EFFECTS OF RESISTANCE AND PLYOMETRIC TRAINING ON VERTICAL JUMP IN WUSHU ATHLETES

A THESIS

SUBMITTED TO

MASTER'S PROGRAMME IN SPORTS SCIENCE IN PARTIAL FULFILLLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN SPORTS SCIENCE

BY

RAJENDRA KUMAR BUDHATHOKI

SYMBOL NO 2842003

TU REGISTRATION NO. 5-1-47-53-98

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KATHMANDU, NEPAL

DECLARATION

Except where otherwise acknowledged in the text, the analysis in this thesis represents my own original research.

Rajendra Kumar Budhathoki

June 2024

RECOMMENDATION

This is to certify that the thesis Submitted by Rajendra Kumar Budhathoki entitled "Effects of Resistance and Plyometric Training on Vertical Jump in Wu-Shu athletes" is recommended for external examination**.**

Prof. Dr. Ram Krishna Maharjan

Thesis Supervisor

June 2024

VIVA-VOCE SHEET

We have conducted the viva-voce examination of the thesis Submitted by **Rajendra Kumar Budhathoki e**ntitled "Effects of Resistance and Plyometric Training on Vertical Jump in Wu-Shu athletes " and find that the thesis to be an independent work of the student written according to the prescribed format. We accept the thesis as the partial fulfillment of the requirements for Master of Arts in Sports Science.

Evaluation Committee:

Prof. Pashupati Adhikari ....
Coordinator
Master's Programme in Sports Science

Prof. Ram Krishna Maharjan ....
Thesis Supervisor
Master's Programme in Sports Science

Dr Prakash Pradhan ....
External Examiner
Master's Programme in Sports Science

Viva Date: 30 June 2024

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Kirtipur, Kathmandu

ABSTRACT

The purpose of this study was to compare the effects of 3 different training protocols—plyometric training, resistance training, and their combination in improving vertical jump performance Forty subjects (15 Male and 15 Female and (11 to 20) age group) continuously practicing Wu-Shu were randomly assigned to 1 of 4 groups: resistance training (n=10), plyometric training (n=10), plyometric plus weight training (n=10), and control (n=10). Subjects in each training group trained 2 days per week, whereas control subjects did not train in any training activity beyond their regular Wu-Shu training. Resistance training group trained resistance exercises only, plyometric training group trained plyometric exercises only and combined training group trained both resistance training and plyometric training in alternate day. Resistance exercises included back squat, Romanian dead lift, forward step lunge, standing calf raised and one leg step lunge, whereas, plyometric exercises included jump and reach, countermovement jump, jump to box, front barrier hob, jump twitch and jump, pike jump, double leg tuck jump and depth jump. Vertical jump was measured before and after 12 weeks of training. Data were collected by jump and reach method by using vertec device and analyzed by Welch's ANOVA. Results showed that all training treatments elicited significant ($p< 0.05$) improvement in vertical jump. Furthermore, Games-Howell post hoc multiple analysis was applied to uncover specific differences between groups. Results demonstrated that the combination training group produced significantly greater improvements in vertical jump than the other 2 training groups (plyometric training and resistance training) and control group. Moreover, results showed that the post-test of vertical jump was increased from pre-test of resistance group, plyometric group and combined group by 3.15%, 4.55% and 5.71% respectively. This study concludes to provides support for the use of a combination resistance training and plyometric drills to improve vertical jumping ability and explosive performance in general.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

B.S.	=	Back Squat
C.M.J.	=	Countermovement Jump
CON	=	Control Group
CT	=	Combined Training
D.J.	=	Depth Jump
D.J.B.	=	Double leg jump to Box
D.T.J.	=	Double Leg Tuck Jump,
F.B.H.	=	Front Barrier Hob,
J.T.R.	=	Jump twist and reach,
O.L.S.L.	=	One Leg Step Lunge
P.J.	=	Pike jump
PT	=	Plyometric Training
R.D.F.	=	Rate of Development of force
R.D.L.	=	Romanian Dead Lift
RM	=	Repetition Maximum
RT	=	Resistance Training
S.C.R.	=	Standing Calf Raise
S.J.	=	Squat Jump
S.S.C.	=	Stretch Shortening Cycle
T.G.F.	=	Total ground Contact.
V.J.	=	Vertical Jump
V.J.H.	=	Vertical Jump Height
W	=	Week

EFFECTS OF RESISTANCE AND PLYOMETRIC TRAINING ON VERTICAL JUMP IN WU-SHU ATHLETES

CHAPTER I

INTRODUCTION

1.1 General background

A vertical jump or vertical leap is the act of jumping upwards vertically into the air. The vertical jump is a common measure of an athlete's lower-body explosive power and is often used to assess athletic performance and potential. A vertical jump is a complex dynamic movement that requires the coordination of several muscles in the trunk, arms and legs (Charoenpanicha, Boonsinsukh, Sirisup, & Saengsirisuwana, 2013). During squat jump latissimus dorsi, erector spinae, vastus medialis, rectus femoris and tibialis anterior show significant contributors to this jumping styles, whereas during vertical stop jump, latissimus dorsi, erector spinae, rectus abdominis, vastus medialis, rectus femoris, semitendinosus, tibialis anterior, and medial gastrocnemius are significant contributors to this jumping style (Saengsirisuwan, 2013).

Achieving a high vertical jump is a pivotal demonstration of explosive power and athleticism across a range of sports and athletic disciplines; such as basketball, volleyball, track and field, gymnastics, Wu-Shu, and numerous others. Jumping ability can be considered as fundamental for successful performance in many sports (Sheppard J.M., 2008). An athlete's vertical jump capability is often considered a fundamental indicator of their performance potential.

Vertical jump performance is the result of a complex interplay of factors, including muscular strength, power, neuromuscular coordination, and the utilization of the stretch-shortening cycle (komi, oct 2000). In many sporting activities, the ability for provoking the lower body power can be a pivotal factor for success, (Haff GG, 2001).

Resistance training, also known as strength training, stands as a pillar of athletic conditioning. It is a methodical process that seeks to enhance an athlete's muscular strength and power through the application of external resistance, typically in the form of weights or resistance bands (Ratamess N. A., 2009). In the context of improving vertical jump, resistance training typically targets the muscles involved in the jump, such as the quadriceps, hamstrings, glutes, and calves. Different strength-training modalities have been used to improve lower body power, as measured by vertical jump (VJ). Baker D categorized training into general, special, and specific, serve distinct purpose (Baker, 1996). General strength-training exercises, such as the parallel squat, aim to boost the maximal strength of muscles crucial for jumping. Studies indicate that 1 repetition maximum (1RM) of the squat correlates with enhanced VJ performance (Harman EA, 1990). Following the increase in strength, special strength exercises become pertinent in power-focused training. These exercises excel in improving the stretch-shortening cycle (SSC), thereby refining lower body power. These regimens involve explosive exercises that emphasize achieving maximum or near-maximum initial rate of force development. Examples are power clean/snatches/pull/push etc. Whereas Specific strength exercises simulate the demands of activities like jumping, providing a similar training stimulus. Examples are loaded jump, repetitive jump training, depth jump etc.

Resistance training induces hormonal adaptation (W.J, 2005), morphological and neural adaptation that intensifies the RDF (rate of development of force) and 1 RM (Williams, 2007). It also elevates the levels of certain anabolic hormones, including testosterone, growth hormone, insulin, and insulin-like growth factor-1 (J R. N., 2005). Morphological adaptations encompass change in muscle size, fiber type and myosin heavy chain (MHC), muscle fiber hypertrophy, hyperplasia and myofibrillar proliferation. Additionally, neural adaptations are change in motor unit activation, recruitment of motor units, firing frequency, coordination, agonist activation and decreases in antagonist co-activation. (AG F. W., 2007)

Plyometric is referred as designed exercise to enhance muscle through the use of jump training (Eduardo sae´ Z-saed de Villarreal & Mikal, 2009). Plyometric training, often referred to as a type of exercise that involves rapid stretching and contracting of muscles (eccentric and concentric movements) to generate explosive power. Plyometric exercises aim to enhance neuromuscular coordination and the utilization of the stretch-shortening cycle in muscles, improving an athlete's ability to produce force quickly and efficiently (Markovic, 2007). Plyometric exercise involves rapid, forceful movements that utilize a pre-stretch or countermovement, leveraging the stretch-shortening cycle (SSC) (Wilk, 1993).

Plyometric training is based on stretch shortening cycle (SSC) consists of three phases crucial for efficient movement. Phase I, the eccentric phase, involves preloading the agonist muscle group(s), storing elastic energy in the series elastic component (SEC), and stimulating muscle spindles. During Phase II, the amortization phase, there's a delay between the eccentric and concentric muscle actions, allowing Type Ia afferent nerves to synapse with alpha motor neurons. This phase must be brief for optimal power production. Phase III, the concentric phase, utilizes the stored elastic energy from Phase I to enhance force production. Additionally, alpha motor neurons stimulate the agonist muscles, facilitating a reflexive concentric muscle action known as the stretch reflex. These phases work synergistically to optimize movement efficiency and power output (G. Gregory Haff N. T., 2015).

Additionally, since this training includes muscle lengthening, it may also improve flexibility, increase the amount of stored elastic energy in the muscles (Kubo, et al., 2007), provoke more muscle units, and come out in higher (neural) firing frequency (McLaughlin, 2001) and enhance joint proprioception (Swanik, et al., 2116)

Combined training, often referred to as "resistance-plyometric combined training" or "concurrent resistance and plyometric training," is a structured exercise regimen that combines elements of both resistance training (RT) and plyometric training (PT) within the same training program. This integrated approach aims to optimize athletic performance by concurrently improving muscular strength, power, and explosive capabilities, leveraging the benefits of both modalities. (Suchomel & S., 2016).

Wu-Shu is an ancient Chinese martial art, encompasses a rich tapestry of movement, philosophy, and tradition and characterized by dynamic movements and acrobatics. The vertical jump is a fundamental skill in Wu-Shu, essential for executing high-flying kicks, agile aerial maneuvers, and dynamic acrobatic sequences. Mastery of the vertical jump enhances an athlete's ability to perform advanced techniques and contributes to overall athletic excellence in Wu-Shu competitions.

1.2 Statement of problem

In the realm of sports and athletic performance, the advancement and innovation of vertical jump capabilities is a key indicator of lower-body power and explosiveness bearing substantial significance in numerous competitive sports disciplines, including basketball, volleyball, Wu-Shu, gymnastic, and track and field. Athletes and coaches are continually in search of the most effective training methodologies to enhance vertical jump performance, seeking to gain a competitive edge in their respective disciplines.

Wu-Shu athletes continually seek to enhance their performance, with vertical jump capability being a pivotal aspect of their skill set. While both resistance training (RT) and plyometric training (PT) have been independently recognized for their positive influences on vertical jump performance, a comprehensive understanding of the comparative impact of these training modalities, as well as the potential synergies resulting from their combination (CT), remains limited within the context of Wu-Shu. The existing body of literature predominantly focuses on singular training approaches, overlooking the nuanced interplay between resistance and plyometric training in the specific domain of Wu-Shu athleticism.

This research seeks to bridge this gap by undertaking a rigorous comparative analysis of resistance training, plyometric training, and their synergic effect on vertical jump performance among Wu-Shu athletes. The investigation aims to discern not only the individual contributions of resistance training and plyometric training but also the potential additive benefits or interactions when both modalities are integrated. Additionally, the study will explore the specific training adaptations in the unique context of Wu-Shu, thereby contributing valuable insights to the existing body of knowledge in sports science and athletic training.

By elucidating the distinct and combined effects of resistance training and plyometric training in the realm of vertical jump performance within the Wu-Shu discipline, this research aspires to inform evidence-based training strategies tailored to the specific needs of Wu-Shu athletes. Such insights are not only essential for optimizing athletic performance but also contribute to the advancement of training methodologies in martial arts sports, thereby benefiting athletes, coaches, and the broader sporting community.

Athletes and coaches continually seek effective training methods to enhance vertical jump height. While both resistance training and plyometric training have been independently shown to improve vertical jump performance, there is limited research comparing the effectiveness of these two training modalities when applied either separately or in combination.

There is very little research carried out on the Nepalese sports and less emphasis given on research from government. Training modalities for enhancement of vertical jump has not yet identified. Internationally we are lacking our medals in many sports that require height. As we cannot increase our height, our only option and focus is increase in vertical jump

1.3 Objectives of the study

The general objective of the study is to see the effects of resistance and plyometric training on vertical jump, however, the specific objectives are mentioned below:

1.3.1 To determine the individual effects of resistance and plyometric training or combined training on improving vertical jump performance.

1.3.1 To compare the effects of different trainings on vertical jump performance

1.3.3 To offer evidence-based recommendations for athletes, coaches, and fitness professionals on the selection and implementation of training modalities to improve vertical jump performance.

1.4 Significance of problem

Significance of this research is multifaceted and extends to various fields, including sports science, athletic performance, and physical conditioning. Here are several key reasons

1.4.1 Understanding the most effective training modality for improving vertical jump performance in Wu-Shu athletes can lead to substantial performance gains. This research can help athlete full potential and advantage in competitions. Coaches, trainers, and athletes can ratify the research findings to develop evidence-based training programs tailored to individual needs resulting in more efficient and effective training regimens.

1.4.2 Coaches and trainers can use the findings to design training programs that maximize the vertical jump performance of their Wu-Shu athletes. This can lead to improved team performance and better-trained athletes.

1.4.3 Sports organizations and institutions can allocate resources more strategically by investing in the training methods that have been proven to yield the best results. This can lead to cost savings and better overall program effectiveness.

1.4.4 The findings can have applications in Wu-Shu and others sports directly related to vertical jumping. Explosive lower-body power is beneficial in a wide range of sports and physical activities, including martial arts, gymnastics, and even military training.

1.5 Delimitation of study

Following are the delimitations of study:

1.5.1 The study focused exclusively on Wu-Shu.

1.5.2 It examined the effects of three specific training modalities resistance training, plyometric training and combined training on vertical jump performance.

1.5.3 The research implemented training programs of a fixed duration (12 weeks) for each training modality, limiting the investigation to short-term effects.

1.5.4 The study limited its analysis to specific age ranges or gender groups, depending on the available participant pool, rather than considering all possible age and gender combinations.

1.6 Organization of the study

In chapter I there is mentioned introduction with general background, statement of problem, objectives, significance of study, and delimitation of study of. In chapter II there will be the package of literature review with theoretical and empirical literature related to the research ensuring research justification. There is a conceptual framework of variables interconnected each-others along with defining variables. Chapter III outlines the research’s methodology and design which describes overall process of framework and path through which researcher need to conduct. It mentions research design, population of study, sample size and sample design, instrumentation and its validation, experimental procedure including testing, warm up, recovery time and training protocol, data collection procedure, data analysis plan, limitation and ethical consideration. Chapter IV deals with presentation, analysis and interpretation of collected data. Rough data is collected and presented in tables. Analysis and interpretation of data is performed along with testing hypothesis, thereafter to reach in major findings and conclusion of the study. Chapter V deals with summary of major findings, conclusion and recommendations. It presents summary, conclusion and discussion of the study. Based on findings of the study, this chapter also presents necessary three recommendations such as for policy making, practical implication and future research consideration. At the last part of the study, all necessary appendices and a bibliography are also included.

CHAPTER II

LITERATURE REVIEW

The literature review serves as a foundational element in research, offering a critical overview of existing knowledge on a topic. It systematically surveys scholarly articles, books, and other sources to identify what is already known, highlight significant theories and findings, and expose any gaps or inconsistencies. This process is essential for situating the current study, demonstrating the researcher's familiarity with the field, and justifying the need for the new investigation.

