Chapter – II

REVIEW OF RELATED LITERATURE

“The literature in any field forms the foundations upon which all future work will be built”.

A study of relevant literature is an essential step to get a fall picture of what has been done with regard to the problem under study such a review brings about a deep and clear perspective of the overall field.

Improvements of athletic capacity in high performance sport mainly achieved through an increase in the quality of training. In physical preparation the quality of training can be improved by developing highly specific means of training. The aim of this paper is to present examples of highly specific means of fitness training of world class athletes can be developed.

The first example presents a test profile of specific motor abilities of top class tennis players the second one deals with the improvement of specific strength training methods of ski jumpers, and third deals with the development of specific training devices of Alpine Sky racers.\(^{44}\)

\(^{44}\) E. Mullen, et. al., “Specific Fitness Training in Competitive Sports” University Magazine University of Salzburg, (32:1) (Jan,2000)216-220.
According to Paton and Hopkins\textsuperscript{45}, most endurance athletes use high-intensity training to prepare for competitions. In this review we consider the effects of high-intensity interval and resistance training on endurance performance and related physiological measures of competitive endurance athletes. METHODS. There were 22 relevant training studies. We classified training as intervals (supramaximal, maximal, submaximal) and resistance (including explosive, plyometrics, and weights). We converted all effects on performance into percent changes in mean power and included effects on physiological measures that impact endurance performance. FINDINGS. All but one study was performed in non-competitive phases of the athletes’ programs, when there was otherwise little or no high-intensity training. Endurance performance of the shortest durations was enhanced most by supramaximal intervals (~4\%) and explosive sport-specific resistance training (4-8\%). Endurance performance of the longest durations was enhanced most by intervals of maximal and supramaximal intensities (~6\%), but resistance training had smaller effects (~2\%). Interval training achieved its effects through improvements of maximum oxygen consumption, anaerobic threshold, and economy, whereas resistance training had benefits mainly on economy. Effects of some forms of high-intensity training on performance or physiology were unclear. CONCLUSIONS. Addition of explosive resistance and high-intensity interval training to a generally low-intensity training program will produce substantial gains in performance.

More research is needed to clarify the effects of the various forms of high-intensity training on endurance performance, to determine whether prescribing specific forms of resistance training can improve specific deficits of an endurance athlete's physiology, and to determine the effects of combining the various forms in periodized programs.

Brown and others conducted the benefits of traditional strength training for dancers has been examined, no such investigation has been performed for plyometric training. Therefore, the purpose of this study was to compare the effects of plyometric training and traditional weight training on aesthetic jumping ability, lower-body strength, and power in collegiate dancers. Eighteen female dancers who were enrolled in a minimum of one intermediate or advanced ballet or modern class at Skidmore College volunteered to participate in the study. Twelve subjects were randomly assigned to a plyometric (n = 6) or traditional weight training (n = 6) group. The remaining six subjects served as a self-selected control group. The plyometric group performed 3 sets of 8 repetitions of 4 different lower-body plyometric exercises twice a week. The weight training group performed 3 sets of 6 to 8 repetitions of 4 lower-body isotonic exercises twice a week. The control group refrained from all forms of strength training. Each subject maintained her normal dance classes throughout the six week intervention. All subjects were tested prior to and following the six-

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week training period. Testing consisted of assessments of jumping skill and lower-body strength and power. Strength was assessed via 3 one-repetition maximum tests: leg press, leg curl, and leg extension. Power was assessed with a Wingate anaerobic power test and vertical jump height tests. Aesthetic jumping ability was assessed via an evaluation by dance faculty at Skidmore College on balloon, jump height, ability to point the feet in the air, and overall jumping ability. There were no differences in the descriptive measures of jumping ability, strength or power among the groups at the start of the study. The plyometric group significantly increased leg press strength (37%), standing vertical jump height (8.3%), and aesthetic jump height (14%). The weight training group significantly increased leg press strength (32%), leg curl strength (23%), mean anaerobic power (6%), aesthetic jump height (22%), and aesthetic ability to point the feet in the air (20%). No significant changes were seen in the control group. The results of this study indicate that either plyometric training or traditional lower-body weight training can be useful in improving variables applicable to dance. This study also supports the notion that short-term dance training alone may not be sufficient to elicit improvements in these variables.

Johnson, Salzberg and Stevenson⁴⁷ were conducted the systematic review to evaluate the efficacy and safety of plyometric training for improving motor performance in young children; to determine if this type of

training could be used to improve the strength, running speed, agility, and jumping ability of children with low motor competence; and to examine the extent and quality of the current research literature. Primary research articles were selected if they (a) described the outcomes of a plyometric exercise intervention; (b) included measures of strength, balance, running speed, jumping ability, or agility; (c) included prepubertal children 5-14 years of age; and (d) used a randomized control trial or quasiexperimental design. Seven articles met the inclusion criteria for the final review. The 7 studies were judged to be of low quality (values of 4-6). Plyometric training had a large effect on improving the ability to run and jump. Preliminary evidence suggests plyometric training also had a large effect on increasing kicking distance, balance, and agility. The current evidence suggests that a twice a week program for 8-10 weeks beginning at 50-60 jumps a session and increasing exercise load weekly results in the largest changes in running and jumping performance. An alternative program for children who do not have the capability or tolerance for a twice a week program would be a low-intensity program for a longer duration. The research suggests that plyometric training is safe for children when parents provide consent, children agree to participate, and safety guidelines are built into the intervention.
Rubley and others measure the effects of low-frequency, low-impact plyometric training on vertical jump (VJ) and kicking distance in female adolescent soccer players. Sixteen adolescent soccer players were studied (age 13.4 ± 0.5 years) across 14 weeks. The control group (general soccer training only) had 6 subjects, and the plyometric training (general soccer training plus plyometric exercise) group had 10 subjects. All subjects were tested for VJ and kicking distance on 3 occasions: pre-test, 7 weeks, and 14 weeks. Data were analyzed using a 2 (Training) × 3 (Test) analysis of variance (ANOVA) with repeated measures on the factor test. No significant difference in kicking distance was found between groups at pre-test (p = 0.688) or 7 weeks (p = 0.117). The plyometric group had significantly greater kicking distance after 14 weeks (p < 0.001). No significant difference in VJ height was found between groups at pre-test (p = 0.837) or 7 weeks (p = 0.108). The plyometric group had a significantly higher VJ after 14 weeks (p = 0.014). These results provide strength coaches with a safe and effective alternative to high-intensity plyometric training. Based on these findings, to increase lower-body power resulting in increased VJ and kicking distance, strength coaches should implement once-weekly, low-impact plyometric training programs with their adolescent athletes.

Sedano Campo\textsuperscript{49} and others 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 time 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.

Meylan and Malatesta\textsuperscript{50} were determine the influence of a 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 changes in explosive actions after the 8-week period were recorded for the CG. The current study demonstrated that a plyometric training.
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.

Mc Daniel\textsuperscript{51} stated athletes who use caffeine before exercising or competition may be helping themselves more than they think. Caffeine is classified as a stimulant and is the most common drug used in the world. Caffeine has the same affects that amphetamines and cocaine have, just in a lesser degree. Caffeine crosses the membranes of all the body's tissues. It can wield effects on the central nervous system and the peripheral tissues that result in physiological effects. Studies have shown that caffeine can help an athlete perform better in a variety of different activities. It has been shown to be a powerful ergogenic aid that is beneficial in athletic performance and training. Caffeine has been shown to increase speed and power output, improve the length an athlete can train, and assist the athlete in resisting fatigue. Caffeine has also been proven to stimulate the brain which contributes to an athlete's clearer thinking and ability to concentrate harder on the task at hand. Studies have shown that up to 25% of athlete's ages 11-18 years old have used caffeine in effort to increase their athletic performances. Because of caffeine's effect on the body and its ability to

\footnote{Larry W. Mc Daniel, et al., “The Effects of Caffeine on Performance in Sports”, \url{www.brianmac.co.uk}}
increase an athlete's performance Olympic Committees have debated on whether caffeine should be tested before the Olympic Games.

