Effect of Six-Weeks of Plyometric Circuit Training on the Jumping Performance of Female College Players

Raj Kumar Ph. D.[1] & Harish Kumar Ph. D.[2]

[1]Director Sports, Punjabi University, Patiala -147002, [Punjab]
[2]Department of Physiotherapy & Sports Science, Punjabi University, Patiala -147002, [Punjab]

Abstract

Effect of six weeks of two types of plyometric circuit training programmes on jumping performance of female college level players and athletes were compared. Circuit Training Programme-I used depth jumping in combination with hopping and hurdling while Circuit Training Programme-II comprised only of depth jumping from boxes varying in heights from 15-45cms. The results show that gains in jumping abilities as a result of CTP-II are much higher than the gains accruing as a result of CTP-I. The amount of gain in abilities is not uniform. The gain varies from ability to ability. CTP-II has proved more effective in improving the jumping abilities of the subjects because it is more saturated with depth jumping exercises.

Key Words: **Vertical Jump, Depth Jumping, Standing Broad Jump, Spike Jump**

Introduction:

The improvement in jumping records in various international competitions (Asian and Olympic) in the past thirty years has witnessed a dramatic change in the positive direction. This has attracted the attention of various physical educationists and sports scientists to analyse the causes for this boom. As the performance in jumping events is largely determined by ones muscular strength and also to a number of other related strength factors the training of athletes therefore, is mainly directed to improve the strength ability of the athletes. Old traditional techniques include the weight training and run jumps. These training techniques are no doubt very effective methods used world over for the training of athletes, but with the recent advent of plyometrics (depth jumps) which is based on the principle of overload, an improvement of much greater magnitude in the jumping performance has been reported by the research as is also reflected in the improvement in jumping records of athletes in the past 30-40 years. Depth jumping (Plyometric drills) produces explosive re-active movements since it trains the eccentric part of muscle contraction. The fundamental research in the area was conducted by Russians in the mid and late 1960s. This has unveiled a great potential in the plyometrics. The scientific basis of depth jumping according to *Miller and Power (1981)* is concentric (shortening) contraction. These depth jumping exercises are based on the principle of pre-stretching of the muscles in an amortisation phase to use the kinetic energy developed in this phase in the contraction. The mechanical energy gets stored within the muscle *(Marey and Demeny, 1885).* When two jumps in succession are performed, the second jump is always higher than the first one because of the mechanical energy stored during the falling power phase of the first jump. Many researchers have advocated depth jumping as training aid for improving the jump ability of sportsmen/women *(Verhoshansky, 1967; Lenz and Losch, 1979).* Recently *Walker and Kenneson (1986)* have ascribed

a catalytic role to plyometric exercises in improving the jumping ability.

Advanced countries which are dominating in the field of sports have been using these techniques (plyometrics) for the training of their athletes since the sixties. However, in India which has great genetic potential, very little effort has been made to make use of plyometrics method of training. Strong and consistent steps in this direction are the need of the time, but before it is actually applied on Indian athletes/sportsmen, there is a need to prepare a plyometric circuit suitable for Indian athletes. Unfortunately no scientifically prepared and tried Circuit Training Programme is available in our country.

The present study is aimed to develop a plyometric circuit training suitable for female college players. The investigator not only prepared a circuit training unit but also studied the effects of six- weeks of training on jumping performance of the subjects included in the sample.

Materials and Methods:

In all two hundred (N=200) female college level players and athletes preparing for different inter-college competitions were randomly selected for the purpose of the study. The subjects belonged to five games namely volleyball, basketball, hockey, kho-kho, and kabaddi, and five athletic events i.e. long jump, high jump, shot-put, discus throw and javelin throw. Twenty subjects were selected from each category for the study. The selected subjects were tested on various jumping ability tests which included (i) Standing broad jump (ii) Vertical jump (iii) Three successive double foot jump (iv) Three successive right foot jump (v) Three successive left foot jump (vi) Three meter spike jump

The subjects were put to progressive six-week plyometric circuit training with a frequency of three times in a week and tested again after the completion of experimental period on jumping ability test to find out whether or not their jumping abilities improved.

Investigators tried boxes of different heights ranging from 10cms to 36cms with different athletes for more than three months. Not only the different heights were tried but also the distances between their placements were tried. As a result of prolonged efforts, it was decided to have two parallel circuits with different exercises but with boxes of the height ranging between 15cms to 45cms only. After standardisation of the height of the boxes for depth jumping as well as the distance between the successive boxes and jogging distances in accordance with the capabilities of the subjects selected two sets of six-week Circuit Training Programmes were devised. These have been described in tables 1 & 2.