2.1 Theoretical literature review

Theoretical literature review involves exploring existing theoretical frameworks, models, and concepts that underpin these training modalities and their impact on vertical jumping. Here are some theoretical literature review focusing on these aspects:

2.1.1 Neuromuscular Adaptations theory

The neuromuscular adaptations theory is fundamental to understanding how different training modalities affect muscle function and force production. Resistance Training is known to enhance muscle strength and power through neural adaptations, including improved motor unit recruitment, synchronization, and rate coding. Plyometric Training (PT): Plyometric emphasizes the stretch-shortening cycle and rapid force development, enhancing neuromuscular efficiency through increased stretch reflex activity. Combined Training (CT): Combined training, by combining resistance training and plyometric training, may exploit the benefits of both, optimizing muscle strength and the ability to apply that strength quickly.

2.1.2 Biomechanical Principles

Biomechanical theories explain how different training modalities may influence movement patterns and force production during vertical jumping. Resistance Training (RT): It can lead to may influence movement patterns and force production during vertical jumping, potentially affecting movement mechanics during the jump. Plyometric Training (PT): It optimizes the stretch-shortening cycle, enhancing force transfer during the takeoff phase of the jump and improving jump height. Combined Training (CT): biomechanical impact may involve a combination of resistance training and plyometric training effects, leading to optimized force production and movement efficiency.

2.1.3 Specificity and Transfer of Training

The principle of specificity emphasizes aligning training modalities with the specific demands of the target activity, such as vertical jumping. Specific Adaptations: Different training modalities lead to specific adaptations, with RT enhancing maximal strength and power, PT focusing on rapid force development, and CT combining both. Transfer of Training: Theoretical models suggest that improvements in RT and PT may positively influence vertical jump performance through specific adaptations and improved neuromuscular control.

2.2.4 Muscle Fiber Recruitment Theory

This theory suggests that different types of muscle fibers (Type I, Type II a, Type II x) are recruited depending on the intensity and nature of the exercise. The Type I (slow twitch) motor units are recruited with light intensity exercise. When the load is increased, the Type II a (fast twitch) will be recruited with the help of the Type I fibers. When the load increases even greater, the Type II x will be recruited with the help of the Type II a and Type I motor units. Resistance training involves lifting weights or using resistance to challenge muscles, leading to the recruitment of motor units and activation of both fast-twitch and slow-twitch muscle fibers to overcome the resistance. Plyometric training involves rapid stretch-shortening cycles, primarily activating fast-twitch muscle fibers to generate explosive force. Combined training integrates both resistance and plyometric exercises, engaging a wide spectrum of muscle fibers through varying intensities and contraction velocities, thereby promoting comprehensive muscle recruitment and adaptation

2.2.5 Energy Systems Theory

This theory postulates that various energy systems (ATP-PC, glycolytic, oxidative) are utilized during exercise depending on its duration and intensity.

Resistance training primarily relies on the ATP-P Cr and glycolytic energy systems to fuel high-intensity, short-duration exercises such as heavy lifting. Plyometric training predominantly utilizes the ATP-P Cr system during the concentric phase and the glycolytic system during the eccentric phase of rapid muscle stretching and contraction. Combined training taxes both the ATP-P Cr and glycolytic systems due to the intermittent nature of resistance and plyometric exercises, fostering adaptations to enhance energy system efficiency and power output.

2.2.6 Structural Adaptation Theory

This theory focuses on the structural changes that occur within muscles, tendons, and ligaments in response to training stimuli. Resistance training induces hypertrophy and increases muscle cross-sectional area, contributing to greater force production and strength gains. Plyometric training enhances tendon stiffness and muscular elasticity, facilitating more efficient energy storage and release during stretch-shortening cycle movements. Combined training elicits structural adaptations in both muscle tissue and connective structures, optimizing force transmission and mechanical efficiency for improved performance in activities like vertical jumping.

2.2.7 Metabolic Stress Theory

This theory suggests that metabolic stress, characterized by factors such as lactate accumulation and cellular pH changes, plays a significant role in muscle adaptation and growth. Resistance training creates metabolic stress through high-intensity muscular contractions, leading to metabolic adaptations such as increased muscle glycogen storage and improved lactate clearance. Plyometric training induces metabolic stress by rapidly depleting energy stores and accumulating metabolites such as lactate, promoting adaptations related to buffering capacity and anaerobic metabolism. Combined training synergistically enhances metabolic stress by combining the metabolic demands of resistance and plyometric exercises, eliciting adaptations that enhance energy production and utilization during activities like vertical jumping.

2.2 Empirical Literature review

The empirical literature section focuses on reviewing studies that have collected and analyzed data related to the research topic. This includes summarizing methodologies, findings, and conclusions from previous research, emphasizing both the strengths and limitations of these studies. This section is crucial for demonstrating the relevance and originality of the current study, as it builds on and contributes to the existing body through empirical evidence.

According to Paula F Sperlic, M Behringer, J Mester J (2016), resistance training throughout the year, using bodyweight or external weight, significantly improves vertical jump performance in healthy basketball players.

Hoffman et al. (J R Hoffman, February 2004) conducted on the research by assigning twenty members of National Collegiate Athletic Association Division III collegiate football team 4-days-wk-1 for 15 weeks. to either an Olympic lifting (OL) group or power lifting (PL) group. They came to know that OL can provide a significant advantage over PL in vertical jump performance changes.

In the research conducted by Channell et al. (BT Channell, 2008) on topic of “Effect of Olympic and traditional resistance training on vertical jump improvement in high school boys” twenty-seven male student athletes were recruited from a high school football program at a rural school in the Southeast and the subjects were divided into an Olympic training group (n = 11), a power training group (n = 10), and a control group (n = 6). They were in conclusion that Olympic lifts as well as power lifts caused improvement in vertical jump performance and that Olympic lifts caused a modest advantage over power lifts for vertical jump improvement in high school athletes.

In examination held by Marios Christou et al. (M Christou, 2006) on the topic of the effects of resistance training on the physical capacities of adolescent soccer players, eighteen soccer players with age group 12-15 were divided into two groups as a soccer (SOC: n = 9) and strength soccer (STRSOC: n = 9) and 8 subjects of similar age were assigned as a control group. All subjects were allowed to train a soccer program 5 times a week for the purpose of the development of technical and tactical skills. Additionally, the STRSOC group executed a strength training two times a week for 16 weeks. The result was found that maximum strength of the upper and lower body as well as vertical jump were improved with the addition of resistance training. So it recommended to merge the soccer with resistance training for an overall development of the physical abilities of young boys. Mehmet (Mehmet Emin Demiri, 2022) found out that the impact of six-week plyometric training program on basketball players had reported substantial gains in physical performance including vertical jump. In this A total of 24 participants, aged between 18 and 36, who regularly practiced basketball, voluntarily took part in the research. There were division of two groups as an experimental group (n=12) and a next control group(n=12). The experimental group underwent the plyometric training program three days a week for six weeks. Meanwhile, both groups continued their regular basketball training during the season.

In a research reviewed by Gregory F Martel et al. (Mertel, Harmer, Logan, & parker, OCT 2005), nineteen female volleyball players (aged 15 ± 1 year) were randomly assigned to perform 6 weeks of APT or flexibility exercises (CON) with both interventions twice weekly, both alongside traditional preseason volleyball training. They came in conclusion in larger improvement (after 4 weeks (APT = 3.1% and an additional 8% ($P < 0.05$) from week 4 to week 6) in vertical jump by combination of aquatic plyometric training and volleyball training than CON group.

The systematic review on “effectiveness of plyometric training vs complex training on explosive power of lower limb” conducted according to the Cochrane Collaboration Guidebook and the criteria of Preferred Reporting Elements for Systematic Reviews and Meta-analyses set findings of this review suggests that unloaded PLT and CT have a similar significant effect on explosive performance (jump ability, sprint ability) in short term (within 10 weeks), but loaded PLT has a better effect (wang, lv, min, Ji, & Dong, 2022).

In the study conducted by Gehri DJ et al., the objective was to determine the most effective plyometric training technique for improving vertical jump ability, positive energy production, and elastic energy utilization. Data was collected before and after a 12-week training period, during which participants were divided into two groups: the countermovement group and the depth jumping group. The result showed significant increases in vertical jump height for both the countermovement and depth jumping training groups. Additionally, it declared depth jump had more significant vertical jump (Gehri, 1998).

In a separate study by Stuarto et al. titled "Relative Effects of Isokinetic and Plyometric Training on Vertical Jumping Performance," it was discovered that both training groups—Group I, which trained with isokinetic exercises, and Group II, which trained with plyometric exercises—showed significant improvements in vertical jump performance (E & Noble, March 17, 2013). Subjects in the training groups trained three times per week for up to 8 weeks. The plyometric group completed three sets of 10 repetitions of depth jumps from a height of 34 inches. Resistance was progressively added to the depth jumps, starting in weeks 3, 5, and 7, with weights of 10, 15, and 20 pounds, respectively.

Kopil Kumar Thapa, on six weeks study of effectiveness of plyometric drills on high school students in Kathmandu, found significance improvement in vertical jump in experimental group than in control group. The study was held with 20 girl students of Jan Sewa Secondary School as experimental group and 20 girl students Bishow Rastriya Secondary School as control group (Thapa, 2003)

Kelvin et al. (2009) compared the effects of a weight-training program, a combined program of weight training and plyometric training, and two combined programs of weight training and resisted jump training on vertical jump performance among 37 intercollegiate assigning to four training groups. The study found no significant differences in the mean vertical jump heights between the pretest and posttest measurements, either among the different training groups or within each group over the 6-week period. (Kelvin Carlson M. M., 2009).

Mikalik et al. (2008) compared short-term complex and compound training programs for thirty-one college-aged volleyball players (20 women and 11 men) by dividing them into two groups and conducting training sessions twice a week for 4 weeks. The study observed significant improvements in both vertical jump height and power output in both training groups. However, there were no significant differences in the gains achieved between the two programs or in the rate at which gains were made within each group (Mihalik, Libby, Battaglini, & McMurray, 2008).

Emilija Stojanovic et al (October 2016), significantly contributed to our understanding of the impact of plyometric training on vertical jump (VJ) performance. By systematically searching six electronic databases, including PubMed, MEDLINE, ERIC, Google Scholar, SC Index, and Science Direct, the study employed specific coding criteria such as training status, training modality, and type of outcome measures to evaluate the effectiveness of plyometric training. The findings highlight that plyometric training serves as an effective method for enhancing VJ performance, particularly in female athletes, as evidenced by improvements in countermovement jump (CMJ), squat jump (SJ), and drop jump (DJ). Furthermore, the research emphasizes that the positive effects of plyometric training on VJ performance are more pronounced in interventions lasting 10 weeks or longer (Emilija Stojanović, 2016).

Adams K et al during the research on the effect of six weeks of squat, plyometric and squat-plyometric training on power production came to conclude that the combination training group exhibited significantly better performance than the plyometric training and the weight-training groups alone in vertical jump height. The research was conducted among forty-eight subjects equally divided in four group as strength, plyometric, strength and plyometric and control group. The study was performed in two days in a week up to 7 weeks (Kent Adams, 1992).

In other research on the topic of comparison of training modalities for power development in the lower extremity Tony Bauer et (Bauer & E, 1990) al randomly assigned twenty-two male and fifteen female physical students into five groups such as (1) Free weight n=8, (2) Hydra Gym n=8, (3) Plyometric n=8, (4) Hydra gym with plyometric n=7, (5) free weights with plyometric n=6. The 10 weeks training revealed that there was no significance difference between groups in vertical jump.

H T Ford et al (HT Ford Jr, 1983) was interested to assess the impacts of structured training programs on 5 physical fitness test parameters. Fifty high school boys participated for 10 weeks, each assigned to one of three programs: wrestling, softball, and plyometric; weight training alone; or weight training combined with plyometric exercises. They were in conclusion on no significant difference between three groups for vertical jump.

In the research by Lyttle et al (AD & Wilson, 1996), thirty-three participants who were not previously experienced weight and plyometric training were divided randomly in three groups as explosive maximal power training group, combined weight and plyometric training group and control group. After 8 weeks training both training groups were equally effective in vertical jump ability. There was no significance difference between them in vertical jump performance.

In a research study conducted by IG Fatouros et al. in 2000, it was revealed that the combined training group exhibited significantly greater improvements in vertical jump performance compared to both the plyometric training alone and weight training alone groups. (Fatouros & Jamutas, 2000). Forty-one men were randomly assigned in that research as plyometric training (n= 11), weight training (n= 10), plyometric plus weight training (n= 10), and control (n= 10). Vertical jump and other measurements like mechanical power, flight time, and maximal leg strength were taken before and after 12 weeks of training. Subjects in each training group trained 3 days per week, but no training given to control subjects. Data were analyzed by a 2-way analysis of variance (repeated-measures design).

2.3 Variables identified

These can be categorized into independent variables, intermediate variables, dependent variables and control variables. Here is breakdown of variables in this research:

2.3.1 Independent variables

Training modalities

- Resistance training: This could involve exercises using weights, resistance bands, or other equipment designed to increase muscle strength and power.
- Plyometric training: Involves explosive, rapid movements that aim to improve muscle power and elasticity.
- Combined training: This variable explores the impact of combining resistance and plyometric training. It's often represented as an interaction term between the two training modalities.

2.3.2 Dependent variables

Vertical Jump Performance is the primary outcome variable, representing the height or distance achieved in a vertical jump.

2.3.3 Intermediate variables

These variables help explain the relationship between the independent variable (training modality) and the dependent variable (vertical jump performance).

a. Participant’s characteristics
Age (Categorical: e.g., youth, adult, senior)
Sex (Binary: male, female)
Skill Level (Categorical: e.g., novice, intermediate, advanced)

b. Biomechanical factors: They can include factors like muscle strength, power, neuromuscular coordination, muscle hypertrophy, rate of force development, and more.

Muscle strength

- Strength gains from resistance training may contribute to overall vertical jump improvement.

Power

- Both resistance and plyometric training aim to enhance power, which is a key factor in vertical jumping ability.

Muscle elasticity

- Plyometric training may particularly influence muscle elasticity, impacting the ability to generate quick, powerful movements.

The Rate of force development

- RFD is the development of maximal force in minimal time and is typically used as an index of explosive strength

Neuromuscular coordination

- It plays a pivotal role in the execution of a vertical jump. A vertical jump is a complex movement that involves the integration of neural signals and muscular actions to generate the necessary force for upward propulsion.

3. Training Protocol

- Standardized exercise selection, intensity, duration, and frequency for each training modality.

4. Nutrition and Rest

- Ensuring participants maintain consistent nutrition and rest patterns.

5. Testing Environment

- Controlling environmental conditions like temperature and humidity during performance measurements.

4. Control variables

These are other factors that might influence the dependent variable but are not the main focus of the study. These are variables that are held constant or controlled for to minimize their potential influence on the dependent variable. Control variables can include:

a. Baseline vertical jump performance.
b. Consistency in training compliance.
c. Previous training experience.
d. Equipment and facilities conditions.

2.4 Conceptual framework

Conceptual framework is a representation of the relationship between the variables, or the characteristics or properties that is to be studied in the form of written or visual and are generally developed based on a literature review of existing studies about the topic. The conceptual framework for this thesis outlines the theoretical basis and key variables related to the comparison of resistance, plyometric training and combined training in improving vertical jump performance. This framework guides the research design, helping to formulate hypotheses and interpret findings within a structured theoretical context.

