



ISSN: 0975-833X

RESEARCH ARTICLE

ASSESSMENT OF PHYSICAL FITNESS COMPONENTS AS PREDICTION FACTORS OF LONG JUMP PERFORMANCE

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ARTICLE INFO

Article History:

Received 20th October, 2012
Received in revised form
22th November, 2012
Accepted 17th December, 2012
Published online 16th January, 2013

Key words:

Running broad jump,
Physical fitness,
performance.

ABSTRACT

The purpose of this study was to determine whether selected physical fitness components (coordinative ability, speed, strength, cardiovascular endurance and flexibility) can be utilized as prediction factors of long jump performance. Measurements were observed from 50 selected long jumpers sampled from Indira Gandhi Institute of Physical Education and Sport Sciences, University of Delhi. Test included shuttle run, 50m dash, standing broad jump, 12 minutes walk/ run (cooper test) and sit and reach. Analysis was done using t-test and product moment correlation at 0.05 level of significance. Findings showed that a significant relationship between running broad jump and cardiovascular endurance ($r = 0.41$), coordinative ability ($r = -0.50$), explosive leg strength ($r = 0.43$) and speed ($r = -0.48$) and no significant differences in arm and shoulder endurance ($r = 0.17$). It was concluded that performance in cardiovascular endurance, coordinative ability, explosive leg strength, speed and flexibility are related to running broad jump performance. The study recommends that training programs for long jumpers need to be systematic and scientific in developing physical fitness components.

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INTRODUCTION

Running is an elemental, natural part of human activity and a gift from the evolutionary process. Pre-historic ancestors, who lived on this planet millions of years ago, run every day, either to hunt for food or to escape from danger. By such running they developed strong hearts, lungs, blood vessels and limbs (WHO, 2003; Healthy People 2010; U.S. Department of Health and Human Services, 2000). From the earliest times running has been a natural part of man's existence. One of the earliest examples of competitive running can be found in the works of Homer, who tells of races ran in the 12th century BC. Thus, man has been racing on foot for over three thousand years (Blacklock, and Kennett, 2000). It was the Greeks who elevated running to the level of their gods at Olympia, and the spectacle of athletes running and engaging in other contest of exertion to sculptor's of fertile images of human beauty. The revival of the Olympics Games in 1896 has resulted in standardization of events and competitions.

The events have become all the more popular now (Woff, 1999; Blacklock, and Kennett, 2000; Middleton, 2000; Swaddling, 2002; Miller, 2004). Apart from the pleasure and thrill of competition, athletics contribute greatly towards the total development of personality by inculcating character traits such as courage, determination, etc (Coakley, 2009). The modern track and field events have developed into highly technical competitions involving constant training and practice. It is therefore, essential that the training should start

at an early age at school. A school boy may not develop sufficient competence in these events but he is sure to learn the fundamentals of these events and can develop into star performers later on (Mannell, 2007). The long jump with a run-up was included in the first modern Olympic Games in 1896 in Athens. However in four subsequent Olympics there was also a long jump from a standstill (Swaddling, 2002). Long jump or broad jump is a popular field event. Traditionally, strong sprinters participated in the event perhaps because of the advantage of speed. The main requirements for excellent performance in long jump are speed, spring or bounce and fine co-ordination (Linthorne, Guzman, and Bridgett, 2005). However, the following have contributed to outstanding performances in long jump; greater number of athletes participating in the event, better informed coaches from junior high levels through the collegiate and club ranks, extensive research into the event, the dissemination of information through clinics, periodicals and films, better and consistent running and jumping surfaces, specialty shoes and scientific strength training (Attig, 1987; Linthorne, Guzman, and Bridgett, 2005).

