CHAPTER - II

REVIEW OF RELATED LITERATURE

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2.1 Introduction

A valuable study depends upon the relevant literature to get a clear picture and outlook with regard to the problem under the study. Thus review helps to bring out a deep and clear insight in to the work to be done. Research is considered to be more structured and systematic process of controlled observation that may lead to development of an organized body of knowledge. This organized body is the result of a scientific analysis accurate observation and experimentation. As far a research is concerned it can never be undertake in isolation of the work that has already been done on the problems which are directly or indirectly related to a study proposed by an investigator. One of the important steps in the planning of any research study is a careful review of the research journals, books, dissertations, and other sources of information on the problem to be investigated. Therefore, a review of the related literature must precede any well planned research study. In the words of Mouly (1964) "A review of related literature is a very important step not only in finding a problem, but also in the formation of hypothesis, in the selection of methods and tools to be employed. Besides it is essential to be developed of the problem and derivation of an effective approach to its solution."
2.2 Need for review

According to Goodyear (1945) "The Key to the vast shore house of published literature may open doors to sources of significant problems and explanatory hypothesis, and provides helpful orientation for the significance of the problems, background for selection of procedure and comparative data for interpretation of results. In order to be truly creative and original, one must read extensively and critically as a stimulus to thinking". In the words of Best (1997) “A familiarity with the literature in any problems area helps the student to discover what is already known what other have attempted to find out, what methods of attack have been promising or disappointing and what problems remains to be unsolved” Primary as well as secondary data can be used as related literature. Primary data of beginning or original, or all new data which have been gathered, are in the process of being gathered. While secondary data are those it that have been collected previously and reported by some individual other than the present investigator. The important objectives of the review of related literature are given below:

- To enable the investigator to define the limits of this field
- To avoid unfruitful and useless problem area.
- To avoid unintentional duplication of well established findings.
- To give an understanding of the research methodology
- To know previous recommendations Chanda, & Sharma (1997).

In this chapter, the investigator includes the literature related to the present study, under the following heads.

2.3 Reviews related to Circuit training

A Mallesh et al., (2018) to find out the effectiveness of Sports Specific Circuit Training and High Intensity Interval Training on aerobic capacity in male basketball players. Study design: Quasi experimental study design. Subject: 40 subjects of basketball players with age group 18-25 years of male gender, having

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agility score of <11.5 and V – sit and reach scores plus or above half inch from the point of zero. **Intervention:** 20 subjects in the group A received Sports Specific Circuit Training and 20 subjects in group B received High Intensity Interval Training. **Outcome measures:** Aerobic Capacity (VO$_2$ Max). **Results:** Statistical analysis was done by using Paired ‘t’ and independent ‘t’ test showed significant improvement in improving aerobic capacity (VO$_2$ Max). **Conclusion:** It is concluded that there is statistically significant improvement in aerobic capacity High Intensity Interval

**Sangari and Annadurai (2017)** to achieve the purpose of these study thirty women inter collegiate basketball players were selected from affiliated colleges of Bharathiar University, Coimbatore and Tamilnadu. The age of the subjects was ranged between eighteen to twenty five years. The selected subjects (N=30) were divided into two equal groups consisting of fifteen (n=15) in each. Experimental group I named as Plyometric Circuit Training (PCT), Experimental Group II- acted as Control Group (CG). Training was given for sixty minutes duration per day for three days a week in the morning session. This was done for a period of twelve weeks. After twelve weeks of training all the subjects were tested on again on agility and speed and the readings were recorded in their respective units as post-test scores. To test the significant changes made from the base line to post test on all the groups individually, ‘t’ test was applied. The significance of the means of the obtained results was tested at 0.05 level of confidence and it was concluded that there is a significant improvement in speed and agility.

**Muniraj (2016)** many researchers proved strength training is one of the appropriate methods planned to develop physical, physiological and performance of the sports persons. Hence, it is good to find out the impact of own body weight circuit training program on the selected physical and physiological variables of school boys. To achieve the purpose of the study, thirty (30) physically active boys were randomly selected from G. S. Hindu Higher Secondary School, Srivilliputtur, Virudhunagar Dist, TN, during the academic year 2014-15. Their age ranged from 15 to 17 years.

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The selected subjects were divided into two (15) equal groups, namely Training (TG) and control (CG) groups. The training group underwent weekly three days for 12 weeks of own body weight circuit training and no treatment was given to the Control group. The collected data were analysed and computed by t test. The result of the study shows that own body weight circuit training produced a significant changes in physical (Muscular strength-\(t = 5.24\) and Speed-\(t = 8.76, P < 0.05\)) and physiological (Resting heart rate-\(t = 6.55\) and Breath holding time-\(t = 10.86, P < 0.05\)) variables of the training group.

Shiv Kumar et al., (2016)\(^5\) the present study was undertaken to study the comparative effect of SAQ and circuit training program on selected physical fitness variables of school level basketball players. Thirty (30) school level basketball players aged between 14-17 years will randomly be selected from Simpkins School Agra U.P. The subjects were randomly divided in three groups as group A (SAQ training group), group B (circuit training group) and group C (control group). After the pre-test with Physical fitness test Experiment Group-A underwent a training SAQ programme of selected exercise. Experiment Group-B received a Circuit training program of selected exercises, whereas the Control group did not participate in any training program. Group A has gone under SAQ training program and Group has gone under circuit training for 60 minutes three times a week except Sunday for duration of 12 weeks. Post data was collected after 12 weeks of experimental period. Analysis of Variance (ANOCOVA) was applied at 0.05 level of significance and Post hoc mean comparison was done by using LSD test. It may be concluded that SAQ training program was significantly better than circuit training program for speed and agility whereas circuit training program was better than SAQ training program for abdominal, arms & shoulder endurance being studied by the researcher. In case of explosive strength no significant difference was found between both the training programs.

Vikesh Kumar (2016)⁶ the purpose of present study was to find out the effect of circuit training on selected motor abilities among university male students. For the purpose of the study total 60 boys, ages ranged from 18 to 25 years were selected as subjects from the Department of Physical Education (T), Guru Nanak Dev University, Amritsar, Punjab (India). The subjects were purposively divided into two groups: Group-A: Experimental (N1=30) and Group-B: Control (N2=30). All the subjects were informed about the aim and methodology of the study. The subjects from Group-A were subjected to 8-week of Circuit Training Program. Group-B acted as control who did not participate any special training apart from the regular curricular activities. The training program starts with warm up exercises for 10 minutes (jogging, slow space running, stretching exercises etc.), then Sit ups (lower abdominals), push-ups, Squat jumps, Compass jumps, Astride jumps, Shuttle runs were selected for the main training schedule. Volume and intensity: Experimental group performed 20 to 30 seconds work on each exercise with a 20 to 30 seconds recovery. They performed 2 to 4 sets with a 2 to 3 minutes recovery between each set. T-test was used to find out the statistical significances of each age groups pre and post mean differences. The level of significance was set at p<0.05 level of confidence. The results of the study stated that the Circuit Training had significantly improved the speed, leg power, arm power and agility of the subjects.

Vrachimis et al., (2016)⁷ the purpose of the present study was to examine the effect of circuit training (CT) on resting heart rate variability (HRV) and other cardiovascular disease (CVD) risk factors such as blood lipids and blood glucose and on fitness components. Twenty-four healthy untrained adults (age 26.5 ±5.1 years; height 1.67 ±8.4 m; weight 66.8 ±15.1 kg; 26.3% ±5.2%; maximum oxygen uptake (VO2max) 48.5 ±10.0 ml·kg⁻¹·min⁻¹) were assigned to either CT (n= 12) involving bodyweight exercises, or control (CON, n= 12) groups. Prior to the start and following the end of the six-week training period, time, frequency-domain and

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nonlinear measures of resting HRV, arterial blood pressure, body composition, fasting blood lipids, lipoproteins and glucose, VO2max, upper body muscular endurance (UBME) and abdominal and hip flexor (AHFME), back strength (BS) and handgrip were assessed. None of the resting HRV measures (P> 0.05) were affected by the CT intervention. However, diastolic blood pressure decreased (P = 0.03), lean body weight (P = 0.03) increased, VO2max(P = 0.03), UBME(P<0.001), AHFME (P= 0.04), and BS (P = 0.03) were significantly higher following CT, whereas the other variables were not influenced by the CT. Six week of CT involving bodyweight exercises has no significant impact on resting HRV. However, this type of training might decrease the risk for development of CVD by reducing arterial blood pressure and by improving body composition, aerobic capacity, muscular endurance and strength.

Chittibabu (2014)\(^8\) the purpose of the study was to evaluate the effectiveness of a basketball specific endurance circuit training on the heart rate of high school male basketball players. To achieve the purpose of the study twenty four (24) male high school basketball players were selected from Neyveli Lignite Corporation Sports School, Neyveli and St. Joseph Higher Secondary School, Manjakuppam, Cuddalore. These students were randomly distributed into two groups namely basketball specific endurance circuit training group (N=12) and control group (N=12). The mean age of the selected players was 16.85 ± 0.67. Resting and exercise heart rate were selected as criterion variables. Exercise heart rate was measured during multistage fitness test using polar heart rate monitor. The basketball specific endurance circuit training was administered 3 days per week for six weeks. They performed 2 minutes of work at 90 to 95% of targeted heart rate using the Karvonen method. They performed 8 repetitions during the first and second week, followed by 10 repetitions during the third and fourth week and 12 repetitions during the fifth and sixth week of training. This was followed by 2 minutes of active resting at 60 to 70% of targeted heart rate. In this study 1:1 work rest ratio was followed. Both the groups were tested before and after training, the collected data was analysed using ANCOVA. The result of the study showed that resting heart rate and exercise heart rate between the groups was

\(^8\) B. Chittibabu, “Effect of basketball specific endurance circuit training on the heart rate of high school male basketball players”. International Journal for Life Sciences and Educational Research, 2:3 (July 2014): 80 - 84,
significant, indicating a significant difference between the two groups on post-test scores. The findings of the study show that significant decrease in resting and exercise heart rate. It can be concluded that basketball specific endurance circuit training is effective in improving the cardiovascular fitness of male high school boys during competitive phase.