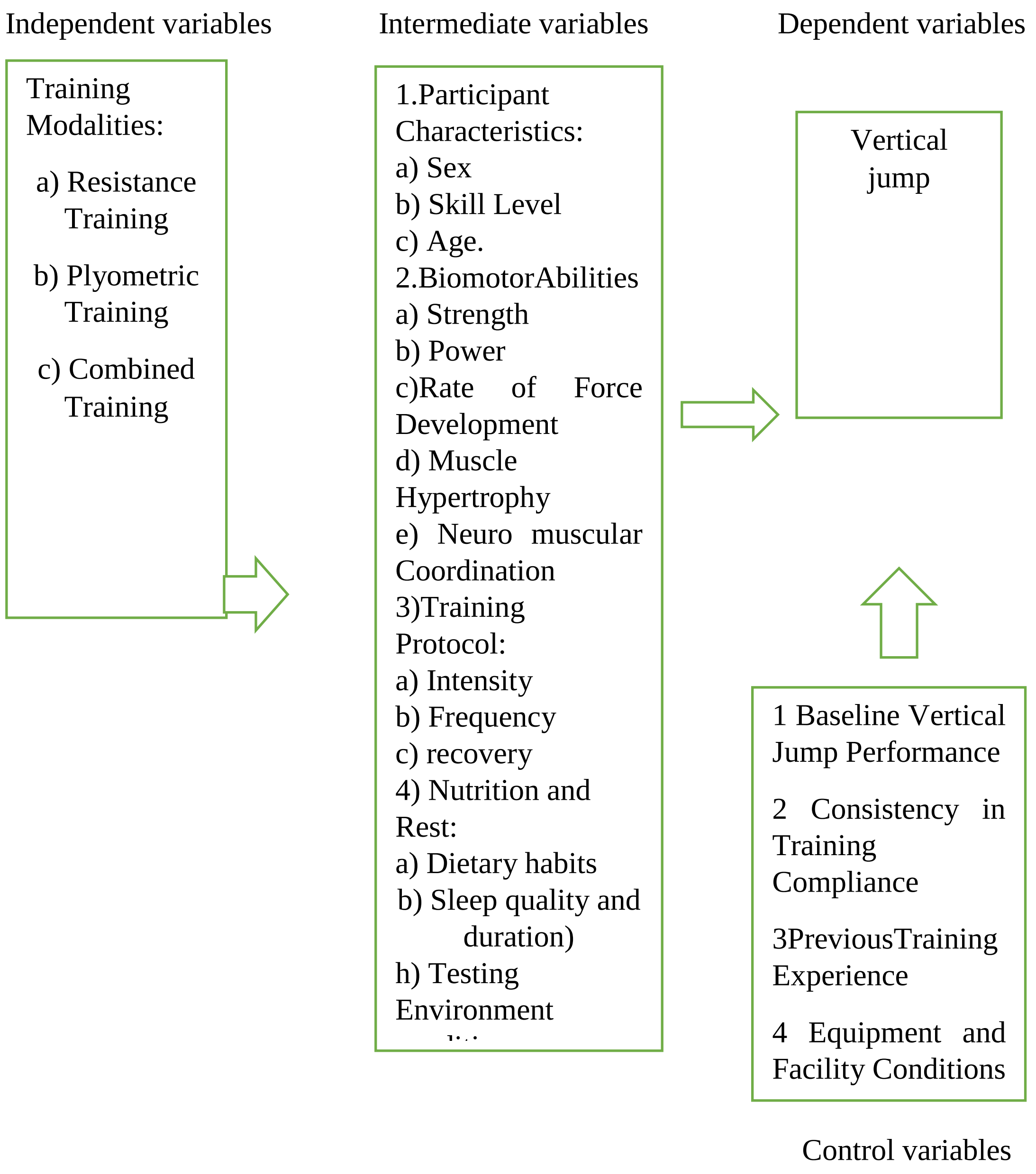


Figure 1: Conceptual framework

In this research study, independent variables are manipulated to observe their effect on dependent variables, while intermediate variables explain the process of linking them. Control variables are kept constant to ensure the observed effects are due to the independent variables, maintaining the study's validity.

2.5 Formulation of Hypothesis

Based on the review of empirical literature and the conceptual framework, the hypotheses for this research are formulated as follows:

Primary null Hypothesis (H_0): There would be no significant differences in improving vertical jump (VJ) among the resistance training (RT), plyometric training (PT), combined training (CT), and control group (CON).

Alternative Hypothesis (H_1): There would be significant differences in improving vertical jump (VJ) improvements among the resistance training (RT), plyometric training (PT), combined training (CT), and control group (CON).

Secondary null hypothesis (H_{01}): There would be no significant differences in improving vertical jump (VJ) between the combined training (CT) group, and plyometric training (PT), resistance training (RT), and control (CON) groups.

Alternate hypothesis (H_2): There would be significant differences in improving vertical jump (VJ) between the combined training (CT) group, and plyometric training (PT), resistance training (RT), and control (CON) groups.

Alternate hypothesis (H_3): There would be significant differences in improving vertical jump height (VJH) between the plyometric training (PT) and combined training (CT) group, resistance training (RT), and control (CON) groups.

Alternate hypothesis (H_4): There would be significant differences in improving vertical jump height (VJ) between the resistance training (RT) and combined training (CT) group, plyometric training (PT), and control (CON) groups.

CHAPTER III

METHODOLOGY

This chapter presents the operational framework of study. It outlines successive sequences of research design, population, sample size and sample design, subjects' characteristics, instrumentation and its validity, experimental procedure, data collection procedure and statistical analysis providing a clear roadmap for how the research was conducted.

3.1 Research design

The study is true experimental research. The study employs a randomized controlled trial (RCT) design. Researcher has manipulated independent variables to explore its effects on dependent variable (Vertical Jump) The study spans 12 weeks. Pre-test, mid-test, and post-test assessments is conducted to measure vertical jump performance.

3.2 Population

Athletes who are playing Wu-Shu in Kathmandu valley is the population of this study.

3.3 Sample size and sample design

Forty (40) Wu-Shu athletes were recruited voluntarily from Hari siddhi Wu-Shu Quan situated in Lalitpur of Kathmandu valley for the study. For this research, athletes were assigned randomly to one of four training groups as resistance group (RT), plyometric group (PT), combined group (CT) and control group(CON). The selection of athletes for each training group was employed a simple random sampling method based on the average mean of their initial vertical jump performance. After the initial testing phase, athletes were divided into four different groups according to their average mean vertical jump scores. Subsequently, each group is randomly assigned to form the respective training groups—Resistance Training (RT) group, Plyometric Training (PT) group, Combined Training (CT) group and Control Group (CG) group. The use of simple random sampling aims to enhance the comparability of participants across training groups, contributing to the robustness and reliability of the study findings.

3.4 Subjects characteristics

The subjects recruited for this study were continuously playing Wu-Shu athletes including both male and female ranging in age from 11 to 20 years with good health without recent injuries affecting training participation. Participants recruited were volunteered participated and were having various Wu-Shu training experiences ranging from several months to several years. Participants were provided with all the necessary information regarding the study's procedures both orally and in writing. Each subject completed questionnaire including demographic characteristic, training background, physical condition mental condition and skill level. Participants with a history of traumatic events or surgeries involving the lower extremities within the past two years were excluded from the study. Sex and age group data of subjects are presented in table1.

Table 1: Sex and Age group physical characteristics of subjects

Group	Sex		Total	Age group (year)		Total
	Male	Female		11 to 15	16 to 20	
Resistance group	4	6	10	7	3	10
Plyometric group	4	6	10	7	3	10
Combined group	7	3	10	7	3	10
Control group	8	2	10	6	4	10
Total	23	17	40	27	13	40
Percentage	57.5%	42.5%	100%	67.5%	32.5	100%

Table 2: Mean ± S.D) Descriptive data of subjects' characteristics

Group		Height(cm)	Weight(kg)	Age(y)	BIM (kg/m2)
Resistance group	Mean	151.30	46.00	14.00	19.88
	N	10	10	10	10
	Std. Deviation	10.781	11.106	3.464	2.793
Plyometric group	Mean	149.40	45.60	14.20	19.97
	N	10	10	10	10
	Std. Deviation	13.542	15.320	3.155	4.41
Combined group	Mean	149.90	43.30	13.70	19.02
	N	10	10	10	10
	Std. Deviation	13.195	11.016	3.433	3.16
Control group	Mean	149.20	43.00	14.50	18.88
	N	10	10	10	10
	Std. Deviation	12.927	12.127	3.808	2.50
Total	Mean	149.95	44.47	14.10	19.44
	N	40	40	40	40
	Std. Deviation	12.181	12.094	3.350	3.21

3.5 Instrumentation and its validity

An instrument is a tool or mechanism used for data collection. Validity refers to the extent to which the instrument accurately measures what it is intended to measure, ensuring the results are credible and reliable. Instruments for data collection and its validity are mentioned below:

3.5.1 Questionnaire

A structured questionnaire was designed to collect data with a set of questions including information of participants' demographic, training background, skills level, physical condition, mental condition, economic condition and feeding and sleeping life style. The questions were inclusive of characteristics from simple primary inquiries, secondary or follow-up inquiries, and also incorporated patterns of Likert scaling (Appendix 1: The Questionnaire design).

3.5.2 Jump and reach measuring device

The "jump and reach" method was used as a quantitative technique to assess vertical jump height using Vertec device. Subjects jump and reach the target point in vertec device and reached height was measured.

Validity of jump and reach using vertec device

The "jump and reach" method is a quantitative technique commonly used to assess vertical jump height. The jump and reach method using the Vertec device has been widely used and accepted as a valid tool for assessing vertical jump height in various sports and fitness settings.

In the research study by John S Leard, Melissa A Cirillo, Eugene Katsneison, and Deena A. Kimiatek (2007), Just Jump method of measuring vertical jump using Vertec height is a valid measure when compared with the 3-camera system (John S Leard, 2007 December).

3.5.3 Training equipment

Training protocols employed various weight-training and plyometric equipment were employed during training protocol. For weight training, barbell with different weights and various weighted dumbbell were used. For plyometric, different height plyometric boxes, small and long plastic pipes and sticks were used.

3.6 Experimental procedure

An experimental procedure in research is a systematic method used to test hypotheses by manipulating variables and observing their effects under controlled conditions. This process involved testing, warm up, recovery timing training protocol and cool down to ensure reproducibility and accuracy of the results.

3.6.1 Testing

In this study, two testing were performed as followings:

Vertical jump testing

Vertical jump testing was conducted 3 times during the study. Pretest was performed before the starting of the training, mid testing was conducted in 6 week and post test was conducted after the completion of 12 weeks training. From a standing position on the flat smooth floor, participants performed a vertical jump using initial countermovement (with an arm swing) reaching up and striking the highest possible vein of a Vertec measuring device and landing back on the floor. The point of height was recorded. Prior to testing for vertical jump height, all participants were allowed to undergo a 5-min warm-up followed by standard dynamic stretching exercises. Subjects then performed 3 maximal vertical jumps on the floor with 3minutes rest between each jump (Luebbers, 2003) with the highest performances being recorded for that session. The selection of this test was due to its high validity (0.80) and reliability (0.93) coefficients (Margaret J. Safrit, 1990) as it allows arm movement and a squat motion before the jump, such as accompanied in sports.

Estimated 1RM testing

The one-repetition maximum (1RM) test is a widely used field-based measure of strength. As the name implies, the 1RM is the heaviest weight that can be lifted once with proper lifting technique (Kraemer WJ, 2006). Maximal Dynamic Strength is usually assessed either by the one repetition maximum test (1-RM) or by a repetition maximum test with submaximal loads, which requires the application of a formula to estimate the value of 1-RM (Naclerio & Jiménez, 2009). In order to reduce injury and time reducing subjects for resistance training were allowed to perform multiple repetition maximum with weighted comfortable in designed exercise, then their estimated 1RM value for that resistance exercise was calculated by using following formula from Brzycki (Brzycki, 1993).

Estimated 1RM=W.(36/37-r)

Where W=weight, r=repetitions

Estimated 1RM was measured for each subject for each exercise.

3.6.2 Warm up

Subjects were instructed to perform warm up every training day before initiating the specific designed training to prepare physiologically and psychologically and reduce injury. Subjects were guided to undergo jogging and running for 10 minutes as a general warm up. Then they were preferred to follow dynamic stretching instead of Proprioceptive Neuromuscular Facilitation (PNF) and ballistic stretching ((Yamaguchu, 2005), (Yamaguchi, Taichi, Ishii, Kijoro, & Yamanaka, 2006). Additionally, sports specific movements were followed. there has been a growing interest in warm-up procedures, including dynamic movements such as hops, skips, jumps, and movement-based exercises for the upper and lower body, aimed at increasing core body temperature, intensifying motor unit excitability, improving kinesthetic awareness, and extending active ranges of motion (Faigenbaum A. a., 2007) (Kang, 2006). It has been stated that warm-up protocols in inclusion of moderate to high intensity dynamic movements can increase power performance in youth {(Faigenbaum A. M., 2006) (Theophanis Siatras, 2003)}.

3.6.3 Recovery timing for training protocol

Blackard and Ebben (1997) highlighted the importance of incorporating a recovery period in complex training protocols to reduce fatigue and maintain consistent focus on performance. They suggested a minimum of 48 hours of recovery between sessions (Ebben, 1997). D Chu suggested a recovery period for plyometric should range from 48hrs to72hrs in a week (Chu, Jumping into plyometric, 1992). Consequently, all Subjects in the three training groups adhered to rest periods of at least two days between successive sessions to standardize the timing across all groups. They also recommended 2 to 5 -minutes recovery between sets to ensure uniform recovery intervals across the groups. (WP Ebben, 1997). Similarly, it is recommended 3-5 minutes' rest between sets (Salles, PhD, Miranda, Novaes, & Willardson, 2012). Additionally, according to Adams et all (Adams, 1992) to ensure adequate recovery, all power athletes adhere to a schedule of performing squats and plyometric exercises twice weekly. Therefore, by this recommendations, participants of RT PT and CT were trained 2 days in a week during study. Additionally, recovery time (rest time) between exercises was maintained 4 minutes while that was 3 minutes between set to normalize recovery across the groups. Recovery timing between session, sets and exercises during training of all groups are shown in table 3.

Table 3: Recovery timing for Training Protocols

Exercise modality	Session	Exercise	Set
RT	=>48hrs	4mins	3mins
PT	=>48hrs	4mins	3mins
CT	=>48hrs	4mins	3mins

3.6.4 Training protocol

The week prior to the start of the respective training programs, participants' pretesting maximal VJH were recorded. Subjects were subsequently randomized into four groups: resistance training (n=10), plyometric training (n=10), combined plyometric and resistance training (n=10), and a control group (n=10). The three training groups underwent training twice a week for 12 weeks, but control group was not trained. Training periodization is shown in table 3. The training was closely supervised by my supervisor prof. Dr Ram Krishna Maharjan. On Saturday, plyometric group and combined group were trained plyometric exercise and resistance group was trained resistance exercise. Similarly, On Tuesday, resistance group and combined group were provided training of resistance exercises and plyometric group was provided training of plyometric exercise. Day wise training was shown in figure 2. Before commencing the training periods, subjects in all training groups were instructed on the correct execution of all exercises to be utilized throughout the training regimens. Lower extremity exercises were included in training protocol as the principle of specificity (Uppal, 2021). The training programs were formulated specially to overload the lower extremity muscles used in vertical jumping movement. To equate training volume between resistance and plyometric training, 4 exercises were instructed to perform in each session.