Caffeine is a complex substance that is found in many organic compounds and is consumed by humans in coffee, tea, and chocolate. Caffeine is the most commonly used drug in the world. Food industries are adding caffeine to a wide variety of foods and drinks. Caffeine is found in a number of 'natural health products' and in many over-the-counter drugs. The affect caffeine has on the body ranges from various adenosine receptors in several types of body tissues.

Caffeine is ergogenic in most if not all aerobic exercises. Studies have shown that as an ergogenic aid caffeine enhances endurance type exercises such as running, swimming, cycling, and tennis. Studies have shown that caffeine also provide benefits in anaerobic activities such as resistance training. Olympic committees are debating whether or not caffeine should be tested prior to the Olympic Games because of its ergogenic effects. "Glucose recovery slows drastically after 3-4 hours, so recovery rates after 4 hours are excellent proxies for glycogen storage 24 hours after exercise. If you have 66% more fuel for the next day's training or competition, there's no question you'll be able to go further and faster".

So far there has been little evidence demonstrating that the administration of caffeine substances prior to or after exercise produces a negative effect. One article stated, "The mechanisms involved in actions of these compounds are varied and complex and extend well beyond the
traditional explanation of sparing of muscle glycogen to probably involve fundamental aspects of muscle contractility." Many scientists have conducted a number of tests and experiments to determine caffeine's effects and will continue researching caffeine as an ergogenic aid.

Hossein and Nezhad Monireh\textsuperscript{52} find out the plyometric training a leap/jump motions that can be used for athletes power improvement. These exercises may seem rather intensive. It can be done in a few weeks, changes in immune and hematological blood parameters, and ultimately affect the athlete's performance. Therefore the aim of the study is to assess the effects of a short term plyometric training program on some hemorrhheological parameters in college basketball players. A group of Twelve (N=12) male basketball players aged 18 – 24 years, who participated in intercollege basketball competitions organized by the Department of Sports, Islamic Azad University of Shahre-e-rey, volunteered to participate in this study. Their mean height, weight, and age were 181.25 ± 9.69 cm, 75.85 ± 6.68 kg, 21 ± 1.9 years. All subjects, after having been informed about the objective and protocol of the study, gave their written consents and the study was approved by the local Committee of Ethics. Subjects were asked to perform plyometric exercises for 6 weeks and 3 sessions per week. Blood samples were collected 24 hour before and after the exercise period of the anterior forearm vein. Student’s t-test for dependent data was used to

assess the Post-Pre differences. Level of \( p \leq 0.05 \) was considered significant. The results from our study are very encouraging and demonstrate the benefits of short term plyometric training program on hemorrhheological parameters in male College basketball players. The result of this study showed that plyometric training in HGB was significantly decreased (\( P<0.02 \)). Lymphocytes (Lymph) and Neutrophils (Neut) after exercise were significantly increased (\( P<0.04, P<0.02 \)). However, Post-exercise RBC, HCT, MCV, MCH, MCHC, monocytes (Mon) and PLT were also lower but the differences between pre- and postexercise values were not significant. The plasma viscosity, WBC, eosinophils (Eos), and were also higher than preexercise values, but the differences were not significant. In conclusion, the use of plyometric training program with respect to a suitable substrate does not a significant change in the hemorrhheological parameters. Therefore this training program may was working to improve explosive power in preparation season without worrying about immune and hematological systems disorder in the college basketball players.

Monsef Cherif\(^53\) and others conducted a study to investigate the effect of a combined program including sprint repetitions and drop jump training in the same session on male handball players. Twenty-two male handball players aged more than 20 years were assigned into 2 groups: experimental group (n=11) and control group (n=11). Selection was based on variables

“axis” and “lines”, goalkeepers were not included. The experimental group was subjected to 2 testing periods (test and retest) separated by 12 weeks of an additional combined plyometric and running speed training program. The control group performed the usual handball training. The testing period comprised, at the first day, a medical checking, anthropometric measurements and an incremental exercise test called yo-yo intermittent recovery test. 2 days later, participants performed the Repeated Sprint Ability test (RSA), and performed the Jumping Performance using 3 different events: Squat jump (SJ), Countermovement jump without (CMJ) and with arms (CMJA), and Drop jump (DJ). At the end of the training period, participants performed again the repeated sprint ability test, and the jumping performance.

The conventional combined program improved the explosive force ability of handball players in CMJ ($P=0.01$), CMJA ($P=0.01$) and DJR ($P=0.03$). The change was 2.78, 2.42 and 2.62% respectively. No significant changes were noted in performances of the experimental group at the squat jump test and the drop jump with the left leg test. The training intervention also improved the running speed ability of the experimental group ($P=0.003$). No statistical differences were observed between lines or axes.

Additional combined training program between sprint repetition and vertical jump in the same training session positively influence the jumping ability and the sprint ability of handball players.
Williford, Scharff – Olson and Blessing\textsuperscript{54} suggested that the aerobic dance exercise is currently one of the most commonly practised adult fitness activities. The majority of the research pertaining to this form of exercise supports its application as a valid cardiovascular training alternative, especially for adult females if performed according to the American College of Sports Medicine (ACSM) guidelines. If, however, the participant is interested in modifying body composition, training frequency, duration, or efforts toward caloric restriction may need to be increased or altered beyond those employed in the aerobic dance training investigations. The amount of energy expended during a bout of aerobic dance can vary dramatically according to the intensity of the exercise. 'Low intensity' dance exercise is usually characterised by less large muscle activity and/or less lower extremity impact, and music of slower tempo. Dance exercise representative of this variety requires a cost of approximately 4 to 5 kcal/minute. Several trials, however, have shown that vigorous 'high intensity' aerobic dance which entails using the large muscle groups can require 10 to 11 kcal/minute. The associated training outcomes could be affected by such differences in dance exercise intensity and style.

Redding\textsuperscript{55} and others validated dance-specific exercise method of measuring aerobic fitness; no such test has been developed to measure high intensity capabilities in dance. The purpose of this study was to initiate an


intermittent high intensity dance-specific fitness test. The test was designed to be able to observe changes in heart rate (HR), thereby allowing for a measurement of physical fitness at high intensities. Sixteen professional dancers (4 males and 12 females) volunteered to take part in this study. The fitness test protocol consists of movements that are representative of contemporary dance, and contains exercise and rest periods that mimic the intermittent nature of dance. The participants performed four trials. The physiological variables measured were HR (b.min(-1)) for each one minute bout of the four minute test for all trials, oxygen uptake (VO(2)) throughout the test, and end blood lactate (BLa mmol.L) for each trial. In addition, five of the participants undertook a maximal oxygen uptake treadmill test, and the scores obtained were compared with those from the dance test. Results show HR consistency across each one minute bout of the test and across each of the four trials of testing for all participants, indicating that the test is reliable. There was good reliability between bouts of each trial (typical error as % of CV = 1.5), intraclass "r" = 0.8, and good reliability between the four trials (typical error as % of CV = 2.1), intraclass "r" = 0.82. There were no significant differences between the maximal VO(2) and BLa scores established in the treadmill and dance tests, demonstrating validity. Thus, the results of this study indicate that the high intensity dance-specific test is a reliable and valid means of assessing and monitoring the cardiovascular fitness of dancers. The test allows dancers to be assessed within an environment that they are accustomed to (the studio), using a mode of
exercise that is relevant (dance), and it is of adequate intensity to be representative of performance.

