Medicina Sportiva (2016), vol. XII, no 1, 2721-2726
Journal of the Romanian Sports Medicine Society

An effective procedure to individualize the training load for depth jumping

Sukhwinder Singh
Guru Nanak Dev Engineering College, Ludhiana, Punjab, India

Abstract. *Aim.* The study investigated effects of load for depth jump training based on vertical and depth jump performance of male athletes. *Material and Method*. Purposively selected forty (N=40) volunteer randomly assigned to depth jump training (n=20) and control group (n=20). Experimental group trained twice weekly for 10-weeks, performing 6-sets of 10-repetitions per session. Dropping height of 20cms from which depth jump performance was maximum and higher than vertical jump performance was the initial training intensity. It was progressed up to 40cms height from which performance was remained higher than vertical jump performance. Vertical jump performance of Experimental and Control group was measured before and after 10 weeks. ***Results*.** Analysis of Covariance was applied to compare scores. The alpha level was set at 0.05. Results showed significant ($F_{1, 37}$=73.73; p<0.0001) improvement in experimental group as compared to control group. *Conclusion.* It is concluded that the procedure adopted for individualization of depth jump training load induces significant adaptations.
Key words: *individualization of load, depth jumping, vertical jump, step progression.*

Introduction

Individualization in training is one of the main requirements of contemporary training. It refers to the idea that coaches must treat each athlete individually according to his or her abilities, potential, learning characteristics, and specifics of sport, regardless of performance level. Model the whole training concept according to the athlete's physiological and psychological characteristics to naturally enhance training objectives (1).

Depth (Drop) jump training is a common and most searched form of Plyometric drill. Verhoshansky (2) has described depth jumping as the procedure requires athletes to drop from a height and upon landing, immediately perform a jumping movement. Depth jumps is a type of dynamic exercise where an individual steps off a box 20 to 80 centimeters in height, lands, and performs an explosive vertical jump (3).

Depth jumps use the athlete's body weight and gravity to exert force against the ground. Depth jumps are performed by stepping out from a box and dropping to the ground, then attempting jump back up to the height of the box. Because depth jumps are of a prescribed intensity, one should never jump from the top of the box, as this adds height and increases the landing stress. Rather one should attempt to step out into space before dropping to the ground. Controlling height dropped helps not only to accurately measure intensity but also to reduce overuse problems. Upon making contact with the ground, the athlete directs the body up as fast as possible. The key to performing this exercise and decreasing the Amortization Phase is to stress the "touch and go" action off the ground (4).

An elevated surface (box or bench) approximately 12 to 36 inches high 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. Apply the shock method by using the 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, to create as efficient a performance as possible. This requires handling the surprise of landing and subsequent takeoff in as optima 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 (5).

In practical terms, the task of determining a 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 to find the proper height; one that lets the athlete maximize the height jumped plus achieves the shortest Amortization Phase (4).
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 three jumps is registered. The athlete is made to carry out the same operation, landing on the same point from a height which is progressively higher by 20-40-60 centimeters. (Depth Jump Test), and from each different height of fall, the subsequent jump is read off of the graduated board. The value of the greater 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 training process(6). By knowing an athlete's sergeant (standard) vertical jump, then testing in a depth jump from an 18-inch box, relatively weak athletes will jump several inches less than their vertical marks, as opposed to stronger athletes who will reach or exceed their vertical jump marks after a drop from the same height(7).
Chu (4) described that measure an athlete's vertical jump performance and then the athlete performs a depth jump from an 18-inch box height, trying to attain the same score. If the athlete successfully executes this task, he or she may move to a higher box. The box height should be increased in 6-inch increments. This is repeated until the athlete fails to reach the vertical jump height. This then becomes the athlete's maximum height for depth jumps. If the athlete cannot reach the vertical jump height from an 18-inch box, either the height of the box should be lowered or depth jumping abandoned for a time in favour of strength development. If the athlete cannot rebound from a basic height of 18 inches, he or she probably does not have the musculoskeletal readiness for depth jumping.
Radcliffe and Farentinos (5) described as: using boxes of different heights or a stair-step apparatus, the athlete drops from levels between 12 and 42 inches onto grass or a firm but resilient mat. Upon landing, the athlete immediately jumps upward or reaches or surpasses 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 one or two 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.
Countermovement vertical jump height has been used as a test protocol to measure successful depth-jump performance. Investigator assessed the subjects under the delimitations of the present study for vertical and depth jumping abilities. They were able to perform depth jumping. The study explored depth jumping as described by Chu (4), the exercise was performed by taking step off from the box and drop 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 short as possible. Therefore, the purpose of this study was to investigate the influence of depth jump training on vertical jump performance of college level male athletes by individualizing the training load based on performance in vertical and depth jump tests.