Since participants included in this study were two age groups 11 to 15 and 16 to 20 and different experiences in training, they were trained with different load and intensity as following principle of individual difference. Moreover, since number of participants in each group were equal, it supported the consistency in age group different training as administered in each training group. Also, most of participants have no experience of resistance training and systematic plyometric training, they were guided basic exercise techniques in first week in order to prevent injury and psychologically prepared. The training volume varied between the two training days each week. Having 1day heavy loading followed by next light day in each week, the training regimen intensifies physiological stress on participants' bodies, promoting progressive overload that necessitates rapid adaptation. (Jackson, 2010).

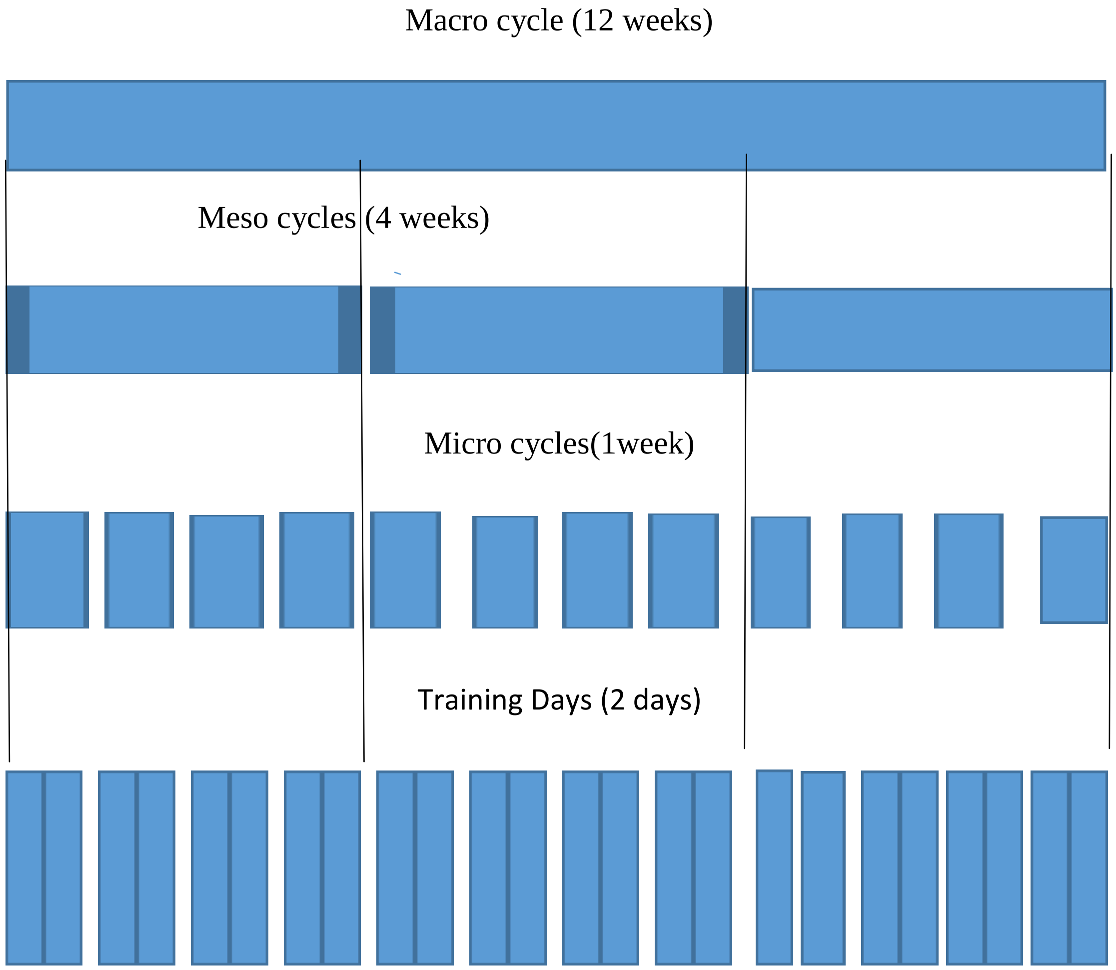


Figure 2: Training Periodization

Table 4: Day-wise Group Training

Training Day	Group	Exercise
Saturday	Plyometric and combined group	Plyometric
Saturday	Resistance group	Resistance
Tuesday	Resistance and combined group	Resistance
Tuesday	Plyometric group	Plyometric

Resistance training protocol

Resistance training included the different leg exercises. As the resistance training with external load was new for them, they were incorporated with lifting external light loads with sticks, progressively to an unloaded, light barbell and finally to a weighted barbell. Concentration on proper form throughout the correct technique-driven progression (Stricker & Faigenbaum, 2020) was provide in order to physically and psychologically prepared for resistance training. In first training day of first micro-cycle (Week 1), they were incorporated with stick with 4 -5 feet length for back squat and Romanian dead lift exercises, then they were incorporated with forward step lunge and standing calf raise with short pipes. Whereas, in second training day of first micro-cycle, they were made familiar with free barbell in back squat and Romanian dead lift exercises and 2 ,3 kg weights dumbbell was introduced with forward step lunge and standing calf raise. During each training session, subjects' body position lifting velocity and weight griping was monitored to be correct as guideline of essential strength training and conditioning fourth edition. In training day 1 of second micro-cycle (week 2), their estimated 1RM (One Repetition Maximum) test, as mentioned above, was administered with their comfortable weight in each exercises to determine an appropriate resistance training intensity and evaluate the effectiveness of resistance training program. In second training day of second micro-cycle, RT group performed resistance training with intensity 70%1RM with 6 repetitions to develop strength. The resistance training protocol from week 1 to week 4 was shown in table 7. From third week repetition was reduced from 6 to 5 along with increase in 1 RM repetition for explosive power as recommendation of essential of strength and conditioning book as shown as table 5. In week 3 and week 4 the training intensity was maintained 80% in training day 1 and 75% in training day 2, but set was increased to 11 to 15 age group to make consistent set and repetition with 15 to 20 age group participants. From week 5 to week 12, new exercise with higher intensity with similar mechanism exercise, one leg step lunge was introduced in place of forward step lunge. In training day 1 of week 5 to week 8, intensity was maintained 85%1RM with increased from 80%1 RM of previous loading along with decreased repetition in each exercise by 1 and similarly, in training day 2, 80%RM intensity was maintained from 75% of previous loading along with decreased repetition by 1 in each exercise. Likewise, in both training days of week 9 to week 11, training intensity was increased by 5% of previous week loading and reached up to 90% and 85% in successive days along with decreased repetition by 1 except one leg step lunge in each day. Careful adjustments were made to increase training weights, ensuring that subjects were capable of completing the assigned sets and repetitions effectively. But, at last the intensity was reduced to 85%1RM in training day 1 and 80% 1RM in training day 2, as well as volume was reduced in both days to provide low loading and low volume for post vertical height testing. Resistance training protocol from week 5 to week 12 was shown in table 6. The rest period between exercise was allowed 4 minutes and rest period between set of exercise was given 3 minutes as mentioned above in order to replenish anaerobic energy stored. The subjects were instructed to lift each load with maximal intent of movement.

Table 5: Resistance Training Protocol from week 1 to Week 4

		SATURDAY AND TUESDAY					
WEEK	DRILL	TRAINING DAY 1			TRAINING DAY 2		
			Set x Rep			Set x Rep	
		%1RM	(11to15) age group	(16to20) age group	%1RM	(11to15)age group	(16to20) age group
W 1	B.S.	With stick	2x7	3x7	With stick	2x6	3x6
	R.D.L.	With stick	2x7	3x7	With stick	2x6	3x6
	F.S.L.	With stick	(2x7)2	(2x7)2	With stick	(2x6)2	(2x6)2
	S.C.R	With stick	2x7	2x7	With stick	2x6	2x6
W2	B.S.	ESTIMATED			70%RM	2x6	3x6
	R.DL.	1RM TEST			70%RM	2x6	3x6
	F.S.L.				70%RM	(2x6)2	(2x6)2
	S.C.R				70%RM	2x6	2x6
W3	B.S.	80%1RM	3x5	3x5	75%1RM	3x5	3x5
	R.D.L.	80%1RM	3x5	3x5	75%1RM	3x5	3x5
	F.S.L.	80%1RM	(2x5)2	(3x5)2	75%1RM	(2x5)2	(3x5)2
	S.C.R	80%1RM	2x5	3x5	75%1RM	2x5	3x5
W4	B.S.	80%1RM	3x5	3x5	75%1RM	3x5	3x5
	R.D.L.	80%1RM	3x5	3x5	75%1RM	3x5	3x5
	F.S.L.	80%1RM	(3x5)2	(3x5)2	75%1RM	(3x5)2	(3x5)2
	S.C.R	80%1RM	3x5	3x5	75%1RM	3x5	3x5

Note: W=Week, B.S.=Back Squat, R.D.L.=Romanian Dead Lift, F.S.L.=Forward Step Lunge, S.C.R.=Standing Calf Raise, T=Training Day.

Table 6: Resistance Training Protocol from Week 5 to Week 12

T.D.	SATURDAY AND TUESDAY				
WEEK	DRILL	TRAINING DAY 1		TRAINING DAY 2	
		%1RM	Set x Rep	%1RM	Set x Rep
W5	B.S.	85%1RM	3x4	80%1RM	3x4
W6	R.D.L.	85%1RM	3x4	80%1RM	3x4
W7	O.L.S.L.	85%1RM	(3x4) 2	80%1RM	(3x4) 2
&	S.C.R	85%1RM	3x4	80%1RM	3x4
W8					
W9	B.S.	90%1RM	3x3	85%1RM	3x3
W10	R.D.L.	90%1RM	3x3	85%1RM	3x3
&	O.L.S.L.	90%1RM	(3x4) 2	85%1RM	(3x4) 2
W11	S.C.R	90%1RM	3x3	85%1RM	3x3
W12	B.S.	85%1RM	3x3	80%1RM	3x3
	R.D.L.	85%1RM	3x3	80%1RM	3x3
	O.L.S.L.	85%1RM	(3x3) 2	80%1RM	(3x3) 2
	S.C.R	85%1RM	3x3	80%1RM	3x3

Note: W=Week, B.S.=Back Squat, R.D.L.=Romanian Dead Lift, O.L.S.L.=One Leg Step Lunge, S.C.R.=Standing Calf Raise, T.D.=Training Day

Table 7: Volume assignment on the basis of training goal

Training goal	Goal repetition	Sets
Strength	<6	2-6
Power	3-5	3-5
Hypertrophy	6-12	3-6
Endurance	>12	2-3

Plyometric Training Protocol

Plyometric training included jump and reach, double leg jump to box, front barrier hob, and countermovement jump for age group11 to 15 year participants and included double leg tuck jump in place of countermovement jump for age group 16 to 20 in week 1 to week 4 training days. As countermovement jump is low intensity exercise and double leg tuck jump is medium intensity exercise. The classification of plyometric exercises depends on the degree of intensity and Depth jumping highest intensity followed by box jump as shown in figure 3 (Chu, Jumping into plyometric, 1992). The volume of plyometric exercise was increased from week 1 to week 4. As already mentioned above, the training volume fluctuated between two training days of each micro-cycle maintaining decreased 1 repetition in each micro-cycle(week). Plyometric training protocol from week 1 to week 4 is shown in table 8.

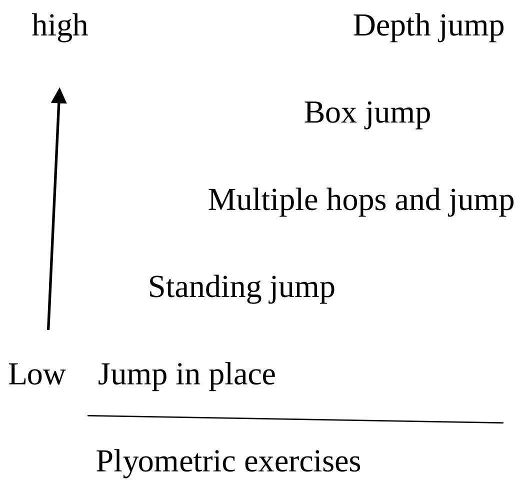


Figure 3: Low to high intensity category of plyometric exercise

Age group 11 to 15 subjects performed 4 exercises of 7 repetitions in each exercise in training day 1 altogether 84 foot contacts whereas age group 16 to 20 participants performed 8 repetitions in each exercise in training day 1 altogether 96 foot contacts following guidelines for volume recommended by strength and conditioning guideline for athletes of different levels of experience as table 9 (hagf & Triplett). Double leg jump to Box and front barrier hop height was fixed 1ft for (11o 14) age group and that of 1.5ft for age group (16 to 20) in first week. They were focused for correct techniques for both in takeoff as swinging hands from down to upward, breathing (inhaling), and knee flexion angle, as well as in landing such as landing with knee and foot same line from frontal view and knee and shoulder in same alignment (in box jump). In week 2, age group (11 to 15) performed two plyometric drills (double leg box jump and front barrier hob) in height of 1ft and 1.5ft according to their height and their comfort jump as well as age group 16 to 20 performed these drills with 2ft height. The volume was increased from 84 and 96 to 120 to 132 from training day 1 of first micro-cycle to training day 1 of fourth micro-cycle (week 4) maintaining the intensity constant from first micro-cycle (week 2) to fourth micro-cycle (week 4) of first meso-cycle. As mentioned above the rest period between set was 3 minutes and that between exercises was 4 minutes. In second meso-cycle (week 5 to week 8), Jump twitch and reach, was introduced to both age group and double leg tuck jump was introduced to age group (11 to 15). similarly, double leg jump to box height was increased by 6 inch with decreasing repetition and the height of front barrier jump was increased by 6 inch (increasing intensity) with decreasing repetition. The volume was decreased to 109 and 123 because volume should be decreased as increased intensity (MH Stone, 1987). In addition, in week 9 to 11 week in third meso cycle, pike jump was introduced and depth jump(2.5ft) was introduced for only age group (15 to 20) because the epiphyseal plates of the bones of less than 15 have potential risk of injury from depth jumps (B Allerheiligen, 1995). Moreover, box jump height was increased by 6 inch (increasing intensity) and repetition decreased by 1 for all groups but remaining being constant. Plyometric training protocol from week 5 to week 12 is shown in table 10. The foot contact was reduced to 105 and 111 for age group (11 to 15) and age group (16 to 20) in training day 1 and reduced to 93 and 99 successively to them. In training day 1 of week 12, the volume was reduced to 93 and 99 and in training day 2 volume reduced to 81 and 87 successively to two group along with decrease in intensity by reducing box jump height and front barrier hob by 6 inch. This training protocol progressed from low to moderate volumes of low-intensity plyometric, low to moderate volumes of moderate intensity to low to moderate volumes of moderate to high intensity (G. Gregory Haff N. T.)