Olson\textsuperscript{56} and others investigated to develop a sub-maximal exercise test for estimating VO2max utilizing aerobic dance. One hundred females between the ages 18 to 40 yr served as the subjects for test validation. The subjects completed a treadmill test to determine VO2max and were assessed for heart rate (HR) response to a bout of aerobic dance. The data associated with responses to treadmill exercise and the aerobic dance tests, in conjunction with descriptive variables (e.g., age, BMI) were utilized in the validation of the multiple regression model. Reliability was determined by correlation and paired "t"-tests of the aerobic dance routine test and retest trials. The construction of the multiple regression equation, via forward entry analysis, and the cross-validation of the regression equation were completed to ensure the validity and reliability of the protocol in accurately estimating VO2max. Test, retest reliability for the dance-exercise routine was demonstrated (r = 0.98). Moreover, no significant differences were shown between the HR responses for the test and retest trials. The multiple regression analysis yielded a three variable multiple prediction equation for estimating VO2max (R = 0.84; SEE, 5.5 ml.kg-1.min-1). The three variables were the HR response to four min of aerobic dance (HR4), body mass index (BMI), and age (years). Cross-validation of the aerobic dance test was determined with a second group of 50 female subjects (R = 0.83; SEE, 5.5

ml.kg-1.min-1). Additionally, the application of the validation group regression equation to the cross-validation group yielded a comparable R of 0.82. Comparison of the predicted values for VO2max from both equations also yielded a highly significant invariance coefficient of 0.96. Finally, the results of "t"-tests between the observed and predicted mean values for VO2max revealed no significant difference (p > 0.05). Therefore, the final prediction equation, based on collapsing the means associated with the validation and cross validation samples (n = 150), was: VO2max (ml.kg-1.min-1) = 130.18-(0.38 * HR4)-(0.81 * BMI)-(0.27 * Age); R = 0.84, SEE = 5.5 ml.kg-1.min-1. These results indicate that a four minute aerobic dance test provides a valid and reliable sub-maximal protocol for estimating VO2max and providing an index of aerobic fitness in apparently healthy 18 to 40 yr old females.

Grant57 and others conducted a study to examine the physiological and psychological responses to a university fitness session entitled 'popmobility'. A popmobility session consists of 20 min of aerobic activities, 5 min of local muscular endurance exercises and 5 min of flexibility exercises. Ten regular participants of these sessions, women of mean(s.d.) age 21.2(1.5) years, took part in the study. A maximal oxygen uptake (VO2max) treadmill test was performed by each subject to obtain VO2max and maximum heart rate values. In a laboratory, heart rate and VO2 were measured throughout a popmobility session for each subject. Rate of

perceived exertion (RPE) was measured every 5 min throughout the session. The mean intensity of the aerobic part of the session ranged from 67.7-82.6% of the subject’s VO2max (mean of 76.4% VO2max). The mean heart rate reserve for the aerobic section was 75.6%. While the relative oxygen consumption remained fairly static during the aerobic section, the RPE score rose. The mean(s.d.) total energy expenditure was 236.6(28.4) kcal (range 203-288). The popmobility session is of adequate intensity to improve the aerobic fitness of its participants. Heart rate, as used as a measure of intensity during a popmobility session, would appear to be a fairly accurate indicator of intensity. However, the use of RPE for exercise prescription in popmobility sessions is inappropriate. Popmobility could also be useful in a weight-reduction programme.

Grant\textsuperscript{58} and others compare the physiological responses and ratings of perceived exertion to aerobic dance and walking sessions completed at a self selected pace. Six women and six men with a sample mean (SD) age of 68 (7) years completed aerobic dance and walking sessions in random order. A treadmill test was performed by each subject from which peak oxygen uptake (.VO(2)) and maximum heart rates (HRmax) were determined. During the aerobic dance and walking sessions, heart rate and .VO(2) were measured continuously throughout. Rate of perceived exertion (RPE) was measured every three minutes throughout the session. The sample means

(SD) for %peak VO(2) were 67 (17)% for the aerobic dance sessions and 52 (10)% for the walking sessions, and the %HRmax sample means (SD) were 74 (12)% for the aerobic dance sessions and 60(8)% for walking sessions. The sample mean (SD) RPE for the aerobic dance sessions was 11(2), and for the walking sessions it was 10(2). %peak VO(2), %HRmax, and RPE were significantly higher for aerobic dance than for walking. However, both the aerobic dance and walking sessions were of adequate intensity to improve aerobic fitness in most subjects. Further investigation into the relation between RPE and %peak VO(2) in a field setting over representative exercise time periods would be useful.

Scully\textsuperscript{59} and others discussed the literature continues to expand supporting major health benefits of regular physical activity and exercise including a reduced risk of cardiovascular disease, hypertension, and stroke as well as protection against some cancers and osteoporosis. However, there is also a growing body of knowledge that substantiates that physical activity also improves psychological well-being. This article will highlight a more recent review article on the effects of physical activity and mental health variables such as depression, anxiety, stress, mood state, and self-esteem (Summary in Table 1). It is important to note that much of this research is referred to as correlative, which means the scientists are studying associations that exist between exercise and mental health variables, and not actual causal relationships. Because of this, although some exercise

prescriptions for certain psychological health variables are presented; at this stage they must be interpreted and used with prudence.

It should be noted that individuals with clinical depression tend to be less active than healthy average adults. Therefore, from a general health perspective, physical activity should be encouraged for this population. It is interesting to note that aerobic and anaerobic exercise seem to be equally effective in producing anti depressive effects. Perhaps most interesting has been the response of patients (with diagnosed depression) describing exercise as "the most important element in comprehensive treatment programmes for depression." It appears that acute exercise bouts (single sessions) as well as chronic exercise training programs (over a period of time) have a positive effect on those with clinical depression. The research does infer that the greatest anti depressive effects seem to occur after 17 weeks of exercise, although observable effects begin from 4 weeks onward. In addition, the effects of exercise on depression seem equivalent with both genders and uninhibited by age or health status. Although no research guidelines exist for an actual exercise prescription, some researchers suggest following the ACSM Guidelines for the Recommended Quantity and Quality for Developing and Maintaining Cardiorespiratory and Muscular Fitness in Health Adults.

According to Webster’s Unabridged Dictionary, anxiety is "distress or uneasiness of mind caused by fear of danger or misfortune." It is a stage of apprehension. The results of over 30 published papers substantiate an
indisputable link with exercise (acute and chronic) and the reduction of anxiety. Most of the research on exercise and anxiety has been of an aerobic nature. The few studies with resistance training and flexibility have actually shown a slight increase in anxiety, but more research in this area is warranted. In regards to the actual aerobic exercise prescription, there appears to be much debate as to whether low-intensity (40-50% maximum heart rate [MHR]), moderate intensity (50-60% MHR), or high intensity (70-75% MHR) is most beneficial. The best compromise from the research suggests that exercise intensity be set at an adjustable level agreed upon by the individual in consultation with a physician (or health practitioner). It appears that even short bursts of 5 minutes of aerobic exercise will stimulate antianxiety effects. The research also indicates that those individuals training for periods of 10 to 15 weeks will receive the greatest beneficial effects.

Blanchette and others find out the potential effects of aerobic exercise on creative potential were explored both immediately following moderate aerobic exercise and after a two hour lag. Sixty college students participated in an experiment consisting of three regimens varying the time when a Torrance Test of Creative Thinking was taken in relation to exercise completion. The results supported the hypotheses that creative potential will be greater upon completion of moderate aerobic exercise than when not preceded by exercise (immediate effects), that creative potential will be

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greater following a two hour lag time following exercise than when not preceded by exercise (residual effects), and that creative potential will not be significantly different immediately following exercise than after a two hour lag time following exercise (enduring residual effects).