Parimalam and Pushparajan (2014)⁹ the intention of the present investigation was to find out the effect of basketball specific training and traditional method of training on agility, explosive power and passing ability of inter collegiate women basketball players. To achieve the purpose of the study 60 inter collegiate women basketball players from Bharathiar University affiliated colleges Tamilnadu, India were volunteered to participate in this study. They were randomly assigned into three groups equally. Each group consisted of 20 subjects. The three groups were named as follows, the experimental group named as a basketball specific training group (BSTG), experimental group-II named as the traditional method of training group (TMTG) and control group-III. After assigning the subjects into various groups the pre test was conducted on the selected variables of agility, explosive power and passing ability. After completion of the pre test, the subjects were treated with their respective training program. Training period was scheduled for twelve weeks. Experimental group-I (BSTG) underwent a basketball specific training programme, experimental group-II (TMTG) underwent traditional method of training programme (that is the subjects in TMTG were asked not to change their normal basketball game practice and in particular their own conditioning and training programme) and control group-III (CG) did not practice any specific training. After 12 weeks of the training period post test was conducted on the dependent variables of agility, explosive power and passing ability for all the three groups. To analyze the treatment effect of training paired ‘t’ ratio was used. To compare the significance of mean differences among all the three groups analysis of covariance was used. Results: The basketball specific training group significantly improved (P<0.05) the selected variables of agility, explosive power and passing ability better than the traditional method of training. Traditional method of training group significantly improved (P<0.05) the selected variables.
variables of agility, explosive power and passing ability better than the control group. The control group did not show any significant improvement on the selected variables. Conclusion: Based on the results it was concluded that the implication of multi components training programme specific to the basketball game might have been the source of its dominance on the improvement of agility, explosive power and passing ability of the women basketball players.

Maria Raj et al., (2013)\(^{10}\) analysed the Comparative effects of Plyometric, Circuit Training and Circuit Breaker Programmes on Selected Motor Components of School Level Basketball Players. The purpose of the study was to compare the effects of plyometrics, circuit training and circuit breaker programmes on selected motor components of school level basketball players. For the purpose of the study; four groups: three experimental groups viz: plyometrics training group (A), circuit training group (B), and circuit breaker programme group (C) and the fourth group served as the control group. Random group design was employed. Reliability coefficients for the test- re-test scores on selected motor components: Cardiorespiratory endurance (1.5 mile Run) 0.87, Hip and back flexibility (Sit and Reach Test) 0.97, Spine flexibility (Bridge Up Test) 0.94, Shoulder flexibility (Shoulder Rotation Test) 0.97, Static balance (Stork Stand Test) 0.97, Dynamic balance (Modified Bass Test) 0.97 were selected to collect the data. To find out the comparative effects of plyometric training, circuit training and circuit breaker programme on selected motor components of school level Basketball players, analysis of covariance was employed, the proposed hypothesis was tested at 0.05 level of confidence. The result revealed significant improvement in most of the selected motor components. All the three experimental groups were effective in improving the Cardiorespiratory endurance (1.5 mile Run), Hip, back and spine flexibility and also balance (static and dynamic). The plyometric groups were comparatively better than the circuit training group and circuit breaker programme in improving the Cardiorespiratory endurance of the subjects. In the case of shoulder flexibility all the three experimental groups did not show any significant improvement.

Karthikeyan et al., (2012)$^{11}$ conducted study on the effects of circuit and moving circuit training on selected strength and power parameters such as leg strength and explosive power in terms of vertical distance. To achieve this purpose, forty five men studying in the Department of physical education and sports science, Annamalai university were selected as subjects at random and they were divided into three groups of fifteen subject each with age ranging from 18 to 24 years namely circuit group underwent their respectively trainings for three days per week for twelve weeks in which the control groups did not participate any special training programme apart from their regular physical education activities as per their curriculum. The following variables namely leg strength and explosive power in terms of vertical distance were selected as criterion variables. All the subject of three groups were tested on selected dependent variables at prior to and immediately after the training programme. The analysis of covariance was used to analyze the significant different, if any among the groups were compared, whenever the obtained ‘F’ ratio for adjusted post test was found to be significant, the Schefee’s post hoc test to find out the paired mean differences, if any. The 0.05 level of confidence was fixed as the level of significance to test the ‘F’ ratio obtained by the analysis of covariance, which was considered as an appropriate. There was significance different among circuit training group, moving circuit training group and control group on leg strength there was significance different among circuit training group, moving circuit training group and control group on explosive power in terms of vertical distance. There was a significance improvement on leg strength and explosive power in terms of vertical distance due to circuit training and moving circuit training.

Pushparajan et al., (2012)$^{12}$, conducted study on effect of intra-session concurrent resistance circuit training and endurance training on physical fitness characteristic of male football players. The study was formulated as pre and post test random group design, in which sixty subject were randomly divided into 4 equal

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groups. The experimental group: 1 (n=15, RCT group) performed resistance circuit training, experimental group: 2 (n=15; ET group) performed the endurance training, experimental group: (n=15, circuit group) performed a concurrent resistance circuit training and endurance training and control group (n=15 cg) did not undergo any specific training. Assessed for speed 50 yard dash, muscular strength programme. The Univariate analysis of variance showed that the training induced significant (p, 0.05) improvement in speed, muscular strength, aerobic capacity for three group. Speed 8.39% for RCT, 6.26% FOR ET, 9.31% for CRCTET, muscular strength 11.14% for RCT, 5.21% for ET, 16.96% CRCTET, Aerobic capacity 5.09% for RCT 7.61 for ET, 7.58 for CRCTET. Conclusion the finding indicates that concurrent resistance circuit training and endurance training programme can elicit improvements in physical fitness characteristics of male foot ball player.

Saharan (2012)\textsuperscript{13} a study was undertaken during the year 2006-2007 at Kurukshetra University Kurukshetra (Haryana) with an aim to assess the influence of circuit training Basketball skills and physical fitness variables of Basketball players. The study discovered that a six week circuit training programme had a positive significant effect on the Basketball skills (field goal speed, accuracy level, dribbling ability) and on physical fitness variables (speed, strength and agility) of Basketball players. Whereas no significant effect of circuit training on flexibility was found.

Jabakumar et al., (2011)\textsuperscript{14} study on impact of circuit training on selected motor fitness and kinaesthetic sense among Hockey. The purpose of the study was to analyse the effect of circuit training on college men Hockey players on selected biomotor variables and kinaesthetic sense. To achieve the purpose 40 men Hockey players were randomly selected from those who participated in the inter-collegiate level tournaments of University of Madras. Their age ranged from 18 and 24 years. The players were selected randomly and divided into two equal groups of 20 members each. Group one was treated as experimental group and the second group was control group. The experimental group was given circuit training for a period of six weeks


and the control group was not given any treatment except of their routine. The data were collected from these two groups prior to and after the circuit training on selected bio-motor variables and kinaesthetic sense. The data collected were statistically examined by using paired ‘t’ test. The results of the study indicate that there was improvement in speed, agility, endurance and kinaesthetic sense after the stipulated period owing to 6 weeks circuit training. In case of explosive Power, there was no significant between the experimental and control group. Even though the circuit training was not given to control group, the previous experience of the players may influenced the performance of explosive power. So, the formulated hypothesis was partially accepted.

**Naghizadeh (1987)**\(^1\)\(^5\) Investigated if Circuit Training could be an effective method to improve aerobic capacity as well as strength. The 47 female volunteers with a range of 17 to 36 years of age were assigned to circuit weight training, jogging and control groups. Each subject was tested prior to and at the end of the 9 week training program on VO\(_2\) maximum and 1-RM bench press and leg press. The data were analysed by use of multivariate ANCOVA. Based on the result of this investigation, there were 124, and 9.6% increased in 10-2 maximum for the circuit weight training a jogging group respectively. The circuit weight training group improved 28.1% in leg press and 20.1% in bench press. There was no significant increase for the jogging group in strength parameters; however, there was a positive change in leg press. The control group did not change significantly in any variable. The conclusion of the study was that continuous circuit weight training is an excellent modality to develop aerobic fitness as well as strength.

**Wilson (1982)**\(^1\)\(^6\) Purpose of this investigation was to determine the effects of a variable resistance circuit weight training programme upon certain cardio-Respiratory fitness and body composition parameters of college age males. Specifically and investigation examined the effects of a three days per week. Eighty male students enrolled in the physical education activity programme at Taxes A and M University served as subject for the study. The subjects were randomly assigned to one of two

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groups, a high intensity circuit training group. All the subjects were asked to work out on the nautilus weight equipment three days per week for eight weeks. They concluded the nautilus training regimens do not effect oxygen up-take and body compositions, and do not affect predictive cardio-Respiratory training measures

Smith (1980)\textsuperscript{17} studied the effects of circuit training on the performance skills of beginners and advance beginners swimmers. 52 male and female students at North Carolina Central University were the subjects. The variable measured for beginner swimmers were breath holding, prone glide, arm stroke and crawl stroke and advance beginner swimmers, treading water, front crawl and back stroke. Students were randomly divided into two equal groups. The experimental groups engaged in six weeks of circuit training and swimming, while the control group engaged six weeks swimming only. Experimental students circuit training on a ten stations universal gym. 3 day/week, 30-31 min/day. Completing the entire circuit twice each training session. They swim for the remain 20 min. of the class period concentrating on the pre-test skills. It was found that the circuit training had a significant effect on the performance skills of the experimental beginner swimmers based on the Red Cross progressive swimming test for beginner swimmers, but there was no significant difference between the experimental and control advanced beginner swimmers.

Edward and Diane (1970)\textsuperscript{18} conducted a study on the effect of circuit training, weight training and interval training on cardio respiratory endurance. Fifty one college males from developmental physical education classes at the University of Mexico were randomly assigned to one of the three exercises programme. The subjects trained for a ten week period at their respective exercise programmes. Pre-test and post-test measures of cardio respiratory endurance were administered under same experimental conditions. The analysis of variance showed no significant differences between the three exercise programmes in the measures of cardio respiratory endurance.


Simmons (1967)²⁹ studied the effect of circuit training upon Cardio Respiratory condition and motor performance. 15 male students in a required physical education course in circuit training showed statistically significant mean improvements in nine to fourteen cardio-Respiratory variables and in all 13 motor fitness variables. The training was done twice a week in 30 minutes period and lasted 12 weeks. Highest means improvement was in rest to work ratio of the brachial sphygmograph, dynamometrical leg strength, dips and shoulder extension, flexibility. Individual difference in changes made between tests one and two appeared related to activity in preceding summer months. Students who began circuit training in excellent physical condition after several month of hard physical labour had lower retest scores view most variable while students who started in poor physical condition increased the majority of scores at retest.

Brooke (1967)²⁰ compared the effect of circuit training and educational gymnastic program using two groups of boys at Coventry Boarding School Cleobury Mortimer, England in programs extending over a period of six weeks each. The test at the beginning and at the end included sit-ups, leg raises, bench jumps, squat jumps, press ups and pull ups. Three scores were obtained on each test: Workout (repetition/minute), speed of the response (highest repetition/10 sec), and performance decrement (decrement curve for repetitions in succeeding 10 sec. interval). Circuit training produced significantly greater gains in three of the performances-Chiefly from increased speed of the muscular response - but the performance decrement rates were not significantly different.