Table 8: Plyometric Training Protocol of Week 1, Week 2, Week 3 and Week 4

W		TRAINING DAY 1		TRAININIG DAY 2	
W1	DRILL	AGE(11TO15)	AGE(16TO20)	AGE(11TO15)	AGE(16TO20)
	J.R	3 x 7	3 x 8	3 x 6	3 x 7
	C.J	3 x 7		3 x 6	
	D.J.B.	3 x 7(1ft)	3 x 8 (1.5 f t)	3 x6(1ft)	3 x 7 (1.5 f t)
	D.T.J.		3 x 8		3 x 7
	F.B.H.	3 x 7 (1ft)	3 x 8 (1.5 f t)	3x6 (1ft)	3 x 7 (1.5 f t)
	T.G.F.	84	96	72	84
W2	J.R	3 x 8	3 x 9	3 x 7	3 x 8
	C.J	3 x 8		3 x 7	
	D.J.B.	3x8 (1ft&1.5ft)	3 x 9 (2ft)	3x 7(1ft&1.5ft)	3 x 8 (2 f t)
	D.T.J.		3 x 9		3 x 8
	F.B.H.	3x8 (1ft&1.5ft)	3 x 9 (2ft)	3x7 (1ft&1.5ft)	3 x 8 (2 f t)
	T.G.F.	96	108	84	96
W3	J.R	3 x 9	3 x 10	3 x 8	3 x 9
	C.J	3 x 9		3 x 8	
	D.J.B.	3 x 9 (1ft&1.5t)	3 x 10 (2ft)	3x81ft&1.5ft)	3 x 9 (2ft)
	D.T.J.		3 x 10		3 x 9
	F.B.H.	3x9 (1ft&1.5ft)	3 x 10 (2ft)	3x8(1ft&1.5ft)	3 x 9 (2ft)
	T.G.F.	108	120	96	108
W4	J.R	3 x 10	3 x 11	3 x 9	3 x 10
	C.J	3 x 10		3 x 9	
	D.J.B.	3x10 (1ft&1.5f)	3 x 11(2ft)	3x9(1ft&1.5f)	3 x 10(2ft)
	D.T.J.		3 x 11		3 x 10
	F.B.H.	3x10(1ft&1.5ft)	3 x 11(2ft)	3x9(1ft&1.5f)	3 x 10(2ft)
	T.G.F.	120	132	108	120

Note: W=Week, B.S.=Back Squat, R.D.L.=Romanian Dead Lift, F.S.L.=Forward Step Lunge, S.C.R.=Standing Calf Raise, J.R.=Jump and reach, C.J.=Countermovement jump, D.J.B.=Double leg jump to Box, D.T.J.=Double Leg Tuck Jump, F.B.H.=Front Barrier Hob, T.G.F.=Total ground Foot Contact.

Table 9: Volume of plyometric exercise

Plyometric experience	Beginning volume
Beginner (no experience)	80-100
Intermediate (some experience)	100-120
Advanced (considerable experience	120-140

Table 10: Plyometric Training Protocol from Week 5 to Week12

W		TRAINING DAY 1 2		TRAINING DAY 2	
W5	DRILL	AGE 11 TO 15	AGE16TO20		
W6	J.T.R.	3 x 9	3 x 10	3 x 8	3 x 9
W7	D.J.B.	3 x9(1.5ft&2ft)	3 x 10(2.5ft)	3 x8(1.5ft&2ft)	3 x 9 (2.5ft)
&	D.T.J.	3 x 10	3 x 11	3 x 9	3 x 10
W8	F.B.H.	3x9(1.5ft&2ft)	3 x 10(2.5ft)	3x 8 (1.5ft&2ft)	3 x 9 (2.5ft)
	T.G.F.	109	123	99	111
W9	D.T.J.	3 x 10		3 x 9	
W10	D.J.		3 x 9 (2.5ft)		3 x 8 (2.5ft)
&	D.J.B	3 x8(2ft&2.5ft)	3 x 9 (3ft)	3 x7 (2ft&2.5ft)	3 x 8 (3ft)
W11	P.J.	3 x 8	3 x 9	3 x 7	3 x 8
	F.B.H.	3x9 (1.5ft&2ft)	3 x 10 (2.5ft)	3x 8 (1.5ft&2ft)	3 x 9 (2.5ft)
	T.G.F.	105	111	93	99
W12	D.T.J.	3 x 9		3 x 8	
	D.J.		3 x 8(3ft)		3 x 7(3ft)
	D.J.B	3 x7(2ft&2.5ft)	3 x 8 (3ft)	3 x6(1.5ft&2ft)	3 x 7 (2.5ft)
	P.J.	3 x 7	3 x 8	3 x 6	3 x 7
	F.B.H.	3x8 (1.5ft&2ft)	3 x 9 (2.5ft)	3x7 (1ft&1.5ft)	3 x 8 (2ft)
	T.G.F.	93	99	81	87

Note: W=Week, J.T.R.=Jump twitch and reach, D.J.B.=Double leg jump to Box, D.T.J.=Double Leg Tuck Jump, F.B.H.=Front Barrier Hob, P.J.=Pike jump, T.G.F.=Total ground Contact

Combined Training Protocol

The combined training protocol consisted of resistance training protocol in conjunction with plyometric training protocol that encompassed exercises used in the 2 protocols separately as described above. Combined group performed combined training protocol. The 2 training protocol were performed on different day, resistance training on training day 1 with resistance group and plyometric training on training day 2 with plyometric group. The training volumes and intensities progressed in a similar manner to those employed in the plyometric and weight-training groups. The combined training protocol from week 1 to 4 (first meso-cycle) is shown in table 11 and combined training protocol from week 5 to week 12 (second mesocycle and third mesocycle was shown in table 12.

Table 11: Combined Training Protocol from Week 1 to Week 4

		TRAINING DAY 1				TRAINING DAY 2	
		RESISTANCE TRAINING				PLYOMETRIC TRINING	
W	DRILL	%RM	Set x Rep			Set x Rep	
			Age11TO 15	AGE16TO 20		AGE 11 TO 15	AGE 16 TO 20
W1	B.S.	With stick	2x7	2x7	J.R	3 x 6	3 x 7
	R.D.L.	With stick	2x7	2x7	C.J	3 x 6	
	F.S.L.	With stick	(2x72	(2x7)2	D.J.B.	3 x6(1ft)	3 x7 (1.5 f t)
	S.C.R	With stick	2x7	2x7	D.T.J.		3 x 7
					F.B.H.	3x6 (1ft)	3 x 7(1.5 f t)
					T.G.F.	72	84
W2	B.S.	ESTIMATED			J.R	3 x 7	3 x 8
	R.DL.	1 RM TEST			C.J	3 x 7	
	F.S.L.				D.J.B.	3x7(1ft&1.5f)	3 x 8 (1.5ft)
	S.C.R				D.T.J.		3 x 8
					F.B.H.	3x7(1ft&1.5f)	3 x 8 (2 f t)
					T.G.F.	84	96
W3	B.S.	80%1RM	3x5	3x5	J.R	3 x 8	3 x 9
	R.D.L.	80%1RM	3x5	3x5	C.J	3 x 8	
	F.S.L.	80%1RM	(2x52	3x5	D.J.B.	3x81ft&1.5ft)	3 x 9 (2ft)
	S.C.R	80%1RM	2x5	3x5	D.T.J.		3 x 9
					F.B.H.	3x8(1ft&1.5f)	3 x 9 (1.5ft)
					T.G.F.	96	108
W4	B.S.	80%1RM	3x5	3x5	J.R	3 x 9	3 x 10
	R.D.L.	80%1RM	3x5	3x5	C.J	3 x 9	
	F.S.L.	80%1RM	(3x52	(3x5)2	D.J.B.	3x9 (1ft&1.5)	3 x 10 (2ft)
	S.C.R	80%1RM	3x5	3x5	D.T.J.		3 x 10
					F.B.H.	3x9 (1ft&1.5)	3 x 10 (2ft)
					T.G.F.	108	120

Note: W=Week, B.S.=Back Squat, R.D.L.=Romanian Dead Lift, O.L.S.L.=One Leg Step Lunge, S.C.R.=Standing Calf Raise, J.R.=Jump and reach, CJ.= Countermovement jump, D.J.B.=Double leg jump to Box, D.T.J.=Double Leg Tuck Jump, F.B.H.=Front Barrier Hob, T.G.F.=Total ground Foot Contacts.

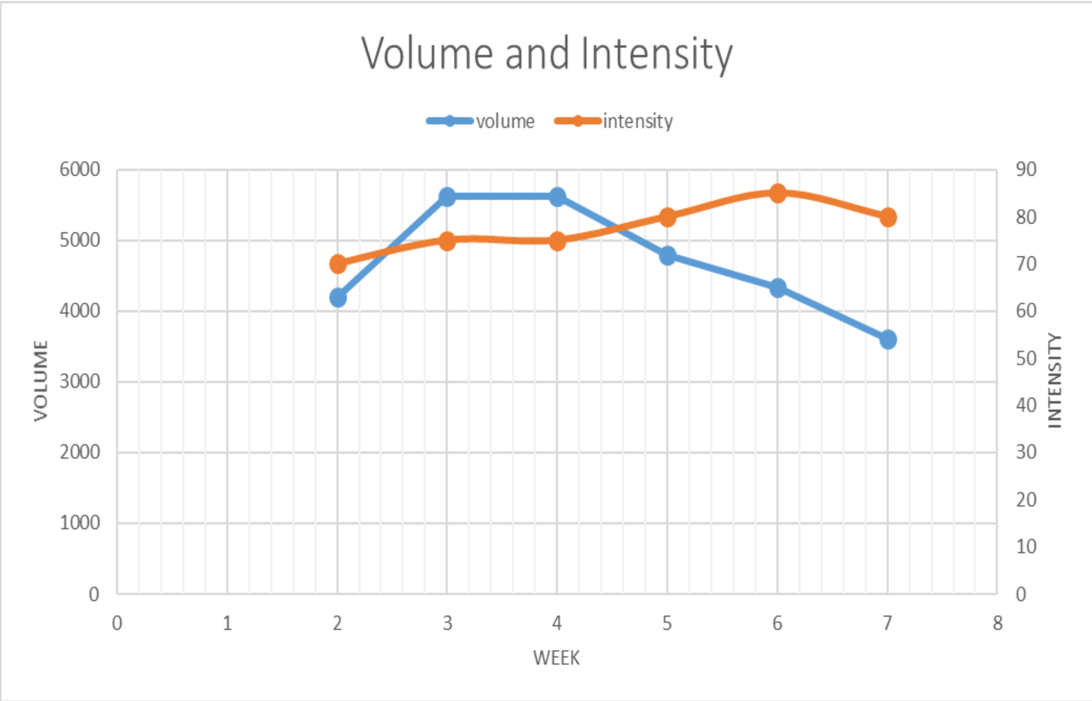
Table 12: Combined Training Protocol from Week 5 to Week 12

W	TRAINING DAY 1			TRAINING 2		
	RESISTANCE TRAINING			PLYOMETRIC TRAINING		
	DRILL	%1RM	Set x Rep		Set x Rep	
					AGE 11 TO 15	AGE 16 TO 20
W5	B.S.	85%1RM	3x4	J.T.R.	3 x 8	3 x 9
W6	R.D.L.	85%1RM	3x4	D.J.B.	3 x8(1.5ft&2ft)	3 x 9 (2.5ft)
W7	O.L.S.L.	85%1RM	3x4	D.T.J.	3 x 9	3 x 10
&	S.C.R	85%1RM	3x4	F.B.H.	3x8 (1.5ft&2ft)	3 x 9 (2.5ft)
W8				T.G.F.	99	111
W9	B.S.	90%1RM	3x3	D.T.J.	3 x 9	
W10	R.D.L.	90%1RM	3x3	D.J.		3 x 8 (2.5ft)
&	O.L.S.L.	90%1RM	(3x4)2	D.J.B	3 x7 (2ft&2ft)	3 x 8 (3ft)
W11	S.C.R	90%1RM	3x3	P.J.	3 x 7	3 x 8
				F.B.H.	3x8 (1.5ft&2ft)	3 x 9 (2.5ft)
				T.G.F.	93	99
W12	B.S.	85%1RM	3x3	D.T.J.	3 x 8	
	R.D.L.	85%1RM	3x3	D.J.		3 x 7(3ft)
	O.L.S.L.	85%1RM	(3x4)2	D.J.B	3 x6(2ft&2.5ft)	3 x 7 (3ft)
	S.C.R	85%1RM	3x3	P.J.	3 x 6	3 x 7
				F.B.H.	3x6 (1.5ft&2ft)	3 x 8 (2.5ft)
				T.G.F.	78	87

Note: W=Week, B.S.=Back Squat, R.D.L.=Romanian Dead Lift, O.L.S.L.=One Leg Step Lunge, S.C.R.=Standing Calf Raise, J.T.R.=Jump twist and reach, D.J.B.=Double leg jump to Box, D.T.J.=Double Leg Tuck Jump, F.B.H.=Front Barrier Hob, P.J.= Pike jump, T.G.F.=Total ground Contact.

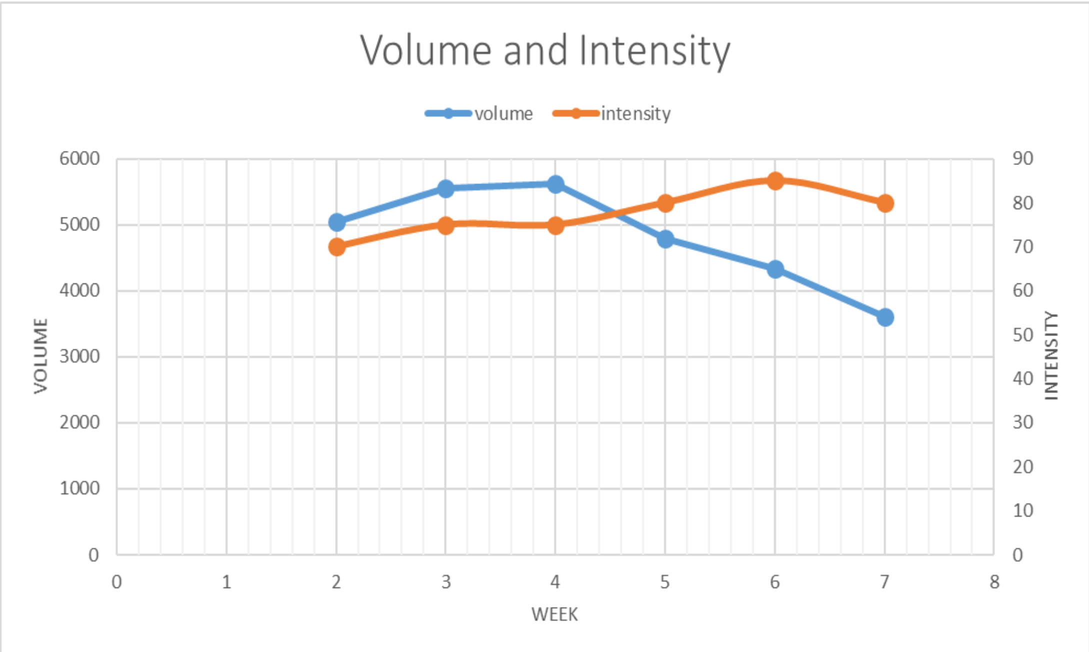
Summary of training protocol

Initially, the volume was increased and then decreased as the intensity is increased. The volume and intensity of resistance training was compared in figure 4 for age group 11 to 15 and in figure 5 for age group 16 to 20. Similarly, the volume (foot contact) was increased initially and the decreased as intensity was increased as shown in figure 6.