Material and method

Participants. Purposive sampling technique was used to select forty male (N=40), Physical Education students, aged between 18 to 21 years. Their mean age, body height, and body mass was 19.4±0.7years, 172.2±3.9cm and 66.8±3.1kg, respectively. All participants were full time students attending classes according to their college curriculum. All were deemed medically fit to undergo the study's training programme and signed an informed consent form prior to participation. The joint Research Board of the university approved all procedures for the study.
Experimental approach to the problem. Forty participants were randomly assigned to experimental (DJ) and control (CG) group. Group-DJ (n=20) performed depth jumping twice a week, while Group-CG (n=20) served as control group. Those participating in the training sessions attended an instruction session before the first test to ensure proper technique and an understanding of the testing process. The participants were tested for proper execution of Depth Jump from a drop height of 45cm (45.2±5.4 cm). To ensure data uniformity, the participants were always tested in the morning by the same group of examiners.
Procedures. A pilot study was conducted to determine the training intensity and load progression. Ten participants were randomly selected from the original sample and performed first a standing vertical jump and then the depth jump performance from a height of 10, 20, 30, 40, 50 and 60cm. Mean maximum vertical jump height was measured at 46.25cm. Mean maximum depth jump height was found to be 48.64cm taken

from a step height of 20cm, with depth jump performance remaining above the initial vertical jump height up to a step height of 40cm (Figure 1). Therefore, a drop height of 20cm, where depth jump performance was at a maximum and higher than vertical jump performance, was taken to be the initial training intensity (4-6). Drop height was then increased across the training sessions according to the step method from a height of 20cm up to 40cm (Table I).

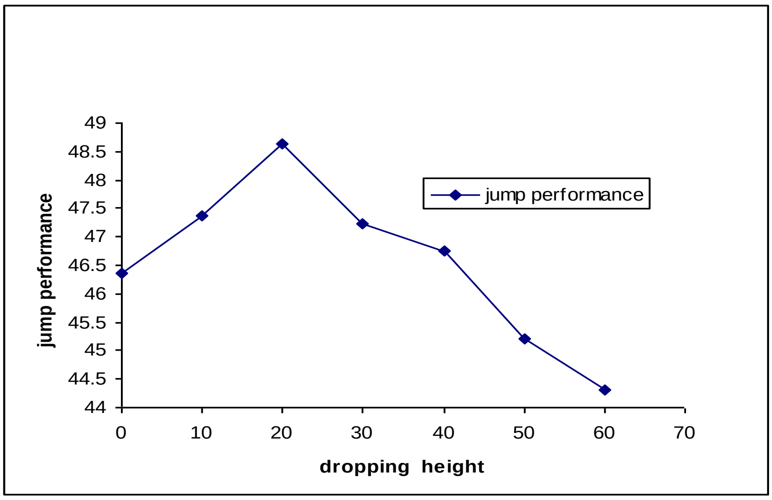

Figure 1. The mean vertical and depth jump performance in pilot study (cm)

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

Table I. Progression of dropping height during experiment

The experimental group trained twice a week for 10-weeks. The Training sessions were administered by dividing experimental group into four smaller subgroups. After a brief warm-up, the group was trained simultaneously on four stations, with the five participants of each subgroup performing in rotation one by one at a station (Figure-2). Each of the participants performed 6 sets of 10 repetitions per session (8). Fifteen seconds of rest was provided as recovery between repetitions by performing a short walk to a cone placed 11m in front of the station (9). Rest between was sets was completed by a 1.5-2 min slow jog to a cone placed 220m from the first cone (10). After training the participants engaged in a cool-down.

The Vertical jump of each participant was measured before and after 10-week period. A 60x120cm black-board painted with one centimeter apart red lines parallel to the ground was fixed firmly to a wall. The board was within the reach of the participant of shortest height. The participant marked maximum reach point with fingertips on the board by raising an arm, after sanding with chalked hand side toward the wall, heels together and on the ground. This reach point was recorded. Then, the participant jumped as high as possible by bending knees and swinging arms to make another mark at the maximal height of the jump. This jump point marked on the board was recorded. The maximum difference between reach point and jump point out of three trials was score in cm.