Brown (1962)²¹ studied the effect of circuit training on the physical fitness of grade 5 girls. Two classes were tested on the AAHPER Fitness test before and after eight weeks of regular physical education classes. The experimental class, chosen by


chance, had a supplemental 10-minutes circuit training programme before each class. Both classes showed significant gains in total score. The experimental group showed significant gains on all tests except the 50-yard dash. The control group showed significant gains on all the tests except the pull-ups (modified) and 50-yard dash. The mean differences between groups were not significant, but the experimental class made greater gains except in the shuttle run. The supplemental circuit training produced generally better, but not significantly better, results than the regular programme.

2.4 Reviews related to Weight training

Nikolic et al., (2017)\(^{22}\) the aim of this study was to determine the effects of complex training (a combination of weight training and biomechanically similar plyometric jumps) on the sprint abilities. Young basketball players (N=31, Age=17-18) from OKK "Konstantin" and OKK "Junior" from Nis were divided into two groups: the experimental group (E, n = 16; AVIS = 186,17cm ± 6,50cm; AMAS = 74,75 ± 9,48kg) and control group (K; n = 15; AVIS = 185,15 ± 9,10cm; AMAS = 79,23 ± 11,87kg). The experimental group (E) was made up of the players from basketball team OKK "Konstantin", which in addition to basketball trainings also took part in complex training. The control group (K) was made up of the players from basketball team OKK "Junior", who at that time only took part in basketball trainings.

To assess their sprint abilities, three tests were used: the 10x5m Shuttle Test (10x5m), Sprint Fatigue Test (SFT) and Sprint Speed at 15m (S15m). The measurement was done with the help of the photocell "MICROGATE", a parameter which was monitored and the processed time was read in 1/100sec. The experimental program lasted for 12 weeks (2x per week). Data processing was carried out using the SPSS statistical program. To determine the effect of complex training on the sprint abilities of young basketball players, the analysis of covariance ANCOVA was used. The results showed that group E achieved significantly greater progress than group K on the tests: 10x5m and S15m. There was no difference between group E and K on the test SFT. Based on these results we concluded that complex training has positive effects on the development of sprint abilities, as well as on the development of the

capacity of changes of direction after a full sprint in young basketball players. However, the aforementioned training method does not lead to improvements in sprint endurance, i.e. it does not lead to an improved index of fatigue.

Suthakar and Asha (2017) the present investigation is to dissect the impact of society's move and resistance preparing with strength and endurance training and their combination on readiness and adaptability of University level male Basketball players. The subjects are chosen from Christ University, Jain University, CMR University and PES University students of Karnataka State. The subject's age runs from 18 to 21 years and is partitioned into four gatherings specifically on Strength Training Group(STG), Endurance Training Group(ETG), Combination of Strength and Endurance Training Group (CSETG) and Control Group (CG) each gathering comprising of 20 subjects. The chosen subjects are at first tried on the standard factors utilized as a part of this investigation and this is considered as the pre–test. In the wake of surveying of the pre–test, the subjects having a place with Strength Training Group(STG), Endurance Training Group(ETG) and Combination of strength and Endurance Training Group (CSETG) are treated with Strength and Endurance Training Practices. To the extent the subjects in Control Group (CG) they are not given any training. It is reasoned that the 12 weeks of preparing hones demonstrated the huge enhancements in Muscular Strength and Endurance because of the treatment gatherings and there are no adjustments in control gathering.

Derakhshandeh et al., (2016) Handball is a team sport in which main activities such as sprinting, arm throwing, hitting, and soon involve. This Olympic team sport requires a standard of preparation in order to complete sixteen minutes of competitive play and to achieve success. This study, therefore, was done to determinate the effect of a 4-week different training on some physical fitness variables in youth Handball players. Thirty high-school students participated in the study and assigned into the Resistance Training (RT) (n = 10: 16.75± 0.36 yr; 63.14±

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4.19 kg; 174.8 ± 5.41 cm), Plyometric Training (PT) (n = 10: 16.57± 0.26 yr; 65.52± 6.79 kg; 173.5 ± 5.44 cm), and Complex Training (CT) (n=10, 16.23± 0.50 yr; 58.43± 10.50 kg; 175.2 ± 8.19 cm) groups. Subjects were evaluated in anthropometric and physiological characteristics 48 hours before and after of a 4-week protocol. Because of study purposes, statistical analyses consisted of a repeated measure ANOVA and one-way ANOVA were used. In considering with pre to post test variables changes in the groups, data analysis showed BF, strength, speed, agility, and explosive power were affected by training protocols (P< 0.05) as well as there is an interaction between training methods and time effect for all variables (P< 0.05). As percentage changes, findings showed there was a significant difference in squat strength, agility, speed, and explosive power (p< 0.05), but no significant difference for BF and chest strength (p>0.05). In conclusion, complex training result in advantageous effect on variables such as strength, explosive power, speed and agility in youth handball players compare with resistance and plyometric training although we also reported positive effect of these training methods. Coaches and players, therefore, could consider complex training as alternative method for other training methods.

Sharma (2014) the purpose of the present study was to find out the effect of nine weeks resistance training program on selected physical fitness variables of Basketball players. For this purpose twenty female basketball players from Delhi University were selected to act as subjects for the study, the age of the subjects ranged from 17 to 21 years. The minimum level of participation was Inter-University. The subjects were further divided into two groups i.e. Control and Experimental group, group-I underwent resistance training and group-II acted as control and continued with their regular physical activity. The training period for the study was three days in a week for nine weeks. Pre data of both the groups were taken prior to the training period; the subjects were tested for speed, back strength and abdominal strength. The dependent’s’ test and analysis of covariance was applied as statistical tool. In all cases 0.05 level was fixed as significance. It was concluded from the results of the study that training groups had improved on back strength, and had no significant improvement on the speed and abdominal strength.

Subramanian (2014)²⁶ the purpose of this study was to examine the effect of eight weeks of supervised strength training on selected physical and physiological parameters such as muscular strength, back strength, flexibility, mean arterial pressure, vital capacity, and resting pulse rate of cricket players. For these purpose 30 male cricket players, aged 18 to 22 years took part in the study. Selected subjects were randomly assigned to either core strength training (n=15) or control (n=15) group. The training regimen lasted for eight weeks. The selected dependent variables were assessed using standard tests and procedures, before and after the training regimen. Analysis of covariance was used to determine the significant difference existing between pretest and posttest on selected dependent variables. The analysis of data revealed that eight weeks of core strength training had significant impact on selected physical and physiological parameters.

Kanniyan and Syed (2013)²⁷ to achieve the purpose of the study, 36 men players between the age group 18 and 25 were selected as subjects. They were divided into three equal groups (n=12). Group-1 underwent complex training; Group-2 underwent contrast training and Group-3 acted as control group which only took part in their normal playing session. The subjects were tested on selected criterion variables - speed, muscular endurance, cardio-respiratory endurance, blood pressure and resting pulse rate. The duration of training was 10 weeks for all the three groups. The analysis of covariance (ANCOVA) was used to find out the significant difference if any, among the experimental and control groups on the selected criterion variables separately. The level of significance was fixed at 0.05 at all levels. Sheffe's test was used as post hoc test. Results The results of the study indicate that there are significant differences among complex training group and contrast training group and the control group in all of the physiological and bio-motor variables selected for the study. Though for some of the variables, complex training group has better improvement, contrast training group has also showed significant performance in

most of the physiological and bio-motor variables. **Conclusions** It is concluded that the complex and contrast training is beneficial for training groups that seek improvements in the selected criterion variables.

**Nelaturi and Paul Kumar (2013)** the reason for this study was to figure out the impact of disconnected and joined weight and plyometric preparing on chosen physical and physiological variables around school men. To confirm the progressions because of the impact of weight preparing on chosen physical and physiological variables around school men, plyometric preparing on chosen physical and physiological variables around school men. To confirm the progressions because of the joined impact of weight and plyometric preparing on chosen physical and physiological around school men. The reason for the study was to discover the impact of weight, Plyometric and Combined preparing on chosen physical and physiological variables to be specific hazardous force, husky perseverance, brawny quality, speed, resting beat rate, breathing holding time and cardiovascular continuance around school men. To realize the motivation behind this study, 80 school men learner were chosen at irregular from in and around the Krishna region of Andhra Pradesh, their age ran from 18-23 years. They were partitioned into four equivalent bunches and every gathering comprised 20 subjects. Group –A experienced weight preparing; Group-B experienced Plyometric preparing and Group-C experienced joined preparing for three days for every week for 12 weeks and Group D went about as a control that did not include any uncommon preparing separated from the customary curricular exercises. While plyometric preparing is requesting and place respectable push on the figure. The volume and power of the plyometric preparing inside every these categories might be directed to low and high practice. The subject of the plyometric assembly cleared the base quality prerequisite test and exhibits both static and changing control test of their physique weight with single leg squat, low power place plyometric preparing.

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Somasundaramoorthy (2011) this study is intended to evolve a pre-season training package by studying on the effect of specific season training package on selected physical, physiological and skill performance variables of college level male basketball players. 60 male Basketball players were randomly selected who participated in the inter-collegiate level Basketball tournaments. The subjects were randomly selected and divided into two equal groups’ namely experimental group and conventional group. After the twelve weeks training regimen. Analysis of covariance was used to determine the significant difference existing between pretest and posttest on selected dependent variables. 0.05 level of significance. Result. The experimental group trained with specific pre season training package has significantly improved the physical variables such as speed, agility, explosive power, strength and flexibility, VO₂ max and significantly improved in all the selected skills variables. Which are very essential physical components for any basketball player to achieve maximum success in their playing career.

Shallaby (2010) this study aimed to identify the effectiveness of plyometric exercises on the special physical abilities and skillful performance of basketball players. It was applied to a sample of 20 players of 16 years old from El-Shoban El-Muslmeen club in Port Said. They were divided into two equivalent groups (experimental and control) of 10 players each. The experimental group applied the plyometric exercises and the control group applied the usual program. The program was applied for 12 weeks with 3 training units at 120 minutes for each unit. Through the training unit, the exercises were united between the two groups except for the part of the special physical preparation. The experimental group performed the plyometric exercises while the control group performed the physical exercise. Then, the scientific coefficients were applied to tests using a sample outside the study sample. The scientific coefficients of constancy were between 0.764 and 0.970 and the reliability was between 0.903 and 984. The results pointed to a significant progress in the

29 S. Somasundaramoorthy, “Effects of specific pre season training package on selected physical physiological and skill performance variables of college level male basketball players”, Published Ph.D Thesis in Bharathiar University, http://shodhganga.inflibnet.ac.in/handle/10603/103019.

improvement percentages for the experimental group in all study tests compared to the improvement percentages of the control group, which were respectively: tests of vertical jump at 27.01%, medicine ball push (3 kg) at 20.14%, running 30m x 5n at 1.62% and shuttle running at 7.53%, which led to an improvement in the skillful performance (passing at 13.62%, dribbling at 13.46% , under-basket shooting at 18.58% and lay-up at 57.97%).