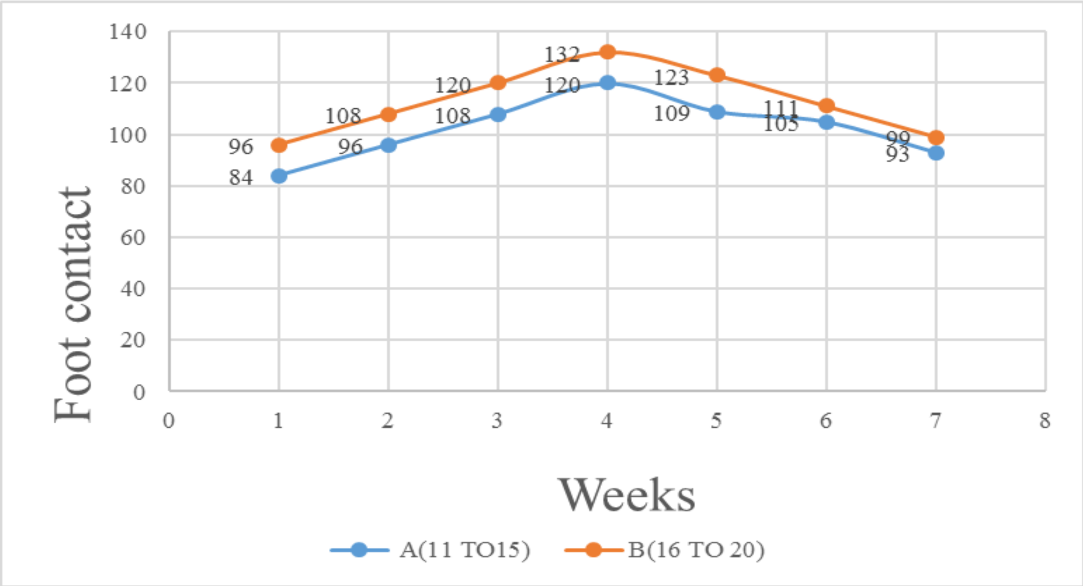
Note: 5=5 to 8 week, 6=9 to 11 week, and 7=12 week in x-axis.

Figure 4: volume and intensity of resistance training for age group 11 to 15 in training day2.



Note: 5=5 to 8 week, 6=9 to 11 week, and 7=12 week in x-axis.

Figure 5: volume and intensity of resistance training for age group 16 to 20 in training day 2.



Note: 5=5 to 8 week, 6=9 to 11 week, and 7=12 week in x-axis.

Figure 6:Volume of plyometric drills for age group 11 to 15 and age group 16 to 20

3.7 Data collection procedures

The following procedures were applied to collect data.

3.7.1 Questionnaire Administration:

- Administering the questionnaire to all participants at predetermined different intervals
- Collecting data on demographic information, training adherence, motivation, perceived exertion, and perceived effectiveness.

3.7.2 Jump and reach test administration:

Data were collected after each test (pretest, mid test and posttest) as each group underwent measurement of vertical jump. Pretesting was conducted the week prior to the initiation of the training period. Mid-testing was conducted during the sixth week of the training period. Post-testing was conducted the week following the completion of the designed training period. Subjects were instructed to avoid exercise for 48 hours and caffeine for 24 hours prior to testing (Luebber, 2003). Training intensity and volume was reduced the final week of training to allow for sufficient recovery prior to post testing. The pretest, mid test and post test data of all groups are shown in appendices.

3.8 Statistical analysis

The statistical analysis for this study was administered using SPSS (Statistical Package for the Social Sciences) for descriptive and inferential statistics. For all subjects, descriptive statistics like mean and standard deviation were calculated for age (years), height (cm), mass (kg), and Body Mass Index (BMI; kg/m2). Descriptive statistics, including frequencies, was calculated for sex and age group. This provided a comprehensive overview of the sample characteristics. Statistical mean and standard deviation for pretest and posttest was calculated. Homogeneity of equal variance was checked using levene's test of homogeneity. Since it determined significance of unequal variance, Welch's ANOVA was employed to compare means of vertical jump across the control group (CON), the resistance training (RT), plyometric training (PT), and combined training (CT) groups. Analysis of Variance was used to find statistical significance in vertical jump between and within the groups. If F-statistic value was greater than 1, then may be significance difference between groups and Welch's ANOVA determined significant difference in vertical jump score across four groups, then Games-Howell post hoc multiple comparisons was performed to assess which group means differ from which others. The 0.05 level was adopted as the probability level of significance throughout the analysis.

3.9 Limitation

The followings are limitation of this study:

- The study's findings may not be generalizable to populations beyond the specific age groups (11 to 15 and 16 to 20) and training experience levels of the participants.
- The 12-week training period may not have been sufficient to fully capture the long-term effects of the training interventions. Longer-term follow-up assessments could provide insight into the sustainability of the observed training adaptations over time.

- Difficult to standardize of training intensity, such as heart rate monitoring or workload tracking, to better standardize training protocols.
- The study did not account for potential confounding variables such as dietary habits, sleep patterns, or concurrent physical activity outside of the structured training sessions.
- While participants were provided with basic exercise techniques and psychological preparation, the study did not assess psychological factors such as motivation, adherence, or perceived exertion during training.

3.10 Ethical consideration

While conducting this research, ethical considerations was prioritized to safeguard the well-being and rights of participants. Confidentiality and privacy was strictly maintained, with data stored securely and accessible only to authorized members of the research team. Concentration was given in place to minimize risks associated with training sessions, and subjects was informed of their voluntary participation and right to withdraw at any time. The study was conducted in accordance with ethical guidelines, seeking approval from our department and Lalitpur Wu-Shu quan before commencement.

CHAPTER IV

ANALYSIS, INTERPRETATION AND DISCUSSION

The aim of this study was to compare the impact of resistance training, plyometric training, and their combined effects on vertical jump performance in Wu-Shu athletes during the course of 12week study. This chapter presents a detailed analysis of the data collected on vertical jump scores from subjects who underwent different training regimens: Resistance Training (RT), Plyometric Training (PT), Combined Training (CT), and a Control group (CON). The goal is to determine which training method is most effective for improving vertical jump performance.

4.1 Descriptive Statistics of pre-test, mid-test and post-test

The mean peak vertical height was determined from the three vertical jump trials conducted by each subject during each testing session. These values were then used to calculate the mean peak vertical jump for each group (RT, PT, and CT) during the pre-testing, mid-testing, and post-testing sessions, as shown in Table 13.

Table 13: Mean and standard deviation of peak vertical jump for each testing

GROUP		Pre-test(cm)	Mid-test(cm)	Post-test(cm)
CON	Mean	224.70	224.50	224.90
	N	10	10	10
	Std. Deviation	25.188	24.528	24.150
RT	Mean	224.80	230.10	231.90
	N	10	10	10
	Std. Deviation	23.423	21.242	21.579
PT	Mean	223.90	230.50	234.10
	N	10	10	10
	Std. Deviation	26.087	26.146	26.316
CT	Mean	224.00	230.90	236.80
	N	10	10	10
	Std. Deviation	29.401	29.441	29.918
TOTAL	Mean	224.35	229.00	231.92
	N	40	40	40
	Std. Deviation	25.094	24.652	25.067

Note: CON=Control group, RT=Resistance group, PT=Plyometric group, CT=Combined group, N=Number of subjects.

The table presents the mean vertical jump height score (in centimeters) for four groups (CON, RT, PT, and CT) measured at three time points: pre-test, mid-test, and post-test. Each group consists of 10 subjects, and the overall sample size is 40. Mean jump height control group remained virtually unchanged from Pre-test (224.70 cm) to Mid-test (224.50 cm) to Post-test (224.90 cm), indicating no significant improvement or decline. Like-wise, mean jump heights of resistance group was increased from Pre-test (224.80 cm) to Mid-test (230.10 cm) to Post-test (231.90 cm) that implies noticeable increase from pre-test to post-test. Similarly, mean jump height score of plyometric group was increased from pre-test (223.90 cm) to mid-test (230.50 cm) to post-test (234.10 cm), that indicates significant improvement observed from pre-test to post-test. Additionally, mean jump height score of combined group was greatly increased from 224.00 cm (Pre-test) to 230.90cm to 236.80 cm (Post-test) indicating greatest in improvement

For control group, it reveled slight decrease in standard deviation from pre-test (25.188) to mid-test (24.528) to post-test (24.150) indicates minor variability reduction, suggesting consistent performance within the group. For resistance group, the reduction in standard from pre-test (23.423) to mid-test (21.242) followed by a slight increase in post-test (21.579) indicates improved consistency in performance, although there was some variability by the post-test. For plyometric group, the relatively stable deviation from pre-test (26.087) to mid-test (26.146) and post-test (26.316) suggests consistent individual responses to the training, with no significant increase or decrease in variability. And for combined group, the overall stable standard deviation pre-test (29.401), mid-test (29.441) and post-test (29.918) indicates consistent performance across the entire sample, with minimal change in variability from pre-test to post-test. Standard deviations remained relatively stable across all groups, with minor fluctuations.

All intervention groups (RT, PT, CT) showed significant improvements. Combined training (CT) was the most effective, followed by plyometric training (PT) and resistance training (RT).

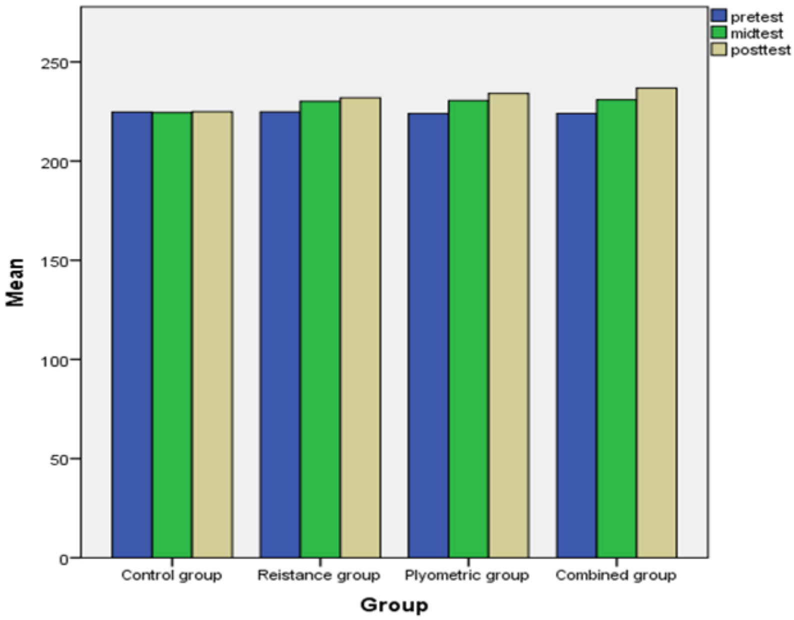


Figure 7: pre-test, mid test, and post-test of mean vertical jump of four groups

The bar graph presents the mean vertical jump heights for four groups (Control, Resistance, Plyometric, and Combined) across three time points: pre-test, mid-test, and post-test. Overall, the data demonstrates that intervention groups (resistance, plyometric, and combined) show marked improvements in vertical jump heights, with combined training being the most effective method. This highlights the importance of varied training programs in enhancing athletic performance

4.2. Descriptive Statistics of vertical jump score

The difference between post-test and pre-test vertical jump height of subjects is referred to vertical jump score. Mean and standard deviation of four groups are shown in table 14.

Table 14: Mean and standard deviation of vertical jump score

G	N	Mean(cm)	Mean Inc %	S.D.	S.E.	95% Confidence Interval for Mean		Min	Max
CON	10	.20	0.09%	1.135	.359	-.61	1.01	-2	2
RT	10	7.10	3.15%	3.143	.994	4.85	9.35	2	11
PT	10	10.20	4.55%	1.751	.554	8.95	11.45	8	13
CT	10	12.80	5.71%	1.619	.512	11.64	13.96	11	16
Total	40	7.58	3.37%	5.163	.816	5.92	9.23	-2	16

Note: G=Group, N=No of subjects, S.D.=Standard Deviation, S.E.=Standard Error, Min=Minimum, Max=Maximum

The table 14 presents the mean vertical jump height score (in centimeters) for four groups (COM, RT, PT, and CT) measured at three time points: pre-test, mid-test, and post-test. Each group consists of 10 subjects, and the overall sample size is 40. The analysis of vertical jump height improvements among four groups, Control (CON), Resistance Training (RT), Plyometric Training (PT), and Combined Training (CT)) provides insightful results. The control group (CON) exhibited minimal improvement with a mean change of 0.20 cm (Increase%=0.089%, SD=1.135), indicating negligible effectiveness of no training intervention. The variability in this group is high, as reflected by a standard deviation of 1.135, and the confidence interval (-0.61 to 1.01) includes zero, suggesting that the observed change is not statistically significant. The range of performance in the control group spanned from -2 to 2 cm, further emphasizing the lack of consistent improvement.

In contrast, the resistance training group (RT) showed a substantial improvement with a mean increase of 7.10 cm (Increase%=3.16%, SD = 3.143). The standard error of 0.994 indicates moderate variability in the response to resistance training. The 95% confidence interval (4.85 to 9.35) does not overlap with the control group's interval, indicating a statistically significant improvement. subjects in this group exhibited improvements ranging from 2 to 11 cm, demonstrating the effectiveness of resistance training in enhancing vertical jump height.

The plyometric training group (PT) achieved an even greater mean improvement of 10.20 cm (Increase%=4.55%, SD = 1.751), with a low standard error of 0.554. The confidence interval (8.95 to 11.45) is narrow, reflecting consistent improvements across subjects. This group's performance ranged from 8 to 13 cm, underscoring the efficacy of plyometric exercises in significantly boosting vertical jump performance.

The combined training group (CT) showed the highest mean improvement of 12.80 cm (Increase%=5.71%, SD = 1.619). The standard error of 0.512 indicates very low variability, and the confidence interval (11.64 to 13.96) is the narrowest among all groups, highlighting the consistent and significant enhancement in vertical jump height. subjects in this group exhibited improvements ranging from 11 to 16 cm, demonstrating the superior effectiveness of a combined training approach.

Overall, the total sample analysis, combining all groups, resulted in a mean improvement of 7.58 cm (Increase%=3.37%, SD=5.163), with a standard error of 0.816. The confidence interval (5.92 to 9.23) indicates significant overall improvement in vertical jump height across all subjects. The total range from -2 to 16 cm reflects the broad variability introduced by the differing effectiveness of each training modality. The mean of vertical jump scores and percentages with consecutive groups were shown in graph.

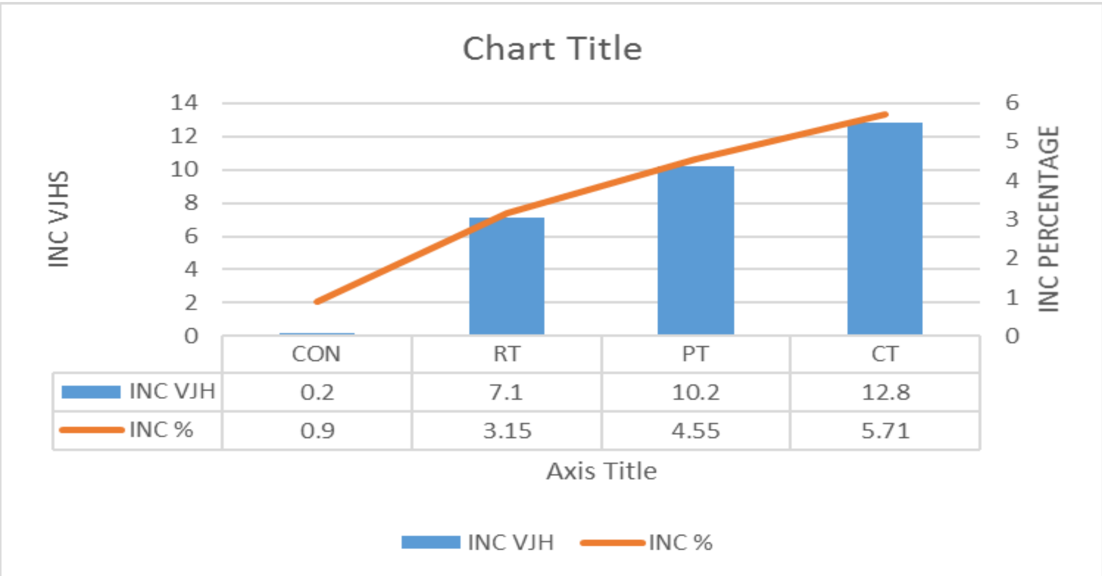


Figure 8: Vertical jump score and vertical jump increase percentage of four groups

The illustrated graph above indicates the vertical jump scores and vertical jump score increase percentage of four groups during 12 week of training period. It revealed that combined group has highest significant vertical jump height score(12cm) with vertical jump increase (5.71%) whereas control group has negligible vertical jump height score (0.2cm) with vertical jump increase percentage (0.9%)

4.3 ANOVA analysis of vertical jump height score for four groups

Since there were four groups, ANOVA test was used to analyze mean difference in vertical jump height. To ensure the validity of subsequent ANOVA tests, firstly the Levene's test of homogeneity of variance was conducted. Result of Levene's test of homogeneity of variance is shown in table 15.