Table 1: Components of Circuit Training Programme-I

	Details of Activity
1	First 10 meters comprised of 3 hops on left foot followed by 3 hops on right foot.
2	Next 10 meters comprised jogging.
3	Double foot depth jumping on five boxes each of 25cm height (L=90cm × B=45cm) interspersed at a distance of 1.15 meters from each other.
4	Jogging for 10 meters.
5	Two legged hurdle jumping over five hurdles each of 42cms height and separated from each other by a distance of 1.30 meters.
6	Jogging for 10 meters.
7	Double foot depth jumping on five boxes each of 30cm height (L=90cm × B=45cm) and placed at a distance of 1.12 meters from each other.

8	Jogging for 10 meters.

Table 2: Components of Circuit Training Programme-II

	Details of Activity
1	First 10 meters included five depth jumping on boxes each of height 15cm (L=90cm × B=45cm) situated at equal distances of 1.20 meters from each other.
2	Next 10 meters comprised jogging only.
3	Depth jumping on five boxes each of 35cm height (L=90cm × B=45cm) interspersed at a distance of 1.10 meters from each other.
4	Jogging for 10 meters.
5	Double foot depth jumping of five boxes each of 25cm height (L=90cm × B=45cm) interspersed at a distance of 1.15 meters from each other.
6	Jogging for 10 meters.
7	Depth jumping on five boxes each of 45cm height (L=90cm × B=45cm) and placed at a distance of 1.10 meters from each other.
8	Jogging for 10 meters.

The duration of training was kept as six-weeks without break. The frequency was kept as thrice per week with a change in load after every two weeks.

In all 144 repetitions were made obligatory six- repetitions for the first two-weeks, eight repetitions for the third and the fourth weeks and ten repetitions for the last two weeks. For arriving at the finality, various combinations were tried and the best ones retained. The final repetitions as indicated above worked out to be as under:

Week I and II 2x3x6 =36 Repetitions

Week III and IV 2x3x8 =48 Repetitions

Week V and VI 2x3x10=60 Repetitions

Total Repetitions = 144

Each group of players/athletes was divided into two subgroups of 10. The subjects in each group were given one week conditioning exercises to bring them to athletic form. This orientation programme consisted of running, callisthenics, and usual body fitness exercises. Each group of subjects (N=10) was administered six-week circuit training Programme I and II as per description given above.

Jumping abilities of the subjects were measured both after the orientation programme and again after completing the Circuit Training for six-weeks.

Results and Discussion:

Effect of CTP-I and II on body weight of female players and athletes (Table 3 and 4).

Tables 3 & 4 enlist the mean values of body weight of the female players before and after the administration of six-weeks of Circuit Training Programme I and II respectively. Both the Circuit Training Programmes produced on an average a slight decrease (statistically insignificant) in body weight ranging between 0.3 to 1.4 kg in the players.

The mean value of body weight before the start of CTP-I has been observed to be 53.9 Kg. which is found to be statistically not different from the mean value of body weight recorded (52.4 Kg) in the female subjects before the start of CTP-II. The Circuit Training Programme-I which lasted for six-weeks reduced an average decrease in body weight of the order of 0.8 Kg which in percentage term works out to be 1.5. A similar picture of decrease in body weight of the same magnitude is demonstrated by the subjects who underwent six-weeks of circuit training–II programme. The results therefore very clearly reflect changes in the body weight of the subject undergoing the above mentioned exercises programme. The circuit training probably affected the body composition of the subjects in a positive manner by stimulating the energy metabolic processes towards loss of excess

body fat and building up of the muscle component of the athletes and players. This type of trend is generally observed in almost all type of athletes and players undergoing conditioning programme. The net effect is in the redistribution of body fat in the different sites of the body depending upon the body segments recruited for muscular action. As body composition has not been studied in the present endeavour, it is difficult to comment on the changes in body composition and the distribution of fat in the various regions of the body as a result of Circuit Training Programme. But based on the findings from some other studies *(Adams, 1984; Brown et al., 1986 and Gehri et al., 1998)* it can be safely said that the slight reduction in body weight in the subjects of the present study is in agreement with the above studies and can be considered as a normal positive training response.

