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Plyometric training for improvement of physical fitness component in Handball players

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Handball is a fast body contact Olympic team sport that requires running, jumping, sprinting, throwing, repeated sprinting, faking, hitting, blocking and pushing. The purpose of this studywas to investigate the effect of plyometric training on shooting performance and some selected physical fitness qualities. Plyometric movements, in which a muscle is loaded and then contracted in rapid sequence, use the strength, elasticity and innervations of muscle and surrounding of hopping, skipping, jumping and throwing activities designed to make the athlete faster going from slow muscles to fast muscles requires performing quick, "explosive" movements. Based onthe findings, studied literature plyometric training has positive effect on improvement of shooting performance and physical fitness qualities of handball players. Therefore, it recommendedconducting plyometric training on handball players to enhance shooting performance and physical fitness qualities.
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Introduction

Handball is a fast body contact Olympic team sport that requires running, jumping, sprinting, throwing, repeated sprinting, faking, hitting, blocking and pushing. It requires a high standard of preparation to complete sixty minutes of competitive play and to succeed. At present, the requirements for the players have changed as the game of handball has developed over the years. The amount of training and the number of matches have increased considerably and the recently introduced rule on quick throw-off and the tightening-up of the rule about passive playing have led to an increased number of attacks and intensity for players (Ronglan et al., 2006). This has contributed to increasing the dynamics and physical demands imposed on the players. With this development, there is a need to check, plan and carry out optimal physical training regimes for handball players. From this, handball players require various technical skills (e.g. shooting, passing and throwing) and physical characteristics (e.g. jumping ability, power, speed and agility) at different levels of competition (Ziv & Lidor, 2009). On the other hand, the research work of Hakan (2018), revealed as in all sport branches, there are many factors at the heart of success in handball such as theoretical knowledge, psychological, technical and tactical characteristics. In handball, it is necessary to look at not only technical and tactical practices, but also different issues such as training and training plans and technical tests. In handball, players' changing their places as quickly as possible, meeting the ball and using the ball will not give the opponent enough time for defense. Thus, the ability of speedor speed comes to the forefront as the most important motor characteristic of handball. Likewise, Handball is a sport branch that requires powerful effort composed of defense and offensive organizations to carry out walking, passing, bouncing, shooting, block, short distance fast running (Marques et al., 2011). Subsequently, plyometric exercises first appeared in coaching texts in the 1960s (Radcliffe & Farentinos, 1999). In plyometric exercises, the sudden lengthening and shortening of muscle length by the contraction and stretching of muscles result in a rapid release of energy stored inthe muscles, because of these exercises simultaneously enhance important abilities, i.e. power, speed and endurance. Perhaps one of the most successful methods is the one that involves plyometric exercises (Boumpa, 2005). Apart from, plyometric exercises have shown to improve jump performance in many sports. These exercises combine strength with speed of movement to produce power. Similarly, plyometric exercise involves starting, stopping, and changing movement directions that contribute to agility development. Besides that, in relation to rank plyometric method is the most frequently used method for conditioning in handball (Lehnert et al., 2009). On the other hand, plyometric

training involves exercises designed to produce fast, generate quick, and improve the functions of the nervous system as well as the purpose of improving performance in sports to powerful movements involving explosive concentric muscle contraction preceded by an eccentric muscle action (Chu, 1998). These types of explosive muscular contractions are in practical instances such as jump shot in handball. In fact, plyometric is a type of training that develops the ability of muscles to produce force at high speeds in dynamic movements; these movements involve a stretch of the muscle immediately followed by an explosive contraction of the muscle. This pattern of muscle contraction is also known as the stretch-shorten cycle (SSC). From this, motor ability, sprinting, jumping, flexibility and throwingaccuracy represent physical activities that are considered as important aspects of the game and contribute to high performance of the team (Zapartidis et al., 2009b). Plyometric movements, in which a muscle is loaded and then contracted in rapid sequence, use the strength, elasticity and innervations of muscle and surrounding of hopping, skipping, jumping and throwing activities designed to make the athlete faster going from slow muscles to fast muscles requires performing quick, "explosive" movements (Pallav, 2015). These activities must allow for minimal contact with the ground (lower body) or the hand contact surface (upper body). Plyometric is the best answer for these types of exercise needs. A lower body plyometric exercise emphasizes quick foot movements and the ability to get off the ground quickly. Upper body plyometric exercises emphasize using medicine balls to teach the muscle to respond more quickly to external forces (Salvi, 2012). Competitive handball players are required to throw the ball with both high velocity and accuracy.Speed and accuracy have been frequently analyzed in team handball players both expert and novice levels (Rousanoglou et al., 2014).