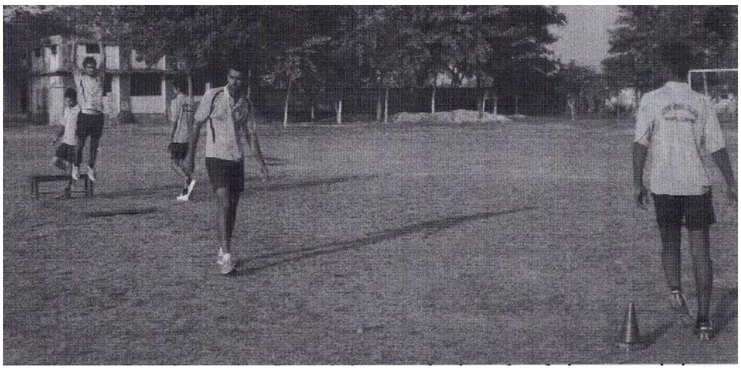

Figure 2. A subgroup of participants during depth jump training

For measuring depth jump performance during pilot study, the participant stand on the dropping height with chalked hand side toward the wall. Then took a step and dropped to a gymnastic mat, immediately after landing on both feet jumped as high as possible. Marked jump height by swinging arms. This jump point marked on the board was recorded. The maximum difference between reach point and jump point out of three trials was score in cm.

Data analysis. The data was analyzed using Statistical Package for the Social Sciences (SPSS) version 22.0 for Windows and was summarized using descriptive statistics of mean, standard deviation and percentage. Analysis of covariance was applied to find significance of difference between groups. Pre-test scores were used as the covariate and post-test scores, adjusted for covariance, were the dependent measures. The alpha level was set at 0.05.

Results

The mean and standard deviation values for vertical jump performance obtained from pre-test and post-test scores of experimental (DJ) and control (CG) group are presented in Table II.

Analysis of covariance with pre-test scores as a covariate showed significant differences ($F_{1,\ 37}$=73.73; p<0.0001) in vertical jump performance of experimental and control group. The experimental group improved significantly as compared to control group. The difference between adjusted means was to 5.03cms.

Mean & standard deviation	Pre-test	Post-test
Experimental group	46.61±4.12	50.93±3.14
Control group	44.7±3.86	44.58±3.49

Table II. The mean and standard deviation values for vertical jump performance in the studied groups during pre- and post-test (cm)

Discussion

After the 10-week period of designated for depth jump training program, the vertical jump performance of experimental group and control group showed significant difference. The analysis of data revealed that experimental group was found to be significantly different as compared to the control group.

These vertical jump performance findings revealed that depth jump training load individualized as per the procedure adopted in the present study was effective in bringing about a significant training effect. Similar findings pertaining to the depth jump training for improvement in vertical jump performance have been reported by many authors (11-16).

The mechanisms thought to contribute to greater power output during a drop jump are the stretch reflex (17), the storage and use of elastic energy (18, 19) and potentiation of the contractile machinery (20). Muscle stretching during a drop jump landing may trigger a stretch reflex (21), which may increase muscular stiffness leading to an improved ability to store potential elastic energy (22). Elastic energy stored in the series elastic elements during stretching can be released during shortening. The storage and use of elastic energy is enhanced with high stretch speed, high eccentric force, and short time delay after the stretch (23). The stretch may induce potentiation of the contractile machinery. This potentiation has been shown to increase with stretch speed and to decrease with the amount of time delay after the stretch (24). Thus, to be an effective training method, drop jumping should fully exploit these mechanisms to enhance athletic performance.

The question of optimal elevation is a vexed one and one that has been argued over since the inception of depth jumping. Various researches have been conducted to determine the optimum dropping height for depth jump training. By increasing the height of drop, one can increase the stretch load imposed on the muscle.