Table 3: Effect of CTP-I on body weight (kgs) of female players

	Before CTP-I				After CTP-I					
Games & Events	**Mean**	**SD**	**SEM**	**CV**	**Mean**	**SD**	**SEM**	**CV**	**Mean Diff.**	**'t'**
Volleyball	53.8	7.55	2.39	14.0	52.4	7.60	2.40	14.5	1.4	0.43
Basketball	57.7	6.22	1.97	10.8	56.6	5.94	1.88	10.5	1.1	0.40
Hockey	52.4	5.95	1.88	11.4	51.5	5.90	1.87	11.5	0.9	0.36
Kho-kho	49.5	6.82	2.16	13.8	49.1	6.89	2.18	14.0	0.4	0.13
Kabaddi	53.5	8.02	2.54	15.0	52.5	7.67	2.43	14.6	1.0	0.29
Long Jump	51.6	4.84	1.53	9.4	51.1	4.65	1.47	9.1	0.5	0.24
High Jump	48.2	4.42	1.40	9.2	47.9	4.38	1.39	9.2	0.3	0.15
Shot put	57.4	6.28	1.98	10.9	57.2	6.49	2.05	11.4	0.2	0.09
Discus Throw	62.7	8.68	2.75	13.8	61.4	8.42	2.66	13.7	1.3	0.34
Javelin Throw	52.4	3.78	1.19	7.2	51.3	3.76	1.19	7.3	1.1	0.65

Table 4: Effect of CTP-II on body weight (kgs) of female players

	Before CTP-II				After CTP-II					
Games & Events	**Mean**	**SD**	**SEM**	**CV**	**Mean**	**SD**	**SEM**	**CV**	**Mean Diff.**	**'t'**
Volleyball	49.6	4.86	1.54	9.8	48.5	4.55	1.44	9.4	1.1	0.52
Basketball	52.2	6.54	2.07	12.5	51.4	6.14	1.94	11.9	0.8	0.28
Hockey	53.0	2.54	0.8	4.8	52.2	2.29	0.72	4.4	0.8	0.79
Kho-kho	50.8	4.92	1.56	9.7	49.5	5.08	1.61	10.3	1.3	0.58
Kabaddi	55.5	4.48	1.42	8.1	54.5	4.35	1.38	8.0	1.0	0.51
Long Jump	49.8	4.57	1.44	9.2	49.3	4.56	1.44	9.3	0.5	0.27
High Jump	51.2	3.91	1.24	7.6	50.8	3.80	1.20	7.5	0.5	0.26
Shot put	54.5	3.34	1.06	6.1	54.0	3.39	1.07	6.3	0.5	0.33
Discus Throw	57.7	5.27	1.67	9.1	56.4	4.95	1.57	8.8	1.3	0.57
Javelin Throw	50.0	3.02	0.96	6.0	48.8	3.06	0.97	6.3	1.2	0.88

Effect of CTP-I and II on ability to jump

An analysis of the improvement in the various jumping ability measures after CTP-I and CTP-II programmes in the light of components of the training regimens has been discussed below:

Table 5: Training effects on Vertical Jump (mtrs.) as a result of six weeks CTP-I

	Before CTP-I		After CTP-I				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff.**	**%↑**	**'t'**
Volleyball	0.263	0.427	0.304	0.039	0.041	15.59	2.229*
Basketball	0.250	0.067	0.291	0.071	0.041	16.4	1.319
Hockey	0.234	0.043	0.294	0.041	0.060	25.64	3.168*
Kho-kho	0.227	0.046	0.274	0.044	0.047	20.70	2.317*
Kabaddi	0.237	0.048	0.287	0.053	0.050	21.1	2.197*
Long Jump	0.246	0.041	0.290	0.052	0.044	17.89	2.060
High Jump	0.219	0.025	0.281	0.023	0.062	28.31	5.665*
Shot put	0.223	0.065	0.301	0.086	0.078	34.98	2.287*
Discus Throw	0.226	0.057	0.281	0.055	0.055	24.34	2.202*
Javelin Throw	0.246	0.037	0.321	0.038	0.066	26.83	3.853*
All Combined	0.237	0.048	0.292	0.052	0.055	23.21	7.761*

Table 6: Training effects on Vertical Jump (mtrs.) as a result of six weeks CTP-II