Tsimahidis et al (2010)\(^{31}\) studied on the “The effect of sprinting after each set of heavy resistance training on the running speed and jumping performance of young basketball players”. The purpose of this study was to investigate the effect of a 10-week heavy resistance combined with a running training program on the strength, running speed (RS), and vertical jump performance of young basketball players. Twenty-six junior basketball players were equally divided in two groups. The control (CON) group performed only technical preparation and the group that followed the combined training program (CTP) performed additionally five sets of 8-5 repetition maximum (RM) half squat with one 30-m sprint after each set. The evaluation took place before training and after the 5\(^{th}\) and 10\(^{th}\) weeks of training. Apart from the 1RM half squat test, the 10 and 30-m running time was measured using photocells and the jump height (squat, countermovement jump, and drop jump) was estimated taking into account the flight time. The 1RM increased by 30.3 +/- 1.5% at the 10\(^{th}\) week of training for the CTP group (p<0.05), whereas the CON group showed no significant increase (1.1 +/-1.6%, p>0.05). In general, all measured parameters showed a statistically significant increase after the 5\(^{th}\) and 10\(^{th}\) weeks (p<0.05), in contrast to the CON group (p>0.05). This suggests that the applied CTP is beneficial for the strength, RS, and jump height of young basketball players. The observed adaptations in the CTP group could be attributed to learning factors and to a more optimal transfer of the strength gain to running and jumping performance.

Cristea et al., (2004)\(^{32}\) conducted a study on obesity with the aim to determine the effects of different amounts and intensities of exercise training. As


subjects sedentary, overweight men and women (aged 40-65 years) with mild to moderate dyslipidemia were recruited. The main outcome measures were body weight, body composition (via skin-folds), and waist circumference. They were treated with the interventions of eight-month exercise programme with 3 groups: group (1) high amount/vigorous intensity (calorically equivalent to approximately 20 miles [32.0 km] of jogging per week at 65%-80% peak oxygen consumption); group (2) low amount/vigorous intensity (equivalent to approximately 12 miles [19.2 km] of jogging per week at 65%-80%), and group (3) low amount/moderate intensity (equivalent to approximately 12 miles [19.2 km] of walking per week at 40%-55%). Subjects were counselled not to change their diet and were encouraged to maintain body weight. Results of 302 subjects screened, 182 met criteria and were randomized and 120 completed the study both low-amount groups had significantly greater improvements than controls but were not different from each other. Compared with controls, all exercise groups significantly decreased abdominal, minimal waist, and hip circumference measurements. There were no significant changes in dietary intake for any group. The conclusions of the present study are: In no dieting, overweight subjects, the controls gained weight, both low-amount exercise groups lost weight and fat, and the high-amount group lost more of each in a dose-response manner. These findings strongly suggest that, absent changes in diet, a higher amount of activity is necessary for weight maintenance and that the positive caloric imbalance observed in the overweight controls is small and can be reversed by a modest amount of exercise. Most individuals can accomplish this by walking 30 minutes every day.

Donnelly et al., (2003) examined the long-term effects of a supervised program of moderate-intensity exercise on body weight and composition in previously sedentary, overweight and moderately obese men and women. He hypothesized that a 16-month program of verified exercise would prevent weight gain or provides weight loss in the exercise group compared with controls. Participants were recruited from 2 midwestern universities and their surrounding communities. One hundred thirty-one participants were 52 randomized to exercise or control groups, and 74 completed the intervention and all laboratory testing. Exercise was supervised, and the level of

energy expenditure of exercise was measured. Controls remained sedentary. From the results he concluded that moderate-intensity exercise sustained for 16 months is effective for weight management in young adults.

Westcott (2001) conducted a study to assess the way to increase the intensity and effectiveness of resistance training by comparing training with a slower repetition speed to training with a conventional repetition speed. Slower repetition speed may effectively increase intensity throughout the lifting phase while decreasing momentum. Two studies were done with untrained men (N=65) and women (N=82), (mean age=53.6) who trained two to three times per week for eight to 10 weeks on a 13 exercise Nautilus circuit performing one set of each exercise. Participants exclusively trained using regular speed repetitions for 8 to 12 repetitions per set at 7 sec each (2 sec lifting, 1 sec pause, 4 sec lowering) or a slow(R) training protocol where they completed 4 to 6 repetitions per set at 14 sec each (10 sec lifting, 4 sec lowering). All of the participants were tested for either the 10 repetition-maximum (RM) weight 61 loads (regular-speed group) or the 5-RM weight load (slow-speed group). The results of the study were: In both studies, slow training resulted in about a 50% greater increase.

Kraemer et al., (2001) conducted a study to find out the exercise effects on bone mass in postmenopausal women are site-specific and load-dependent. Fifty-six (56) subjects were randomized to either heavy or light resistance training. Only resistance training that involved heavier loads mineral density. 59 Cullinen and Caldwell (1998) recommended that a part of an adult fitness program should include strength training because of the additional benefits it provides. Also he stated that much of the strength training research has been done on male subjects. Consequently, he attempted to to determine what effects weight training had on untrained healthy, young women. Twenty three healthy, normal-weight women participated in the weight training program and 10 women served as the control group. The program consisted of two sessions per week and included two sets of 10 reps for each exercise.


At the end of 12 weeks, the weight-trained group demonstrated no change in body weight. However, percent body fat significantly decreased and fat-free mass) significantly increased. This represents an impressive 10% loss in percent body fat. Muscular strength also increased for the weight-trained women. From his study, the major findings of increased strength, fat-free mass, resting metabolic rate and decreased body fat indicate the potential favourable effect of resistance training in weight management programs.

**Rhodes et al., (2000)**\(^{36}\) investigated the effects of one year of progressive resistance exercise on dynamic muscular strength and the relations to bone mineral density in elderly women. His main aim is to study the paucity of long term studies on exercise training in elderly women. Forty four healthy sedentary women (mean age 68.8 years) volunteered for this study and were randomly assigned to either an exercise group or a control group. The exercise group was involved in three one hour sessions a week for 52 weeks of supervised Pre to strengthen the large muscle groups of the body, while the 54 control groups were instructed to continue their normal lifestyle. The exercise circuit included three sets of eight repetitions at 75% of one repetition maximum focused on the large muscle groups. Statistical analyses (analysis of covariance) showed significant strength gains (p29%), bilateral leg press (>19%), and unilateral biceps curl (>20%). No significant difference between groups was evident in body weight, grip strength, flexibility, waist to hip ratio, or the sum of eight skin folds.

**Cullinen and Caldwell (1998)**\(^{37}\) studied the weight training that increases muscle & strength, and decreases body fat. 20 females participated in a weight-training program to determine the effects of training on resting metabolic rate, fat-free mass, strength, and dietary intake. 10 subjects trained for 12-weeks (2 total-body workouts/week; 6 exercises x 3 sets x 10 reps) program and ten subjects were controls. The results indicated a low-volume of moderate-intensity resistance training increased strength and decreased body fat without dieting. All women should

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incorporate resistance training in their fitness regimens, especially young women seeking improvements in their body composition. Furthermore, the total time commitment for an improvement in body composition was only 2 hours per week, making weight training a time efficient training method.

Parker et al., (1996)\(^{38}\) studied the effects of strength training on cardio Respiratory responses during a sub maximal walk and weight-loaded walking test in older females. After 16 weeks of weight training women aged 60-77 showed reduced heart rate, systolic blood pressure, and rate pressure product while treadmill walking with and without a weight load of 40% bodyweight. They concluded that strength training reduces cardio Respiratory stress during daily tasks in healthy older women.

Evans (1996)\(^{39}\) progressive resistance exercise can produce substantial increases in strength and muscle size, even in the oldest old. For many older patients, resistance training represents the safest, least expensive means to lose body fat, decrease blood pressure, improve glucose tolerance, and maintain long-term independence.

Verill et al., (1992)\(^{40}\) Circuit and Weight Training has been recommended and has been reported to improve strength, lean body mass, self efficacy, and may decrease risk factors for coronary artery disease. There appears to be considerable benefit and minimal risk of resistive exercise training for patients with cardio Respiratory impairment. This mode of exercise may allow patients to perform daily strength tasks safely, more efficiently, and with greater self confidence.” O’Hagan et al. (1995) studied the response towards the resistance training in young women and men. Six women and 6 men trained the elbow flexors 3 days per week for 20 wks, one arm performing in each session 3 5 sets of 10 maximal concentric actions on an accommodating resistance device, the other arm 3 5 sets of 8 12 coupled eccentric/concentric actions on a weight training device. With results collapsed across the two training modes, the women made significantly (p less than 0.05) greater


relative increases than men in strength measured on the weight (116 vs. 46 percent) and accommodating (99 vs. 46 percent) resistance devices, and gestate absolute (3.5 vs. 1.3 n.m) and relative (13.7 vs. 3.2 percent) increases in strength measured on an is kinetic dynamometer. Absolute (cm2) and relative (percent) biceps, brachial is, and total elbow flexor cross sectional area (f > m CT scans) 58 increased significantly, however, the women's vs. men's respective relative and absolute increases did not differ significantly: biceps (13 vs. 7 percent, 0.9 vs. 1.0 cm2), brachial is (53 vs. 31 percent, 2.1 vs. 2.3 cm2), and total (26 vs. 15 percent, 3.1 vs. 3.3 cm2) flexor area. Biceps type I and II fibber area, and the II/I area ratio did not increase significantly. The data indicate that in response to the same short term training program, muscle size increases similarly in women and men but women make greater relative increases in strength.

**Stone et al., (1991)** 41 Regular physical activity can improve cardio Respiratory fitness and may reduce the likelihood and debilitating effects of cardio Respiratory disease. Weight-training has generally been believed to have limited value in modifying risks of cardio Respiratory disease. Effects shown of resistance training on parameters associated with cardio Respiratory fitness and 57 diseases include: heart rate decreases for maximal work and recovery from short term weight-training, increased ventricular mass, and increased ventricular wall and septum thickness. Studies suggest that myocardial hypertrophy resulting from resistive training can be accompanied by positive myocardial adaptations.

**Walberg (1989)** 42 commented on the value of weight training in the treatment of obesity. He noted that resistance exercise appeared to prevent the loss of or even increase muscle mass during energy restriction. Walberg argued that resistance exercise is less likely than aerobic exercise to acutely increase lipid and energy utilization but may indirectly aid weight reduction by increasing lean tissue and metabolic rate. He concluded that the value of aerobic exercise during weight loss was apparent but the potential of resistance exercise in weight remained unclear.

