because, in these kinds of SSC exercises, the muscle group's externally measured tension ("metron") is greater ("plio") than the muscle group's internal tension [5].

Over the past decades, various classification schemes for plyometric exercises have been employed. Verkhoshanski [6] proposed the first classification scheme, which divided plyometric exercises into two categories: impact (involving an additional external load) and non-impact (involving no additional

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external load). Plyometric training is conceptually composed of two contractions: an explosive concentric contraction and an eccentric contraction. In the meantime, scientists commonly refer to the stretch-shortening cycle (SSC) as the change from the eccentric to the concentric phases of action [7].

In recent times, plyometric training has been divided into three categories: assisted (such as when an elastic band is used to assist), resisted (such as when the exercises are carried out in a variety of outdoor conditions like sand, water, and extra external loads), and traditional (such as jumps in place, standing jumps, multiple hops and jumps, bounds, and drop jumps) [8]. In many sports where sprinting, jumping, and direction-changing are required, plyometric training is frequently employed to enhance physical performance [9]. In team sports, athletes' physical fitness levels play a significant role in determining their success [10]. This makes sense because in order to outperform opponents during play, athletes must put forth numerous short-term efforts like sprints, jumps, change of direction (COD), etc [11, 12, 13]. Furthermore, these skills could also distinguish the athlete's level of play [14,15].

Research on team handball has grown significantly in recent years as a result of the increased popularity of this game over the past few decades [16]. The influence of this shift in demographics has resulted in a consistent rise in the pool of potential athletes participating in team handball [17]. Players' technical and physical skills have consequently significantly improved, with a focus on improving their ability to move quickly and with great power [18]. This means that both offensive and defensive game scenarios typically involve quick-witted and high-paced play [19]. As a result, players in modern handball must be able to execute a variety of explosive motor skills, including jumping vertically and accelerating and decelerating [20].

These days, a growing amount of experimental research has investigated how plyometric training affects an athlete's speed-strength fitness characteristics. For example, Hammami et al., [21] study found that plyometric training for the upper and lower limbs is a useful and time-efficient method for improving young female handball players whole-body physical performance. According to one study, plyometric training can significantly improve athletic performance in team sports like team handball [22] considering that players frequently run, accelerate, jump, or throw. Furthermore, team handball is typified by regular physical altercations between players and calls for accelerations to initiate counterattacks or COD to defeat the opposition [23]. Since handball demands a high level of speed-strength fitness, plyometric training can complement an athlete's regular training regimen and has some advantages over other training techniques (e.g., easy to use in any context, beneficial effects on strength and power, low interference with other training methods).

Drawing from prior research, our hypothesis was that level of speed-strength fitness team handball players could be enhanced through plyometric training. The purpose of this study is to assess the effects of plyometric training intervention on speed, lower limb muscle power and change of direction speed among handball athletes in order to shed light on the effects of plyometric training on speed-strength fitness performance.

Materials and Methods

Electronic searches were carried out by the investigators (KM and EB). Search engines used to locate published articles included MEDLINE, EMBASE, Scopus, Science Direct Databases Directory of Open Access Journals (DOAJ), PubMed, and Google Scholar. The terms "Plyometric training", "speed", "change of direction speed", "lower limb muscle power", and the conjunctions "OR/AND" were used as essential terms. Searches could only be conducted in English. The studies detailing how body flexibility is affected by suryanamasakar are considered for literature review.

Study Participants

Thirty intercollegiate level team handball athletes were randomly assigned to 2 groups (i.e., PTG and GG) using the method of randomly permuted blocks using Research Randomizer, a program published on a publicly accessible official website (www.randomizer.org) their ranged from 18 to 23 years. All subjects were advised not to decrease or increase their daily sports and regular activities over the course of the study.

Procedure

To minimize any learning effects, two familiarization sessions for the testing procedures and three familiarization sessions for the plyometric exercises were held prior to the start of the intervention, right before the baseline assessments. Data on demographics were gathered. In addition, participants were instructed to eat a regular food and abstain from caffeine for three hours prior to testing, as well as to refrain from any strenuous activity for a full day. To reduce the impact of circadian fluctuations, pre-post measurements were carried out for all participants at similar times of day, involving linear sprint, CODS, and SLJ on the same day. Every participant underwent the same testing in the same order. On the day of the test, participants completed a general warm-up that lasted ten minutes.