	Before CTP-II		After CTP-II				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff.**	**%↑**	**'t'**
Volleyball	0.288	0.023	0.332	0.025	0.044	15.28	4.070*
Basketball	0.253	0.035	0.313	0.023	0.060	23.71	4.527*
Hockey	0.243	0.051	0.296	0.033	0.053	21.81	2.766*
Kho-kho	0.238	0.039	0.301	0.043	0.063	26.47	3.448*
Kabaddi	0.282	0.035	0.332	0.048	0.050	17.73	2.630*
Long Jump	0.253	0.047	0.314	0.049	0.061	24.11	2.822*
High Jump	0.258	0.057	0.310	0.054	0.052	20.16	2.097
Shot put	0.302	0.048	0.427	0.058	0.125	41.39	5.242*
Discus Throw	0.258	0.046	0.355	0.061	0.097	37.60	4.005*
Javelin Throw	0.227	0.026	0.301	0.031	0.074	32.60	5.789*
All Combined	0.260	0.046	0.328	0.056	0.068	26.15	9.377*

Table 7: Training effects on Three meter Spike Jump (mtrs.) as a result of six weeks CTP-I

	Before CTP-I		After CTP-I				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	2.406	0.079	2.463	0.589	0.057	2.36	1.829
Basketball	2.426	0.119	2.482	0.124	0.056	2.30	1.029

Hockey	2.340	0.084	2.418	0.066	0.078	3.33	2.313*
Kho-kho	2.285	0.057	2.352	0.048	0.067	2.93	2.842*
Kabaddi	2.373	0.123	2.447	0.097	0.074	3.11	1.499
Long Jump	2.340	0.057	2.407	0.057	0.067	2.86	2.617*
High Jump	2.326	0.079	2.401	0.056	0.075	3.22	2.453*
Shot put	2.365	0.107	2.501	0.144	0.136	5.75	2.399*
Discus Throw	2.432	0.048	2.509	0.050	0.077	3.16	3.496*
Javelin Throw	2.368	0.052	2.459	0.049	0.091	3.84	3.980*
All Combined	2.366	0.091	2.444	0.091	0.078	3.30	6.057*

Table 8: Training effects on Three meter Spike Jump (mtrs.) as a result of six weeks CTP-II

	Before CTP-II		**After CTP-II**				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	2.368	0.057	2.428	0.062	0.060	2.53	2.266*
Basketball	2.462	0.130	2.542	0.121	0.082	3.33	1.424
Hockey	2.352	0.084	2.430	0.082	0.078	3.31	2.095
Kho-kho	2.281	0.638	2.381	0.054	0.100	4.38	3.780*
Kabaddi	2.420	0.038	2.501	0.038	0.081	3.34	4.739*
Long Jump	2.268	0.081	2.363	0.074	0.095	4.18	2.738*
High Jump	2.404	0.105	2.498	0.092	0.094	3.91	2.129*
Shot put	2.340	0.064	2.523	0.066	0.183	7.82	6.272*
Discus Throw	2.320	0.115	2.489	0.075	0.169	7.28	3.872*
Javelin Throw	2.380	0.119	2.487	0.103	0.107	4.49	2.152*
All Combined	2.360	0.103	2.464	0.095	0.104	4.41	7.400*

(a) Improvement in the ability to jump as high as possible (Tables 5-8).

Tables 5-8 indicate the responses to two types of training programmes using either only depth jumping (CTP-II) or depth jumping in combination with hopping and hurdling (CTP-I) in improving ability to jump as high as possible assessed by vertical jumping and three meter spike jumping. Maximum benefits of CTP-I in vertical jumping ability and three meter spike jumping ability are shown by the subjects belonging to shot-put, Javelin, High jump and Hockey while as a result of Circuit Training Programme-II maximum improvement in vertical jumping and three meter spike jumping ability occurred in shot-putters, discus throwers, javelin throwers, kho-kho players, long jumpers and basketball players in that order. Both the training programmes i.e. CTP-I and CTP-II caused a substantive degree of improvement in the ability of both the game players and athletes to jump as high as possible. This is evident from the percentage of improvements witnessed in vertical jumping ability test which has been found to be about 19.9% and 21.0% after test CTP-I and CTP-II in case of game

players and 26.5% and 31. 2% after CTP-I and CTP-II respectively in case of athletic group. It is clearly indicated that athletes improve their vertical jumping ability more than the game players' inspite of the same type of Circuit Training Programme. The greater magnitude of improvement in vertical jump ability in case of athletes is difficult to be explained but it is thought that the potential traits possessed by them for athletic excellence may be responsible for the phenomenon. The training programme somehow or the other is able to stimulate the physiological mechanisms involved in jumping more effectively in case of athletes than the game players and make them high responders to Circuit Training Programme-II by virtue of its 100% depth jump nature and thus has been able to surpass Circuit Training Programme-I in showing greater improvements in the vertical jump ability. It may be because of the same reason of high ingredient of plyometrics in the training programme that the training responses of female athletes and players to CTP-I and CTP-II indicate a greater magnitude of training response in vertical jumping ability than other jumping ability measures.