Statement of the problem

Handball is intense and one of the fastest team sports, characterized by repeated jumps, sprints, changes in direction, body contact at high speed, and specific technical movement patterns occurring in response to the varying tactical situations of the game (Karcher & Buchheit, 2014). Handball players undergo various types of training to maximize their performance. A Plyometrictraining program has been advocated as a suitable technique for sports, which need vertical jumping ability and explosiveness improvement (Karadenizli, 2016). Generally, plyometric training is the best way to provide power / speed to react immediately during the game and to provide the player to jump higher and to improve the jumping ability of the leg muscles (Zeynep,2013). According to Muller, (2008) stated that, in team handball, shooting on goal is one of the most important aspects of the handball game. Shooting the ball hard is not enough to beat a good goalie; accuracy is essential. Shooting for the corners is one of the important principles of shooting. For a shot to be successful, it requires maximum ball velocity and precision as well as an element of surprise for the defensive players and goalkeeper. In handball players perform, more often repeated short sprinting with change of direction. However, plyometric drills usually involve stopping, starting, and changing directions in an explosive manner. These movements are components that can assist in developing agility (Miller et al., 2006). For handball players, successful match performance requires several physical attributes such as speed, power, strength and agility, plus the ability to maintain performance during repeated sprints (Michalsik et al., 2013). All training activities were only handball game oriented exclusive of incorporating physical fitness exercises. This attitude might arrange players developing poor fitness levels in opposition to predictable norms. In fact, players showed restriction on their physical fitness qualities and skill performance when the researcher's observation in their training program. Accordingly, the investigator believes that if the trainer gives enormous concentration to plyometric training on their training program, it would have an impact on players shooting performance and physical fitness. Researchers have carried out many studies to investigate the effect of plyometric training on the physical demands of handball players and they have drawn different conclusions. Conroy (1998) came to conclude that plyometric training does not have a significant effect on the athletes' speedand does not decrease their time. Conroy (1998) also concluded that plyometric training did not lead to a significant difference between a control and experimental group in terms of improvement in the vertical jump. However, other research demonstrates that plyometric traininghas a positive effect on the vertical jump and increases it (Shahdadi, 1999), this indicates that there is a controversial research issue regarding it and this requires a comprehensive investigation. Reaching athletic achievement is necessary and many necessary requirements to work to raisethe level of athletic performance and fulfill the best achievements. This can be achieved through the best methods and ways that can achieve it. Thus, several coaches in several countries adoptedplyometric training methods and they achieved advanced results in volleyball, handball, basketball, football and arena games, swimming, gymnastics and weightlifting. That is, plyometric exercises and good level of techniques work together to enable the progress in the level of achievement of various sporting events and skills

(Bastosi, 1999). It is worth indicated that some important and extremely common activities in handball include: jumping and shooting over the head of the opponent into the goal (Shahdadi, 1999), the player's shooting at a speed of more than 70 miles per hour (Amirtash, 2006) and passing the opponent around 6 and 9 meter lines of the handball court and 30 meter speed, which are effective features for elite handball players to execute counterattacks (Agha & Ghahremanloo, 2007). All of these abilities have a substantial impact on the result of a match and they are suitable predictors of successful performance in handball, which determine the winner and the loser. Numerous studies have discovered positive effects of short-term plyometric training on jumping performance in basketball (Matavulj et al., 2001); soccer (Ramirez-Campillo et al., 2014); volleyball (Milic et al., 2008); handball (Chelly et al., 2014) and other team sport games, there is expensive tiny data around their particular impact on handball physical skills. These studies as of now appeared that plyometric training significantly improved jumping performance. However, there has been no other specific research focused on the effect of plyometric training on shootingperformance and other physical requirements of handball. Thus, this study aims to bridge the gap by investigating in detail about the effects of plyometric training on shooting performance and physical fitness qualities of handball players.

Concept of Plyometric training

Plyometrics have been used for many decades in the Russian and eastern European training of track and field athletes. Verkhoshanski, a well-known track and field coach in Russia, began the concept that he referred to as shock training or jump training. However, former Purdue University women's track coach Fred Wilt first coined the actual term plyometric in 1975. The word plyometric is actually a derivation from the Greek words plythein or plyo, which means to increase and metric, which means to measure. Consequently, the purpose of plyometric may be thought of as "to increase the measurement." Typically, the measurement is sports performance outcomes demonstrated in testing or competition such as throwing, serving velocity, jump heightor sprint speed (Davies, 2000). Conceptually, plyometric training is characterized by the operation of the stretch-shortening cycle (SSC), which is the mechanism underlying the tissue response contractile and elastic elements and pointed out that their different length shortening behavior was vital in movements. Moreover, the power/strength produced during the initial phase of the stretch-shortening cycle positively influences neuromuscular control and joint stabilization (Mikulic, 2010). Thus, plyometrics, which is the exercise the athlete performs) also known as "jump training" or"plyos", are exercises based on maximum muscle force production in a shortest possible time to improve speed and power. Plyometric exercises involve rapid stretching (i.e. lengthening) of a muscle immediately before a rapid concentric contraction. This combined action is commonly called the stretch shortening cycle (SSC) (Hermassi et al., 2014). A popular type of training exercise is plyometric training (Zatsiorsky, 1995). This type of training uses jumping exercises to involve the neuromuscular system in rapid force development and improved use of tissue elasticity to improve power, rate of force development, and the abilityto absorb force. Besides, plyometric training is very stressful, but the stress comes from the mechanical impact demands placed on relevant tissues and the ability of the nervous system to respond rapidly to these quickly applied forces. It is essential that the musculoskeletal system is given time to adapt to the demands of plyometric training programming. Plyometrics are merely a part of an overall strength training and conditioning program that includes strength, speed, agility, aerobic and anaerobic training, flexibility training, and proper nutrition. Plyometrics have a purpose, which is usually described as power and speed training, but plyometrics are not a panacea (Lindstedt, 2003). Plyometrics, virtually all of the things required during athletic events involve one's ability to exert force in a rapid manner. This ability to exert force can be in the form of jumping, hopping, and changes of direction. Improving one's ability to exert force in a rapid manner can have a positive influence on sports performance. Priorto improving one's ability to exert force rapidly, it is important that athletes can absorb force during various movements. Improving absorption of force involves an adequate strength base, and strong and elastic connective tissue. Plyometric training considered to enhance the muscle's ability to utilize SSC. SSC is an eccentric contraction (where the muscle and tendon lengthens under contraction), which isimmediately followed by a concentric contraction (Asadi et al., 2016). Use of SSC during plyometric exercises enables the muscle-tendon unit to produce the maximum amountof force in the shortest time possible. Due to this, and the fact that SSC is an integral part of athletic actions, it is important to include plyometric exercises into an athlete's training plan (Requena & Cronin, 2012). Plyometric training is defined as a quick, powerful movement involving an eccentric contraction followed immediately by an explosive concentric contraction (Verhoshanski, 1983). This is accomplished through the stretch-shortening cycle or an eccentric-concentric coupling phase. The eccentric concentric coupling phase is also referred to as the integrated performance paradigm (which states