Long jump is an exciting event and requires a competitor to have speed, explosive leg strength as well as proper co-ordination of distance, strides and spring action of the body at take-off stage level. (Ngetich, 1998; Renwick, 2001). From a spectator point of view and technique, the long jump is by far less complicated than any of the other three jumping events (high jump, triple jump and pole vault). Long jumpers are also fast sprinters and specialist. They work hard to perfect their jumping skills and performance as do the athletes of the other

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field events. The distance a long jumper can jump is influenced by other factors; the speed of the approach run, the conversion of this speed to forward-upward force at the take-off, the range through which he can apply this forces at an optimum angle and the efficiency with which these factors terminate at the landing in the pit (Hubbard, 2001; Linthorne, Guzman, and Bridgett, 2005). The world's top long jumpers have always been outstanding sprinters though some without outstanding sprinting ability may become top performers if they specialize in the event and perfect all the long jumping techniques. Specific areas to be considered in long jump are; the approach run, the take-off, the action in the air (the flight), and the landing (Linthorne, Guzman, and Bridgett, 2005). However it is important to determine the predictors of long jump performance.

Review of Related Literature

Several interesting studies have compared the effects of various types of explosive training, slow weight training and plyometric training in performance in field events. Wilson and Newton (1993), compared the effects of traditional resistance training (3-6 sets of 6-10 RM squats), plyometric training and explosive training (loaded jump squats), performed twice/week for 10 weeks with experienced trainees. The traditional and explosive groups improved peak power equally on a 6 seconds cycle test. Both groups also increased significantly on vertical and counter-movement jump, with the explosive group increasing to a greater degree. However, the explosive group had been practicing jumping and the traditional group had not, and only the traditional group increased significantly on maximal knee-extension force. In a follow-up study, Wilson, Murphy and Giorgi (1996) compared the effects of traditional weight training (squats and bench presses) with plyometric training (depth jumps and medicine ball throws). Fourteen variables related to strength and power was tested, and the traditional group increased significantly on seven variables whereas the plyometric group increased only on three. Also, both groups increased significantly on counter movement jump, with no significant between-group difference. Similarly, Holcomb, Lander, Rutland and Wilson (1996) compared the effects of resistance training and plyometric-style training involving various types of depth jumps, finding no significant difference between the groups differences in increases in jump height or power performance.

These authors concluded that plyometric training was no more effective for increasing power than traditional resistance training. Linthorne, Guzman, and Bridgett, (2005) utilized the broad jumping criteria, distance, body weight and for distance/body weight. 141 elementary school boys aged 12 years old were selected for the study. The highest multiple correlation for distance jump were 0.756 at 12 years with 60 yards shuttle run, arm strength, skin fold, total cognitive and cable tension strength average, 0.768 at 15 years with physical fitness media, 60 yards shuttle run, body weight and cable tension strength average multiple correlation for distance, body weight and for distance/body weight were also reported. The distance jumped and distance weight both Moore, Hickey and Reiser (2005) observed significant ($p < 0.05$) increases in performance (measured using countermovement vertical jump, 4 repetition maximum squat, 25-m sprint, and figure-8 drill) after a 12 week, tri-weekly training programme incorporating

traditional weight training combined with Olympic style lifting (OSL) and also traditional weight training (TWT) combining plyometric style exercises (PE). They found significant increases ($p < 0.05$) in vertical jump for the OSL (9%) and PE (7%) groups, in squat performance (299% for the OSL and 280% in the PE group), a decrease in the 25m sprint times (11% and 9% for OSL and PE respectively) and significant ($p < 0.05$) increases in foot speed (12.3% for the OSL and 12.2% for the PE groups). However, they did not find any significant differences between the training groups, suggesting that there is no advantage of training using either Olympic style lifting or plyometric exercises when they are combined with traditional strength training. Toji, Sueti and Kaneko (1997) investigated the differences when training was performed by adult collegiate athletes using five repetitions at 30% maximum strength (F_{max}) followed by five isometric contractions (100% F_{max}) and compared to five repetitions at 30% F_{max} and five contractions undertaken at high speed with no load (0% F_{max}) on the elbow flexor muscles.

