Mechanical Power of Leg Extensor Muscles in Male Handball Players

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Abstract

The present study was conducted on eighteen male Handball players (age: 15.83 ± 0.62 years) comprising of players training under the guidance of Punjab State coaches in Patiala (India). The main objective of the study was to find the status of mechanical power variables of leg extensor muscles in male handball players and to find the relationship between them. The experimental protocol developed by *Bosco et al (1983), Mcguigan et al (2006)* were used to measure the mechanical power variables of leg extensor muscles in male handball players. For the purpose of statistical analysis of the data, Karl Pearson's coefficient of correlation was calculated with the help of SPSS version 9.0. The results of this study indicate that there was a highly significant correlation exists between the squat jump flight time, squat jump height, countermovement jump height, countermovement flight time, Eccentric Utilization Ratio (EUR), Elasticity Index (EI) and peak power (0-15sec), peak power (45-60sec) and Mean Power (0-60sec).

Key words: Mechanical Power, Vertical jump test, Leg Extensor Muscles, Muscular Power.

Introduction

Vertical jump ability is of considerable importance in numerous handball events. Coaches and trainers are greatly interested in developing training techniques designed to improve power performance of the legs and vertical jump ability *(Blattner, 1980)*. There is no doubt that high-level handball practice and the vertical jump is very important for the shooters or defence actions. During the last few years, performing plyometric exercises in general *(Wilt, 1978)* and drop jumps *(Komi and Bosco, 1978)*, also called depth jumps *(Wilt, 1978)*, in particular, has become very popular in training. Increases in vertical jumping performance after drop jump programmes have been reported in several studies *(Blattner and Noble, 1979; Steben and Steben, 1981; Clutch et al., 1983)*. Strength is the ability to produce maximal force, which is considered a basic motor ability and contributes to high performance in most physical activities and sports for prevention of injury *(Coyle et al, 1981, Pangrazi, 1999)*. Numerous studies of young athletes indicate that specific training in track and field, gymnastics, swimming, soccer, basketball improve vertical jumping performance, explosive strength of upper and lower limbs. Soccer, *(Gorostiaga et al, 2002)*, basketball *(Foley 1988, Klizning, 1991)*, volleyball *(Mills et al. 2005)*, and tennis training *(Huff, 1972, Liemohn, 1983)* improve the explosive strength of lower limbs and consequently vertical jumping performance. Very few studies have examined the effect of a handball training program on fitness characteristic in young athletes. Handball is a very dynamic team sport, requiring continuous alterations of intensity and kinetic actions and it is characterized by a great number of side movements, jumps, throws, and body contacts all of which strictly depend on muscular strength. Previous studies have reported that the high performance in many sporting endeavors is characterized by the ability to display high amounts of muscular power. Power is the product of muscular force and velocity or as an instantaneous value during a given movement. The latter, often referred to as peak power (PP), is typically associated with explosive movements such as sprinting, jumping and may be an important variable associated with success in a given discipline. The measurement of Peak Power by strength and conditioning-coaches is an important consideration in the training process. Changes in PP throughout the annual plan may be indicative of training status or adaptation to the workload and could be used to plan or adjust the training program based on the athlete's performance. The knowledge of mechanical power components of lower extremities of athletes of selected game disciplines can be of great interest for coaches and sport scientists to optimize talent selection for sport disciplines where jumping is an integral part of game. Therefore, the aim of the present study was to find the status of mechanical power of leg extensor muscle in male handball players.

Materials & Methods

Eighteen male Handball players with mean age of 15.83 ± 0.62 years; height of 176.61 ± 5.05 cm; body mass of 59.00 ± 6.53 kg) were briefed about the purpose of the study and the experimental protocol *(Bosco et al., 1983, Mcguigan et al., 2006)* to be administered before starting the study on players undergoing training under the guidance of Punjab State coaches in Patiala (India). All the risks involved were also explained to each player and voluntary consent was taken from them. Each volunteer was first subjected to physical examination that included measurements of corporal data like date of birth, age, training age, height, body mass and sports discipline. The participants performed an adaptation process previous to the vertical jump test so that error could be minimized.