that in order to move with precision, forces must be loaded (eccentrically), stabilized (isometrically), and then unloaded/accelerated (concentrically). Plyometric exercise stimulates the body's proprioceptive and elastic properties to generate maximum force output in a minimum amount of time (Brady, 1992). Plyometric training is an effective mode of training as it enhances motor learning and neuromuscular efficiency promoting the excitability, sensitivity, and reactivity of the neuromuscular system to increase the rate of force production (power), motor-unit recruitment, firing frequency (rate coding), and synchronization (Jack, 2013). All movement patterns that occur during functional activities involve a series of repetitive stretch shortening cycles. Besides that, the neuromuscular system must react quickly and efficiently following an eccentric muscle action to produce a concentric contraction and impart the necessary force (or acceleration) in the appropriate direction. Therefore, specific functional exercises that emphasize a rapid change in direction utilized to prepare each athlete for the functional demands of a specific activity. This training provides the opportunity to train specific movement patterns in a biomechanically correct manner at a more functionally appropriate speed. This provides functional strengthening of the muscle, tendon, and ligaments specific to the demands of everyday activities and sports. Apart from this, the ultimate goal of plyometric training is to improve the reaction time of the muscle action spectrum (eccentric deceleration, isometric stabilization, and concentric acceleration). From this, the speed of muscular exertion is limited by neuromuscular coordination. This means that the body will move most effectively and efficiently within a range of speed that the nervous system has programmed to allow. This training improves both neuromuscular efficiency and the range of speeds set by the central nervous system. From that, optimum reactive performance of any activity depends on the speed at which muscular forcescan be generated (Wilkerson, 2004). The mode of plyometric training is determined by the general part(s) of the body that are performing the given exercise. For example, a depth jump is alower body plyometric exercise, whereas a medicine ball chest pass is an upper body exercise (Potach, 2000).

Training fitness

Athletes prepare to achieve a specific goal through structured and focused training. As the intent of training is to increase the athlete's skills and work capacity to optimize athletic performance. That is training undertaken across a long period and involves many physiological, psychological, and sociological variables. During this time, training is progressively. Throughout training, human physiological and psychological functions are modeled to meet demanding tasks (Bompa & Gregoryhaff, 2009). Training is a process of preparing an individual for any event. Usually in sports, we use the term sports training to denote a well-planned training program, preparing players for attaining the highest level of sports performance. However, nowadays individuals who take up physical activity do so either for health and fitness or for competing in sports at different levels. Hence, sport training involves physical, technical, Intellectual, psychological and moral preparation of sports persons through physical training (Dibakar & Ezhilmaran, 2016). Sport training is a process of athletic improvement, which is conducted based on scientific principles through systematic development of mental and physical efficiency, capacity andmotivation, enables athletes to produce outstanding and record-breaking athletic performance (Harre, 1982).

Variables of training

The efficiency of a physical training program results from the manipulations of volume (duration, distance, repetitions, or volume load), intensity (load, velocity, or power output), and density (frequency), which are key variables in training. These variables should manipulate according to the functional, physiological, and psychological requirements of the training goal or competition. Thus, when designing the training plan, the coach must first decide which variable to emphasize to meet the performance objective. The manipulations of these variables will establish distinct training-induced outcomes that can significantly affect the athlete's performance (Bompa & Gregoryhaff, 2009).

Intensity: - Exercise intensity is a measure of "how hard is the exercise and is related to the power output. The exercise intensity lies somewhere on a continuum between rest (basal metabolic rate) and maximal effort, which coincides with the maximal oxygen uptake for that activity. Exercise intensity can be monitored by measuring sub maximal oxygen consumption (Daniels, 1985), heart rate (Lambert et al., 1998), blood lactate (Swart, 2004), the weight lifted during the exercise (Sweet et al., 2004), or the perception of effort (Foster et al., 2001). Training intensity is the major training stimulus that influences adaptation and performance. Athletes advised to incorporate high intensity training into their training programs after they have developed a sufficient base (Laursen & Jenkins, 2002). If too much high intensity training is carried out the athlete will be at risk of developing symptoms of fatigue associated with over reaching (Meeusen et al., 2006) and overtraining or will increase the risk of getting injured (Noakes, 2001). The intensity of plyometric drills typically classified as low, medium, or high. When the athlete

reaches high-intensity levels, volume should decrease. The intensity of plyometric drills for the lower extremities related to foot contacts, direction of jump, speed and jump height (Namrata, 2014).