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2.5 Reviews related to Physical variables

Busko et al., (2017) the purpose of this study was to investigate the relationship between somatotype, muscular strength, power output measured in maximal cycle ergometer exercise bouts, and maximal power output and height of rise of the body mass centre (jump height) measured in akimbo counter movement jump (ACMJ), counter movement jump (CMJ) and spike jump (SPJ), in male basketball players. Methods: Thirteen male basketball players (second division, age 19.4 ± 0.8 years, body height 192.9 ± 5.6 cm, body mass 88.8 ± 8.6 kg, training experience 9.3 ± 0.8 years) participated in the study. Somatotype was determined using the Heath-Carter method. Maximal joint torqueses were measured under static conditions. Power output was measured in 2 maximal cycle ergometer exercise bouts, 10 seconds each, with increasing external loads equal to 7.5 and 10.0% of the body weight (BW). All jump trials (ACMJ, CMJ and SPJ) were performed on a force plate. Results: The mean somatotype of basketball players amounted to: 2.8–4.2–3.2. The sum of the joint torques for left and right lower extremities (0.613), trunk (0.631) and all six measured muscle groups (0.647) were significantly correlated (p< 0.05) with the mesomorphic component. Endomorphic, mesomorphic and ectomorphic components were correlated insignificantly with values of maximal power and height of jump during ACMJ, CMJ and SPJ trials. The power output measured in maximal cycle ergometer exercise bouts with increasing external loads was significantly correlated (p< 0.05) with mesomorphy and ectomorphy. Conclusion: It can be assumed that basketball players’ anthropometric characteristics can influence their level of performance but it is not a decisive factor.

Halder et al., (2016) the study aimed to assess and compare the physical and physiological performances of Indian female college basketball players (BB) with sedentary females (SS) of same age group. Randomly selected 20 female college students, 10 each in 2 groups, BB (19.0 ± 0.8) and SS (19.7 ± 1.3) respectively, volunteered for this study. Standing height, body weight, resting blood pressure, resting and maximum heart rate (RHR and MHR respectively), resting oxygen


consumption (VO2rest), maximal aerobic capacity (VO2max), anaerobic power, hand grip strength (HGS) and back leg strength (BLS) were recorded. Body surface area (BSA), body mass index (BMI), maximum oxygen pulse (O2Pmax), fatigue percentage and relative peak power output (RPP) were calculated. Significant difference was observed between BB and SS in body weight (P<0.001), BSA (P<0.01), BMI (P<0.001), HGS (left; P<0.05 and right; P<0.01) and BLS (P<0.01). No significant difference was observed in height and blood pressure among the players and sedentary females, while, significantly lower RHR (P<0.01), higher MHR (P<0.01), VO2max (P<0.001), O2Pmax (P<0.01) were noted in sportswomen compared to sedentary females. Peak anaerobic power, average anaerobic power (both P<0.01) and RPP (P<0.001) of sportswomen was also significantly higher than the sedentary group. The study revealed that female college basketball players were physiologically potent than sedentary students of similar age group. It is once again substantiated the fact that involvement in sports or games like basketball, renders a person with better physiological health and physical fitness as compared to sedentary individuals.

Karthi et al., (2014) Fitness is the key to enjoy our life. Exercise is an important key for a total fitness, regular exercise is necessary to develop and maintain an optimal health. To achieve this purpose 15 Basketball, 15 football and 15 Hockey players from Sri Subramaniya swamy Govt.Arts College, Thiruttani, Tamilnadu how were participated in intramural and extramural tournaments. The subject’s age ranged between 18 to 24 years. The selected criterion variables are speed and cardio respiratory endurance. The physical variables speed assessed with 50 m dash and cardio respiratory endurance assessed with 12 min run/walk test. The collected data were treated with one way (ANOVA). If obtained ‘F’ ratio is significant Scheffe’s post hoc test was will be used. Level of significant was fixed at 0.05. The result shows that basketball players were better speed comparing than the hockey and Football players. Cardio respiratory endurance was better football players comparing than the basketball and hockey players.

Chatzinikolaou et al., (2010)\textsuperscript{46} the study evaluated on the Time course of changes in performance and inflammatory responses after acute plyometric exercise. The objectives of the present investigation were to study the inflammatory and performance responses after an acute bout of intense plyometric exercise during a prolonged recovery period. Participants were randomly assigned to either an experimental group (P, n = 12) that performed intense plyometric exercises or a control group (C, n = 12) that rested. The delayed on set of muscle soreness (DOMS), knee range of motion (KROM), creatine kinase (CK) and lactate dehydrogenises (LDH) activities, white blood cell count, C reactive protein (CRP), uric acid (UA), cortical, testosterone, IL-6, IL-1b strength (isometric and isokinetic), and countermovement (CMJ) and static (SJ) jumping performance were measured at rest, immediately post exercise and at 24, 48, 72, 96, and 120 hours of recovery. Lactate was measured at rest and post exercise. Strength remained unchanged throughout recovery, but CMJ and SJ declined (p < 0.05) by 8-20%. P induced a marked rise in DOMS, CK, and LDH (peaked 24-48 hours post exercise) and a KROM decline. An acute-phase inflammatory response consisting of leukocytes (post exercise and at 24 hours), an IL-6, IL-1b, CRP, and cortical elevation (during the first 24 hours of recovery) and a delayed increase of UA (peaked at 48 hours) and testosterone (peaked at 72 hours) was observed in P. The results of this investigation indicate that performing an acute bout of intense plyometric exercise may induce short-term muscle damage and marked but transient inflammatory responses. Jumping performance seems to deteriorate for as long as 72 hours post exercise, whereas strength appears to remain unchanged. The acute-phase inflammatory response after a plyometric exercise protocol appears to follow the same pattern as in other exercise models. These results clearly indicate the need of sufficient recovery between successive plyometric exercises training sessions. Improving repeated sprint ability in young elite soccer players: repeated shuttle sprints vs. explosive strength training.

Santos et al., (2010)\(^{47}\) the aim of the study was conducted on the Effects of Plyometric Training Followed by Detraining and Reduced Training Periods on Explosive Strength in Adolescent Male Basketball Players. The effects of plyometric training followed by detraining and reduced training periods on explosive strength in adolescent male basketball players. The aims of this study were to determine the effects of (a) plyometric training on explosive strength indicators in adolescent male basketball players and (b) detraining and reduced training on previously achieved explosive strength gains. Two groups were formed: an experimental and a control group. The former was submitted to a 10-week in-season plyometric training program, twice weekly, along with regular basketball practice. Simultaneously, the control group participated in regular basketball practice only. At the end of this period, the experimental group was subdivided into 2 groups: a reduced training group and a detraining group. All participants were assessed on squat jump, countermovement jump, Abalakov test, depth jump, mechanical power, and medicine ball throw at the beginning and at the end of the 10-week in-season plyometric training and on weeks 4, 8, 12, and 16 of the in-season detraining and reduced training periods. In the first phase of the study, the experimental group significantly increased all the assessed indicators (p < 0.05). In the following phase and in general all the groups maintained the previously achieved results. In conclusion, plyometric training showed positive effects on upper- and lower-body explosive strength in adolescent male basketball players. Moreover, we can state that both detraining and a reduced training program indistinctly contribute to maintenance of strength levels. These results highlight the unique power that basketball-specific training seems to have on the sustainability and maintenance of sport performance.

Trzaskoma et al., (2010)\(^{48}\) conducted a study on the effect of a short-term combined conditioning training for the development of leg strength and power. The aim of the study was to compare the effect of combined weight and pendulum training exercises with those isolated ones on muscle strength and vertical jump performance.


A total of 38 young active men were divided into 4 groups performing different combinations of strength and power training and measured directly and 2 weeks after the training program. Weight training and pendulum swing exercises, involving lower body during dynamic bounces, were used. Results of 1 repetition maximum (1RM) in full squat and squat jump with the barbell, maximal force measured during counter movement jump (CMJ), and hip and knee flexor and extensor isometric strength were analyzed. Significant differences (p \leq 0.05) in strength test (1RM squat, hip and knee flexor and extensor strength) were found when performing weight training (1RM-10.2%; maximal torques-23.2%). Positive significant increase (p \leq 0.05) in all strength and power parameters (maximal torques-from 2, 468.9 +/- 387.4 to 2, 712.4 +/- 501.6 Nxm; 1RM squat-from 93.9 +/- 15.0 to 111.4 +/- 15.6 kg; CMJ power-from 3, 050.7 +/- 478.5 to 3, 419.8 +/- 506.6 W; CMJ jump height-from 48.8 +/- 4.1 to 53.4+/-.3.0 cm) after the training program was found when combined training was used. Seated safety position during the pendulum swing is responsible for significant training effect with reduced loads. Plyometric pendulum swing training combined with traditional training can be an alternative, effective method to increase muscle strength and power during short pre or in-season meso cycles.

Wu YK, et al., (2010)\textsuperscript{49}. The present study has demonstrated briefly Relationships between three potentiation effects of plyometric training and performance. This study measured the potentiation effects of plyometric training [normalized electromyography (EMG) in triceps surae, stiffness and elastic energy utilization of the Achilles tendon] and investigated the correlations between these effects and performances [voluntary electromechanical delay (EMD) and jump height]. Twenty-one subjects were randomly assigned either to the control group (10 subjects: age 22.3+/-.1.6 years) or to a training group (11 subjects: age 22.1+/-.1.6 years) that performed 8 weeks of plyometric training. Results: As compared with the performances before training, normalized EMG in the soleus was significantly (P<0.001) increased after 4 and 8 weeks of training. Tendon stiffness, elastic energy storage, release and jump height determined after training were significantly increased (P<0.05), with a concomitantly reduced voluntary EMD (P=0.01). These

variables also showed significant differences vs the control group (all P<0.05). The other variables remained unchanged. Correlations were observed between tendon stiffness and either voluntary EMD (r=-0.77, P=0.014) or jump height (r=0.54, P=0.031). Conclusions: Plyometric training specifically potentiated the normalized EMG, tendon stiffness and elastic energy utilization in the myotendinous complex of the triceps surae. Although these changes are possibly essential determinants, only increases of tendon stiffness were observed to correlate with performance improvements.