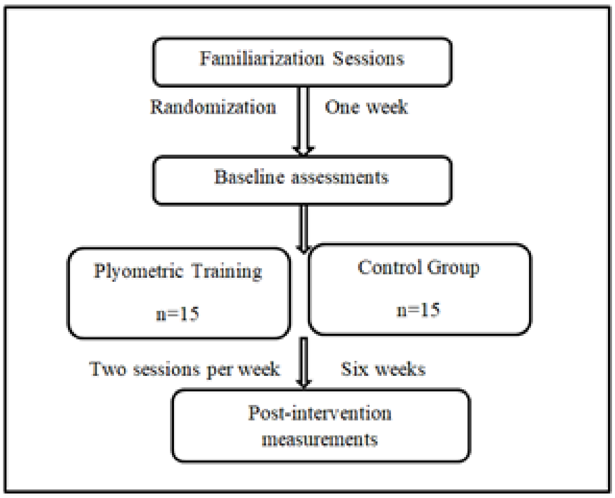

Figure 1. Schematic of the study design

Table 1. Participants Characteristics ($\bar{x} \pm \sigma$)

Groups	No. of subjects	Age (In years)	Height (In centimeters)	Weight (In Kilograms)	BMI (In Kg/m²)
PT (G1)	15	20.7 ± 0.7	175.3 ±4.2	75.1 ± 4.1	24.43 ± 0.97
Control (G2)	15	20.8 ± 0.7	175.1 ± 4.1	74.9 ± 3.1	24.47 ± 1.37

Training intervention

For six weeks, plyometric training was conducted on Tuesday and Thursday (two non-consecutive weekdays). With the exception of the day they completed the plyometric training programme (part of regular training), the respondents completed their regular 60-minute workouts four times a week in addition to one game day. A prescribed warm-up that comprised dynamic stretches lasting roughly ten minutes and running at progressively faster speeds while being directed by spoken cues [24]. The number of jumps was used to determine the training volume, and it was increased weekly. The complexity and intensity of the jump exercises increased throughout each training session. A technique-based jump progression was used to determine the intensity (exercise complexity). Table 2 provides details on plyometric training. The handball athletes were taught the mechanics of the jumps and encouraged to jump as hard as they could; all jumps were performed on the same floor in the same environment, with rest lasting 30 and 90 seconds, respectively.

Assessment Protocols

Anthropometric measurements:

The stadiometer was used to measure the height, a portable digital scale with a 0.1 kg precision was used to weigh participants who were minimal and did not wear shoes. Using a tape measure and a standard procedure, height was measured. The body mass index (BMI) was computed as follows: weight (kg) divided by height (m^2) squared.

Speed

The protocols for the linear sprint speed test were modified from those described in an earlier study, and the tests were run over 10 and 30 meter distances [25]. An outdoor track was used for the testing. Standing behind a start line with their chosen leg forward, participants were told to begin only upon the assessor's command. The interclass correlation coefficient (ICC) values between timekeepers were 0.99 for both 10 m and 30 m. Two independent assistants who were not involved in the study were chosen to serve as timekeepers, and they were tasked with timing each trial using a hand stopwatch (Casio S053 HF-70W-1DF, Casio Computer Co., Ltd., Tokyo, Japan). For analysis, the two timekeepers' recorded times were averaged. A linear sprint test lasting 10 and 30 metres was performed in two trials, with a one-minute break in between each trial. The fastest trial was chosen for additional examination. For the 10 m sprint test, the internal consistency coefficient (ICC) was 0.66 (95% confidence interval [CI]: 0.44–0.80), and for the 30 m sprint test, it was 0.80 (95% CI: 0.66–0.88).

Lower limb muscle power

The muscle power in the lower limbs was evaluated using the standing long jump (SLJ). The testing procedure was modified using techniques described in an earlier investigation [26] and carried out on an outdoor track. Participants were told to swing their arms and countermove to a depth of their choice while standing behind a start line with their feet slightly apart. Then, they were to take off and land on both legs. There was verbal encouragement to jump as far as they could. From the starting line to the closest point of contact on the landing that is, the rear of the closest heel—the measurement was taken. After one minute of rest in between each of the two jumps, the longest jump was chosen for examination. In the test-retest scenario, the ICC was 0.88 (95% CI: 0.81–0.93).

Change of direction speed

The Modified Agility T-test, or MAT, was utilized to measure the speed with direction changes, such as sprinting forward, shuffle walking to the left and right, and running backward. The protocol was modified based on procedures described in a prior investigation (Figure 2) [27]. Two independent assistants who were not involved in the study were designated as timekeepers (ICC between timekeepers was 0.99), and they were tasked with using a hand stopwatch (Casio S053 HF-70W-1DF) to record the timing of each trial.