The vertical jump test measurement system consisted of a portable hand-held computer unit connected to a contact mat (Swift Performance, New South Wales, Australia). It has been previously reported that the system is reliable compared with a force platform ***(****Cronin et al, 2001****).***

Vertical Jump Tests: Three jumps Squat jump (SJ), Counter Movement Jump (CMJ) and Continuous Vertical Jump Test for 60 seconds (CVJT) were administered according to the experimental protocol *(Bosco et al, 1983, Mcguigan et al, 2006).*

Explosive strength and endurance variables: In this study, Eccentric Utilization Ratio (EUR) was calculated from vertical jump height (CMJ/SJ) or peak power (CMJ/SJ) by using *Sayers et al (1999)* peak power formula. Muscle Elasticity index was calculated from the jump height reached in CMJ and SJ Jumps

(CMJ – SJ *100 / SJ) *(Sayers et al, 1999)*. The explosive strength and endurance variables were power peak (PP), mean power (MP) and fatigue index (FI). Concerning the CVJT (Continuous Vertical Jump Test), the PP was estimated by the mechanical power produced in the first 15 seconds of a 60-second work. The MP was estimated by the amount of work during a 60-second continuous effort. For PP and MP, the results were expressed in watts/kg (W/kg), according to the equation described by *Bosco et al (1983)*. The fatigue Index (FI) was calculated as the difference between the power peak (work produced in the first 15 seconds) and the mean power generated in the last 15 seconds of a continuous vertical jump work of 60 seconds relative to first 15 seconds peak power. The result was expressed in percentage (%).

Test procedure and data collection

The participants were told to perform a 15-minute routine warm-up before performing the tests through stretching, running, coordination exercises and consecutive jumps (two sets of five vertical jumps). Three squat jumps (SJ) and three counter movement jumps (CMJ) were performed in random order on a jump mat connected to an electronic timer without the aid of an arm swing; this was standardized by having participants hold their hands on their hips. Two minutes rest period between attempts was established. The SJ involved the subject flexing the knee to approximately 90 degree maintaining the position for 3 seconds, and then jumping on the command ‘‘go.’’ The CMJ was performed under the same conditions but involved flexion of the knee followed immediately by extension of the legs. Test was executed following the original protocol for both jumps *(Sayers et al., 1999)*. On the next day, again the participants performed a 15-minute routine warm-up before the tests through stretching, running, coordination exercises and consecutive jumps (two sets of five vertical jumps).The participants were told to perform the continuous vertical jump Test (CVJT) during a work performed at maximal effort, with no pauses between jumps for 60 seconds. The subjects were told to keep chest in vertical position, with no excessive advance to avoid influence in the results; as well as to keep knees in extension during the flight, remaining with hands around waist. The participants were given stimulus to jump the highest as possible during the tests.

Statistical Analysis: Mean and standard deviation for all the attributes age, height, body mass and biomechanical transients related to vertical jumps were calculated. Karl Pearson’s coefficient of correlation was calculated with the help of SPSS version 9.0 software to find the relationship between the biomechanical transients. The level of significance was $p<0.05$.

Results & Discussion

Table 1: Mean±SD of Age, height & body mass of male Handball players

Game	N	Age, years	Height, cm	Mass, kg
Handball	**18**	**15.83 ±0.62**	**176.61 ±5.05**	**59.00 ±6.53**

Table 2: Mean±SD of Mechanical power variables of the three vertical jump tests of male Handball players

Squat Jump (SJ)		Counter Movement Jump (CMJ)		EUR	EI	Continuous Vertical Jump test 60 seconds (CVJT) Mechanical Power (w/kg)			
JH, cm	Flight Time, Sec	JH, cm	Flight Time, Sec			PP (0-15 sec)	PP (45-60 sec)	MP (0-60 sec)	FI
26.06 ±3.96	0.462 ±0.033	29.17 ±3.13	0.487 ±0.029	1.09 ±0.06	12.84 ±9.01	15.55 ±3.00	11.72 ±2.60	13.47 ±2.38	22.90 ±17.27

JH - Jump Height; FT-Flight Time; EUR-Eccentric Utilization Ratio; EI-Elasticity Index; MP- Mechanical Power; PP-Power Peak; MP- Mean Power; FI - Fatigue Index

Table 3: Correlation Matrix for various mechanical power variables of the three vertical jump tests of male Handball players

	AGE	HEIGHT	WEIGHT	SJ HEIGHT	SJFT	CMJJH	CMJFT	EUR	EI	PP15	PP45	MP60
HEIGHT	.392	-										
WEIGHT	.553*	.297	-									
SJHEIGHT	.340	.489*	.209	-								
SJFT	.322	.469*	.204	.990**	-							
CMJJH	.350	.525*	.339	.877**	.871**	-						
CMJFT	.355	.475*	.365	.872**	.877**	.990**	-					
EUR	-.291	-.203	-.137	-.694**	-.682**	-.283	-.296	-				
EI	-.128	-.206	.122	-.694**	-.689**	-.265	-.271	.957**	-			
PP15	-.052	-.269	-.197	.339	.380	.338	.348	-.143	-.191	-		
PP45	.333	-.177	-.001	.323	.263	.134	.124	-.468*	-.411	.330	-	
MP60	.205	-.282	-.117	.366	.355	.177	.189	-.474*	-.459	.729**	.826**	-
FI	-.317	-.045	-.120	.053	.138	.241	.260	.294	.211	.542*	-.606**	-.138