Research has attempted to identify the particular drop-jumping height that produces greatest gains in vertical jump (25-27). Lees and Fahmi (26) reported maximal rebound height occurred at drops of 0.12 m; maximal vertical forces occurred at 0.36 m; and maximal vertical velocity occurred at 0.12 m. Asmussen and Bonde-Peterson (28) reported optimal drop height was 0.4 m. Voigt et al. (29) found a 0.3-m drop height produced significantly higher jump heights than at 0.6 m or 0.9 m. Komi and Bosco (19) reported that rebound height continued to increase up to a drop height of 0.6 m for males and 0.5 m for females. Conversely, Bobbert et al. (20, 30) found no significant difference in rebound height at drop heights of 0.2 m, 0.4 m, and 0.6 m; peak

force did increase, they noted, as drop height increased. While many athletes believe that large drop heights are needed to achieve maximal gains in the rebound vertical jump, in fact rebounding technique can deteriorate at greater drop heights, leading in turn to greater impact forces and increased risk of injury (25).
When eccentric training was introduced in the 1960s, it was assumed that high drop jumps (75-115 cm) were necessary to achieve maximum results (2). Later, studies recommended that drop heights should not exceed 40 to 60 cm (11, 18-19). Further, Studies indicate that a further reduction in drop height may be appropriate i.e. 20 to 40 cm (5, 20, 30).
The dropping height from which an athlete's depth jumps performance is maximum and higher than his/her vertical jump performance will be the optimum training height for the athlete at that stage of training (4-6). Previous studies applied the wide range of dropping heights. Dropping height vary from study to study without establishing a connection between the capabilities of the athletes. After studying the existing literature in the field, investigator applied a practical procedure to determine the optimal dropping height for participants. Investigator tested first a standing vertical jump and then the depth jump performance from a height of 10, 20, 30, 40, 50 and 60cm. The (fig. 1) is showing the relationship between dropping height and average jumping performance of ten subjects. Jumping performance is taken at the Y-Axis and dropping height at the X-Axis. "0" dropping height represents vertical jump performance. It is evident from the curve that the average depth jump performance (48.64cm) from 20cm dropping height is maximum as compared to the other heights and higher than vertical jump performance (46.25cm). Thus 20cm dropping height was selected as initial training intensity.
Dropping height progression of depth jumps applied within the training procedures of previous studies has been varied within wide margins (8, 12-13). It has not been quantified according to the capabilities of athletes under consideration. So another main finding of this study represents the training associated improvement in vertical jump performance in experimental group is the application of step method of progression based on the data obtained through vertical and depth jump tests.
Mean maximum depth jump height was found to be 48.64cm taken from a step height of 20cm, with depth jump performance remaining above the initial vertical jump height up to a step height of 40cm (Fig. 1). Thus, training load was progressed from the dropping height of 20 to 40cm during the ten weeks of experiment (Table 1) according to the step method. 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 consider general training principles of strength training (1). These may be considered as the limitations of the present study.
Thus while planning a depth jump training program, coaches and physical educators should quantify the training load by measuring the vertical and depth jump performance of athletes. These simple measurements enable the trainer to determine initial training intensity and progression of load for better training outcomes.

Conclusion
Analysis of data reveals that depth jump training according to the procedure adopted for individualization of load is effective in bringing about a significant training effect. So, physical educationists and coaches should consider the findings of present study while planning for depth jump training.

References

1. Bompa TO (1999). Periodization: theory and methodology of Training. Champaign, IL, USA: *Human Kinetics*, pp 36-37, 46-50.
2. Verkhoshansky Y (1968). Are depth jumps useful? *Yessis Review of Soviet Physical Education and Sports;* 3:75-8.
3. Wilson G, Murphy A, Giorgi A (1996). Weight and Plyometric Training: Effects on eccentric and concentric force production. *Canadian Journal of Applied Physiology*; 21: 301-315.
4. Chu DA (1998). Jumping into plyometrics. Champaign IL: *Human Kinetics*, pp 15-17,113.
5. Radcliffe JC, Farentinos RC (1999). High-powered plyometrics. Champaign, IL: United States of America: *Human Kinetics*, pp 60, 154-5.
6. Zanon S (1974). Plyometry in jumping. *Die Lehre der Leichtathletik;* 16: 1-13.
7. Costello F (1884). Using weight training and plyometric to increase explosive power for football. *National Strength and Conditioning Association Journal*; 6(2): 22-25.
8. De Villarreal ES, González-Badillo JJ, Izquierdo M (2008). Low and moderate Plyometric Training frequency produces greater jumping and sprinting gains compared with high frequency. *The Journal of Strength and Conditioning Research;* 22(3): 715-725, *doi: 10.1519/JSC.0b013e318163eade*.
9. Read MM, Cisar C (2001). The influence of varied rest interval lengths on depth jump performance. *Journal of Strength and Conditioning Research;* 3(15): 279-283.