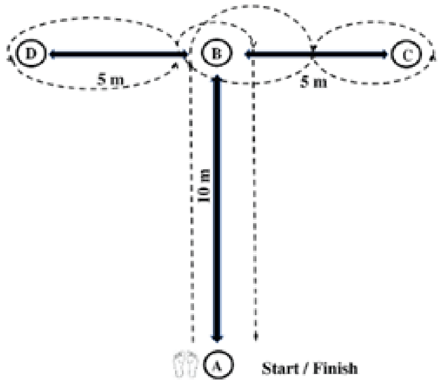

Figure 2. Change-of-direction speed time was measured using the modified agility T-test configuration. Cones measuring 0.64 metres in height were positioned at points A, B, C and D. The participants' instructions were to run from point A to point B, turn 90 degrees from cone B to cone C, turn 180 degrees at cone C towards cone B, weave at cone B towards cone D, turn 180 degrees at cone D towards cone B and finally run to the start/finish line. Without touching the cones, participants had to turn or weave around them. If the cones moved during a direction change, the trial was discarded, and participants had to restart it after three minutes of rest (i.e., slowly standing or walking). With their backs constantly facing the start/finish line, the participants finished the test.

Note: The movement pattern during the test is indicated by the black dotted line.

Table 2. Plyometric training schedule

Exercises	1-2 weeks	3-4 weeks	5-6 weeks
Squat jump	2 x 5*	3 x 5	3 x 5
Plyo-pushup	2 x 5	3 x 5	4 x 5
Jump lunges	2 x 5	3 x 5	3 x 5
Tuck jump	2 x 5	3 x 5	3 x 5
Double leg speed hops	2 x 10	3 x 10	3 x 10
Burpee	2 x 5	3 x 5	4 x 5
Medicine ball (MB) throw (kg)	2 x 10 (1)	2 x10 (2)	2 x10 (3)
Alternative leg bounds	-	-	3 x 10
Total no. of jumps/Push ups/MB throws (kg)	*60/20/20(1)*	*90/30/20(2)*	*125/40/20(3)*

*denotes sets x repetitions

Statistical Analysis

The data analysis procedure in this study consisted of two steps: the Shapiro-Wilk test and the Paired Sample t-test. This study employs a paired sample t-test hypothesis test. This test's objective is to compare the pretest and posttest results. For the statistical analysis in this study, IBM SPSS Statistics 16.0 was used. (SPSS, Inc.; USA; Chicago, IL)

Results

Adverse effects

There were no withdrawals from the study, injuries or missed training sessions among the participants.

The six-week study involved thirty days of plyometric practice, comprising one pretest, thirty treatments, and one post-test. The results of the computation of lower limb muscle power, speed, and direction-changing speed are as follows.

The data are displayed as means ± SD and sig. value; if the sig. ≥ 0.05, the data are considered normally distributed

Based on the results of table 3 above, the Shapiro-Wilk test instrument was used to determine the pretest and posttest results for both the treatment group and the control group. All of the data from the research findings were normally distributed, the hypothesis was then tested using the paired sample t-test in parametric statistics.

Based on the results of Table 3 above and from the results of the hypothesis test with the Paired Sample t-Test, the speed, lower limb muscular power and change of direction speed of experimental group results obtained sig (2-tailed) value of 0.000 <0.05, it can be concluded that there is a significant improvement in the selected variables due to six-week plyometric training. When contrasting the outcomes of the experimental and control groups, there has been a minor increase in speed in the control group. Yet, the experimental group outperformed the control group in terms of speed, lower limb muscle power and change of direction speed.

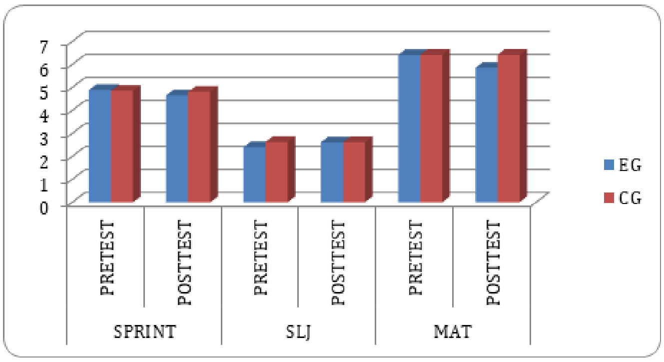

Figure 3. Bar diagram displays the pre- and post-test results for the treatment and control groups for sprint, standing long jump and change of direction speed.

Discussion

This study evaluates how plyometric training affects team handball athletes' speed, lower limb muscle power, and change of direction speed. Our results showed that six weeks

Table 3. Normality test

Groups	Variable	Tests	Shapiro-Wilk		
			Statistic	df	Significant
EG	30 m sprint	Pre	0.95	15	0.50
		Post	0.91	15	0.12
	SLJ	Pre	0.89	15	0.06
		Post	0.93	15	0.29
	MAT	Pre	0.88	15	0.05
		Post	0.90	15	0.08
CG	30 m sprint	Pre	0.92	15	0.20
		Post	0.95	15	0.46
	SLJ	Pre	0.88	15	0.05
		Post	0.88	15	0.05
	MAT	Pre	0.88	15	0.05
		Post	0.93	15	0.29