**Drinkwater et al., (2009)** the present study has demonstrated that Effect of an acute bout of plyometric exercise on neuromuscular fatigue and recovery in recreational athletes. Although plyometric training is widely used by sports coaches as a method of improving explosive power in athletes, many prescribe volumes in excess of the National Strength and Conditioning Association recommendations. The purpose of this study was to assess voluntary and evoked muscle characteristics to assess the neuromuscular impact of a high-volume about of plyometric exercise that was non-exhaustive. Ten athletes who did not have plyometric training experience were in their competitive season for club-level sport volunteered for the study. After at least 2 days without high-intensity activity, subjects were assessed on maximal twitch torque, time to peak torque, rate of twitch torque development, twitch half-relaxation time, rate of twitch relaxation, and voluntary activation by the interpolated twitch technique before, immediately after, and 2 hours after a high-volume plyometric training program (212 ground contacts). Data were analyzed by repeated-measures analysis of variance and described as mean +/- SD and Cohen d. Statistically significant decrements appeared immediately after the training protocol in the total torque generated by maximal voluntary contractions (p < 0.05, d = -0.51) and twitch (p < 0.01, d = -0.92), rate of twitch torque development (p < 0.01, d = -0.77), and rate of relaxation (p < 0.01, d = -0.73). However, we did not observe any differences that remained statistically different after 2 hours. There were no significant differences observed at any time point in time to peak twitch, half-relaxation time, or voluntary activation. We conclude that high-volume plyometric

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training results primarily in peripheral fatigue that substantially impairs force and rate of force development. We recommend that coaches carefully monitor the volume of plyometric training sessions to avoid neuromuscular impairments that can result in suboptimal training.

Meylan et al., (2009) conducted study on Effects of in-season plyometric training within soccer practice on explosive actions of young players. In soccer, explosive actions such as jumping, sprinting, and changes of direction are essential to optimal performance not only in adults, but also in children's games. The purpose of the present investigation was to determine the influence of short-term plyometric training within regular soccer practice on explosive actions of early pubertal soccer players during the in-season. Fourteen children (13.3 +/- 0.6 years) were selected as the training group (TG) and 11 children (13.1 +/- 0.6 years) were defined as the control group (CG). All children were playing in the same league and trained twice per week for 90 minutes with the same soccer drills. The TG followed an 8-week plyometric program (i.e., jumping, hurdling, bouncing, skipping, and footwork) implemented as a substitute for some soccer drills to obtain the same session duration as CG. At baseline and after training, explosive actions were assessed with the following 6 tests: 10-meter sprint, agility test, 3 vertical jump tests (squat jump [SJ], countermovement jump [CMJ], contact test [CT] and multiple 5 bounds test [MB5]). Plyometric training was associated with significant decreases in 10-m sprint time (-2.1%) and agility test time (-9.6%) and significant increases in jump height for the CMJ (+7.9%) and CT (+10.9%). No significant change in explosive actions after the 8-week period was recorded for the CG. The current study demonstrated that a plyometric program within regular soccer practice improved explosive actions of young players compared to conventional soccer training only. Therefore, the short-term plyometric program had a beneficial impact on explosive actions, such as sprinting, change of direction, and jumping, which are important determinants of match-winning actions in soccer performance.

Sedano et al., (2009) conducted a study on effects of lower-limb plyometric training on body composition, explosive strength, and kicking speed in female soccer players. The aim of the present study was to examine how explosive strength, kicking speed, and body composition are affected by a 12-week plyometric training program in elite female soccer players. The hypothesis was that this program would increase the jumping ability and kicking speed and that these gains could be maintained by means of regular soccer training only. Twenty adult female players were divided into 2 groups: control group (CG, n = 10, age 23.0 +/- 3.2 yr) and plyometric group (PG, n = 10; age 22.8 +/- 2.1 yr). The intervention was carried out during the second part of the competitive season. Both groups performed technical and tactical training exercises and matches together. However, the CG followed the regular soccer physical conditioning program, which was replaced by a plyometric program for PG. Neither CG nor PG performed weight training. Plyometric training took place 3 days a week for 12 weeks including jumps over hurdles, drop jumps (DJ) in stands, or horizontal jumps. Body mass, body composition, countermovement jump height, DJ height, and kicking speed were measured on 4 separate occasions. The PG demonstrated significant increases (p < 0.05) in jumping ability after 6 weeks of training and in kicking speed after 12 weeks. There were no significant times x group interaction effects for body composition. It could be concluded that a 12-week plyometric program can improve explosive strength in female soccer players and that these improvements can be transferred to soccer kick performance in terms of ball speed. However, players need time to transfer these improvements in strength to the specific task. Regular soccer training can maintain the improvements from a plyometric training program for several weeks.

Thomas et al., (2009) conducted a study on compare the effect of two plyometric training techniques on muscular power and agility in youth soccer players. Thirty males from as semi-professional football club’s academy were randomly assigned to 6 weeks of depth jump (DJ) or counter movement jump (CMJ) training


K. Thomas et al., “Compare the effect of two plyometric training techniques on muscular power and agility in youth soccer players”. Journal of Medical Science and Sports Exercise, 37:9 (September, 2009).
twice weekly. Participants in the DJ group performed drop jump with instructions to minimize ground–contact time while maximizing height. Participants in the CMJ group performed jumps from a standing start position with instructions to gain maximum jump height. Post training, both groups experienced improvements in vertical jump height (p< 0.05) and agility time (p< 0.05) and no change in sprint performance (p<0.05). There were no differences between the treatments groups (p=0.05) the study concludes that both depth jump and counter movement jump (CMJ) plyometric are worth while training activities for improving power and agility in youth soccer players.

Castagna et al., (2008)\textsuperscript{54} conducted a study on effect of recovery mode on repeated sprint ability in young basketball players. The aim of this study was to examine the effect of recovery mode on repeated sprint ability in young basketball players. Sixteen basketball players (age, 16.8 +/- 1.2 years; height, 181.3 +/- 5.7 cm; body mass, 73 +/- 10 kg; VO\textsubscript{2} max 59.5 +/- 7.9 ml x kg\textsuperscript{-1} x min\textsuperscript{-1}) performed in random order over 2 separate occasions 2 repeated sprint ability protocols consisting of 10x30-m shuttle run sprints with 30 seconds of passive or active (running at 50\% of maximal aerobic speed) recovery. Results showed that fatigue index (FI) during the active protocol was significantly greater than in the passive condition (5.05 +/- 2.4, and 3.39 +/- 2.3, respectively, p<0.001). No significant association was found between VO\textsubscript{2} peak and FI and Sprint total time (TT) in either repeated sprint protocols. Blood lactate concentration at 3 minutes post exercise was not significantly different between the 2 recovery conditions. The results of this study show that during repeated sprinting, passive recovery enabled better performance, reducing fatigue. Consequently, the use of passive recovery is advisable during competition in order to limit fatigue as a consequence of repeated high intensity exercise.

Ziv (2009)\textsuperscript{55} this article reviews a series of studies (n = 51) examining physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male elite basketball players. These studies included relevant information on physical and physiological variables, such as height,


weight, somatotype, relative size, aerobic profile, strength, anaerobic power, agility and speed. Six main findings emerged from our review: (i) differences in physical attributes exist among playing positions and skill levels (e.g. guards tend to be lighter, shorter and more mesomorphic than centres); (ii) maximum aerobic capacity (VO$_2$max) values of female and male players are 44.0-54.0 and 50-60 mLO(2)/kg/min, respectively; (iii) male and female players of higher skill levels tend to have higher vertical jump values; (iv) the more skilled female and male players are faster and more agile than the less skilled players; (v) guards tend to perform more high-intensity movements during game play compared with forwards and centres; and (vi) a water deficit of 2% of bodyweight can lead to reduced physical and mental performance during an actual game. Five limitations associated with the testing protocols used in the studies are outlined, among them the lack of a longitudinal approach, lack of tests performed under physical exertion conditions, and lack of studies using a time-motion analysis. In addition, three practical recommendations for the basketball coach and the strength and conditioning coach are presented. It is concluded that the data emerging from these studies, combined with the knowledge already obtained from the studies on physical and physiological characteristics of elite basketball players, should be applied by basketball and strength and conditioning coaches when planning training programmes for elite basketball players.

Impellizzeri et al., (2008)$^{56}$ was conducted a study on Effect of plyometric training on sand versus grass on muscle soreness and jumping and sprinting ability in soccer players. The lower impact on the musculoskeletal system induced by plyometric exercise on sand compared to a firm surface might be useful to reduce the stress of intensified training periods or during rehabilitation from injury. The aim of this study was to compare the effects of plyometric training on sand versus a grass surface on muscle soreness, vertical jump height and sprinting ability. Parallel two-group, randomized, longitudinal (pretest-post-test) study. After random allocation, 18 soccer players completed 4 weeks of plyometric training on grass (grass group) and 19 players on sand (sand group). Before and after plyometric training, 10 m and 20 m sprint time, squat jump (SJ), countermovement jump (CMJ), and eccentric utilization

ratio (CMJ/SJ) were determined. Muscle soreness was measured using a Likert scale. No training surface x time interactions were found for sprint time (p>0.87), whereas a trend was found for SJ (p = 0.08), with both groups showing similar improvements (p<0.001). On the other hand, the grass group improved their CMJ (p = 0.033) and CMJ/SJ (p = 0.005) significantly (p<0.001) more than players in the sand group. In contrast, players in the sand group experienced less muscle soreness than those in the grass group (p<0.001). Plyometric training on sand improved both jumping and sprinting ability and induced less muscle soreness. A grass surface seems to be superior in enhancing CMJ performance while the sand surface showed a greater improvement in SJ. Therefore, plyometric training on different surfaces may be associated with different training-induced effects on some neuromuscular factors related to the efficiency of the stretch-shortening cycle.

Marques et al., (2008) conducted a study on changes in strength and power performance in elite senior female professional volleyball players during the in-season: a case study. It is often recommended that in-season training programs aim to maintain muscular strength and power developed during the off-season. However, improvements in performance may be possible with a well-designed training regimen. The purpose of this case report is to describe the changes in physical performance after an in-season training regimen in professional female volleyball players in order to determine whether muscular strength and power might be improved. Apart from normal practice sessions, 10 elite female volleyball players completed 2 training sessions per week, which included both resistance training and plyometric exercises. Over the 12-week season, the athletes performed 3-4 sets of 3-8 repetitions for resistance and plyometric exercises during each training session. All sessions were supervised by one of the investigators as well as by the team head coach. Muscular strength and power were assessed before and after the 12-week training program using 4 repetition maximum bench press and parallel squat tests, an overhead medicine ball throw as well as unloaded and loaded counter movement jumps (CMJ). Strength improved by 15% and 11.5% in the bench press and parallel squat, respectively (p < 0.0001). Distance in the BTd improved by 11.8% (p < 0.0001),

whereas unloaded and loaded CMJ height increased between 3.8 and 11.2%. The current findings suggest that elite female volleyball players can improve strength and power during the competition season by implementing a well-designed training program that includes both resistance and plyometric exercises.