Volume: - Volume of training under prescription of training volume may lead to not achieving the desired improvements in strength and muscle performance, and over prescription of training volume may lead to overtraining and overuse injuries. As a result, the optimal number of sets remains an extreme (Wolfe et al., 2004). Lower body plyometric volume typically expressed as the number of foot contacts, whereas Upper body plyometric volume expressed as throws of the medicine ball or distance jumped. Adolescent athletes should perform low-impact plyometric training once weekly to increase lower-body power resulting in increased vertical jump and kicking distance (Kisnerwilk, 1993).

Frequency: - Training frequency refers to the number of training sessions in a defined period. Training frequency may vary depending on the sport, level of performance of the athlete, and stage of training cycle (Smith, 2003). Plyometrics should not perform more than two to three times per week unless you are alternatingdays of upper and lower body plyometric drills. Off-season plyometric routines performed twice per week. In season, one session per week is appropriate for most sports. Track and field athletes may perform two to three times per week (Namrata, 2014).

Duration: This refers to the time or amount of the exercise session. This is sometimes confused with the volume of training, which quantifies training over a period and combines duration and frequency (Smith, 2003). Athletes competing at the international level need to train for approximately 1000 hours per year (Bompa, 1999).

Rest and recovery

Rest and recovery are important, often neglected principles of training. Factors that need to consider during the recovery process after a training session are as follow:

Age**: -** Athletes older than 25 years need longer recovery periods than younger athletes (Bompa, 1999).

Environmental conditions: - Training and competing in the heat imposes more physiological stress on the athlete and requires a longer recovery period (Noakes, 2001).

Type of activity: - Training and competition that induces muscle damage requires longer recovery periods than activities that cause fatigue but no muscle damage or soreness. Evenwithin a specific sport the demands on the players vary depending on their playing position (Takarada, 2003). Ideally, the recovery for each player should customize. It recommended that players are monitored using subjective and objective strategies to ensure that the recovery period is customized (Lambert & Borresen, 2006). A practical tool developed to assist coaches and athletes with monitoring recovery (Kentta & Hassmen, 1998). The work to rest ratio should be 1:5 to 1:10 to be certain that the intensity and proper execution of movement are preserved. It suggested that 1 to 5 minutes of rest needed between plyometric exercises, depending upon the intensity and volume of the workout. Recoveries between sessions recommended to 48-72 hours (Chu, 2000).

Basic principle of training

A plyometric training program should respect basic training principles including the principle of specificity (Bompa & Carrera, 2005). In planning a training program, there are some basic principles that need to be considered. They discussed under the following:

Progression

Plyometric exercise is a form of resistance training and thus must follow the principles of progressive overload a systematic increase in training frequency, volume, and intensity by various combinations. Progressive overload is an essential component of any resistance-training program whether it may be for improving muscle size, strength, or power (Winett & Carpinelli, 2001). To sustain increases in muscle development and performance one constantly needs to progress the program by gradually increasing the demands placed on the body (Rhea et al.,2003). This incorporated into a training program by manipulating any of the following training variables appropriately: increasing the frequency of training; increasing the repetitions in each metabolism that occurs towards the end of a marathon. An advantage of this strategy is that a metabolic overload is imposed without the same mechanical muscle stress and damage that occurs towards the end of a marathon.

Phases of Plyometric training

Both lower extremity (LE) and upper extremity (UE) sports use the plyometric concept as part offunctional movement patterns and skill when performing the sport. Plyometric training utilizes the stretch-shortening cycle (SSC) by using a lengthening movement that is quickly followed bya shortening movement (Ebben & Jensen, 2008). There are three distinct phases involved in plyometric training including the eccentric or loading phase, the amortization, or transition phaseand the concentric or unloading phase (Chmielewski, 2006).

The Eccentric phase

The first stage of a plyometric movement classified as the eccentric phase, but it also been called the deceleration, loading, yielding, countermovement, or cocking phases (Lundin, 1985). This phase increases

muscle spindle activity by pre-stretching the muscle prior to activation. Potential energy is stored in the elastic components of the muscle during this loading phase. A slower eccentric phase prevents taking optimum advantage of the myotatic stretch reflex.

The Amortization phase

This phase involves dynamic stabilization and is the time between the end of the eccentric contraction (the loading or deceleration phase) and the initiation of the concentric contraction (the unloading or force production phase) (Wilk, 1993). The amortization phase, sometimes referred to as the transition phase, is also referred to as the electromechanical delay between the eccentric and concentric contraction during which the muscle must switch from overcoming force to imparting force in the intended direction A prolonged amortization phase results in less- than optimum neuromuscular efficiency from a loss of elastic potential energy (Swanik, 2004). Arapid switch from an eccentric contraction to a concentric contraction leads to a more powerful response. One of the primary goals of plyometric training is to decrease the time to rebound phase.

The Concentric phase

The concentric phase (or unloading phase) occurs immediately after the amortization phase and involves a concentric contraction resulting in enhanced muscular performance following the eccentric phase of muscle contraction. This occurs secondary to enhanced summation and reutilization of elastic potential energy, muscle potentiating, and contribution of the myotatic stretch reflex (Rassier & Herzog, 2005).