According to Anshel\textsuperscript{61}, exercise psychology has become an emerging field of scholarly research, prolific conference presentations, and of increasing relevance to a world that is experiencing a health paradox. Vastly improved medical care, at least in most of the western world, has been accompanied by a paucity of healthy habits (e.g., a deep propensity to avoid physical activity, intake of large portions of high fat food). The result is decreased health and increased health care costs for all age groups, ethnicities, and genders. While reasons for the negative attitude toward exercise abound, the combination of ubiquitous rates of obesity and the resultant poor health and high health care costs has resulted in a flurry of activity by researchers and practitioners to improve exercise and nutritional habits. Perhaps not surprisingly, then, the field of exercise psychology has become increasingly relevant. Therefore, it is surprising that a companion field of exercise psychology has not been given more prominence in the literature. Defining the conceptual framework for applied exercise psychology is overdue. The purpose of this article, then, is to provide a structure for scholars and practitioners in the study and application of applied exercise psychology. The framework is based on the extant

literature, which has focused on the factors that contribute to describing, explaining, predicting, and improving exercise behavior in a culture whose sedentary, generally unhealthy lifestyle is resulting in increasingly poorer health. The need for additional research and practice in applied exercise psychology has never been timelier. Guidelines for future directions in the field are also offered.

Costill and Miller \textsuperscript{62} conducted a study to demonstrates the relationship of leg strength and power to vertical jump. 76 subjects were taken for this study, from Ball State university. In conclusion the explosive power is significantly related to dynamic leg strength on the other hand vertical velocity is related to speed, but only moderately influenced leg strength.

Voight and Draovitch\textsuperscript{63} have suggested some general guidelines, to be followed by athletes and instructor before plyometric training can be initiated. They are:

1. Plyometric training should be specific to the goals established for the athletes.
2. Sports skills should be broken down and trained in their smaller components and repute into coordinated movement pattern.
3. In the preparatory phase, exercise of low meter complexity and intensity should dominate.

\textsuperscript{63} Voight and Draovitch, “Eccentric Muscle Training in Sports and Arthopaedics”, \textit{Dissertation Abstracts International} 24 (1964) 5176-78..
4. Plyometric training sessions should be conducted no more than three
   week during the preparatory phase and two times a week during the
   competitive phase.

5. The plyometric training programme should be progressive in overload.

6. The quality of work is important than the quality of work.

7. The plyometric training may have its greatest benefit at the
   conclusion of the normal workout or practices session. It is
   recommended that only low of medium stress plyometrics be used at
   the conclusion of a workout due to the potential of injury with height
   stress or method plyometrics.

8. Greater the amplitude or intensity, greater the recovery time.

9. When proper technique cannot longer be demonstrated, maximum
   volume has been achieved and the exercise must be stopped.

10. Dynamic testy of the individual on a regular basis will
    provide important motivational feed back as well as feed back as to
    the progress of the plyometric programme.

    Result showed that group I had improved their vertical jump
    performance by more than 5cm (t=2.89, df=22,p<0.01), whilst group II
    showed no significant changes. The investigator concluded that a gradual
    introduction to the plyometrics is unlikely to cause injuries.
Field conducted a study to compare the effects of power development of plyometric versus weight training. For this, the author selected male and female basketball and volleyball players. Among the subjects, group I was trained with box jumping and group II with weight training. For assessing power, vertical jump test was conducted. All the subjects were pre tested 2 day prior to beginning of a week training programme and post tested 3 day after completion of the programme, results were presented in the form of improvement over the weight training regime, deemed not statistically significant.

Blattner and Noble were conducted a study on 48 volunteer male subjects to find out the effects of isokinetic and plyometric training on vertical jumping performance. The subjects (N=48) were randomly assigned to one of the three groups (n=16). Groups I was trained with isokinetic exercise, group II was trained with plyometric exercises and group III was the control. Subjects in the training group were trained three times a week for eight weeks. The isokinetic group performed three sets of 10 repetitions per set of depth jump from a height of 34” with added resistance beginning with weeks 3,5 and 7 of 10,15 and 20 pounds prior to and at the covariance analysis was used to compare post-test scores with the effect of pre-test differences. Results showed both training groups improved significantly.

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vertical jump capacity; however, no significant difference existed among the training groups.

Adams\textsuperscript{66} conducted a study to determine whether significant gains in muscular leg strength and power could be achieved by jumping from heights ranging from .75 meters to 1.5 meters. For this, 177 male and female junior and senior high school pupils in the age range of 12 and 17 served as subjects. The group performed depth jumps from various height (group I from .75 meters, group II from 1.22 meters, group III from 0.61 meters, group IV from 1.22 meters, group V control and group VI participated, in vigorous activities include jumping). Vertical jump test was used to measure each subject's ability to raise his/her center of gravity and standing long jump was used to measure the power of leg in jump forward. The results of this study indicates that depth jump from .75 to 1.5 meters is not significantly effective is developing muscular leg power.

Spurrs, Murphy and Watsford\textsuperscript{67} reported that plyometric training improves running economy (RE) and ultimately distance-running performance, although the exact mechanism by which this occurs remains unclear. This study examined whether changes in running performance resulting from plyometric training were related to alterations in lower leg musculotendinous stiffness (MTS). Seventeen male runners were pre- and post-tested for lower leg MTS, maximum isometric force, rate of force


\textsuperscript{67} RW Spurrs, AJ Murphy and ML Watsford, “The Effect of Plyometric Training on Distance Running Performance”, \textit{Eur J Appl Physiol}. (Mar 2003) 89(1) : 1-7
development, 5-bound distance test (5BT), counter movement jump (CMJ) height, RE, VO(2max), lactate threshold (Th(la)), and 3-km time. 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 (2.7%) and RE at each of the tested velocities, while no changes in VO(2max) or Th(la) were recorded. CMJ height, 5BT, and MTS also increased significantly. No significant changes were observed in any measures for the C group. The results 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. We speculate that the improved RE led to changes in 3-km running performance, as there were no corresponding alterations in VO(2max) or Th(la).

Turner, Owings and Schwane\textsuperscript{68} were determined whether a 6-week regimen of plyometric training would improve running economy (i.e., the oxygen cost of submaximal running). Eighteen regular but not highly trained distance runners (age = 29 +/- 7 [mean +/- SD] years) were randomly assigned to experimental and control groups. All subjects continued regular running training for 6 weeks; experimental subjects also did plyometric training. Dependent variables measured before and after the 6-week period were economy of running on a level treadmill at 3 velocities

\textsuperscript{68} AM Turner, M Owings and JA Schwane, “Improvement in Running Economy after 6 Weeks Plyometric Training”, \textit{J Strength Cond Res.} (Feb 2003) 17(1) : 60-67.
(women: 2.23, 2.68, and 3.13 m.s(-1); men: 2.68, 3.13, and 3.58 m.s(-1)), VO(2)max, and indirect indicators of ability of muscles of lower limbs to store and return elastic energy. The last were measurements during jumping tests on an inclined (20 degrees) sled: maximal jump height with and without countermovement and efficiencies of series of 40 submaximal countermovement and static jumps. The plyometric training improved economy (p < 0.05). Averaged values (m.ml(-1).kg(-1)) for the 3 running speeds were: (a). experimental subjects-5.14 +/- 0.39 pretraining, 5.26 +/- 0.39 posttraining; and (b). control subjects-5.10 +/- 0.36 pretraining, 5.06 +/- 0.36 posttraining. The VO(2)max did not change with training. Plyometric training did not result in changes in jump height or efficiency variables that would have indicated improved ability to store and return elastic energy. We conclude that 6 weeks of plyometric training improves running economy in regular but not highly trained distance runners; the mechanism must still be determined.

Miller and others conducted the study to determine if six weeks of plyometric training can improve an athlete’s agility. Subjects were divided into two groups, a plyometric training and a control group. The plyometric training group performed in a six week plyometric training program and the control group did not perform any plyometric training techniques. All subjects participated in two agility tests: T-test and Illinois Agility Test, and a force plate test for ground reaction times both pre and post testing.