Villarreal et al., (2008) conducted a study on Low and moderate plyometric training frequency produces greater jumping and sprinting gains compared with high frequency. The purpose of this study was to examine the effect of 3 different plyometric training frequencies (e.g., 1 day per week, 2 days per week, 4 days per week) associated with 3 different plyometric training volumes on maximal strength, vertical jump performance, and sprinting ability. Forty-two students were randomly assigned to 1 of 4 groups: control (n = 10, 7 sessions of drop jump (DJ) training, 1 day per week, 420 DJs), 14 sessions of DJ training (n = 12, 2 days per week, 840 DJs), and 28 sessions of DJ training (n = 9, 4 days per week, 1680 DJs). The training protocols included DJ from 3 different heights 20, 40, and 60 cm. Maximal strength (1 repetition maximum [1RM] and maximal isometric strength), vertical height in countermovement jumps and DJs, and 20-m sprint time tests were carried out before and after 7 weeks of plyometric training. No significant difference was observed among the groups in pre-training in any of the variables tested. No significant changes were observed in the control group in any of the variables tested at any point. Short-term plyometric training using moderate training frequency and volume of jumps (2 days per week, 840 jumps) produces similar enhancements in jumping performance, but greater training efficiency (approximately 12% and 0.014% per jump) compared with high jumping (4 days per week, 1680 jumps) training frequency (approximately 18% and 0.011% per jump). In addition, similar enhancements in 20-m-sprint time, jumping contact times and maximal strength were observed in both a moderate and a low number of training sessions per week compared with high training frequencies, despite the fact that the average number of jumps accomplished in 7S (420 jumps) and 14S (840 jumps) was 25 and 50% of that performed in 28S (1680 jumps). These observations may have considerable practical relevance for the optimal design of

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plyometric training programs for athletes, given that a moderate volume is more efficient than a higher plyometric training volume.

Ratamess et al., (2007) conducted a study on effects of ten weeks of resistance and combined plyometric/sprint training with the Meridian Elite athletic shoe on muscular performance in women. The purpose of this investigation was to examine the combined effects of resistance and sprint/plyometric training with or without the Meridian Elite athletic shoe on muscular performance in women. Fourteen resistance-trained women were randomly assigned to one of 2 training groups: (a) an athletic shoe (N = 6) (AS) group or (b) the Meridian Elyte (N = 8) (MS) group. Training was performed for 10 76 weeks and consisted of resistance training for 2 days per week and 2 days per week of sprint/plyometric training. Linear periodized resistance training consisted of 5 exercises per workout (4 lower body, 1 upper body) for 3 sets of 3-12 repetition maximum (RM). Sprint/plyometric training consisted of 5-7 exercises per workout (4-5 plyometric exercises, 40-yd and 60-yd sprints) for 3-6 sets with gradually increasing volume (8 weeks) followed by a 2-week taper phase. Assessments for 1RM squat and bench press, vertical jump, broad jump, sprint speed, and body composition were performed before and following the 10-week training period. Significant increases were observed in both AS and MS groups in 1RM squat (12.0 vs. 14.6 kg), bench press (6.8 vs. 7.4 kg), vertical jump height (3.3 vs. 2.3 cm), and broad jump (17.8 vs. 15.2 cm). Similar decreases in peak 20-, 40-, and 60-m sprint times were observed in both groups (20 m: 0.14 vs. 0.11 seconds; 40 m: 0.29 vs. 0.34 seconds; 60 m: 0.45 vs. 0.46 seconds in AS and MS groups, respectively). However, when sprint endurance (the difference between the fastest and slowest sprint trials) was analyzed, there was a significantly greater improvement at 60 m in the MS group. These results indicated that similar improvements in peak sprint speed and jumping ability were observed following 10 weeks of training with either shoe. However, high-intensity sprint endurance at 60 m 77 increased to a greater extent during training with the Meridian Elyte athletic shoe.

Charles (1967)\textsuperscript{60} conducted a study on the effect of selected explosive weight training exercises upon leg strength, free running speed and explosive power. He has taken an experimental group of 20 fresh male volunteers who were selected randomly from trampoline and hand ball classes. The experimental group went for 5 week explosive weight training program with four sessions per week and three circuits of exercises per session. The groups were tested before and after the program. The experimental group made significantly 13 greater improvements in leg strength, but not in running speed or explosive power.

Maroc (1967)\textsuperscript{61} studied on sixty two under graduate women. They were tested the agility, lower back and hip flexibility, arm and shoulder general and endurance, abdominal strength and endurance and general endurance before and after 18 classes periods including either 10 minutes of circuit training, 20 minutes of circuit training, or 15 minutes of progressive conditioning exercises. All within group improvements were highly significant. Both circuit training groups improved significantly more than the progressive exercises group in flexibility, endurance, abdominal strength and endurance in total physical fitness, however their improvements were quite comparable. Initial performance correlated substantially with progress on the circuit and post-test performance.

Day (1963)\textsuperscript{62} investigated the effects of their training programs of running speed. The experimental groups received particular running performance including repetition sprinting, interspersed sprinting and stair running in addition to standard weight training programme. The control group received only the weight training programme in each class period. All groups improved significantly in their running speed with no differences noted between the groups.


2.6 Reviews related to Physiological variables

Kumar and Sharma (2017)\textsuperscript{63} the aim of the study was to find out the relationship of selected anthropometric variables with playing ability of basketball players. The researcher undertook null hypothesis to investigate the relationship of anthropometric variables with basketball playing ability. Selective sampling device was used to select the subjects. 50 male subjects were selected for the present study, who played semifinals in UAE CBSE Cluster Basketball Championship, from various schools. In anthropometric variables, upper and lower extremities length measurements (Arm length, forearm length, hand length, leg length, knee length and foot length) were measured and playing ability of basketball players were measured by Johnson Basketball Skill test (field goal speed test, basketball throw for accuracy and basketball dribble test). For the purpose of analysis coefficient of correlation was taken between anthropometric variables and basketball playing abilities.

Mishra (2017)\textsuperscript{64} To compare the Physiological Variables and Physical Fitness variables between the National level Basketball and Handball Female Players. To achieve the purpose of this study 30 Basketball and Handball Female players i.e. Basketball (n=15) & Handball (n=15), who participated in the inter college completion organized by Sardar Patel University, Anand, Gujarat, India were randomly selected and used as subjects in this study. Age group ranged from 18-25 years. The study was taken to pinpoint the Physiological Variables and Physical Fitness variables. Therefore, based on literary evidence and scholar's own understanding the following variables were selected for the purpose of this study: 1) Resting Heart Rate, 2) Resting Respiratory Rate, 3) Strength & 4) Endurance. To test the significance of mean difference between the Basketball and Handball players, statistical technique of ‘t’ test was applied. Mean 1.68 and SD 3.85 of Resting Heart Rate of Basketball and Handball female players were respectively 1.67 and 3.00 and the calculated t value 0.63. The Mean and SD of Resting Respiratory Rate of Basketball and Handball female players were respectively 65.11 & 3.62 and 65.77 &


2.57 and the calculated t value 0.57. Strength of the Mean & SD of basketball female players 7.03 & 0.06 and handball were 6.99 & 0.07, Mean difference 0.03, standard error 0.02 and the calculated t value 1.34; The Mean & SD of Endurance of basketball players and handball female players were respectively 14.01& 0.07 and 14.07 & 0.24 and the calculated t value 0.90. Table the t value shows that in Physiological Variables namely Resting Heart Rate, Resting Respiratory Rate there is no significant difference between basketball and handball female players. When compared to the mean values of both the groups, finally it has been found that basketball players have considerably average than handball female players in Resting Heart Rate, Resting Respiratory Rate, Strength and Endurance.

Nivargi (2015) the primary aim of this study was to analyze the effect of meditation on selected physiological variables among basketball players of Karnataka State Women University Vijayapur. 15 basketball players of the Karnataka State Women University, Vijayapur and their age ranged from 20 to 28 years. All 15 players underwent programmed of meditation for a period of 12 weeks. The following physiological variables such as the resting pulse rate and respiratory rate were selected as dependent variables. The data collected from the subjects were analyzed with the concept of dependent that was t test. Finally, it was concluded that resting pulse rate and respiratory rate had significantly improved due to transcendental meditation.

Singh et al., (2012) the purpose of this study is to analysis the differences of physiological variables of basketball players at different levels of competitions. This study is a part of doctorate study having a title “Study of Physiological, Body Composition and Psychomotor variables of Basketball Players at different levels of Competitions”. Study was conducted on 50 basketball male players (25 inter college and 25 under-19 School male basketball players) from. In This study physiological variables were taken (i. Vital Capacity (FVC, PIF & PEF) ii. Vo₂ max). Results


showed that there exists a significant difference between Inter College and Under-19 School Male Basketball Players among their Physiological variables. It showed that Vital Capacity and Vo2max. is Higher in Inter College Basketball Male Players when statistically compared with Under-19 School basketball male players.

Brown et al., (2010) conducted a study on Oxygen consumption, heart rate, and blood lactate responses to an acute bout of plyometric depth jumps in college-aged men and women. Although plyometrics are widely used in athletic conditioning, the acute physiologic responses to plyometrics have not been described. The purpose of this study was to investigate the oxygen consumption, heart rate, and blood lactate responses to a single session of plyometric depth jumps. Twenty recreationally trained college-aged subjects (10 men, 10 women) participated in a single session of 8 sets of 10 box depth jumps from a height of 0.8 m with 3 minutes of passive recovery between each set. Plyometric depth jumping elicited 82.5 +/- 3.1% and 77.8 +/- 3.1% of the measured maximal oxygen consumption (O2max) for women and men, respectively, with no difference in oxygen consumption in ml/kg/min or percent O2max between sexes or sets. Heart rate significantly increased (p < 0.05) from 68.1 +/- 2.9 beatsxmin-1 at rest to 169.6 +/- 1.2 beatsxmin-1 during depth jumping. Sets 5 to 8 elicited a higher (p < 0.05) heart rate (173.3 +/- 1.3 beatsxmin-1) than sets 1 to 4 (164.6 +/- 1.8 beatsxmin-1). Women exhibited a higher heart rate (p < 0.05) during sets 1 and 2 (169.9 +/- 2.8 beatsxmin-1) than men (150.7 +/- 4.4 beatsxmin-1). The blood lactate concentrations were significantly (p < 0.05) increased above resting throughout all sets (1.0 +/- 0.2 mmolL-1 compared with 2.9 +/- 0.1 mmolL-1), with no differences between sexes or sets. Plyometric depth jumping significantly increased oxygen consumption, heart rate, and blood lactate in both men and women, but no significant difference was found between the sexes. Plyometric depth jumping from a height of 0.8 m has similar energy system requirements to what Wilmore and Costill termed "Aerobic Power" training, which should enhance VO2max, lactate tolerance, oxidative enzymes, and lactate threshold.

