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Effects of vertical, horizontal, and combination depth jump training on long jump performance

Dalwinder Singh [1], Sukhwinder Singh [2]

[1] Department of Physical Education, Panjab University, Chandigarh, [2] University College, Dhilwan, Barnala, India

Summary

Study aim: To assess the effects of vertical, horizontal, and combination depth jump training programs on the performance of the running long jump by male athletes.
Material and methods: A total of 80 physical education students ranging in age between 18-21 years with mean depth jump performance of 44.3 ± 5.13 cm from a 45 cm high box were purposively selected to act as subjects. The subjects were randomly assigned to vertical depth jump training (VD), horizontal depth jump training (HD), the combination of both (CD), and a control group (CG). Each week, experimental groups performed 6 sets (10 repetitions per set) twice a week for 10 weeks of depth jump training from a height of 20 cm, which progressed to 40 cm according to the step method. Running long jump (RLJ) was measured before and after 10 weeks. Analysis of covariance, with pre-test scores as a covariate, was applied to compare scores. A pairwise comparison was done by using the Scheffe's *post-hoc* test.
Results: The average increase of RLJ performance in groups VD (0.17 m) and CD (0.23 m) was significantly different ($p<0.05$) than in group CG (0.05 m). Improvement in group HD (0.12 m) was not significantly different than in group CG; moreover, no significant difference existed between training groups.
Conclusions: A combination of both vertical and horizontal depth jumping is required for long jumpers, with a higher proportion of vertical depth jumping.

Key words: Plyometrics – Step Progression – Depth jumping – Long Jump

Introduction

Depth jump training is the common and most-researched forms of plyometric drills. Depth jumping requires athletes to drop from a height and, upon landing, immediately perform a jumping movement [23]. Depth jumps use the athlete's body weight and gravity to exert force against the ground [8]. An elevated surface is required for this exercise. The landing surface should be forgiving yet resilient; grass gymnastic flooring or cushioned turf will work well. The depth jump is a shock-method exercise and comes in the final portion of the training continuum. Therefore, progression into this drill is a must, as well as progression within it. Implement the shock method by using an elevated platform and a drop or fall to the takeoff surface. The key is to initiate a rhythm of landing. The landing is the precise phase we are negotiating in order to create a performance that is as efficient as possible. This requires handling the surprise of landing and subsequent takeoff in as optimal an execution as possible. This aspect makes the depth jump elite in its strength, speed, and quickness. It also can be a source of problems if you do not progress into it properly [19].

In practical terms, the task of determining the proper depth jump height centers on the ability to achieve maximal elevation of the body's center of gravity after performing a depth jump. If the height is too great for the strength of the legs, then the legs spend too much time absorbing the impact of the landing and cannot reverse the eccentric loading quickly enough to take advantage of the serial elastic component of muscle and the stretch reflex phenomenon. The result is a slow jump dependent on strength and devoid of power. Coach and athlete should work on finding the proper height: one that lets the athlete maximize the height jumped plus achieves the shortest amortization phase [8]. Countermovement vertical jump height has been used as a test protocol to measure successful depth jump performance. An athlete is made to carry out a standing high jump after flexing his legs and the maximum height is reached with his hand on a graduated board (Vertical Jump Test). The highest reading of 3 jumps is registered. The athlete is made to carry out the same operation, landing on the same point from a height that is progressively higher by 20-40-60 centimeters and from each different height of fall. The subsequent jump is read off of the graduated board. The value of the greater

Author's address Prof. Dalwinder Singh, Department of Physical Education, Panjab University, Sector 14, Chandigarh, U.T. – 160014, India dalwinder_pu@yahoo.com

height reached in the subsequent jump (after landing), which should be higher than that of the jump from level '0' (standing jump), determines the optimum height of fall for that particular athlete at that moment of the training process [26].