The elastic properties of muscle

Muscles modeled with a contractile element and two elastic elements that are named according to their relationship to the contractile element one in line with (the series elastic element) and one in parallel (the parallel elastic element). When a muscle contracts, tension is not directly transmitted to the ends of the tendon and load not overcome, leading to movement. This would only happen if the connection between the contractile element and its insertion were rigid and inelastic. In reality, the contractile element develops tension, stretching the series elastic element;the degree of stretch is dependent on the load moved. After sufficient tension is generated, the tension at the ends of the muscle is sufficient to overcome the load and the load to move. When aload is applied to a joint (eccentric phase), the elastic elements stretch and store potential energy (amortization phase) prior to the contractile element contracting (concentric phase). An eccentric contraction immediately preceding a concentric contraction significantly increases the force generated concentrically because of the storage of elastic potential energy (Newton, 1999). During the loading of the muscle, the load transferred to the series elastic components and stored as elastic potential energy. The elastic elements then contribute to the overall force production by converting the stored elastic potential energy to kinetic energy, which enhances the contraction (Bosco, 1982).

The muscle's ability to use stored elastic potential energy affected by the variables of time, magnitude of stretch and velocity of stretch. Increased force generation during the concentric contraction is most effective when the preceding eccentric contraction is of short range and is performed immediately (Wilson, 1991). A simple example of the use of the energy stored in the elastic element is the basic vertical, or countermovement, jump. The initial squat (the countermovement) is the eccentric phase that stretches the elastic elements and stores elastic energy (amortization phase). When the jump is performed (the concentric phase), the stored energy is "added" to the tension produced leading to a higher jump. The amount of stored energyused is inversely proportional to the time spent in the amortization phase. When doing a vertical jump, the longer one waits at the end of the countermovement before performing the jump, the lower the eventual jump height due to the inability to recover the stored elastic energy.

Physiology of plyometric training

Plyometric training utilizes the elastic and proprioceptive properties of a muscle to generate maximum force production by stimulating mechanoreceptors to facilitate an increase in muscle recruitment in a minimal amount of time (Wilk, 1993). Muscle spindles and Golgi tendon organs (GTOs) provide the proprioceptive basis for plyometric training. The central nervous systemthen uses this sensory information to influence muscle tone, motor execution, and kinesthetic awareness. Stimulation of these receptors can cause facilitation, inhibition, and modulation of both agonist and antagonist muscle activity. This enhances neuromuscular efficiency and functional strength (Astrand, 2003).

Plyometric training program and Design Guidelines

A systematic and progressive plyometric training program is a vital component of any integrated training program. As plyometric training is one of the more advanced training tools, the athlete needs proper levels of flexibility, core strength, and balance before progressing into plyometric training. Besides that, sport performance professionals must follow very specific program guidelines, proper exercise selection criteria, and detailed program variables for the best outcome and lowest risk of injury (Voight, 1992). According to (Potach & Chu, 2000), Plyometric, like other forms of training, are usually only performed

two or three times a week. Training should occur in a non-fatigued state. Therefore, these exercises should not perform after resistance training or aerobic conditioning. Ample rest between sets should be used in order to avoid turning these speed and power enhancing exercises into endurance training. Generally, rest five to ten times more than it takes you to perform the setof plyometric. Thus, if you do a set of multiple hops that takes four seconds, you should rest 20to 40 seconds prior to the next set or exercise. Another good rule to follow is to limit your sets to no more than 10 repetitions. In fact, it is probably good to use a range of repetitions such as sets of one, three, five, and ten repetitions in order to train explosiveness as well as power endurance across a continuum. The amount of plyometric training or volume performed in any given training session measured by the number of foot contacts. Beginners often perform approximately 80 to 100 foot contacts per session (Potach, 2000). However, half of that amount may be appropriate, particularly for children, older adults, or those who are untrained. Obviously, exercise intensity is an important consideration as well. Eighty-foot contacts of a variety of line hopes, cones, and ankle hopes is dramatically less intense than 80-foot contacts of high box depth jumps, single leg jumps, pike jumps, and maximal overhead jumps and reaches. From the point of view, plyometric programs should start with low intensity exercises. Over time, moderate and eventually higher intensity exercises are incorporated for those who are healthy and fit. The program increases the volume (foot contacts) to a point and then volume eventually decreases as exercise intensity increases, in order to reduce exercise fatigue and increase adaptation to the program.

Pre consideration of plyometric training

Plyometric exercise is not inherently dangerous; however, as with all modes of exercise, injury risk is present. Injuries may occur following an accident, but they more typically occur when training procedures violated and may result from an improper program design, inadequate instruction and supervision, or inappropriate training environment. Personal trainers must understand and address these and other risk factors to improve the safety of the athletes performing plyometric exercise **(**Lachance, 1995). Plyometric are a very high intensity form of training, placing substantial stress on the bones, joints, and connective tissue. While plyometrics can enhance an athlete's speed, power, and performance, it also places them at a greater risk of injury than less intense training methods. Prior to starting a program there are several variables to consider so the training sessionsperformed in a safe and effective manner (Namrata, 2014). A person should have an adequate base of muscle strength and endurance as well as flexibility of the muscles exercised. Criteria to begin plyometric training usually include 80% to 85% level of strength and 90% to 95% range ofmotion (Chu, 2000). Power squat test is a good closed chain exercise to determine whether an athlete has an adequate strength base for lower extremity plyometric. It performed with 60% of an athlete's body weight. Squat repetitions done in 5 seconds, and the depth should be knee flexion close to nine for each repetition. Although static stretching is important in the performance of plyometrics, some ballistic stretching is demanded. Individuals must be able to perform a 30 seconds one-leg stance with eyes open and closed for proprioception and single leg half squat for strength (Tippett, 2001). For shock and high intensity lower extremity plyometric, it recommended that healthy athletes have enough leg and hip strength to be able to perform a squat with 1.5 to 2.5 times the athlete's body weight. For high intensity upper extremity plyometric, it suggested that an athlete be able to perform five clap push-ups in row (Paavo Komi, 2000).