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Univariate ANCOVAs were conducted to analyze the change scores (post – pre) in the independent variables by group (training or control) with pre scores as covariates. The Univariate ANCOVA revealed a significant group effect $F_{2,26} = 25.42, p=0.0000$ for the T-test agility measure. For the Illinois Agility test, a significant group effect $F_{2,26} = 27.24, p = 0.000$ was also found. The plyometric training group had quicker posttest times compared to the control group for the agility tests. A significant group effect $F_{2,26} = 7.81, p = 0.002$ was found for the Force Plate test. The plyometric training group reduced time on the ground on the posttest compared to the control group. The results of this study show that plyometric training can be an effective training technique to improve an athlete’s agility. The results from our study are very encouraging and demonstrate the benefits plyometric training can have on agility. Not only can athletes use plyometrics to break the monotony of training, but they can also improve their strength and explosiveness while working to become more agile. In addition, our results support that improvements in agility can occur in as little as 6 weeks of plyometric training which can be useful during the last preparatory phase before in-season competition for athletes.

Santos and Janeira\textsuperscript{70} 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.

Sáez de Villarreal, Requena and Cronin \textsuperscript{71} studied the effects of plyometric training on sprint performance. The purpose of this meta-

analysis was to attempt to gain a clear picture of the magnitude of sprint performance improvements expected after chronic plyometric training (PT) and to identify specific factors that influence the treatment effects. Studies employing a PT intervention and containing data necessary to calculate effect size (ES) were included in the analysis. A total of 26 studies with a total of 56 ES met the inclusion criterion. Analysis of ES demonstrated that the strategies that seem to maximize the probability of obtaining significantly \( p < 0.05 \) greater improvement in sprint performance included training volume for \(<10\) weeks; a minimum of 15 sessions; and high-intensity programs with \(>80\) combined jumps per session. To optimize sprint enhancement, the combination of different types of plyometrics and the use of training programs that incorporate greater horizontal acceleration (i.e., sprint-specific plyometric exercises, jumps with horizontal displacement) would be recommended, rather than using only one form of jump training \( p < 0.05 \). No extra benefits were found to be gained from doing plyometrics with added weight. The loading parameters identified in this analysis should be considered by the professional sprinters and specialized trainers with regard to the most appropriate dose-response trends PT to optimized sprint performance gains.

Lloyd\(^{72}\) and others find out the effects of 4-weeks of plyometric training on reactive strength index and leg stiffness in male youths.

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Although previous pediatric research has reported performance improvements in muscular power, agility, speed, and rate-of-force development after exposure to plyometric training, the effects on reactive strength index (RSI) and leg stiffness remain unclear. One hundred and twenty-nine boys from 3 different age groups (9, 12, and 15 years) participated and were divided into either an experimental (EXP) or control (CON) group within their respective age groups. The EXP groups followed a twice-weekly, 4-week plyometric training program, whereas the CON groups participated in their normal physical education lessons. Preintervention and postintervention measures were collected for RSI (during maximal hopping) and leg stiffness (during submaximal hopping). Both 12- and 15-year-old EXP groups made significant improvements in both absolute and relative leg stiffness \((p < 0.05)\). The 9-year-old EXP group and CON groups for all ages did not make significant changes in leg stiffness. The 12-year-old EXP cohort also made significant improvements in RSI \((p < 0.05)\). Both 15- and 9-year-old EXP cohorts, and CON groups for all ages, failed to show any significant improvements in RSI. The study concludes that improvements in RSI and leg stiffness after a 4-week plyometric training program are age dependent during childhood.

Markovic\(^{73}\) and others find out the effects of sprint and plyometric training on muscle function and athletic performance. The purpose of this study was to evaluate the effects of sprint training on muscle function and athletic performance. The study concludes that improvements in RSI and leg stiffness after a 4-week plyometric training program are age dependent during childhood.

dynamic athletic performance and to compare them with the training effects induced by standard plyometric training. Male physical education students were assigned randomly to 1 of 3 groups: sprint group (SG; \(n = 30\)), plyometric group (PG; \(n = 30\)), or control group (CG; \(n = 33\)). Maximal isometric squat strength, squat- and countermovement jump (SJ and CMJ) height and power, drop jump performance from 30-cm height, and 3 athletic performance tests (standing long jump, 20-m sprint, and 20-yard shuttle run) were measured prior to and after 10 weeks of training. Both experimental groups trained 3 days a week; SG performed maximal sprints over distances of 10–50 m, whereas PG performed bounce-type hurdle jumps and drop jumps. Participants in the CG group maintained their daily physical activities for the duration of the study. Both SG and PG significantly improved drop jump performance (15.6 and 14.2%), SJ and CMJ height (10 and 6%), and standing long jump distance (3.2 and 2.8%), whereas the respective effect sizes (ES) were moderate to high and ranged between 0.4 and 1.1. In addition, SG also improved isometric squat strength (10%; ES = 0.4) and SJ and CMJ power (4%; ES = 0.4, and 7%; ES = 0.4), as well as sprint (3.1%; ES = 0.9) and agility (4.3%; ES = 1.1) performance. We conclude that short-term sprint training produces similar or even greater training effects in muscle function and athletic performance than doe's conventional plyometric training. This study provides support for the use of
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Vladan Milic, Dragan Nejic and Radomir Kostic were determine the effects of plyometric training on the explosive strength of cadet volleyball players, we studied the effects of a six-week plyometric training program during the second half of the preliminary period of the annual training cycle. The sample consisted of 46 subjects aged 16 (± 6 months). The experimental group consisted of 23 volleyball players, with an average height of 186.35 ± 8.52 and average weight of 70.57 ± 8.98. The control group consisted of 23 high school students, with an average height of 177.35 ± 4.80 and body weight of 68.91 ± 6.48, who had not been exposed to the plyometric method as part of their physical education classes. The sample of measuring instruments consisted of eight tests of explosive leg strength: the two-foot takeoff block jump, the right foot takeoff block jump, the left foot takeoff block jump, the two-foot takeoff spike jump, the right foot takeoff spike jump, the left foot takeoff spike jump, the standing depth jump and the standing triple jump. Using a multivariate and univariate statistical method, we were able to determine a statistically significant difference in explosive strength in favor of the experimental group. We determined an increase in explosive strength for the two-foot and single foot takeoff jumps.

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Arazi and Asadi\textsuperscript{75} find out the effect of aquatic and land plyometric training on strength, sprint, and balance in young basketball players. The purpose of this study was to compare the effect of eight weeks of aquatic and land plyometric training on leg muscle strength, 36.5 and 60 meters sprint times, and dynamic balance test in young male basketball players. Eighteen young male basketball players (age=18.81±1.46 years, height=179.34±6.11 cm, body mass=67.80±9.52 kg, sport experience=4.8±2.47 years) volunteered in this study and divided to three groups; aquatic plyometric training (APT), land plyometric training (LPT) and control group (CON). Experimental groups trained; ankle jumps, speed marching, squat jumps, and skipping drills for eight weeks and 3 times a week for 40 min. The data were analyzed by one way analysis of variance with repeated measures, a Tukey post hoc testing and independent-sample \textit{t}-test. The results showed there were not any significant differences between the APT and LPT groups in any of the variables tested (P>0.05). Significant increases were observed in posttraining both APT and LPT groups in 36.5-m and 60-m sprint times record compare to pretraining (P<0.05). There was a significant difference in relative improvement between the APT and CON in 36.5-m, 60-m, and one repetition maximum leg press (P<0.05). We conclude that plyometric training in water can be an effective technique to improve sprint and strength in young athletes.