By using boxes of different heights or a stair-step apparatus, the athlete drops from levels between 12 and 42 centimeters onto grass or a firm but resilient mat. Upon landing, the athlete immediately jumps upward, reaching or surpassing the mark placed on the wall during the Vertical Jump Test. The athlete continues to move to a higher drop until he or she can no longer attain the same height as in the vertical jump. Allow 1 or 2 minutes of rest between each trial for the muscle systems to recover. The point of the depth or drop height when the athlete attained maximum vertical (rebound) height is the approximate height to train for in this type of plyometric exercise [19]. There are 2 major categories of depth jumping for the purpose of achieving maximum vertical height or horizontal distance after taking off. One type of exercise is performed by stepping off the box and dropping to land on both feet. Try to anticipate the landing and spring up as quickly as possible. Keep the body from "settling" on the landing and make the ground contact as brief as possible. The second category is performed by stepping off the box and dropping to land on both feet. Upon landing, immediately jump as far forward as possible, again landing on both feet [8]. The idea behind plyometrics is simple: exploit the muscles' cycle of lengthening and shortening to increase power [7]. The mechanisms thought to contribute to greater power output during a drop jump are the stretch reflex [14], storage and use of elastic energy [4,13], and potentiation of the contractile machinery [2]. Power is an essential component for successful performance in many sports. Power represents the amount of work a muscle can produce per unit of time. An increase in power gives the athlete the possibility of improved performance in sports in which the improvement of the speed-strength relationship is sought [15]. The principle stimulus in power training is performing a movement dynamically linked with the force magnitude that is taking place in the same exertion. For instance, during sprinting an athlete's force of leg propulsion is 3.5 times that of his or her body weight, but the force used to throw a javelin is much smaller. Thus, the force of acceleration is the main stimulus for power training. In acyclic sports (i.e., jumping events), power is the determinant ability for achieving a good result. On the other hand, in cyclic sports (i.e., sprinting), power is brought into action repetitively and rapidly. Consider these general characteristics of sports requiring power, and then reflect them in a strength training program [3].

Effectiveness of depth jump training in improving acyclic power [6,16,22] and cyclic power [25] is well-known fact. The present study researched its effects on running long jump performance (combination of both cyclic and acyclic activities). The long jump is a contest that determines how far a competitor can jump horizontally after a running start [21]. Therefore, the purpose of this study was to investigate the influence of vertical depth jump training, horizontal depth jump training, and the combination of both vertical and horizontal depth jump training on running long jump performance of college level male athletes by employing depth jumping from optimal dropping height.

Material and Methods

Subjects: Purposive sampling technique was used to select 80 male physical education students ranging in age between 18 to 21 years. Their mean age, body height, and body mass was 19.9±0.8 years, 172.6±4.4 cm and 66.1±2.6 kg, respectively. They were medically fit to undergo the type of training program and completed an informed consent form prior to participate in the present study. They were tested for proper execution of depth jump performance (mean 44.3±5.1 cm) from dropping height of 45 cm. The university's joint research board approved all procedures for the study.

Study protocol: Studied subjects were randomly assigned to 3 experimental groups and 1 control group. Group VD (n=20) trained with vertical depth jumping on Monday and Thursday; group HD (n=20) trained with horizontal depth jumping on Tuesday and Friday; group CD (n=20) trained with vertical depth jumping on Wednesday and horizontal depth jumping on Saturday throughout 10 weeks of training having identical intensities and volumes. Group CG (n=20) served as the control group. All subjects were attending classes according to the college curriculum, except the training session. Running long jump performance was measured for subjects of each group before and after the 10-week period. Participants were part of an instruction session before the pre-test to ensure proper technique and comprehension of the testing process. Testing was demonstrated by the trained athlete. To ensure uniformity in the testing conditions, the subjects were tested in the morning sessions by the same testers, under the supervision of the investigator.

Procedures: A pilot study was conducted to determine the training intensity and progression of load. The investigator randomly selected 10 out of the 80 participants. They were tested for vertical jump performance and depth jump performance from heights of 10, 20, 30, 40, 50, and 60 centimeters. Investigators found the initial increase in

attained height with maximum performance (i.e., 48.64 cm) from 20 cm dropping height and depth jump performance remained greater than vertical jump test performance (i.e. 46.25 cm) up to 40 cm dropping height (Fig. 1).