Narazaki et al., (2009) the aim of this study was to assess physiological demands of competitive basketball by measuring oxygen consumption (VO₂) and other variables during practice games. Each of 12 players (20.4 ± 1.1 years) was monitored in a 20 – min practice game, which was conducted in the same way as actual games with the presence of referees and coaches. VO₂ was measured by a portable system during the game and blood lactate concentration (LA) was measured in brief breaks. Subjects were also videotaped for time – motion analysis. Female and male players demonstrated respective VO₂ of 33.4±4.0 and 36.9±2.6 mL/kg/min and LA of3.2±0.9 and 4.2±1.3 mmol/L in the practice games (P>0.05). They spent 34.1% of play time running and jumping, 56.8% walking and 9.0% standing. Preobtained VO₂ max was correlated to VO₂ during play (r=0.673) and to percent of duration for running and jumping (r=0.935 and 0.962 for females and males, respectively). This study demonstrated a greater oxygen uptake for competitive basketball than that estimated based on a previous compendium. The correlation between aerobic capacity and activity level suggests the potential benefit of aerobic conditioning in basketball.

Chutara et al., (2008) conducted a study on Effect of concurrent endurance and circuit resistance training sequence on muscular strength and power development. The purpose of this study was to examine the influence of the sequence order of high intensity endurance training and circuit training on changes in muscular strength and anaerobic power. Forty eight physical education students (ages, 21.4 +/-1.3 years) were assigned to w of 5 groups: no training controls (C, n =9), endurance training (E,n=10), circuit training (S,n=9), endurance before circuit training in the same session, ( E+S,n=10), and circuit before endurance training in the same session (S+E n=10).subjects performed 2 sessions per week for 12 weeks. Resistance type circuit training targeted strength endurance (Weeks 1-6) and explosive strength and power (weeks 7-12). Endurance training sessions included d 5 repetition run at ate the velocity associated with Vo2 max (Vo2 max) for duration equal to 50 % of the time to exhaustion at vo2 max; recovery was for an equal period at 60 % vo2 max .Maximal strength in the half squat, strength endurance in the 1-leg half squat and hip extension,


and explosive strength and power in a 5 jumps test and countermovement jump were measured pre- and post testing. No significant differences were shown following training between the S + E and E + S groups for all exercise tests. However, both S + E and E + S groups improved less than the S group in 1 repetition maximum (p < 0.01), right and left 1-leg half squat (0 < 0.02), 5 jump test (p < 0.01), peak jumping force (p < 0.05), peak jumping power (p < 0.02), and peak jumping height (p < 0.05). The intra session sequence did not influence the adaptive response of muscular strength and explosives strength and power. Circuit training alone induced strength and power improvements that were significantly greater than when resistance and endurance training were combined, irrespective of the intra session sequencing.

Saunders et al., (2008) compared short-term plyometric training improves running economy highly trained middle and long distance runners. Fifteen highly trained distance runners VO2 max (71.1 +/- 6.0 ml min ((1) kg (1), mean +/- SD) were randomly assigned to a plyometric training (ply; n=7) or control (con; n=8) groups. In addition to their normal training, the ply group undertook 3 x 30 minutes ply sessions per week for 9 weeks, running economy (RE) was assessed during 3 x 4 minutes treadmill runs (14, 16 and 18 km . h(-1)), followed by an incremental test to measure VO2 max. Muscle power characteristics were assessed on a portable unidirectional ground reaction force plate, compared with con, ply improved RE at 18 km . h (1) (4.1%. p=0.002), but not at 14 or 16 km . h(-1). This was accompanied by trends for increased average power during a 5 jump plyometric test (15%, p=0.11), a shorter time to reach maximal dynamic strength during a strength quality assessment test (14%, p=0.009) and a lower VO2 max speed slope (14%, p=0.12) after 9 weeks of ply. There were no significant differences in cardio respiratory measures or VO2 max as a result of ply. In a group of highly trained distance runners, 9 weeks of ply improved RE, with likely mechanisms residing in the muscle, or alternatively by improving running mechanics.
Myer et al., (2006)\textsuperscript{71} determined the effects of plyometric vs. dynamic stabilization and balance training on power, balance, and landing force in female athletes. Neuromuscular training protocols that include both plyometrics and dynamic balance exercises can significantly improve biomechanics and neuromuscular performance and reduce anterior cruciate ligament injury risk in female athletes. The purpose of this study was to compare the effects of plyometrics (PLYO) versus dynamic stabilization and balance training (BAL) on power, balance, strength, and landing force in female athletes. Either PLYO or BAL were included as a component of a dynamic neuromuscular training regimen that reduced measures related to ACL injury and increased measures of performance. Nineteen high school female athletes participated in training 3 times a week for 7 weeks. The PLYO (n = 8) group did not receive any dynamic balance exercises and the BAL (n = 11) group did not receive any maximum effort jumps during training. Pre training vs. post training measures of impact force and standard deviation of center of pressure (COP) were recorded during a single leg hop and hold. Subjects were also tested for training effects in strength (isokinetic and isoinertial) and power (vertical jump). The percent change from pretest to posttest in vertical ground reaction force was significantly different between the BAL and PLYO groups on the dominant side (p < 0.05). Both groups decreased their standard deviation of center of pressure (COP) during hop landings in the medial/lateral direction on their dominant side, which equalized pretested side to side differences. Both groups increased hamstrings strength and vertical jump. The results of this study suggest that both PLYO and BAL training are effective at increasing measures of neuromuscular power and control. A combination of PLYO and BAL training may further maximize the effectiveness of preseason training for female athletes.

Caputo and Denadai (2004)\textsuperscript{72} conducted a study on effects of aerobic endurance training status and specificity on oxygen uptake kinetics during maximal exercise. The main purpose of this study was to analyze the effects of exercise mode,

\textsuperscript{71} GD Myer et al., Effects of plyometric vs. dynamic stabilization and balance training on power, balance, and landing force in female athletes”, \textit{Journal of strength and conditioning research}, 20:2 (May, 2006) : 345-53.

training status and specificity in the oxygen uptake (Vo2 max) kinetics during maximal exercise performed in treadmill running and cycle aerometry. Seven runners (R), nine cyclists (C), nine triathletes (T) and eleven untrained subjects (U) performed the following tests on different days on a motorized treadmill and on a cycle ergometer. The U group showed the lowest values for VO2 max, regardless of exercise mode. Differences in tau VO2 (seconds) were found only for the U group in relation to the trained groups [R=31.6 (10.5) and 40.9 (13.6); C=28.5 (5.8) and 32.7 (5.7); t=32.5 (5.6) and 40.7 (7.5); U = 52.7 (8.5) and 62.2 (15.3). for the treadmill and cycle ergometer, respectively; no effects of exercise mode were found in any of the groups. It is concluded that tau VO (2max) during the exercise performed at VO (2max) is dependent on the training status, but not dependent on the exercise mode and specificity of training. Moreover, the transfer of the training effects on tau VO (2max) between both exercise modes may be higher compared with VO (2max).

Murphy and Watsford (2003) conducted a study to examine whether changes in running performance resulting from plyometric training were related to alterations in lower leg muscles tedious stillness (MTS). 17 male runners were pre and post-tested for lower leg MTS, maximum isometric force, rate of force development, 5-bound distance test (5BT), counter movement jump (CMJ) height, RE, VO2 max, lactate threshold and a 3-km time. The subjects were randomly split into an experimental (E) group which completed 6 weeks of plyometric training in conjunction with their normal running training, and a control (C) group which trained as normal. Following the training period, the E group significantly improved 3-km performance and RE at each of the tested velocities, while no changes in Vo2 max) were recorded. CMJ height, 5 BT and MTS also increased significantly. No significant changes were observed in any measures for the C group. The result clearly demonstrated that a 6-week plyometric programme led to improvements in 3-km running performance. It is postulated that the increase in MTS resulted in improved RE which is believed to make changes in 3km running performance, as there were no corresponding alternations in Vo (2 max) or Th (la).

Millet et al., (2002)\textsuperscript{74} conducted a study on Effects of concurrent endurance and strength training on running economy and VO(2) kinetics. The purpose of this study was to examine the influence of a concurrent HWT + endurance training on CR and the VO(2) kinetics in endurance athletes. Fifteen tri athletes were assigned to endurance + strength (ES) or endurance – only (E) training for 14 wk. The training program was similar, except ES performed two HWT sessions a week. Before and after the training period, the subjects performed two incremental field running tests for determination of VO(2)max and the velocity associated (V(VO2max)), the second ventilator threshold (VT(2)); 2) a 3000 m run at constant velocity, calculated to require 25% of the difference between VO(2)max and VT(2), to determine CR and the characteristics of the VO(2) kinetics; 3) maximal hopping tests to determine maximal mechanical power and lower-limb stiffness; 4) maximal concentric lower-limb strength measurements. Results showed that After the training period, maximal strength were increased (P<0.01) in ES but remained unchanged in E. Hopping power decreased in E (P<0.05). After training, economy (P<0.05) and hopping power (P<0.001) were greater in ES than in E. VO(2)max, leg hoping stiffness and the VO(2) Kinetics were not significantly affected by training either in ES or E.

Diallo et al., (2001)\textsuperscript{75} examined the effectiveness of plyometric training and maintenance training on physical performances in prepubescent soccer on players was examined. Twenty boys aged 12-13 years were divided into two groups (10 in each): Jump group (JG) and control group (CG). JG trained 3 days/week during 10 weeks, and performed various plyometric exercises including jumping, hurdling and skipping. However, all subjects continued their soccer training. Maximal cycling power (P max) was calculated using a force-velocity cycling test. Jumping power was assessed by using the following tests: counter movement jump (CMJ), squat jump (SJ), drop jump (DJ), multiple 5 bounds (MB5) and repeated rebound jump for 15 seconds (RRJ 15). Running velocities included; 20, 30 and 40m (v20, v30, v40m). Body fat percentage (BF percent) and lean leg volume were estimated by


\textsuperscript{75} O. Diallo, E. Dore, P. Duche, P. Van, and E. Raagh, “Effects of plyometric training following by a reduced training programme on physical performance in prepubescent soccer players”, Journal of sports medicine and physical fitness, 41:3 (Sep- 2001): 342-8.
anthropocentric before training; except for BF percent all baseline anthropometrics characteristics were similar between JG and CG. After the training program P max, CMJ, SJ, MB5, RRJ15 and v20M, performances increased in the JG. During this period, no significant performance increase was obtained in the CG. After the 8 week of reduced training, except P max for CG, any increase was observed in both groups. These results demonstrate that short-term plyometric training Programmes increase athletic performances in prepubescent boys. These improvements were maintained after a period of reduced training.