Training was performed 3 days a week for 11 weeks, producing significant increases in maximum power for both groups after this period of training. However, the power increase was significantly greater in the elbow flexor muscles when isometric contractions were used compared to the explosive unloaded exercises. The above results suggest that isometric training at maximum strength (100% F_{max}) is a more effective form of training to increase power production than no load training at maximum velocity. This is further supported by the findings of Tuomi, Best, Martin and Poumarat (2004) who investigated the effects of comparing weight training only (WTO) and weight training combined with jump training (WTC) for a 6 week training programme. Their results showed both groups increased their maximal force/explosive force after the training regime. However, the group combining weight training and jump training were the only group to significantly increase their jump height performance during the countermovement jump. Their results suggest that a change in maximal strength and/or explosive strength does not necessarily cause changes in combined movement patterns such as the stretch shortening cycle.

McBride, Triplett-McBride, Davie and Newton (2002) observed that training with lighter loads increased movement velocity capabilities. However, they only observed trends and not significant increases in sprint times when jump squats equating to a load of 30% of 1RM were undertaken, whereas an 80% of 1RM group were actually significantly slower in the sprint performance test. Interestingly, the 30% and 80% groups did not produce any significant increase in agility performance either. This suggests there is minimal transfer from squat jumps to actual performance. In a review of strength training Delecluse (1997) also observed that strength training is very important to increasing sprint performance when used appropriately. Delecluse (1997) continues that a combination of 3 training methods is most beneficial to enhancing sprint performance 1) heavy traditional resistance training (which is classified as hypertrophy and neural activation training) 2) speed strength training (e.g., plyometrics) and 3) sprint associated training (e.g., over-speed and hindered running). Although this may be the case, Delecluse (1997), concludes by admitting that the design of a training programme for elite level sprinters is about being

individual to the client's needs and as such appears to be impossible to produce a 'one fits all' and 'instant' training programme. Liow and Hopkins (2003), investigated the effect of slow and explosive weight training on kayak sprint performance. The two programs differed only by the time it took to undertake the concentric action of the movement (slow - 1.7 seconds and explosive - < 0.85 seconds). Both training methods improved performance (mean sprint time over the 15 meters increased by 3.4 % [slow training] and 2.3 % [explosive training] with the 90% confidence limits for pair wise differences being $\sim \pm 1.4\%$). Through expressing uncertainty of an effect as 90% confidence or likely limits of the true value of the effect, Liow and Hopkins (2003) suggest that slow weight training was more effective than explosive training (rated as 'possible' with a 74% confidence limit) for improving the acceleration phase of sprinting, where as explosive training was more effective than slow training (rated as 'possible' with a 54% confidence limit) for improving speed maintenance. Blazeovich and Jenkins (2002) examined slow and explosive training velocities in hip flexion and extension, knee extension and flexion and the squat, using 30-50% 1RM for the high velocity group and 70-90% 1RM for the low velocity group. They observed significant increases in 20m acceleration time ($p < 0.01$), squat strength ($p < 0.05$) and hip extension at 1.05 rad.s⁻¹ for the athletes as a whole.

However, they found no significant differences ($p > 0.05$) in torque measurements for hip extension and flexion, or 1 RM for the squat or sprint performance between the slow and explosive training groups. Given the importance of the issue of transfer of training, Baker and Nance (1999) investigated the relationship between Olympic lifting and sprint performance. Using trained Australian rugby league players ($n = 20$) they observed only weak correlations between hang clean and sprint performance ($r = -0.34$ for 10m sprints and $r = -0.24$ for 40m sprints). Therefore, the coefficients of determination (r^2) of .12 and .06 show that only 12% and 6% of the variance in the 10m and 40m sprint respectively are associated with hang clean performance. In practical terms, therefore, this shows that the assumption that there is considerable transfer from Olympic style lifting to sprint performance is incorrect. From the reviewed literature, it is apparent that none of these studies investigated on the relationship between methods of training and performance in long jump. Therefore the purpose of this study was to assess whether selected physical fitness components can be used to predict performance in long jump.