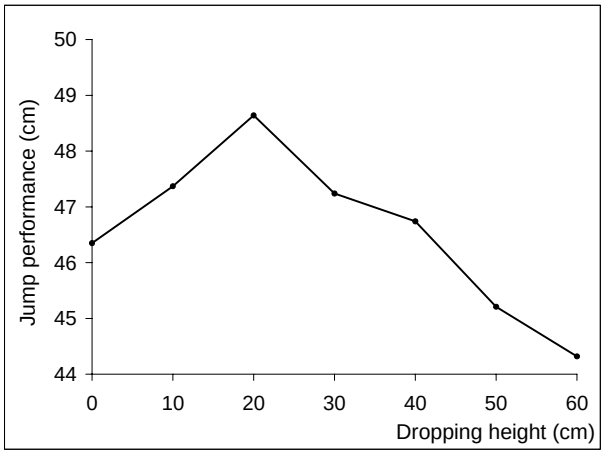


Fig. 1. The mean vertical and depth jump performance in pilot study

Dropping height of 20 cm, from which depth jump performance was maximum and higher than vertical jump performance, was the initial training intensity [8,19,26]. All participants were trained twice a week for 10 weeks, performing 6 sets of 10 repetitions per session [10]. A period of 15 seconds of rest-walk was given for recovery between repetitions [20]; 1.5-2 minutes of slow jogging for 220 m was given for recovery between sets [24]. Dropping height progressed according to the step method from the height with maximum depth jump performance (20 cm) up to the height from which performance was remained higher than vertical jump performance (40 cm) during the 10-week period of training (Table 1).

Table 1. Progression of dropping height (DH) during experiment

Week	I	II	III	IV	V	VI	VII	VIII	IX	X
DH (cm)	20	25	30	25	30	35	30	35	40	35

Training was administered by dividing 20 participants into 4 groups, with 5 subjects per group. After warm up, they were trained simultaneously at 4 stations. Rest-walk between repetitions was given by placing a cone 11 m and 12.1 m ahead of the dropping height for vertical and horizontal depth jump training, respectively. Slow jog between sets was given by placing another cone 220 m from first cone. Subjects participated in cool-down program after training.

To measure running long jump performance, a takeoff area of 2.16 m length (it was the average standing broad jump performance of 10 subjects tested for this purpose) was marked by spreading lime on the surface of the runway from the jumping pit, to identify the takeoff mark. The subject was asked to perform a long jump after a sprint start by taking off from the takeoff area to jump as far as possible. The distance between the landing spot near the takeoff area and takeoff mark in the takeoff area was measured. Three trials were given and performance was recorded to the nearest 0.01 m below the distance measured, if the distance measured was not a whole centimeter. Best performance was considered as the score.

Data analysis: Analysis of covariance was applied to find significance of differences among groups. The pre-test scores were used as the covariate and post-test scores, adjusted for covariance, were the dependent measures. When significant F value was encountered, a pair-wise comparison was done by using the Scheffe's post-hoc test to identify significant differences between groups. The level of significance was set at $\alpha = 0.05$.

Results

The mean and standard deviation values for running long jump performance obtained from pre-test and post-test scores of 3 experimental groups (VD, HD, and CD) and control group (CG) are presented in Figure 2.

Analysis of covariance with pre-test scores as a covariate showed significant differences ($F_{3, 75} = 82.43$; $p<0.001$) in running long jump performance of all the 4 groups. Post-hoc analysis revealed a significant ($p<0.05$) difference between groups VD and CG (mean difference equal to 0.17 m); CD and CG (mean difference equal to 0.24 m). The differences between groups HD and CG, as well as between all training groups were not significant.

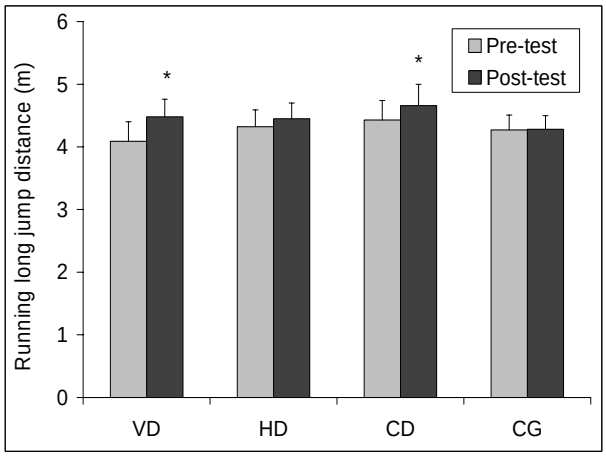


Fig. 2. The mean and standard deviation values for running long jump performance obtained in studied groups during pre- and post-test