10. Verkhoshansky Y (1969). Perspectives in the improvement of speed-strength preparation of jumpers. *Yessis Review of Soviet Physical Education and Sports;* 4: 28-34.
11. Clutch D, Wilton M, McGown C, Bryce GR (1983). The effects of depth jumps and weight training on leg strength and vertical jumps. *Research Quarterly for Exercise and Sports;* 54(1): 5-10.
12. Andrew DPS (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 (0491) degrees: MS.*
13. McClenton LS, Brown LE, Coburn JW, Kersey RD (2008). The effect of short-term VertiMax vs. depth jump training on vertical jump performance. *J Strength Cond Research;* 22 (2): 321-5.
14. Theodoros B, Paul J, Sean S (2008). Effects of two Plyometric Training programmes of different intensity on vertical jump performance in high school athletes. *Serbian Journal of Sports Sciences;* 2(4): 123-130.
15. Potach DH, Katsavelis D, Karst GM, Latin RW, Stergiou N (2009). The effects of a Plyometric Training program on the latency time of the quadriceps femoris and gastrocnemius short-latency responses. *The Journal of Sports Medicine and Physical Fitness;* 49(1): 35-43.
16. Thomas K, French D, Hayes PR (2009). The effect of two Plyometric Training techniques on muscular power and agility in youth soccer players. *Journal of Strength and Conditioning Research;* 23(1): 332-5.
17. Komi PV, Gollhofer A (1997). Stretch reflex can have an important role in force enhancement during stretch-shorten exercise. *Journal of Applied Biomechanics;* 13: 451-460.
18. Bosco C, Komi PV (1979). Mechanical characteristics and fiber composition of human leg extensor muscles. *European journal of applied physiology,* 41: 275-284.
19. Komi PV, Bosco C (1978). Utilization of stored elastic energy in leg extensor muscles by men and women. *Medicine and Science in Sports;* 10: 261-265.
20. Bobbert MF, Huijing PA, Van Ingen Schenau GJ (1987a). Drop jumping I. The influence of jumping technique on the biomechanics of jumping. *Medicine and Science in Sports and Exercise;* 19 (4): 332-338.
21. Nicol C, Komi PV, Hortia T, Kyrolainen H, Takala TES (1996). Reduced stretch reflex sensitivity after exhausting stretch-shortening cycle exercise. *European Journal of Applied Physiology;* 72: 401-409.
22. Walshe AD, Wilson GJ, Ettema GJ (1998). Stretch-shorten cycle compared with isometric preload: contributions to enhanced muscular performance. *Journal of Applied Physiology;* 84(1): 97-106.
23. Bosco C, Komi PV, Ito A (1981). Pre stretch potentiation of human skeletal muscle during the ballistic movement. *Acta Physiologica Scandinavia;* 111: 273-282.
24. Edman KA, Elzinga G, Noble MI (1978). Enhancement of mechanical performance by stretch during tetanic contractions of vertebrate skeletal muscle fibers. *Journal of Physiology;* 281: 139-155.
25. Bobbert MF (1990). Drop jumping as a training method for jumping ability. *Sports Medicine;* 9(1): 7-22.
26. Lees A, Fahni E (1994). Optimal drop heights for Plyometric Training. *Ergonomics;* 37: 141-148.
27. Walsh M, Arampatzis A, Schade F, Brüggeman GP (2004). The effect of drop jump starting height and contact time on power, work performed and moment of force. *J Strength Cond Res;* 18 (3): 561-566.
28. Asmussen E, Bonde-Peterson F (1974). Storage of elastic energy in skeletal muscles in man. *Acta Physiologica Scandinivia;* 91:385-392.
29. Voigt M, Simonsen EB, Dyhre-Poulsen P, Klausen K (1995). Mechanical and muscular factors influencing the performance in maximal vertical jumping after different pre-stretch loads. *Journal of Biomechanics;* 28: 293-307.
30. Bobbert M, Huijing P, Van Ingen Schenaue G (1987b). Drop jumping II: The influence of dropping height on the biomechanics of drop jumping. *Medicine and Science in Sports and Exercise;* 19: 339-346.

Corresponding author
Sukhwinder Singh
Guru Nanak Dev Engineering College, Gill road, Ludhiana, Punjab, India,
Email address: *sukhicheema235@gmail.com*
Mobile: +91-9464975394

Received: February 07, 2016
Accepted: May 25, 2016