Carter

and others conducted the study on the effects of high volume upper extremity plyometric training on throwing velocity and functional strength ratios of the shoulder rotators in collegiate baseball players. To achieve maximal force output, clinicians and coaches have been experimenting with upper extremity plyometric exercises for years, without sufficient scientific validation of this training method. The goal of this study was to examine the effects of an 8-week course of high volume upper extremity plyometric training on the isokinetic strength and throwing velocity of a group of intercollegiate baseball players. Twenty-four Division I collegiate baseball players (age: 19.7 ± 1.3 years; height: 183.9 ± 5.9 cm; mass: 90.7 ± 10.5 kg) were recruited to participate in this study. Throwing velocity, isokinetic peak torque, isokinetic functional strength ratios, and time to peak torque were measured pre- and posttraining. Subjects were rank-ordered according to concentric internal rotation (IR) strength and were assigned randomly to either the plyometric training group (PLY) or the control group (CON). Training consisted of 6 upper extremity plyometric exercises (“Ballistic Six”) performed twice per week for 8 weeks. Subjects assigned to CON performed regular off-season strength and conditioning activities, but did not perform plyometric activities. PLY demonstrated significant increases ($p < 0.05$) in throwing velocity following 8 weeks of training when compared with CON (83.15 mph [pre] vs. 85.15 mph [post]).

There were no statistically significant differences in any of the isokinetic strength measurements between PLY and CON groups pre- to posttraining. Statistically significant differences were seen within PLY for concentric IR and eccentric external rotation (ER) isokinetic strength at 180°·s⁻¹ and 300°·s⁻¹; and within CON for eccentric ER isokinetic strength at 300°·s⁻¹ and concentric IR isokinetic strength at 180°·s⁻¹. The Ballistic Six training protocol can be a beneficial supplement to a baseball athlete’s off-season conditioning by improving functional performance and strengthening the rotator cuff musculature.

Chelly and others find out the effects of in-season short-term plyometric training program on leg power, jump- and sprint performance of soccer players. Our hypothesis was that the addition of an 8-week lower limb plyometric training program (hurdle and depth jumping) to normal in-season conditioning would enhance measures of competitive potential (peak power output [PP], jump force, jump height, and lower limb muscle volume) in junior soccer players. The subjects (23 men, age 19 ± 0.7 years, body mass 70.5 ± 4.7 kg, height 1.75 ± 0.06 m, body fat 14.7 ± 2.6%) were randomly assigned to a control (normal training) group (Gc; n = 11) and an experimental group (Gex, n = 12) that also performed biweekly plyometric training. A force–velocity ergometer test determined PP. Characteristics of the squat jump (SJ) and the countermovement jump (CMJ) (jump height, jump force, and jump height) were analyzed.

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maximal force and velocity before take-off, and average power) were determined by force platform. Video-camera kinematic analyses over a 40-m sprint yielded running velocities for the first step (VS), the first 5 m (V5m) and between 35 and 40 m (Vmax). Leg muscle volume was estimated using a standard anthropometric kit. Gex showed gains relative to controls in PP (p, 0.01); SJ (height p, 0.01; velocity p, 0.001), CMJ (height p, 0.001; velocity p, 0.001, average power p, 0.01) and all sprint velocities (p, 0.001 for V5m and Vmax, p, 0.01 for VS). There was also a significant increase (p, 0.05) in thigh muscle volume, but leg muscle volume and mean thigh cross-sectional area remain unchanged. We conclude that biweekly plyometric training of junior soccer players (including adapted hurdle and depth jumps) improved important components of athletic performance relative to standard in-season training. Accordingly, such exercises are highly recommended as part of an annual soccer training program.

At the University of Maryland, a twelve week study was conducted on football players to test the effectiveness of adding plyometric to conventional training. With the addition of plyometric drills to conventional training, the football players reduced on average of 30 seconds from their 1.5 Mile run, two seconds from 30 yard cone Sprint (which tests the ability and speed at which players can change direction), and increased the maximum weight. They lift in a parallel squat by 16 Pounds.\textsuperscript{89}

Vir\textsuperscript{90} studied the effect of two pre-stretch condition programmes using high and low intensity pre-stretch stimulus to achieve the purpose, 24 male student were assigned to three groups (n=8): high, low and control pre-stretch of lower limb muscles were effected via either dropping down before contracting the jump step (group high) or preparatory counter moment only (group low). The performance criteria sargent jumps and peek power output as well as four anthropometrics measurements were recorded before and after the training period, which lasted for 3 weeks, statistically analysis revealed a significant infra group improvement in the performance criteria a group high scored significantly higher than group low in the sargent jump test. No significant change either between or within groups in anthropometric measures took place. The investigator concluded that pre-stretch conditioning which consists of a high intensity pre-stretch stimulus with proper overloading protocol is likely to be highly effective for athletes.

Gormley\textsuperscript{91} and others find out the effect of intensity of aerobic training on VO\textsubscript{2} max. For that purpose sixty-one health young adult subjects were matched for sex and VO2max and were randomly assigned to a moderate- (50\% VO2 reserve (VO2R), vigorous (75\% VO2R), near-maximal-intensity (95\% VO2R), or a nonexercising control group. Intensity during exercise was controlled by having the subjects maintain target HR based on HR reserve. Exercise volume (and thus energy expenditure) was controlled across the


three training groups by varying duration and frequency. Fifty-five subjects completed a 6-wk training protocol on a stationary bicycle ergometer and pre- and posttesting. During the final 4 wk, the moderate-intensity group exercised for 60 min, 4 d.wk the vigorous-intensity group exercised for 40 min, 4 d.wk and the near-maximal-intensity group exercised 3 d.wk performing 5 min at 75% VO2R followed by five intervals of 5 min at 95% VO2R and 5 min at 50% VO2R. VO2max significantly increased in all exercising groups by 7.2, 4.8, and 3.4 mL.min.kg in the near-maximal-, the vigorous-, and the moderate-intensity groups, respectively. Percent increases in the near-maximal- (20.6%), the vigorous- (14.3%), and the moderate-intensity (10.0%) groups were all significantly different from each other (P < 0.05). There were no significant changes in resting HR and BP in any group. When volume of exercise is controlled, higher intensities of exercise are more effective for improving VO2max than lower intensities of exercise in healthy, young adults.

Park and others were investigate the changes of maximal oxygen consumption, left ventricular function and serum lipids after 36 weeks of aerobic exercise in elderly women without the influence of drugs. Eight elderly women were studied by M-mode and Doppler echocardiography to assess left ventricular size, mass and function. Maximal oxygen consumption (VO(2)max) was determined for each subject by administering

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a treadmill exercise test. The training intensity was decided by heart rate reserve. Subjects performed exercise for 40 minutes a day, 3 days a week at 50-60% of the heart rate reserve during the 36 weeks. Exercise capacity was assessed by VO(2)max with a graded exercise test of the treadmill. Weight and % body fat decreased after training. Cardiorespiratory function improved because of the increase in VO(2)max and VO(2)max normalized for body weight after training. Systolic blood pressure significantly decreased. There are no significant difference in all left ventricular's parameters (end-diastolic dimension, end-systolic dimension, end-diastolic volume, end-systolic volume, stroke volume, cardiac output, ejection fraction, fractional shortening) after 36 weeks. Exercise training did not induce left ventricular (LV) enlargement as evidence of an absence of increase in left ventricular end-diastolic volume. The total cholesterol level and triglyceride level decreased after training. High density lipoprotein-cholesterol significantly increased and low density lipoprotein-cholesterol significantly decreased, atherogenic index (AI) significantly decreased and apolipoprotein A-I increased and apolipoprotein B decreased after training. In conclusion, although there was no significant change in left ventricular function, aerobic training showed a positive influence on body composition, maximal oxygen consumption and serum lipids.
Norris, Carroll and Cochrane\textsuperscript{93} were determine whether fitness alters psychological and physiological indices of well-being, male police officers were assigned to either an aerobic or anaerobic training condition or to a no treatment control group. The training groups met three times per week in 45 min sessions aimed at improving either cardiovascular endurance or muscle strength. Aerobic fitness level, heart rate, blood pressure and self-report of stress and well-being were measured prior to and following 10 weeks of training. Post-training fitness measures confirmed the effectiveness of training and between group differences for physiological and self-report measures were found. Subjects undergoing aerobic training evinced larger changes on the self-report measures of well-being and stress than the anaerobic trainers and both groups showed significant improvement when compared to controls. This experiment provides support for the hypothesis that exercise, and in particular aerobic exercise, has positive effects of well-being. It is suggested that future research might usefully explore the particular contribution of different aspects of the training situation to these effects.