MATERIAL AND METHODS

Selection of Subjects: Fifty subjects from Indira Gandhi Institute of Physical Education and Sports Sciences, University of Delhi, New Delhi were selected as subjects for the present study. The students had volunteered to take part in the study. The subjects were Bachelor of Science 1st, 2nd and 3rd year female students. The mean age of the participants was 22 ± 3.04 years.

Selection of Variable and Their Criterion

Measures: Table 1 presents the physical fitness components which were selected for the present study and were measured. These included coordinative ability, speed, explosive leg strength, cardio-vascular endurance and flexibility was

measured by administering the standard tests of shuttle run, 50 meter dash, standing broad jump, 12 minute cooper's run/walk and sit and reach test respectively. Resulting data was analyzed and presented in means, and standard deviation. T-test, product moment method or Karl parson's correlation coefficient were used to compare and determine the significance of relationship between the dependent and independent variables. The level of significance chosen was 0.05.

RESULTS

The results on physical fitness components of the subjects are presented in Table 1.

Table 1: Inter correlation between running broad jump and physical fitness components

	R.B.J.	C.V.E.	Co-Ord.	E.L.S.	F.A.H	Speed	Flex.
Running Broad Jump	1	0.41*	-0.50*	0.43*	0.17	-0.40*	0.48*
C.V.E.		1	-0.05	0.20	0.39*	-0.39*	-0.82*
CO-ord			1	-0.10	0.05	0.33*	-0.26
E.L.S				1	0.64*	0.32*	0.42*
Arm & shoulder endurance					1	-0.16	0.37*
Speed						1	0.35*
Flexibility							1

* Significant at 0.05 level

$r(0.05)^{(48)}$	=	0.279
R.B.J.	=	Running broad Jump
C.V.E	=	Cardio-Vascular Endurance
CO-ord	=	Co-ordinative ability
E.L.S.	=	Explosive leg strength
F.A.M.	=	Flexed arm hang

Table 1 show that there is significant relationship between running broad jump and the cardio vascular endurance ($r = 0.41$), coordinative ability ($r = -0.50$), explosive leg strength ($r=0.43$), speed ($r=-0.40$) and flexibility ($r=0.48$). However no significant differences was found between flexed arm hang to running broad jump. The inter-correlation among the independent variables revealed that significant relationships exist between most of the variables except between cardio-vascular endurance and coordinative ability, and between coordinative ability and Arm and shoulder endurance which were found to be statistically in significant. The combined effect of all the independent variables (cardio-vascular endurance, speed, coordinative ability, explosive leg strength, flexibility and arms and shoulder endurance) to dependent variable (running broad jump), are presented in Table 2.

Table 2: Partial correlation coefficient

1st Order Coefficient

r 12.3	r 12.4	r 12.5	r 12.6	r 12.7
r 23.4	r 23.5	r 23.6	r 23.7	
r 34.5	r 34.6	r 34.7		
r 45.6	r 45.7			
r 56.7				

1	=	Running broad Jump
2	=	Cardio-Vascular Endurance
3	=	Co-coordinative ability
4	=	Explosive leg strength
5	=	Arm and Shoulder Endurance
6	=	Speed
7	=	Flexibility
r	=	Correlation Coefficient

Results

0.440*	0.378*	0.380*	0.300*	0.032
-0.031	-0.076	0.090	-0.476*	
-0.172	-0.230	0.010		
0.739*	0.575*			
-0.333*				

* Shows that the findings are statistically significant.