Benefit of Plyometric Training on handball players

Plyometric training is widely known as a potential tool for improving functional sports performance. During Plyometric training, the muscles switch rapidly from an eccentric to a concentric phase of contraction. The decreased duration of the amortization phase exploits storedelastic energy and the stretch reflex, allowing a greater than normal release of power during the concentric phase of movement (Ramirez-Campillo, 2015). A Plyometric training program has been offered as a suitable methodology for sports, which need vertical jumping ability, explosiveness and shooting ability improvement. In general, plyometric training is the excellent way to offer speed or power to react directly during the handball game. In addition, it is used to give the players to jump higher and to enhance the jumping capacity of leg muscles. This program offers functional intensification of the tendon, ligaments and muscle particularly to the everyday demand sports and activities. This plyometric training program covers a learning practice requiring an efficient design as well as application with maximum care (Surendra, 2017). Plyometric training programs are often implemented during the pre-season to bring young players to an appropriate initial level of fitness. In addition, it is strongly recommended that handball coaches implement in-season plyometric training to enhance the performance of their players. It is repeated into the standard training improved parts, which are important to handball performance, particularly, the explosive actions, such as sprinting, jumping and ball throwing velocity. Apart from this, plyometric training programs can also improve the physical performance of the lower body in young handball players (Van den Tillaar et al.,

2013). Plyometric training program is the most generally used in distinctive speed force and explosive power development for various sport related activities, which need the incorporation of the greatest speed with highest force of muscle, in which this technique contributed in triumphing over or overcoming the issues that characterize force development (Benzidane, Bensikaddour & Mokrani, 2015). Plyometric training program also contributes to the enhancement of attainment, particularly in activities that employ explosive muscular contractions and plyometric training program in the short term is more efficient to the growth of strength muscle and anaerobic capacity (Sofiane, 2011). Plyometric training of the lower extremities has been shown to increase sprinting speed or velocity. Sprinting velocity is important for sports requiring quick bursts of speed or repetitive change of direction. This is valuable for sports like soccer, handball, volleyball and tennis (Chaouachi, 2014). Plyometric training programs can increase maximal vertical jump height including various jump training programs ranging from six to 24 weeks, including pre-pubertal, pubertal, and adult athletes (Turner, 2003). Plyometric training has been an effective method for the improvement of agility, sprinting, and jumping ability and it also been reported to improve running economy, joint stability, increased joint awareness and decrease the severity of knee injuries (Watsford, 2003) and sprint times decrease (Rimmer & Sleivert, 2000).

Shooting performance in handball

For an effective shooting, the ball must go at the highest speed and aim at the target. Therefore, players must maintain these two parameters throughout the game (Manchado et al., 2013). Players must increase their chances of scoring as fast as possible to score goals (Gorostiaga, 2005). However, about shooting performance, it is thought that reaching the goal in handball should include shooting accuracy. Shooting ability depends on the speed and accuracy of the ball that the players must maintain these two parameters during the competition. As the effect ofthese two parameters can be reduced during the game so; the regular and planned strength, speed strength and technical training programs should be implemented (Zapartis et al, 2007).

Handball shooting

Shots are one of the most important elements of handball. They are vital elements that decide the scores. While shooting the muscles of the lower and upper limbs, the pelvic region and trunk are extremely engaged. One can assume that shooting is performed similarly to passing, but with a stronger action of the trunk and upper limbs. The shot power is conditioned by the distance and hand action time on a ball. The greater the distance that the hand on the ball covers in the time unit the stronger the shot will be (a ball reaches a higher velocity) performed (Janusz & Frantisek, 1997). Shot or throw is the culmination of offense aimed at scoring a goal. This element of technique of handball play directly affects the success of the player and the team regarding the result. That is exactly the reason why many players and coaches observe the shot as the dominant element of handball play and devote it more time in the training process than other elements of the techniques devote. Opinions of handball experts differ in terms of importance of individual elements of handball technique, but they agree that shot is a relevant and important factor (Sinisa, Danijel & Tijana, 2018). In order to achieve success in handball players have to fulfillthe basic aim of scoring. Apart from this accuracy and velocity of the shot, it increasingly gained significance in the result outcome of the handball game.

Types of handball shooting

According to (Clanton & Dwight, 1997), there are four basic shots in team handball.

Set shot is the most natural of all shooting actions and is simply the overhand pass thrownhard. For the set shot to be effective, it must perform quickly. In the preparation phase of movement, the player runs to get into the shooting position. The momentum created frombeing in motion will increase the power of the player's shot. Players attack using three steps and during the second step, the ball is brought up to head height. Elbows are flexed to 90 degrees or greater. At that time, all of the body weight should be on the back foot, upper body should be upright and shoulders perpendicular to the goal. Players should keep their head up and eyes on the goalie. In the execution phase of movement, to shoot step forward and transfer body weight from rear foot to front foot. Shoulders rotated and opened for being parallel to the goal. Player begins moving the arm forward by leading with the elbow, then whip forearm and snap the wrist. In the follow-through phase of movement, momentum of the body continues forward and the motion of the throwing arm continues across the body. The referee awards a 7-meter throw when a fault obstructsa clear scoring opportunity.