Table 15: Test of homogeneity of variance of vertical jump score

Levene Statistic	df1	df2	Sig.
3.825	3	36	.018

Table 15 presents test of homogeneity of variance of vertical jump score. Levene's test for homogeneity of variances yielded a significance value of .018<0.05, suggesting that the assumption of equal variances is violated. This indicates that the variability in vertical jump heights differs significantly across the groups. This violation necessitates the use of a robust test such as Welch's ANOVA as shown as table 16.

Table 16: ANOVA analysis for mean vertical height jump score

Group	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	888.075	3	296.025	70.250	.000
Within Groups	151.700	36	4.214		
Total	1039.775	39			

Table 16 indicates the ANOVA analysis for mean vertical jump score. It revealed significant differences in vertical jump height improvements among the four groups Control group (CON), Resistance Training (RT), Plyometric Training (PT), and Combined Training (CT)). The one-way ANOVA ($F(3,36)=70.25$, $p = .000$ indicates that the differences in mean vertical jump heights between groups are highly significant. However, given the variance heterogeneity, Welch's ANOVA is more appropriate.

Robust Tests of Equality of Means

Welch's ANOVA was used due to the violation of homogeneity of variances.

Table 17: Welch's ANOVA (Robust Tests of Equality of Means)

	Statistic	df1	df2	Sig.
Welch	154.266	3	19.197	.000

Table17 representing the Welch's ANOVA confirmed significant differences between group mean (p=.000<critical value=0.05).

Moreover, Post Hoc multiple comparison was used for statistical validation to uncover specific differences between these four group means by using ANOVA test.

Furthermore, the Games-Howell post hoc test, which is suitable for unequal variances, was used to identify specific group differences and illustrated in table 18.

Table 18: Games-Howell Post hoc Multiple Comparisons

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Lower Bound
CON	RT	-6.900*	1.057	.000	-10.07	-3.73
	PT	-10.000*	.660	.000	-11.90	-8.10
	CT	-12.600*	.625	.000	-14.39	-10.81
RT	CON	6.900*	1.057	.000	3.73	10.07
	PT	-3.100	1.138	.069	-6.40	.20
	CT	-5.700*	1.118	.001	-8.97	-2.43
PT	CT	10.000*	.660	.000	8.10	11.90
	RT	3.100	1.138	.069	-.20	6.40
	CT	-2.600*	.754	.014	-4.73	-.47
CT	CON	12.600*	.625	.000	10.81	14.39
	RT	5.700*	1.118	.001	2.43	8.97
	PT	2.600*	.754	.014	.47	4.73

The table 18 presents multiple comparisons using the Games-Howell test to further elucidate these differences. The control group (CON) showed significantly lower improvements compared to all other groups. Specifically, the mean differences in vertical jump height between the control group and the resistance training, plyometric training, and combined training groups were -6.900, -10.000, and -12.600, respectively, all with p-values of .000<0.05. Although, plyometric training also showed considerable improvement over resistance training, the difference was not statistically significant (mean difference = 3.100, p = .069>0.05). The Resistance Training group had statistically significantly higher vertical jump scores than the Control group (mean difference=6.900, p=0.000) and significantly lower scores than the Combined Training group (Mean Difference = -5.700, p = 0.001<0.05). There was no significant difference between the Resistance Training and Plyometric Training groups (p = 0.069>0.05). The Plyometric Training group scored significantly higher than the Control group and significantly lower scores than the Combined Training group (Mean Difference = -2.600, p = 0.014). Among the training groups, combined training (CT) was the most effective, showing significantly greater improvements than both resistance training (RT) and plyometric training (PT). The mean differences between the combined training group and the resistance training and plyometric training groups were 5.700 (p = .001) and 2.600 (p = .014), respectively.

4.4 Paired samples t-test

A paired t-test was designed to compare the means of the same group under pre and post vertical jump (cm) to determine the significance difference. Paired samples test of control group is shown in table 15. Paired samples t-test of resistance group is shown in table16.

Table 19: Paired samples t-test control group

	Paired Differences					T	Df	Sig(2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 PRE-POST	-.200	1.135	.359	-1.012	.612	-.557	9	.591

Note: t=t test, d f=degree of freedom.

As observed in table19, there was indeed no statistically significance difference (p=.590>0.05) between pre and post vertical jump in control group.

Table 20: Paired samples test resistance group

	Paired Differences					T	df	Sig(2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 PRE-POST	-7.10	3.143	.994	-9.348	-4.852	-7.144	9	.000

Note: df=degree of freedom.

As observed in table 20, there was indeed statistically significance (p=.000<0.05) between pre and post vertical jump in resistance group (RT).

Similarly, since plyometric and combined training groups showed considerable improvement over resistance training, there was almost statistically significance between pre and post vertical jump in both groups.

4.5 General descriptive statistics mean vertical jump height

4.5.1 General descriptive statistics mean vertical height jump between two age groups.

The pre-test and post-test during training, their difference and increase in vertical height between two age group are shown in table 17

Table 21: General mean VJH statistic of 2 age group

Group	N	Pre-test(cm)	Post-test(cm)	Difference(cm)	Inc%
Age 11 to 15	21	211.14	221.62	10.48	4.96
Age 16 to 20	9	254.78	263.62	9	3.53

Table 21 indicates difference in vertical jump height between two age groups, (11 to 15) and (16 to 20). There was higher increase percentage in mean vertical jump height of subjects of age group 11 to 15 (4.96%) than subjects of age group 16 to 20 (3.53%) between pre and post-test.

4.5.2 General descriptive statistics mean vertical height jump between male and female.

The pre-test and post-test during training, their difference and increase in vertical height between male and female are shown in table 18.

Table 22: General mean vertical height of male and female

Group	N	Pre-test(cm)	Post-test(cm)	Difference(cm)	Inc%
Male	15	239.93	250.80	10.87	4.53%
Female	15	208.53	217.73	9.20	4.41%

Table 22 presents difference in mean vertical height jump between male and female. There was higher increase mean vertical jump height of male compared to female during pre and post-test.

4.6 Independent sample test

4.6.1 Independent sample test between two age group (11 to 15) and (16 to 20)

To find the significance difference in vertical performance between two age groups 11 to 15 and 16 to 20, independent sample t-test was performed and illustrated in table 19. And to find the significance difference in vertical performance between male and female, independent sample t-test was performed and illustrated in table 20.

Table 23: Independent sample test between 2 age group

		Levene's test.		T test of equality of mean						
		F	Sig	t	df	Sig-2	M.D.	S.E.D	95%C.I.D.	
									L	U
Diff	E.V.A	2.432	.13	-.314	28	.756	-.365	1.162	-2.75	2.02
	E.V.N.A			-.249	10.09	.808	-.365	1.464	-3.62	2.89

Note: Diff =Difference, EVA=Equal variance assumed, EVNA=Equal variance not assumed, Levene's test= Levene's test of equal variance, M.D.=Mean Difference, S.E.D.=Standard error difference, CID=Confidence of interval of difference L=Lower, U=Upper.

Table 23 showed that there was no significance difference between two age group 11 to 15 1nd 16 to 20 in vertical jump performance after 12 weeks training as p value=0.808>0.05 at 5% significance level.

Table 24: Independent sample test of male and female

		Levene's test.		T test of equality of mean						
		F	Sig	t	df	Sig-2	M.D.	S.E.D	95%C.I.D.	
									L	U
Diff	E.V.A	.274	.60	1.49	28	.162	1.66	1.159	-.708	4.01
	E.V.N.A			1.43	26.23	.162	1.66	1.159	-.716	4.04

Note: Diff =Difference, EVA=Equal variance assumed, EVNA=Equal variance not assumed, Levene's test= Levene's test of equal variance, M.D.=Mean Difference, S.E.D.=Standard error difference, CID=Confidence of interval of difference L=Lower, U=Upper.

Table 24 suggested that there was not significance difference between male and female in vertical jump height after 12 weeks training as p value=0.162>0.05. at 5% significance level.

Result:

The Combined Training group had the highest vertical jump scores among all groups, with scores significantly higher improvement than the control, resistance training, and plyometric training groups. Followed by plyometric training and resistance training for significant of improvement in vertical jump performance. Control group had no statistically significant difference between pre and post vertical jump performance whereas resistance group had significance difference. (Table 15 and table 16).

4.7 Hypotheses testing

Null Hypothesis (H1:0): There would be no significant differences in improving vertical jump (VJH) among the resistance training (RT), plyometric training (PT), combined training (CT), and control group (CON) after 12 weeks of training.

Result: Based on the results of this study ANOVA (F (3,36) = 70.25, p= 0.000) the null hypothesis is rejected and the alternative hypothesis was accepted. Moreover, Welch's ANOVA (pvalue0.000<0.05) strongly suggested the rejection of null hypothesis.

Alternative Hypothesis (H_1): There would be significant differences in improving vertical jump (VJ) among the resistance training (RT), plyometric training (PT), combined training (CT), and control (CON) groups.

Result: Based on the results of this study ANOVA (F (3,36) = 70.25, p = 0.000) the alternative hypothesis was accepted. Moreover, Welch's ANOVA (pvalue0.000<0.05) strongly suggested for acceptance of the alternative hypothesis. That determined that there at least one group performed significance difference than others.

Secondary Null hypothesis (H_{01}) There would be no significant differences in vertical jump (VJ) between the combined training group (CT) and the individual resistance training (RT), plyometric training (PT) and control groups

Result: Based on the result of the study that the combined training exhibited statistically significant better performance than the plyometric training ($p=0.001<0.05$, mean difference=2.6), the weight-training groups ($p=0.14<0.05$, mean difference=5.7), and control group ($p=0.000<0.05$, mean difference=12.6) in vertical jump height. Thus, null hypothesis (H2:0) is rejected.

Alternate hypothesis (H_2) There would be significant differences in improving vertical jump (VJ) between the combined training (CT) group, and plyometric training (PT), resistance training (RT), and control group (CON) after 12 weeks of training.

Result: Based on the result of the study that the combined training exhibited statistically significant better performance than the plyometric training ($p=0.001<0.05$, mean difference=2.6), the weight-training groups ($p=0.14<0.05$, mean difference=5.7), and control group ($p=0.000<0.05$, mean difference=12.6) in vertical jump height. The alternate hypothesis (H_2) is accepted deciding that combined training is effective and better than resistance training and plyometric training in improving vertical jump.

Alternate hypothesis (H_3): There would be significant differences in improving vertical jump (VJ) s between the plyometric training (PT) and combined training (CT) group, resistance training (RT), and control group (CON) after 12 weeks of training.

Result: Since alternate hypothesis (H_2) is accepted, this hypothesis is rejected suggesting that plyometric training is not superior and effective than combined training.

Alternate hypothesis (H_4) There would be significant differences in vertical jump height (VJH) improvements between the resistance training (RT) and combined training (CT) group, plyometric training (PT), and control group (CON) .

Since alternate hypothesis (H_2) is accepted, this hypothesis is rejected, exploring that resistance training is not effective than combined training in improving vertical jump.

Summary of hypothesis testing is shown in table 25.

Table 25: Hypothesis testing

Hn	Hypothesis	P value	Result
H_0	There would be no significant differences in improving vertical jump (VJ) among RT, PT, CT and CON groups	0.000	rejected
H_1	There would be significant differences in improving vertical jump (VJ) among RT, PT, CT and CON groups	0.000	accepted
H_{01}	There would be no significant differences in improving vertical jump (VJ) between CT and RT, PT and CON groups	<0.05 against all	rejected
H_2	There would be significant differences in improving vertical jump (VJ) between CT and RT, PT and CON groups	<0.05 against all	accepted
H_3	There would be significant differences in vertical jump (VJ) between PT and RT, CT and CON groups		Rejected
H_4	There would be significant differences in vertical jump (VJ) between RT and RPT, CT and CON groups		rejected

CHAPTER 5

SUMMARY OF FINDING, CONCLUSION AND RECOMMENDATION

Chapter 5 of this research paper marks the culmination of an in-depth exploration into the comparative effectiveness of resistance training, plyometric training, and their combined impact on vertical jump performance. This chapter synthesizes the findings, draws conclusions from the research outcomes, discusses their implications for sports science and training, addresses some limitations and offers recommendations for future research and practice. By summarizing the key results, exploring the broader implications, and providing actionable insights, this chapter contributes to our understanding of optimal training approaches for enhancing vertical jump performance in athletes.

5.1 Summary of finding

The research conducted a comprehensive investigation into the effects of different training modalities—Resistance Training (RT), Plyometric Training (PT), and Combined Training (CT)—on vertical jump height. Through meticulous statistical analysis, including Welch's ANOVA and Levene's test, the study discerned significant differences among the training groups. Moreover, post hoc Howell multiple comparison evoked specific differences between them.

One of the finding of the study was comparison in pre-test to post-test within-groups (CON, RT, PT and CT). Overall, there was a significant increase in mean vertical jump height from pre-test to post-test across all trained subjects. The mean difference in vertical jump height was found in ascending order of 7.10cm (3.15 %) in RT group, 10.2cm (4.55%) in PT group and 12.80 cm (5.71%), in CT group with notable increase after the interventions whereas, Control group had mean vertical jump height from negligible increased vertical jump 0.2cm (0.9%). These findings support the effectiveness of the training interventions in positively impacting the jumping performance.

Secondly, the finding of the study was comparison in mean difference vertical jump height between groups. In Control vs. other groups, the control group showed significantly lower mean measurements compared to all other groups (RT, PT, CT). Mean differences ranged from -6.900 to -12.600 cm, indicating substantial disparities in measured parameters between the control group and each training group. These findings suggest that all training modalities led to significant improvements compared to no training.

Similarly, in resistance vs. plyometric group, the mean difference was not significant between them whereas in resistance vs. combined resistance group as well as in plyometric vs. combined training groups, there was significant difference in mean difference in vertical jump. Plyometric group exhibited significantly lower mean vertical jump compared to the combined training group, reinforcing the potential superiority of combined training than individual resistance training and plyometric training. These findings support the effectiveness of the training interventions in positively impacting the measured vertical jump.

Additionally, Age-based analysis was also exhibited. Subjects aged 11 to 15 experienced a greater mean increased percentage (4.96%) compared to those aged 16 to 20 (3.53%), suggesting that younger participants may respond more favorably to the training interventions. But independent sample t-test between them cleared that there was no significance difference between them in vertical jump performance.