Findings

The finding of the study revealed that there is significant relationship between running broad jump performance and cardio-vascular endurance ($r=0.41$), running broad jump performance and coordinative ability ($r=-0.50$), running broad jump and explosive leg strength ($r=0.43$), running broad jump and speed ($r=-0.48$). In the case of running broad jump and arm and shoulder endurance the correlation obtained was ($r=0.17$) which is less than the required value of 0.27 and thus was not significant. To determine the combined effect of the independent variables (coordinative ability, speed, explosive leg strength, cardio-vascular endurance, arm and shoulder endurance and flexibility) on dependent variable (running broad jump), partial correlation method was employed. The following result was found. The partial correlation between running broad jump and cardio-vascular endurance keeping co-ordination ability constant is ($r=0.44$), running broad jump and cardio-vascular endurance keeping explosive leg strength constant is ($r=0.37$), running broad jump and cardio-vascular endurance keeping Arm and Shoulder endurance constant is ($r=0.38$), and running broad jump and cardio-vascular endurance keeping speed constants is ($r=0.30$).

On the other hand, it was found that there was significance between cardio-vascular endurance and speed, keeping flexibility constant ($r=0.47$), significance was also found between explosive leg strength and Arm and Shoulder endurance keeping speed constant ($r=0.73$), explosive leg strength and Arm and shoulder endurance keeping flexibility constant ($r=0.57$). Lastly, there was significance between Arm and shoulder endurance and speed keeping flexibility constant ($r=-0.33$). The rest were found to have no significant because there partial correlation falls below 0.27, which is required for the correlation to be significant.

Interpretation of Findings

The event of running broad jump can be classified into four phases namely approach run, take off, flying phase and landing. The horizontal distance jumped by the athlete depends on the jumper's speed during the approach run and the take off force produced by the jumper to convert the horizontal momentum into angular momentum and also tremendous amount of flexibility possessed by the jumper for performing the movement at various joint and large amplitude, especially while executing the take off. Broad jumpers spend considerable time on training for speed and developing strength of legs (especially take off leg). In addition, they perform several strengthening and mobility movements to increase flexibility (Ngetich, 1998). Therefore when selecting potential broad jumper and to improve long jumping ability, due consideration should be given to such physical fitness components of coordinative ability, explosive leg strength, speed and flexibility. The partial correlation obtained in the study indicates that all the independent variables namely coordinative ability, speed, cardio-vascular endurance standing broad jump, flexed arm hang and flexibility contribute to excellent performance in running broad jump. Enough time should be allocated for improving speed, strength, flexibility, coordinative ability and cardio-vascular endurance. On the other hand to predict the performance in long jump, the relationship between each of the independent variables to long jumping ability is considered at the same time to analyze the performance in all the fitness components

employed, in the study. The hypothesis stated in the study complies with the physical fitness component chosen to predict the performance of running broad jump (Ngetich, 1998).

Conclusions and Recommendation of the Study

From the findings of the study the following conclusion was drawn

- Performance in cardio-vascular endurance, coordinative ability, explosive leg strength, speed and flexibility is significantly related to running broad jump performance and that these variables may be used as prediction factors in running broad jump performance.
- Relationship of Arm and shoulder endurance to running broad jump ability is not found to be significantly related to performance in running broad jump. Therefore it may be treated as a poor predictor of running broad jump performance.
- For better prediction of running broad jump performance, all the physical fitness components namely speed, coordinative ability, explosive leg strength, cardio-vascular endurance, Arm and Shoulder endurance and flexibility may be considered in combination instead of studying the influence of each of the independent variables on running broad jump performance.

The following recommendations were made in light of the conclusion drawn

- The present study may be repeated with different subjects with different age and gender. It would be interesting to repeat the study on elite long jumpers from different geographical locations.
- Teachers of physical education and coaches may make their training programs systematic and scientific by including training methods for developing these motor fitness components which help in predicting performance in long jump.
- Physical education teachers and coaches may utilize those physical fitness components which have been found to be significantly related to running broad jump performance while selecting the potential jumpers.

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