Vertical jumping as a test is commonly used to measure lower body power. The primary muscle groups of the lower body which are involved in vertical jump include extensors of the hip, knee and ankle. *Robertson and Fleming (1987)* measured the contribution of each muscle groups in vertical jumping and reported 40% contribution of the hip extensors, 24.2% of knee extensors and about 36% of the ankle extensors towards vertical jumping. Based on the knowledge of the primary muscle groups of lower body involved in the vertical jump, a number of trainers have used training programmes consisting of a chain of exercises that involve extension of the hip and the knee such as the squat or extension of the hip, knee and ankle, such as clean for improving vertical jumping ability. Following this approach increases in vertical jumping have been reported following a weight training programme by *Gauffin et al (1988)* and *Adams et al (1992).* Adams et al further reported a significant increase in hip and thigh power following a seven-week programme of periodised parallel squats. In the present study the comparison of the training response of the subjects in their ability to jump vertically to two types of plyometric training programmes, indicate greater magnitude of improvement following a training programme which consisted only of depth jumping (CTP-II). The results of the present study are in agreement with several other studies which have reported that plyometric training resulted in a significant effect on increasing hip and thigh power specific to vertical jump *(Miller, 1982 and Brown et al, 1986).* It seems that the plyometric training bridge the gap between strength and speed and exploits the stretch -shortening cycle and thus increases the rate of force development and power output. In addition it seems that CTP-II programme comprising of just depth jumps is more effective as compared to CTP-I in enhancing neuro-muscular efficiency which in turn facilitates excellent transfer of power to other bio-mechanically similar movements that require a powerful thrust from the hips and thighs such as the vertical jump. The superiority of plyometric training seems to be established over power lifting as well, because in power lifting as the performance improves the power output actually decreases. *According to Gar Hammer (1993)* the power lifting although makes the athlete stronger and increases his ability to lift more weight, but the

movement speed substantially decreases, may be because of the lack of typical explosive movements in power lifting. As the plyometric training programmes adopted in the present study contains exercises to develop explosivity by employing depth jumping in case of CTP-II programme and depth jumping in combination with hurdling and hopping in CTP-I, it can be stated with confidence that these plyometric training programmes are more effective in improving the vertical jumping ability of the athletes as compared to the traditional methods employing power stresses of plyometric training. However, there is a need to conduct further studies to reveal the optimum degree of weight training and plyometrics to achieve best results.

(b) Improvement in the ability to jump forward (Tables 9-16)

lifting alone. Further the CTP-II programme has proved, beyond doubt, more effective than the CTP-I programme in improving vertical jump performance. Therefore, it is suggested that to build explosiveness in movement, the training programme should be a plyometric one as well as it must contain a grater component of depth jumping in it. Further it is thought that combination of weight training and plyometric can produce better results. This recommendation is made in the light of the need for an adequate strength base to reduce the chances of injuries from the high

The trends of improvements in the ability to jump forward as assessed by three successive double foot jump, three successive right foot jump, three successive left foot and standing broad jumps indicate maximum improvement in case of kho-kho and hockey players after the completion of CTP-I.