Similarly, in sex based analysis, male experienced a greater mean increased percentage (4.53%) compared to female (4.51%), suggesting potential sex-based differences in training response. But independent sample t-test between them cleared that there was no significance difference between them in vertical jump performance.

5.2 Conclusion and discussion

The research findings provide a comprehensive understanding of the impact of different training modalities on vertical jump height, offering valuable insights for athletic training and performance enhancement. Through rigorous statistical analysis, the study reveals significant improvements in vertical jump height across all structured exercise programs, including Resistance Training (RT), Plyometric Training (PT), and Combined Training (CT), compared to a control group. Notably, Combined Training emerges as the most effective approach, with subjects undergoing

CT exhibiting the most substantial enhancements in jump performance. This suggests that integrating resistance and plyometric exercises in a comprehensive training program yields synergistic benefits surpassing those of singular training modalities.

The purpose of this study was to determine whether resistance training, plyometric training, or a combination of both can enhance vertical jump performance. The results indicate that while both long-term resistance and plyometric training can improve vertical jumping ability, their combination proves to be even more effective.

Moreover, while all training methods demonstrate efficacy, individual responses vary, emphasizing the importance of tailored training programs to maximize outcomes within timeframe. These findings have practical implications for coaches, trainers, and athletes, who can use this information to design evidence-based training programs customized to individual needs and goals. particularly in activities requiring explosive power like vertical jumping.

Through compliance with the training protocol more significant results may be revealed. Combined training emerges as a practical and valuable modality for incorporation into athletic strength and conditioning programs. By combining multiple exercises, combined training offers more variety than single-method protocols, potentially providing a more robust training stimulus. This variety not only enhances the effectiveness of the training but also allows for more efficient use of time during training sessions.

The effectiveness of plyometric training in improving vertical jump has been supported by previous various studies [(E & Noble, March 17, 2013), (Gehri, 1998), (Mertel, Harmer, Logan, & parker, OCT 2005), (Mehmet Emin Demiri, 2022)]. Some studies had found that plyometric training is not more effective significant than other training in improving vertical jump [(AD & Wilson, 1996), (Kelvin Carlson M. M., 2009)]. Furthermore, previous investigations that followed a combination training of resistance and plyometric training found increased in vertical jump performance [Kelvin et al. (2009), (Fatouros & Jamutas, 2000)]. But in contrast some previous researches that used combining resistance training and plyometric training demonstrated no differences in vertical jump performance with resistance training and plyometric training [(Bauer & E, 1990), (HT Ford Jr, 1983), (Kelvin Carlson M. M., 2009)].

5.3 Recommendation

This recommendation aims to provide strategic insights and actionable steps to address identified gaps and enhance outcomes. By implementing these recommendations, we can foster meaningful progress and drive impactful change in the vertical jump. On the basis of the above conclusions, the following recommendations are made.

5.3.1 Recommendations for Policy Implications

1 Integration of Combined Training Programs:

- Policy makers should consider promoting and integrating combined training programs that incorporate both resistance and plyometric exercises into physical education curricula and sports training regimens.
- Allocating resources and funding for the development and implementation of such programs can enhance the overall effectiveness of training interventions, particularly in settings such as schools, sports clubs, and community fitness centers.

2 Age-Specific Training Guidelines:

- Develop age-specific training guidelines and recommendations to optimize training responses across different age groups.
- Tailoring training programs to accommodate the unique physiological and developmental characteristics of individuals within specific age brackets can maximize training efficacy and reduce injury risks.

2 Investment in Research and Education:

- Prioritize investment in research initiatives aimed at further elucidating the mechanisms underlying training adaptations and age-related differences in training responses.
- Disseminate evidence-based findings through educational campaigns targeting coaches, trainers, educators, and healthcare professionals to

ensure informed decision-making and practice in designing and implementing training programs.

5.3.2 Recommendation for practical implication

The result from this experiment provide insight in vertical jump performance and explosive power. Based on the findings of this research, there are several practical Integrate both resistance and plyometric training recommendations for coaches, trainers, educators, and healthcare professionals:

- Adopt combined exercises into regular fitness and sports programs to maximize improvements in physical attributes. This combination has been shown to produce superior results compared to either modality alone.
- Design age-specific training programs that consider the unique physiological and developmental needs of different age groups. Younger participants (ages 11 to 15) may benefit more significantly from these interventions compared to older ones (ages 16 to 20), indicating a need for tailored vertical jumping performance, provided that the training protocols maintain the appropriate intensity and volume.
- A 12-week duration appears sufficient for improving vertical jump performance, given that the training protocols maintain the appropriate intensity and volume.
- In this study, a frequency of 2 training days per week was found to be effective for vertical jump training. Such protocols should be included in preseason or postseason training periods.
- Utilize principles of progressive overload and periodization to gradually increase the intensity and complexity of training exercises. This approach helps to optimize adaptations while minimizing the risk of overtraining and injury.
- Conduct regular assessments to monitor participants' progress and adjust training programs accordingly. This ensures that the training remains effective and aligned with individual goals and capabilities.
- Provide ongoing education and professional development opportunities for coaches and trainers to stay updated on the latest research and best

practices in combined training modalities. This can enhance the effectiveness of training programs and ensure safety.

- Include flexibility and recovery sessions in training programs to support overall physical health and reduce the risk of injury. Adequate recovery is crucial for long-term success and performance enhancement.
- Educate participants on the importance of balanced nutrition in supporting their training efforts. Proper nutrition is essential for recovery, muscle growth, and overall health.

Summary

By applying these practical recommendations, trainers, coaches, and educators can effectively utilize the insights from this research to develop comprehensive, evidence-based training programs. These programs should aim not only to improve physical performance but also to promote overall health and well-being among participants of various age groups and fitness levels.

5.5.3 Recommendation for future research consideration

- Further research is needed to determine the optimal training load, including the number of sets, repetitions, and intensity, to be used in a combined training protocol, due to contrasting findings in the literature regarding combined training.
- More sample size to be included will be advised in a further research to explore the outcome.
- Another recommendation is to assess parameters such as strength, power, agility, endurance, balance, and flexibility to capture the holistic effects of training interventions.
- For future studies, another modification to consider is extending the overall training period from 12 weeks to 6 months or even a year. This extension could potentially yield more significant improvements and results in the testing measures.
- Future research should consider monitoring and supervising to control possible confounding variables, such as dietary intake or additional physical activity performed outside of the training sessions.

- Further explore age-related differences at various stages of development, from childhood through adolescence to adulthood and aging as well as sex related differences in training responses and adaptations.
- Conduct research with all elite subjects with same vertical jump height.

APPEDICES

Appendix A Questionnaire

Tribhuvan University
Master's Programme in Sports Science
Comparison of Resistance training, plyometric training and their synergic effects in vertical jump: An experimental research in Wu-Shu athletes.
Research Questionnaire prepared by Rajendra Kumar Budhathoki
(For the thesis as the partial fulfillment of the requirements for Master of Arts in Sports Science.)

Respondents .... Date:

Signature

Section A General information

Q1. Name	
Q2. Sex	
Q3. Completed age	
Q4. Cast	
Q5. Permanent Address	…..municipality/VDC……District……Province
Q6. Temporary Address	…..municipality/VDC……District……Province
Q7. Education	
Q8. Height	…meter……cm ……ft…….inch
Q9.Weight	…….kg

Section B Sports background

Q10. How many years(months) did you play Wu-Shu?	…………years……….months
Q11. Have you ever played other sports before playing Wu-Shu?	1 Yes 2 No
Q12. If yes, Which sports had you played?	……
Q13. If yes, have you ever won the medal?	1 Yes 2 No 8 Don't know 9 Not stated

Q14. How many days do you play Wu-Shu in a week?	1) 1day 2) 2days 3)3 days 4)4 days 5)5 days 6)6 days
Q15. Up to when you are planning for continuation of Wu-Shu?	1) 1 year 2) 2 years 3) 5 years 4) 10 years 8)Don't know

Section C Skills related information

Q16.What sort of training do your coaches give priority?	1)Simple 2)little hard 3) Hard 8)Don't know 9)Not stated
Q17. Does your coach do warm up before training?	1) Yes 2) No 8 Don't know 9
Q18. Does your coach do cool down after training?	1) Yes 2) No 8 Don't know 9
Q19. Have you ever do Resistance training?	1) Yes 2) No 8 Don't know 9) Not stated
Q20. If yes, how many days in a week, time duration and what types of exercises?	…..days…..hrs/min…………………exercises
Q 21. If yes, have you felt it is helpful in your sports?	1) Yes 2) No 8 Don't know
Q22. Have you ever do Plyometric training?	1) Yes 2) No 8 Don't know 9) Not stated
Q23. If yes, how many days in a week, time duration and what types of exercises?	1) Yes 2) No 8 Don't know 9) No stated
Q 24. Have you ever record vertical jump?	1) Yes 2) No 8 don't know
Q25. If yes how was it done	…………
Q26. How are you satisfy to your recent vertical jump?	1) Not very happy 2) Somewhat happy 3) Very much happy

Section 4 Physical information

Q28. How do you categorize your physical fitness?	1)As per requirement 2)More than average 3)Average 4)Fully fit 5)Don't know
Q29. Have you ever witnessed injury of any kind during game?	1) Yes 2) No 8) Don't know
Q30. If yes, how much do you heal?	1) Fully fine 2) More fine 30 Somewhat fine 4)Not yet
Q31. If yes, How is it affecting in game?	1) More affected 2) Not so affected 3) Not affected at all 4)Don't know

Section 5 Economic information

Q32. How much resources do you have for your sports?	1)Enough 2) Somewhat enough 3) Not enough 4) Not as required 5)Don't know 6)Not stated
Q33. How many family member earn money?	1) 1 member 2) 2 member 3) 3 or more members 4) No member
Q34. How much money do you spend in following subjects in average?	1) Food item…. 2) sports equipment…. 3)transportation…4)Training expense… 50 Others…

Section 6 Psychological information

Q35. Who is your inspiration for this sports?	……….
Q36. Have you motivate others to involve in sports?	1) Yes 2) No 8 Don't know 9) No stated
Q36. Have you motivate others to play your sports?	1) Yes 2) No 8 Don't know 9) No stated

Section 6 Food habit and sleeping pattern

Q37. Do you know about balance diet?	1) Yes 2) No
Q38. How do you eat market food?	1) Average 2) Less 3) No
Q39. When do you eat before playing?	1) Before half hour 2) Before 1 hour 3) Before 2 hour 4) Before 3 hour 5) Others
Q40. When do you eat after playing?	1) After half hour 2) After 2 hour 3) After 3 hour 4) Others
Q41. Do you drink water during playing?	1) Yes 2) No 3) Sometimes
Q41.Do you eat other special food during playing?	1) Yes 2) No
Q43. How is your food habit?	1) Vegetarian 2. Non vegetarian 3) Both
Q44. How long do you sleep in a day in average ?	1) 6 hrs 2) 7 hrs 3) 8hrs 4) 9hrs or more

Appendix B Age, sex, height and weight of subjects

Table 26: Age, sex, height and weight of Resistance group

N	Age	Sex	Height(cm)	Weight(kg)
1	16	M	171	58
2	20	M	161	54
3	13	M	153	41
4	20	F	161	70
5	12	M	142	40
6	13	F	151	42
7	11	F	153	41
8	12	F	142	38
9	12	F	142	42
10	11	F	137	34

Table 27: Age, sex, height and weight of Plyometric group

N	Age	Sex	Height(cm)	Weight(kg)
1	16	M	170	50
2	19	M	161	61
3	20	M	160	77
4	13	F	153	45
5	13	F	153	39
6	13	F	153	46
7	14	F	147	50
8	11	M	138	32
9	11	F	132	29
10	12	F	127	27

Table 28: Age, sex, height and weight of Combined group

n	Age	Sex	Height(cm)	Weight(kg)
1	20	M	165	53
2	17	M	165	54
3	18	M	159	58
4	14	M	163	43
5	13	M	155	43
6	11	M	139	30
7	11	F	142	50
8	11	F	147	45
9	11	M	132	27
10	11	F	132	30

Table 29: Age, sex, height and weight of Control group

n	Age	Sex	Height(cm)	Weight(kg)
1	20	M	165	60
2	20	M	160	52
3	18	F	159	54
4	17	F	158	54
5	13	M	152	45
6	12	M	142	36
7	11	M	150	46
8	12	M	137	30
9	11	M	137	28
10	11	M	132	27

Appendix C Pre-test, mid-test and post-test vertical jump of four groups.

Table 30: Pre, mid and post-test of Resistance group

N	Pre-test				Mid-test				Post-test			
1	260	262	261	262	264	262	262	264	266	265	266	266
2	255	257	257	257	259	259	257	259	259	260	260	260
3	235	235	236	236	241	241	240	241	244	244	243	244
4	233	233	233	233	234	234	233	234	234	235	235	235
5	228	229	229	229	231	235	234	235	240	240	240	240
6	221	223	222	223	228	228	229	229	232	231	232	232
7	210	210	210	210	215	215	215	215	216	217	217	217
8	206	205	206	206	211	212	212	212	216	216	215	216
9	200	202	202	202	215	216	216	216	209	209	209	209
10	190	190	190	190	196	196	196	196	200	200	199	200

Table 31: Pre, mid and post-test of Plyometric group

N	Pre-test				Mid-test				Post-test			
1	263	263	261	263	268	269	269	269	274	273	274	274
2	259	259	257	259	265	266	266	266	270	270	270	270
3	244	245	244	245	248	250	249	250	252	255	255	255
4	231	233	233	233	237	236	237	237	240	241	239	241
5	223	225	224	225	229	230	230	230	230	232	233	233
6	217	216	216	217	224	223	223	224	227	228	228	228
7	210	213	213	213	229	229	229	229	225	226	225	226
8	201	203	203	203	210	210	210	210	215	215	215	215
9	190	190	190	190	192	194	194	194	198	198	197	198
10	190	191	191	191	195	196	196	196	200	201	201	201

Table 32: Pre, mid and post-test of Combined group

N	Pre-test				Mid-test				Post-test			
1	263	264	263	264	269	270	270	270	279	280	280	280
2	256	257	257	257	261	262	261	262	266	268	268	268
3	252	253	253	253	260	261	261	261	266	266	265	266
4	250	250	250	250	256	258	258	258	260	261	262	262
5	224	225	225	225	233	233	234	234	237	239	240	240
6	204	206	205	206	212	213	213	213	217	219	219	219
7	204	205	205	205	211	211	211	211	216	216	215	216
8	200	200	199	200	207	207	206	207	211	212	212	212
9	190	190	189	190	197	197	197	197	202	203	203	203
10	190	190	190	190	196	196	196	196	198	201	202	202

Table 33: Pre, mid and post-test of Control group

N	Pre-test				Mid-test				Post-test			
1	262	265	263	265	263	263	264	264	263	263	263	263
2	262	263	260	263	261	261	261	261	262	261	260	262
3	235	238	238	238	237	238	238	238	238	237	238	238
4	229	230	231	231	230	231	231	231	231	231	231	231
5	219	220	221	221	220	220	221	220	221	220	221	221
6	200	200	221	221	221	221	221	221	220	221	221	221
7	217	217	217	217	217	216	218	218	218	218	217	218
8	198	199	199	199	198	199	199	199	199	200	200	200
9	196	198	198	198	197	198	198	198	198	200	119	200
10	193	194	194	194	194	194	195	195	194	195	195	195

Training photos

Fig. Front barrier hob

Fig. One leg step lunge

Fig. Back squat and box jump

Fig. warm up

Fig Back squat

Fig. box jump

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