Legend: VD – Vertical depth jumping; HD – Horizontal depth jumping; CD – Combination of vertical depth jumping and horizontal depth jumping; CG – Control group. * Significantly ($p<0.05$) different from CG

Discussion

After the 10-week period designated for the vertical, horizontal, and combination depth jump training programs, the running long jump performance of 3 experimental groups and the control group showed significant difference. Further, the analysis of data reveals that experimental groups VD and CD were found to be significantly different as compared to the control group, but the paired adjusted final mean for running long jump performance of experimental group HD was not found to be significantly different as compared to the control group. These findings do not find any support from existing literature as reviewed by the investigators; further research may be conducted in this direction. These running long jump performance findings revealed that vertical depth jump training and the combination of vertical and horizontal depth jump training were effective in bringing about a significant training effect. These findings may be attributed to the physiological adaptations such as reduction of the amortization phase, greater cross sectional recruitment, and threshold elevation for the inverse stretch reflex [18]. It is further supported by the fact that plyometric training stimulates chemical, mechanical, and neurological factors that influence the force and stiffness of the contracting muscle [12].

Horizontal depth jump training alone is not effective in bringing about a significant training effect. Thus, it is important to conclude that long jump performance depends upon the ability to raise the body vertically at the time of takeoff after gaining horizontal momentum during the approach run. This finding may be attributed to the results that indicate a negative correlation between jump length and contact time with the takeoff board during the long jump takeoff. In good performances, the center of gravity began to rise immediately after the first touch of the board, while in poorer jumps it remained at about the same height during the early contact phase [5,11]. There appears to be one main possibility for failure of this research to support horizontal depth jumps: the subjects who engaged in the present study were professional physical education students, thus they could have been adapted to the horizontal jumping exercises due to their previous horizontal jump training experience. Thus, horizontal depth jump training did not create the load effect required to produce an extra stimulus. It is already reported that depth jumps did not produce jump increases beyond that of a jumping routine that was a normal part of practice [9].

An increase in running long jump performance of 0.17, 0.12, 0.23, and 0.05 meters was observed in groups VD, HD, CD and CG, respectively; the respective post-training percentage increments being 4, 2.8, and 5.2%. Thus, the trends are in favor of the group CD, it is in line with the suggestion that jumping involves both horizontal and vertical components. It seems to make sense that both horizontal and vertical jump training would contribute to the improvement of jumping performance [8]. A comparison of groups VD and HD showed trends in favor of group VD: it indicates that vertical depth jump training is more effective for improving long jump performance as compared to horizontal depth jump training. It is also worth mentioning that training associated effects on running long jump performance obtained between the paired adjusted final means of 3 experimental groups were not statistically significant. From this prospective of the present study, it does not support in any 1 of the 3 treatments of applied depth jumps as a more effective one.

Dropping height progression of depth jumps applied within the training procedures of previous studies has been varied within wide margins [1,10,17]. It has not been quantified according to the capabilities of subjects under consideration. So another main finding of this study represents the training-associated improvement in long jump performance in experimental groups CD and VD is the application of step method of progression based on the data obtained through vertical and depth jump tests (Fig. 1). But further research is needed in the field to fix optimum step duration, increase in dropping height, and duration of experiment for depth jump training. For determination of these variables of step method we considered general training principles of strength training [3]. These may be considered as limitations of the present study.

Summing up, the combination of both vertical and horizontal depth jumping is required for long jumpers, with a greater proportion of vertical depth jumping. But vertical depth jump training is more effective for improving long jump performance as compared to horizontal depth jump training. Thus, while planning a depth jump training program for long jumpers, coaches and physical educators should include more vertical depth jumping along with horizontal depth jumping.

References

1. Andrew D.P.S. (1999) The effectiveness of three modified Plyometric depth jumps and a periodized weight training program on selected functional tests for power of the lower extremity. University of South Alabama; pp.68.

2. Bobbert M.F., P.A.Huijing, G.J.Van Ingen Schenau (1987) Drop jumping I. The influence of jumping technique on the biomechanics of jumping. *Med.Sci.Sports Exerc.,* 19:332-338.