***significant at the 0.05 level; ** significant at the 0.01 level**

JH - Jump Height; FT-Flight Time; EUR-Eccentric Utilization Ratio; EI-Elasticity Index; MP- Mechanical Power; PP-Power Peak; MP- Mean Power; FI - Fatigue Index

The results of present study demonstrate a close relationship between the various mechanical power variables of the three vertical jump tests (Squat jump, Counter movement jump and Continuous vertical jump test for 60 seconds) of male handball players. Height has shown significant correlation with squat jump height, squat jump flight time, counter-movement jump height and counter-movement jump flight time at 0.05 level of significance. Highly significant correlation was observed between the squat jump height and squat jump flight time, counter-movement jump height and counter-movement jump flight time at 0.01 level of significance. Highly significant negative correlation was observed between the squat jump flight time, squat jump height and Eccentric Utilization Ratio (EUR), Elasticity Index (EI) at 0.01 level of significance. Highly significant correlation was observed between the Eccentric Utilization Ratio (EUR) and Elasticity Index (EI) at 0.01 level of significance. High significant correlation was observed between the Peak Power (0-15sec) and Mean Power (0-60sec) at 0.01 level of significance. Significant correlation was observed between the Power (0-15sec) and Fatigue Index (FI) at 0.05 level of significance. Highly significant correlation was observed between the Peak Power (45-60sec) and Mean Power (0-60sec) at 0.01 level of significance. Highly significant negative correlation was observed between Peak Power (45-60sec) and Fatigue Index (FI) at 0.01 level of significance.

Francisco et al., (2010) observed that the average squat jump height 15.8±4.2cm, flight time 357±44.4msec, countermovement jump height 16.9±4.8cm, flight time 369.0±49.9msec and elasticity index 7.1±3.2 for male table tennis players (age 11.32±1.82 years). Whereas in the present study the average value of squat jump height 26.06±3.96cm, flight time 462±33msec, countermovement jump height 29.17±3.13cm, flight time 487±29msec and elasticity index 12.84±9.01 was observed. The Eccentric Utilization Ration (EUR) has been suggested as a useful indicator of power performance in athletes. *McGuigan et al., (2006)* observed the average value of Eccentric Utilization Ration (EUR) 1.03±0.20 for male soccer players, 1.00 ±0.17 for softball male players, 1.03±0.20 for football male players & 1.01±0.20 for rugby male players. While in the present study the average value of EUR 1.09±0.06 was observed. In the present study the average Mean Power (0-60sec) recorded during the vertical jump test for handball players (age 15.83±0.62 years) was 13.47±2.38w/kg whereas *Bosco et al. (1983)* found that average Mean Power (0-60sec) for school going Boys (age 17.3±0.8 years) was 22.2±1.8 w/kg. *Jefferson et al., (2007)* found the average Peak Power (0-15sec) 27.76±3.78w/kg, Mean Power (0-60sec) 19.56±2.59w/kg & fatique index (%) (FI) 48.60±7.01 for male volleyball players (age 19.01±1.36 years). In another study by *Jefferson et al., (2006)* of the Intermittent vertical jump tests (IVJT) observed the average Peak Power (0-15sec) 24.68±2.70w/kg, Mean Power (0-60sec) 18.79±2.23w/kg & fatique index (%) 57.50±9.51 for the male handball and basketball players (age of handball players 25.74±4.71years & basketball players 18.60±0.77years). Whereas the in the present study the value of average Peak Power (0-15sec) 15.55±3.00w/kg, Peak Power (45-60sec) 11.72±2.60w/kg, Mean Power (0-60sec) 13.47±2.38w/kg & fatique index (%) 22.90±17.27 was observed.

Conclusion: In conclusion, based on the above considerations, the reported jumping test might offer the possibility of evaluating the mechanical power of the leg extensor muscles during explosive stretch-shortening type exercises, which involve both metabolic and mechanical behaviour of skeletal muscles. The measurement of Peak Power by strength and conditioning-coaches is an important consideration in the training process. Changes in Peak Power throughout the annual plan may be indicative of training status or adaptation to the workload and could be used to plan or adjust the training program based on the athlete's performance.

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