Mughal\textsuperscript{94} and others conducted the study on the effects of aerobic exercise, on changes in blood pressure, in patients with essential hypertension. A 12-weeks aerobic exercise intervention trial was conducted, to examine the influence of brisk walking on resting systolic and diastolic

blood pressure, pulse pressure, mean arterial blood pressure, body weight and body mass index in patients with essential hypertension. For the purpose of the study twenty-seven men with stage 1 or 2 essential hypertension (not on antihypertensive medication) participated in the study. The aerobic exercise training protocol consisted of 30 minutes of brisk walking 3 to 5 times per week, at 50% of VO2max on an ergometer cycle. The data were analyzed by comparing exercise responses at baseline and 12-weeks. Statically significant decrease in resting systolic [mean+SEM, 143.2+1.4 to 137.5+1.2 mmHg, mean reduction -5.7 mmHg, p<0.01] and diastolic [mean+SEM, 91.8+1.0 to 90.4+0.9 mmHg, the mean reduction -1.4 mmHg] blood pressure were found (p<0.05). Reduced pulse pressure from baseline value of -3.7 mmHg, (p<0.01) and mean arterial pressure of -3.4 mmHg (p<0.01) was noted. No discernible effects on mean body mass index was observed although mean body weights decreased -1.1kg, (p<0.05). Brisk walking yielded significant increase in VO2max (p<0.05). The results concluded that aerobic exercise caused small reduction in resting systolic and diastolic blood pressures in men with stage 1 or 2 essential hypertension. A lifestyle change such as exercising, may play a role in reducing the risk of hypertension.

Plyometric exercises are used to train the eccentric aspect of muscle action. Many athletes have tremendous strength but they are often unable to produce the power necessary in explosive activities. They fail to bridge the
gap between sheer strength and power. Plyometric work seeks to bridge this gap.\textsuperscript{95}

Milburn and Butts\textsuperscript{96} compared the training responses to aerobic dance and jogging in college females. The purpose of this study was to compare the physiological alterations that occur in college females as a result of a 7-wk jogging and aerobic dance-training program. Forty-six subjects (18-29 yr) volunteered to participate and included 15 dancers, 19 joggers and 12 controls. All subjects were given a pre and post VO2 max treadmill test. The joggers and dancers trained 4 d/wk, 30 min/d for 7 wk at an intensity that represented approximately 83 and 84\% of their initial maximal heart rates, respectively. Both experimental groups significantly (P less than 0.05) increased their VO2 max, VEmax, and maximal treadmill running times and significantly (P less than 0.05) decreased their maximal heart rates as a result of the training. The control group showed no significant (P greater than 0.05) changes in any of the variables measured. It was concluded that both aerobic dance and jogging were equally effective (P less than 0.05) exercise modalities for improving cardio respiratory endurance when performed at similar intensities, frequencies, and duration's.

Mc Cord, Nicholus and Patterson\textsuperscript{97} examined the effect of low impact dance training on aerobic capacity, sub maximal heart rates and body composition of college-aged females. The purpose of this study was to examine the effects of a 12 week program of low impact aerobic dance conditioning on VO2 max, sub maximal heart rates and body composition of college-aged women. Sixteen women exercised three times per week for approximately 45 minutes per session at 75-85\% of their heart rate reserve. VO2 max was measured by indirect calorimetric using treadmill protocol. Sub maximal heart rates were measured by electrocardiograph, and body fat was assessed by hydrostatic weight. All testing was conducted within one week pre-and post training. Training sessions consisted of a 5-10 minute warm up 30-35 minute low impact aerobic dance segment and a 5 minute cool down. Posttest results revealed a small (7\%) but significant increase in VO2 max (pre: 38.3 ml/kg/min; post: 41.3 ml/kg/min X +/-SD, p less than 0.05). Sub maximal heart rates at minutes 2-3, 3-4, and 4-5 of the graded exercise test decreased significantly. Body fat decreased from 25+/- 6.8\% to 21+/-6.3\% (p less than 0.01) with no post training change in body weight. It was concluded that low impact aerobic dance is as effective as other endurance training regimens in improving cardiovascular fitness and decreasing body fat.

Parker and others tried to analyze the failure of target heart rate to accurately monitor intensity during aerobic dance. Fourteen untrained females (age 19+/1, range 18-21) were studied to examine the heart rate - VO2 relationship during a single aerobic dance training session. These findings were used to help explain the changes in VO2 max resulting from an aerobic dance training program. VO2 max and body composition were determined before and after an 8 wk training period. In addition, the heart rate VO2 responses to an aerobic dance training session were monitored and compared to the heart rate responses of treadmill jogging performed at the same VO2. The aerobic dance session elicited a significantly lower oxygen pulse than did treadmill exercise (7.2 +/- 0.3 vs. 8.1 +/-0.8 ml. beat - 1; P less than 0.01). There were no significant changes in percent body fat, whereas VO2 max increased by 11% (34.4+/ - 0.9 vs 38.1 +/- 0.8 ml kg-1 min-1; P less than 0.05). No significant changes in any of the parameters tested were observed in 10 untrained controls. These findings indicate that the heart rate elicited from aerobic dance represents a lower relative exercise intensity (VO2) than that of the running. Therefore, the assumption that aerobic dance training produces the same cardiovascular adaptations as running training when performed at the same target rate may be unwarranted.

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Thomas and Ballor\textsuperscript{99} analyzed physiological responses during aerobic dance of individuals grouped by aerobic capacity and dance experience. This study examined the effects of aerobic capacity (peak oxygen uptake) and aerobic dance experience on the physiological responses to an aerobic dance routine. The heart rate (HR) and VO\textsubscript{2} responses to three levels (intensities) of aerobic dance were measured in 27 women. Experienced aerobic dancers (AD) (mean peak VO\textsubscript{2} = 42 ml. kg\textsuperscript{-1}. min\textsuperscript{-1}) were compared to subjects with limited aerobic dance experience of high (HI) (peak VO\textsubscript{2} greater than 35 ml. kg\textsuperscript{-1}. min\textsuperscript{-1}) and low (LO) (peak VO\textsubscript{2} less than 35 ml.kg\textsuperscript{-1}. min\textsuperscript{-1}) aerobic capacities. The results indicated the LO group exercised at a higher percentage of peak heart rate and peak VO\textsubscript{2} at all three dance levels than did either the HI or AD groups (HI = AD). Design of aerobic dance routines must consider the exercise tolerance of the intended audience. In mixed groups, individuals with low aerobic capacities should be shown how and encouraged to modify the activity to reduce the level of exertion.

Garber\textsuperscript{100} and others conducted a study to find out if aerobic dance is an effective alternative to walk-jog exercise training? In order to compare the physiological effects of an 8 week aerobic dance program to those of a walk-jog exercise training program, 60 male and female University employees ages 24-48 years were randomly assigned to an aerobic dance


program (N=22), a walk-jog program (N=24), or a sedentary control group (N=15). Subjects who had an exercise compliance rate less than or equal to 85% were dropped from the study, as were control subjects who had scheduling conflicts or illnesses precluding post-treatment testing. Thirty-five subjects completed the 8 week period with a compliance rate greater than or equal to 85%, leaving 14 in the aerobics group, 11 in the walk-jog group and 10 in the control group. Significant increases (p less than 0.001) in maximal oxygen uptake occurred in the aerobics (+3.9 ml/kg-1/min-1) and walk-jog group (+3.4 ml/kg-1/min-1), while no significant change was observed in the control group. Peak heart rate decreased significantly (p less than 0.05) in the aerobics (-4 b/min-1) and walk-jog groups (-3 b/min-1) but was unchanged in the control group (-1 b/min-1) following the treatment period. Body weight, peak respiratory exchange ratio and peak minute ventilation remained the same in the aerobics, walk-jog and control groups throughout the treatment period. It is concluded that aerobic dance programs can result in similar improvements in aerobic power as a walk-jog program. Thus, an aerobic dance program is an effective alternative to a traditional walk-jog training regime.