Table 9: Training effects on Standing Broad Jump (mtrs.) as a result of six weeks CTP-I

	Before CTP-I		After CTP-I				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	1.508	0.148	1.625	0.150	0.117	7.76	4.206*
Basketball	1.438	0.232	1.551	0.235	0.113	7.86	1.082
Hockey	1.509	0.222	1.641	0.233	0.132	8.75	1.297
Kho-kho	1.337	0.140	1.490	0.155	0.153	11.44	2.315*
Kabaddi	1.455	0.100	1.604	0.103	0.149	10.24	3.273*
Long Jump	1.373	0.220	1.466	0.213	0.093	6.77	0.960
High Jump	1.393	0.169	1.495	0.150	0.102	7.32	1.430
Shot put	1.441	0.238	1.558	0.222	0.117	8.12	1.138
Discus Throw	1.435	0.193	1.521	0.181	0.086	5.99	1.029
Javelin Throw	1.370	0.222	1.452	0.218	0.082	5.99	0.833
All Combined	1.426	0.191	1.540	0.192	0.114	7.99	4.206*

Table 10: Training effects on Standing Broad Jump (mtrs.) as a result of six weeks CTP-II

	Before CTP-II		After CTP-II				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**

Volleyball	1.484	0.120	1.631	0.137	0.147	9.90	2.555*
Basketball	1.445	0.110	1.610	0.107	0.165	11.42	3.409*
Hockey	1.589	0.161	1.745	0.166	0.156	9.82	2.138*
Kho-kho	1.333	0.251	1.519	0.263	0.186	14.00	1.617
Kabaddi	1.486	0.094	1.674	0.084	1.188	12.65	4.702*
Long Jump	1.558	0.279	1.659	0.289	0.101	6.48	0.794
High Jump	1.536	0.196	1.638	0.197	0.102	6.64	1.159
Shot put	1.622	0.171	1.759	0.166	0.137	8.45	1.817
Discus Throw	1.480	0.183	1.605	0.192	0.125	8.45	1.489
Javelin Throw	1.405	0.201	1.518	0.213	0.113	8.04	1.223
All Combined	1.494	0.194	1.636	0.197	0.142	9.50	5.134*

Table 11: Training effects on Three Successive Double Foot Jump (mtrs.) as a result of six weeks CTP-I

	Before CTP-I		**After CTP-I**				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	4.511	0.443	4.687	0.450	0.176	3.90	0.881
Basketball	4.311	0.670	4.471	0.667	0.160	3.71	0.535
Hockey	4.398	0.626	4.617	0.613	0.219	4.98	0.790
Kho-kho	3.984	0.497	4.159	0.517	0.175	4.39	0.771
Kabaddi	4.230	0.393	4.407	0.371	0.177	4.18	1.035
Long Jump	4.012	0.750	4.191	0.750	0.179	4.46	0.534
High Jump	4.087	0.581	4.255	0.569	0.168	4.11	0.654
Shot put	4.140	0.655	4.396	0.737	0.256	5.80	0.821
Discus Throw	4.113	0.706	4.239	0.707	0.126	3.06	0.399
Javelin Throw	4.288	0.496	4.444	0.494	0.156	3.64	0.705
All Combined	4.207	0.585	4.387	0.610	0.180	4.28	2.160*

Table 12: Training effects on Three Successive Double Foot Jump (mtrs.) as a result of six weeks CTP-II

	Before CTP-II		**After CTP-II**				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	4.564	0.727	4.754	0.784	0.190	4.16	0.562
Basketball	4.372	0.437	4.603	0.427	0.231	5.28	1.196
Hockey	4.589	0.524	4.808	0.530	0.219	4.77	0.929
Kho-kho	3.830	0.960	4.084	0.976	0.254	6.63	0.587
Kabaddi	4.418	0.386	4.642	0.366	0.224	5.07	1.331
Long Jump	4.412	0.411	4.617	0.393	0.205	4.65	1.140
High Jump	4.181	0.799	4.366	0.819	0.185	4.42	0.511
Shot put	4.719	0.693	4.951	0.704	0.232	4.92	0.743
Discus Throw	4.307	0.643	4.522	0.617	0.215	4.99	0.763

Javelin Throw	3.945	0.534	4.146	0.532	0.201	5.10	0.843
All Combined	4.334	0.660	4.549	0.666	0.215	4.96	2.293*

Table 13: Training effects on Three Successive Right Foot Jump (mtrs.) as a result of six weeks CTP-I

	Before CTP-I		**After CTP-I**				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	4.265	0.408	4.426	0.401	0.161	3.77	0.889
Basketball	4.230	0.734	4.410	0.733	0.180	4.25	0.548
Hockey	4.225	0.538	4.439	0.539	0.214	5.06	0.888
Kho-kho	3.934	0.557	4.140	0.576	0.206	5.23	0.813
Kabaddi	4.310	0.475	4.461	0.466	0.151	3.50	0.717
Long Jump	3.931	0.707	4.138	0.714	0.207	5.26	0.651
High Jump	4.289	0.656	4.466	0.66	0.177	4.12	0.602
Shot put	4.290	0.841	4.411	0.84	0.121	2.82	0.321
Discus Throw	4.193	0.785	4.358	0.790	0.165	3.93	0.462
Javelin Throw	4.141	0.419	4.318	0.399	0.177	4.27	0.966
All Combined	4.181	0.612	4.357	0.610	0.176	4.21	2.037