Table 4. Paired Sample t Test

Groups	Variables	Paired Difference				t	df	Sig. (2 tailed)
		Mean ± SD	Std. Error Mean	95% Confidence Interval				
				Lower	Upper			
EG	Pre-post speed	0.25±0.07	0.01	0.21	0.29	12.85	14	0.000
	Pre-post LLMP	0.21 ± 0.14	0.04	0.28	0.13	5.77	14	0.000
	Pre-post CODS	0.57 ± 0.13	0.03	0.50	0.64	17	14	0.000
CG	Pre-post speed	0.03 ± 0.10	0.02	0.03	0.09	1.23	14	0.238
	Pre-post LLMP	0.01 ± 0.03	0.01	0.01	0.02	1	14	0.334
	Pre-post CODS	0.01 ± 0.02	0.01	0.02	0.007	1	14	0.334

*Statistically significant difference, mean scores at point comparisons from baseline: sig (2-tailed) value of ≤ 0.05; data are presented as means ± SD.

of plyometric training increased handball players' speed, lower limb muscle power, and change of direction speed.

Many experimental studies conducted in the last few decades have suggested that plyometric training has positive effects on both the performance of sport tasks like sprint time, change of direction speed, and jump performance, as well as speed-strength capacities like muscle strength, muscle power, explosive strength, and even endurance performance [28,29].

Plyometric training significantly improved agility, according to our research. Research from the past has confirmed this finding: athletes' change of direction speed is affected more by upper and lower limb plyometric training when compared to active controls. Three reviews that used different inclusion criteria than the current study yielded results that were comparable to ours, indicating an increase in agility [30]. Increases in sprint performance may be explained by a number of physiological factors, some of which share similarities with the previously mentioned improvements in lower body muscle power and strength. First, motor unit recruitment patterns are changed by plyometric exercise (primarily in the fast muscle fibres) [31]. It increases the frequency of motor unit activation, which improves the lower extremities' maximum muscular strength and power capacity. This allows athletes to sprint faster at the start of a race and extend their strides [10].

Gains in direction speed following plyometric training may, in fact, be linked to three things: (1) stronger quadriceps muscles; (2) more effective braking ability; and (3) improved muscle force output and movement efficiency [32]. Additionally, plyometric training may enhance athletes' mental readiness prior to high-intensity exercise [33], enabling them to perform better in activities requiring rapid changes in speed.

According to Karadenizli [34] the 10-week upper and lower limb plyometric training program's horizontal and vertical jump and sprint drills improved the young female handball players' agility performance. Furthermore, studies suggest that muscle coordination, balance, flexibility, and explosive strength all affect agility [35].

Furthermore, it has been established in the literature that plyometric training is a simple, effective, and time-saving technique for enhancing agility in other athletes [36]. Previous research [37, 38] has demonstrated improvements in athletes' lower body muscle strength performance following plyometric jump training. The current findings indicate that benefits can be achieved in both the upper and lower extremities provided the regimen incorporates both upper and lower limb training. There are multiple possible explanations for the changes. First, the type of plyometric exercises (i.e., combining exercises for the upper and lower limbs) utilized in the training protocol, and second, certain neural adaptations align with those previously covered in the muscle power section [39]. Plyometric training enhances handball athletic performance markers like speed, strength, power, and COD. This helps with both linear and multidirectional handball movements like jumping, throwing, running and sprinting [40]. Based on the findings of this research, plyometric training has beneficial effects on the handball athletes.

Conclusions

The study underscores the intense impact of plyometric training on speed-strength fitness of handball players. Male team handball players who participated in a six-week plyometric training intervention showed improvements in their speed-strength performance (i.e., speed, lower limb muscle power and change of direction speed) when compared to an active control group. For the speed, lower body muscle power and change of direction speed, the improvements were moderate in magnitude. As a result, plyometric training may be recommended as a useful training strategy to encourage changes that support the growth of male handball players' speed-strength performance.

Highlights

Plyometric training has been shown to provide benefits for athletes' upper and lower body speed-strength performance; in fact, our data show significant increases in speed, lower limb muscle power, and change of direction speed as well as increased flexibility, upper body muscle strength, and power. Since many sports heavily rely on these speed-strength fitness components all of which were enhanced by the plyometric training regimen for both the upper and lower limbs the improvements that we observed should help the coaches, other researchers, and physical education specialists. As a result, as previously indicated, we suggest plyometric training as a useful training method to enhance multiple critical speed-strength fitness level in handball athletes.

Plyometric training can be considered an essential component of neuromuscular training sessions that focus on preventing upper and lower extremity injuries because, if the programme is well-designed and professionally supervised, there won't be any additional strain on the athlete's musculoskeletal system, as shown by the lack of papers reporting injuries during programme implementation.

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