Bell and Bassey\textsuperscript{101} made a comparison to find the relation between oxygen uptake and heart rate during different styles of aerobic dance and a traditional step test in women. The oxygen uptake and heart rate in various

styles of dance and in a graded step test have been compared in ten healthy women aged [mean (SD)] 34 (5) years. Dance was choreographed into progressively more energetic sequences typical of community classes, and videotaped. Oxygen uptake was assessed using a respirometer carried in a back-pack. Each of the two tests (dance and step) took 15-20 min and measurements were made in randomized balanced order on the same day. The mean oxygen costs of dance ranged from 1.29 l.min-1 for low impact style to 1.83 l. min-1 for high impact style with arm work; mean heart rates were 135 and 174 beats. min-1 respectively. Low impact dance raised heart rates above 60% of predicted maximum and so would provide training; during high impact dance recorded heart rates sometimes exceeded recommended safe limits. The addition of arm work significantly increased heart rates in both high and low impact dance but when oxygen pulses for each style of dance were compared no significant differences attributable to arm work were found. Moreover calculated differences attributable to arm work were found. Moreover calculated differences between oxygen pulses for each style of dance were compared no significant differences attributable to arm work were found. Moreover calculated differences between oxygen uptakes in stepping and dance at the same heart rates (those recorded during dance) were not significant for any of the four styles. Analysis of variance confirmed that neither arm work nor impact contributed significantly to the differences, so there was no evidence that these forms of
dance change the normal relation between heart rate and oxygen uptake found in dynamic activities with large muscle groups such as stepping.

Darby, Browder and Reeves\textsuperscript{102} conducted a study to find the effects of cadence, impact, and step on physiological responses to aerobic dance exercise. The physiological responses to aerobic dance exercise of varied impact (high, low), step (less arm movement vs. more arm movement), and cadence (124 vs. 138 beats min\(^{-1}\)) were investigated. Experienced, female aerobic dancers (N=16) performed activities that combined the levels of impact and step for 3 trials of 8-min each. Dependent variables included heart rates, percentage of maximal heart rate, oxygen consumption, percentage of maximal oxygen consumption, and respiratory exchange ratio. Repeated measures analyses of variance indicated a significant Impact x Step interaction whereby oxygen consumption was greater for the high impact-less arm movement activity (jog), while the low impact-more arm movement activity (power jack) was greater for heart rate. The interaction of aerobic dance characteristics (e.g., impact, arm movement) that may alter physiological responses to aerobic dance exercise should be identified in future aerobic dance routines and studies.

Schaeffer-Gerschutz, Darby and Browder\textsuperscript{103} were analyzed the differentiated ratings of perceived exertion and physiological responses during aerobic dance steps by impact/type of arm movement. Overall ratings of perceived exertion, i.e., undifferentiated RPE, are often used as indicators of exercise intensity during walking, jogging, and cycling, however, conflicting results concerning RPE during aerobic dance exercise have been reported, and the use of differentiated RPE, i.e., local RPE and central RPE, has not been investigated. The purposes of this study were to assess local, central, and over-all RPE, and physiological responses (heart rate (HR); % HRmax; absolute and relative VO2, % VO2 max, ventilation (VE), ventilator equivalent (VE VO2(-1), and oxygen pulse) during aerobic dance exercise varied by Arm Movement (Static Arm vs Dynamic Arm) and Impact (High vs. Low). Trained women (N=25, max VO2 = 50.4 +/- 7.5 ml kg-1. min-1) competed four aerobic dance steps. No RPE were significantly correlated with heart rate or VO2; however, for all steps all RPE were significantly (r=40-62) correlated with VE VO2 (-1) or VE. No interactions were present for RPE or physiological variables, and main effects were noted for Impact and Arm Movement. All RPE were greater for High Impact and for Static Arm Movement. Because VE and VE. VO2 (-1) were correlated with Overall RPE for all steps, this may suggest that participants "attended to" perceived changes in respiratory phenomena during aerobic dance exercise.

It appears that during combined arm-and-leg aerobic dance exercise the use of Overall RPE is sufficient to assess perceptual sensations associated with the intensity of the exercise. Changes in Overall RPE were proportionate to objective measures of exercise intensity, i.e., HR and VO₂; however, it is recommended that both HR and Overall RPE be used to assess fully a participant's objective and subjective responses during aerobic dance exercise.

Kin, Kosar and Korkussuz¹⁰⁴ investigated step aerobics and aerobic dancing on serum lipids and lipoproteins. To examine the effect of 8 weeks of step aerobics and aerobic dancing on blood lipids and lipoproteins. Forty-five sedentary female college student volunteers randomly assigned to one of the three groups as step aerobics (n=15), aerobic dancing (n=15) and the control group (n=15). The step aerobics and aerobic dancing groups participated in sessions of 45 min per day, 3 days per week for 8 weeks with 60-70 percent of their heart rate reserve. At the end of the 8 week period, a significant difference has been found between the step aerobics group and the control group and between the aerobic dancing group and the control group in TC levels (F[2,44] = 8.38; p<0.01). A significant difference in HDL-C levels (F[2,44]=3.65; p<0.05) and TC:HDL-C ratio (F[2,44]=11.56 p<0.01) has been found only between the step aerobics group and the control group. These results indicate that step aerobics training is an effective training

mode for modifying lipid and lipoprotein profiles of female college-aged students.

Asikainen\textsuperscript{105} et al. (2002) performed an experiment on Randomized, controlled walking trials in postmenopausal women: the minimum dose to improve aerobic fitness? The American College of Sports Medicine recommends 20-60 minutes of aerobic exercise three to five days a week at an intensity of 40/50 - 85\% of maximal aerobic power (VO\textsubscript{2} MAX) reserve, expending a total of 700-2000 kcal (2.93-8.36 MJ) a week to improve aerobic power and body composition. Voluntary; healthy, non-obese, sedentary, postmenopausal women (n=121), 48-63 years of age, were randomized to four low dose walking groups or a control group; 116 subjects completed the study. The exercise groups walked five days a week for 24 weeks with the following intensity (\% of VO (2) MAX) and energy expenditure (kcal/week): group W1, 55\% 1500 kcal; group W2, 45\%/1500 kcal; group W3, 55\%/1000 kcal; group W4, 45\%/1000 kcal. VO\textsubscript{2} MAX was measured in a direct maximal treadmill test. Sub maximal aerobic fitness was estimated as heart rates at sub maximal work levels corresponding to 65\% and 75\% of the baseline VO\textsubscript{2} MAX. The body mass index (BMI) was calculated and percentage of body fat (F \%) estimated from skin folds. RESULTS: The net change (the differences between changes in each exercise group and the control group) in VO\textsubscript{2} MAX was 2.9 ml/mm/kg/ (95\%
confidence interval (CI) 1.5 to 4.2) in group W1, 2.6 ml/mm/kg (95% CI 1.3 to 4.0) in group W2, 2.4 ml/mm/kg (95% CI 0.9 to 3.8) in group W3, and 2.2 ml/mm/kg (95% CI 0.8 to 3.5) in group W4. The heart rates in standard sub maximal work decreased 4 to 8 beats/min in all the groups. There was no change in BMI, but the F% decreased by about 1% unit in all the groups. Walking (for 24 weeks) at moderate intensity 45% to 55% of VO$_2$ MAX, with a total weekly energy expenditure of 1000-1500 kcal, improves VO$_2$ MAX and body composition of previously sedentary, non-obese, postmenopausal women. This dose of exercise apparently approaches the minimum effective dose.