Table 14: Training effects on Three Successive Right Foot Jump (mtrs.) as a result of six weeks CTP-II

	Before CTP-II		**After CTP-II**				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	4.067	0.466	4.316	0.496	0.249	6.12	1.158
Basketball	4.241	0.595	4.462	0.586	0.221	5.21	0.833
Hockey	4.554	0.688	4.773	0.723	0.219	4.80	0.693
Kho-kho	3.957	1.215	4.201	1.213	0.244	6.16	0.449
Kabaddi	4.159	0.522	4.375	0.529	0.216	5.19	0.918
Long Jump	4.479	0.349	4.664	0.318	0.185	4.13	1.236
High Jump	4.285	0.633	4.456	0.627	0.171	3.99	0.607
Shot put	4.859	0.875	5.107	0.906	0.248	5.10	0.623
Discus Throw	4.151	0.838	4.301	0.866	0.150	3.61	0.393
Javelin Throw	3.989	0.794	4.221	0.848	0.232	5.81	0.632
All Combined	4.274	0.748	4.488	0.762	0.214	5.01	2.004

The important components of this circuit included hurdling, hopping in combination with some depth jumping also. The single leg hopping component was meant to train the subjects to jump forward as quickly as possible allowing shortest possible time for the feet to remain in contact with the ground. The other component i.e. depth jumping is recognised as most effective method for developing the reactive ability of the neuro-muscular system. The outcome of the Circuit Training Programme-I reveal maximum improvements in distance jumping in case

of kho-kho and hockey players and minimum improvement in shot put and discus throwers. The variations in the training responses may be due to the difference in the body weight of these players and athletes. Kho-kho and hockey players have lighter bodies than the throwers and it is thought that the training programme has caused similar improvements in the explosive power in the lower parts of the body of both Kho-Kho and Hockey players as well as shot-putters and discus throwers, but the gains in this faculty relative to their body weights is different, more in case of former than the latter. It may be due to these reasons that there are differences in the performance of the subjects in distance jumping.

Table 15: Training effects on Three Successive Left Foot Jump (mtrs.) as a result of six weeks CTP-I

	Before CTP-I		After CTP-I				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	4.392	0.368	4.577	0.352	0.185	4.21	1.148
Basketball	4.340	0.608	4.527	0.637	0.187	4.30	0.671
Hockey	4.341	0.545	4.520	0.549	0.179	4.12	0.732
Kho-kho	4.086	0.527	4.312	0.547	0.226	5.53	0.940
Kabaddi	3.927	0.476	4.123	0.506	0.196	4.99	0.892
Long Jump	4.110	0.647	4.286	0.637	0.176	4.28	0.613
High Jump	4.066	0.515	4.274	0.528	0.208	5.11	0.891
Shot put	3.938	0.624	4.100	0.657	0.162	4.11	0.565
Discus Throw	4.261	0.672	4.429	0.672	0.168	3.94	0.559
Javelin Throw	4.200	0.691	4.413	0.683	0.213	5.07	0.693
All Combined	4.166	0.568	4.356	0.577	0.191	4.58	2.346*

Table 16: Training effects on Three Successive Left Foot Jump (mtrs.) as a result of six weeks CTP-II

	Before CTP-II		After CTP-II				
Games & Events	**Mean**	**SD**	**Mean**	**SD**	**Mean Diff**	**%↑**	**'t'**
Volleyball	4.484	0.577	4.721	0.593	0.237	5.28	0.906
Basketball	4.270	0.480	4.536	0.514	0.266	6.22	1.197
Hockey	4.529	0.528	4.762	0.545	0.233	5.14	0.971
Kho-kho	3.781	0.991	4.057	1.004	0.276	7.29	0.619
Kabaddi	3.800	0.725	4.045	0.705	0.245	6.44	0.766
Long Jump	4.271	0.419	4.461	0.405	0.190	4.44	1.031
High Jump	3.880	1.171	4.066	1.191	0.186	4.79	0.352
Shot put	4.589	0.583	4.844	0.619	0.255	5.55	0.949
Discus Throw	4.389	0.683	4.615	0.685	0.226	5.14	0.739
Javelin Throw	3.929	0.760	4.143	0.759	0.214	5.44	0.630
All Combined	4.192	0.752	4.425	0.762	0.233	5.56	2.178*