Jump shot is the most used shot in team handball. Developing the ability to jump and shoot over the defense, as well as jumping inside the goal area, will make athletes a more effective scoring threat.

Wing shot is the jump shot performed at a difficult shooting angle.

Fall shot is the basic technique of the circle runner. It allows receiving the ball on the 6- meter line and shooting without using three steps.

The referee awards a 7-meter throw when a fault obstructs a clear scoring opportunity. Generally, the set shot and the fall shot are used for a 7-meter shot.

The 7-meter throw is an important part of the game to go scoring (THF, 2010).

Shooting accuracy

Accuracy is one of the most important terms in order to reach optimum results in team handball because of being high intensity intermittent types of sport (Beyza, 2012). That is, accuracy is the distance from the desired point of impact of the projectile and the actual point of impact on the target. Success or failure depends on whether a team attains its ultimate aim, that of scoring a goal. Throwing efficiency is the key to winning or losing matches and has been the subject of various studies (Marques et al., 2007). The factors that determine throwing velocity are technique; coordination and maximum explosive power of the muscles in the upper and lower body, hence the importance of developing training methods that improve both accuracy and throwing velocity (Manchado et al., 2013. Accuracy and throwing velocity in handball are regarded as basic parameters of performance during competition (Hore, 1996). The main objective of the competition in the game of team handball is to score the ball into the opponent's goalkeeper team from a convenient location without the presence of blocking defenders. From this point, shooting is considered as one of the most important offensive skills that play a major role in tip the team on the other. Besides that, the goal of proficiency and mastery of the fundamental skills provides an opportunity for one of the attackers to reach a suitable place to hit the target in different ways, without potential hazard. On the other hand, the most common shooting in team handball against the goalkeeper was done by executing the upward leap (up forward) in the games. As this, two basic factors are of importance with regard to the efficiency of shots: accuracy and throwing velocity of the faster the ball is thrown at the goal, the less time defenders and goalkeeper have to save the shot (Kilani & Finch, 2001). By training, physical fitness and technique can be improved, while biomechanical variables could halt. The offensive players, however, attempt to throw a ball on goal from a position without being tackled or obstructed by the opposing defensive players. In competition, 73-75% of all throws during the game constitute jump throws, followed by the standing throw with run-up (14- 18%), penalty throw (6-9%), diving throw (2-4%) and direct free throw (0-1%) (Wagner et al., 2008).

Agility in Handball

Agility is an ability to change direction accuracy and quickly while moving rapidly. It is obviously necessary for a successful handball player. The sudden change of direction, thetwisting and rapid running and forward running backward are the hallmarks of quality players of agility (Bhupinder, 2013). The rate of coordination (agility) in handball dynamics has changed so suddenly that the athlete must quickly change direction, with the lowest stall and accelerate back towards where it came from. To increase braking ability rapidly to a rapid movement in the other direction, you need to train these agility movements. Rate of coordination is found in the structure of the following points and action both technical and tactical: changes in direction ofthe ball or without the ball, branding, passing the ball coming successively with the threat score, the movement of the fundamental position laterally, forward, and backward and attacking the opponent with the ball (Cazan et. al., 2013). Handball involves multidirectional changes of direction (Massuca et al., 2014). Athletes often perform stop-and-go changes of direction in a response to unpredictable stimuli (ball, opponent etc.) over a relatively small court (Karcher, 2014). Quick starts, stops, and changing direction fast are the fundamentals of handball performance. In the game of handball, diverting of the ball occurs very frequently, the players must be ready to receive the ball and act accordingly for that agility required (Pankaj, 2019). Agility is helpful for handball players in various aspects in a game situation during one to one faint, group tactics, dodging, scoring the goal & it is helpful for pivot players (Singh & Deol, 2016).

Speed in handball

Speed is one of the essential components in handball to shoot and to travel from one corner to thefore court. It also depends on reaction time that a player moves to score to the opponents and in the same way, he is reacting on the return from the opponent court. Speed directly influences the capacity of handball players to exert the maximum force in the shortest possible time (Bhupinder, 2013). The value of a handball player lies to a large extent on the qualities that are trained in including speed in the scope and the basis of which currently principles and skills are required for the development of the tactical and technical content specific to the modern game handball teams practiced by the best teams in the world. Specialists in the field claim that the shares of the motive power of the handball game implies in competition and especially in the preparation, a mixture between heavy proportion of strength, resistance, speed, the suppleness and skill (Marques, 2006). Handball players are required to cover distances from 20 to 30 meters with maximal speed in the transition from defense to offense or, after a ball loss, to prevent a fast break (Hermassi et al., 2014; Ingebrigtsen et al., 2013). Speed training in handball to aspects of running that are observed in handball: starting speed, acceleration, running lengths of between 5m and a maximum of 30m (in fast breaks), possibly combined with a change in direction for elite and sub-elite team handball

players have indicated that strength, jumping abilities and maximal running speed have an impact on performance (Buchheit, 2009). As it happens in most team sports, the handball players are required to have the ability to speed off with maximum speed on distances of 20 to 25 meters and to be able to repeat these sprints several times during the game (speed - resistance, power - resistance). The ability to run and sprint repeatedly at high intensity is of paramount importance for success (Souhail, 2010). Speed consists of a number of components all of which are independent qualities: acceleration speed, maximum speed, and speed endurance. Performance in the 10-m sprint is influenced by acceleration speed, while performance in the 40-m sprint is dependent on both acceleration speed and maximum speed. Speed improved by increasing the power to weight ratio. As this, plyometric training (i.e., counter-movement jumps or loaded squat jumps) is effective for improving speed (Cronin & Hansen, 2005). According to (Cazan et. al., 2013), in handball, game can identify the following attributes and skills specific, which must measured:

The starter speed: when fighting directly to the opponent, related to the limited space and land, it is very important that the player have a quick start so as to exceed the opponent directly. This can only be achieved if at the beginning of muscular contractions, the athlete is able to generate a maximum of force, and create an initial speed high. Speedstart encountered the structure following moments and share technical and tactical actions: triggering counter attack quickly re ball after the goal, debranding place open to receive the ball, crossing steering ball or without the ball, branding directly or indirectly penetration among defenders, defensive retreat after losing the ball or after a goal is scored, the input intercept the balls.

The rate of acceleration: In a very short time from the start of the race, the athlete reaches the maximum speed. This time depends on the strength and rapidity of the muscle contraction, while the acceleration power depends on both the arms and legs. Speed acceleration reached in the following moments of structure and technical and tactical actions: counter, quick, throw the ball after the goal, crossing the ball or without the ball direction, branding and defensive retreat after losing the ball or after a goal scored.

Speed acceleration: Speed acceleration found in the following moments of structure and technical and tactical actions: counter, quick, throw the ball after the goal, crossing the ball, without the ball direction, branding and defensive retreat after losing the ball or aftera goal scored.

Explosive power in handball

Power is an important factor in handball, highlighted in game situations involving sprinting, changing of direction, jumping and physical contacts with the opponent. However, since theforce actions repeated several times during the game, the power resistance has to be trained (Buchheit, 2008). Vertical jump capability is critical for success in handball. From this, jumping is utilized during the jump shot, jump attack from attack line, blocking and defending the opponent for a successful player must not only be able to jump high but must also be able to reach that height quickly. This requires an ability to generate power in a very short time. It is a value signifying some significant and very general activities in handball namely, jumping as wellas shooting over the opponent head into the target (Ghuman & Godara, 2013). Vertical jumps and hops are used to increase the explosive power of the lower extremities (Ebben, 2005). Explosively in handball, motion translates into speed, the detention and the maximum force, so the force is likely to be mobilized and used in a very short time in a specific gesture (neutralization striker, 1 against 1) (Negrea & Cazan, 2011). It is a capacity to release the maximum force in the shortest time quickly. A power player is not only strong but generates the force quickly. The handball player makes a powerful shooting or power of legs when jumping to words for an attack and available to clear the court from the back rear court. The power is also known as the strength ability of the player is during the use of power in shooting, throwing & passing. The players are used to having fall strength in their body muscles of both lower and upper extremities (Bhupinder, 2013). Muscle power, which is a function of the interactionbetween force of contraction and the speed of contraction, is associated with the explosiveness ofthe muscle. The relationship between force and speed of contraction and the subsequent point at which peak power occurs varies between athletes (Jennings et al., 2005). A fundamental way of increasing muscle power is to increase maximal strength, particularly in untrained athletes.

Recommendations

Based on the results of the research it can be submitted recommendations as follows:The present investigation indicates that plyometric training using shooting accuracy, hexagonal obstacle, flying 30 meter, and vertical jump had a substantial impact on several parameters important to handball performance, including shooting performance, agility, speed and explosive power. Furthermore, the data suggest that such an intervention is implemented within the training regimen without adversely affecting other aspects of performance. Thus, handball coaches should be encouraged to incorporate plyometric training into the training schedule of their teams, as a simple and practical method of enhancing their

playing ability and then the goal of the exercise achieved.

In handball, agility is one of the important aspects that influence the player's skills. Hence, the plyometric training would improve the playing ability by giving much more training by increasing the agility. Not only speed and strength are very essential in the game of handball but also power is an important component for handball players. Hence, this type of training may be given to players who need to improve their power. From the findings to conclude that, plyometric training is helpful in improving shooting performance, agility, speed and explosive power in handball players. So this training method is recommended to handball players for improving fitness qualities and skilled performances.

Plyometric training is the most frequently used method for conditioning in handball. Therefore, it would seem highly prudent to implement plyometric training programs in handball training and in team sports abroad, due to its effect on performance.

The plyometric training program should be a part of physical preparation of handball players and it is necessary to raise the awareness of the trainers with the importance of plyometric training in the direction of the skill, because of their significant influence on raising the level of the player physically and skillfully. By its nature handball requires several physical attributes such as speed, power, strength and agility, plus the ability to maintain performance during repeated sprints and to maximize their performance players undergo various types of training. Therefore, in order to succeed: players, coaches, technical committee's and administrators should give plyometric training as well as different types of training.

When applying the plyometric training method, you need to select the loads according to what suits the players' levels. Further studies should be conducted in the same area on different samples in terms of ageand training experience. Moreover, this research is used as an input and experiment of research results if choosing similar problems as the object of research**.**

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