3. Bompa T.O. (1999) Periodization: Theory and Methodology of Training. Champaign, IL, USA: Human kinetics.

4. Bosco C., P.V.Komi (1979) Mechanical characteristics and fiber composition of human leg extensor muscles. *Eur.J.Appl. Physiol.,* 41:275-284.

5. Bosco C., P.Luhtanen, P.V.Komi (1976) Kinetics of the take-off in long jump. In: Komi P. (ed) Biomechanics VIB. Baltimore, MD: University Park Press, pp. 174-180.

6. Brown M.E., J.L.Mayhew, L.W.Boleach (1986) Effect of plyometric training on vertical jump performance in high school basketball players. *J.Sports Med.Phys.Fitness*, 26:1-4.

7. Chu D.A. (1989) Plyometric exercises with the medicine ball. California: Bittersweet Publishing Company.

8. Chu D.A. (1998) Jumping into plyometrics. Champaign, IL: Human Kinetics.

9. Clutch D., M.Wilton, C.McGown, G.R.Bryce (1983) The effects of depth jumps and weight training on leg strength and vertical jumps. *Res.Q.Eexerc.Sport*, 54:5-10.

10. De Villarreal E.S., J.J.González-Badillo, M.Izquierdo (2008) Low and moderate plyometric training frequency produces greater jumping and sprinting gains compared with high frequency. *J.Strength Cond.Res.*, 22:715-725.

11. Klissouras V., P.Karpovich (1967) Electrogoniometric study of jumping events. *Res.Q.*, 38:41-48.

12. Komi P.V., C.Bosco (1978) Utilization of stored elastic energy in leg extensor muscles by men and women. *Med.Sci.Sports*, 10:261-265.

13. Komi P.V., A.Gollhofer (1997) Stretch reflex can have an important role in force enhancement during stretch-shorten exercise. *J.Appl.Biomech.*, 13:451-460.

14. Komi P.V (1973) Measurement of the force-velocity relationship in human muscle under concentric and eccentric contractions. In: Joki E. (ed), Medicine and Sports. Basel, Switzerland:S. Karger AC, pp. 224-229.

15. Luebbers P.E., J.A.Potteiger, M.W.Hulver, J.P.Thyfault, M.J.Carper, R.H.Lockwood (2003) Effects of plyometric training and recovery on vertical jump performance and anaerobic power. *J.Strength Cond.Res.*, 17:704-709.

16. Matavulj D., M.Kukolj, D.Ugarkovic, J.Tihanyi, S.Jaric (2001) Effects of plyometric training on jumping performance in junior basketball players. *J.Sports Med.Phys.Fitness*, 41:159-164.

17. McClenton, L.S., L.E.Brown, .J.W.Coburn, R.D.Kersey (2008) The effect of short-term VertiMax vs. depth jump training on vertical jump performance. *J.Strength Cond.Res.*, 22:321-325.

18. Pettitt R. (1999) The role of plyometrics in the scope of a periodized training model. *J.Perf.Enhan.*, 1:11-20.

19. Radcliffe J.C., R.C.Farentinos (1999) High-powered Plyometrics. Human kinetics. Champaign, IL.

20. Read M.M., C.Cisar (2001) The influence of varied rest interval lengths on depth jump performance. *J.Strength Cond.Res.*, 15:279-283.

21. Srivastava A.K. (2007) Teach Yourself Long Jump. New delhi-2: Sports Publication.

22. Steben R., A.Steben (1981) The validity of the stretch-shortening cycle in selected jumping events. *J.Sports Med.*, 21: 28-37.

23. Verkhoshansky Y. (1969) Are depth jumps useful? *Yessis Rev.Soviet Phys.Educ.Sports*, 3:75-78.

24. Verkhoshansky Y. (1968) Perspectives in the improvement of speed-strength preparation of jumpers. *Yessis Rev.Soviet Phys. Educ.Sports*, 4:28-34.

25. Young W.B., R.James., I.Montgomery (2002) Is muscle power related to Running Speed with changes of direction? *J. Sports Med.Phys.Fitness*, 42:282-288.

26. Zanon S. (1974) Plieometry in jumping. *Die Lehre der Leichtathletik*, 16:1-13.

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