In general, game players reap greater benefits of training in standing broad jump ability than the athletes. Though it is explained to some extent above, but another reason may be the fact that in some games like kho-kho and kabaddi, the game situation demands flying diving etc. which involves almost the same type of muscular action as is witnessed during the execution of standing broad jump and thus may be providing an additional stimulus for the development of forward jumping movement.

Generally speaking the CTP-II comprising only depth jumping programme has successfully produced a significant increase in almost all the jumping ability measures chosen in the present study. Such findings get the support from some previous studies *(Muthiah, 1980; Ikai et al, 1984 and Holcomb et al, 1996).* The improvements noticed can be attributed to the improvement in muscular force generation through the combined effect of voluntary contraction and involuntary contraction caused by the reflex action (myotatic). This reflex has been put to action repeatedly in the Circuit Training Programme while jumping from boxes of varying heights. Muscle spindles, the sense organ or the muscles, react to sudden stretch by sending appropriate signals to the spinal cord, which produces the stretch reflex resulting in muscular contraction to oppose this sudden stretch. The series and parallel elastic components of muscles also get stretched during the stretching phase of muscles and result in a combination of utilisation of this stored elastic energy and the force developed by the contractile machinery of the muscles. The net effect is a greater amount of work output from the stretched muscles. The six-weeks Circuit Training Programme-II has probably acted as per the above and has thus resulted in improvements in various jumping abilities included in the present study. As regards CTP-II training, the improvement in all the jumping tests concerning distance jumping, a general picture indicate a greater degree of improvement as compared to CTP-I. This may be ascribed to the fact that CTP-II programme comprised of only depth jumping. Pure depth jumping from boxes varying in heights from 15 to 45cms has therefore, proved more effective as compared to depth jumping used in combination with hopping and hurdling as in the case of CTP-I. The results are in agreement with the results reported by other researchers *(Miller, 1981; Hakkinen et al, 1985; Harvey, 1994 and Gehri et al, 1998).*

In plyometrics the most important muscular contraction is the eccentric contraction. The eccentric contraction also plays a great role in action like jumping, pushing and throwing etc. It has been established in many Soviet studies that the performance in executing a jump is not limited by the strength of the leg extensors and the spine extensors at the time of take off, but by the strength that these muscles show during their stretching. This implies that the force generated during the landing is significantly greater than during the push off stage. In other words strength needed most by the jumper is not for extension of the pushed off leg, but to prevent excessive flexion of the support leg in this stage. The Circuit Training Programmes employed in the present study not only successfully produced maximum eccentric contraction to develop maximal tension in the muscles but the continuation of the circuit for six-weeks duration conditioned the central nervous system to switch the eccentric contraction

to concentric contraction to produce the observed training effects.

Normally a volitional contraction takes approximately six to eight tenths of a second to achieve maximal contraction, however in sports the entire skill is accomplished in majority of the cases between one and two tenths of a second. Thus the key to get a maximally explosive push off is to have the muscles respond with maximal force in the shortest possible time. This is actually what the present Circuit Training Programmes employed in the present study are aiming at i.e. first causing a strong eccentric contraction followed by its conversion to a strong concentric contraction in the shortest possible span of time. Jumping from the high boxes, the legs (knees, hips and ankles) at the movement of landing bend and stretch the muscles of the respective joint.

The stretching of the muscles generates the stretching reflex also called the myotatic reflex. The speed and intensity of this reflex directly depends upon the magnitude and the quickness of the stretching produced on the muscles. The plyometric training schedules employed in the present investigation are thus acting on both the central nervous system and the muscular system in influencing the events involved in the switch over from the eccentric phase of contraction to the concentric phase. As the improvements in the ability to jump forward are witnessed to a higher degree after the CTP-II programme than after the CTP-I. It, therefore, seems that the former regimen is more effective in influencing the CNS and muscular events more effectively and accelerates the kinetics of switching over from eccentric to concentric modes of contraction. This physiological mechanism makes the Circuit Training Programme-II superior to Circuit Training Programme-I for developing the explosive muscular power in athletes and players.

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