EFFECT OF 4-WEEK PLYOMETRIC TRAINING ON VERTICAL JUMP IN SECONDARY VOLLEYBALL PLAYERS

BY

WONG YEE KI
12013668

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We hereby recommend that the Honours Project by Miss Wong Yee Ki entitled "Effect of 4-Week Plyometric Training on Vertical Jump in Secondary Volleyball Players" be accepted in partial fulfillment of the requirements for the Bachelor of Arts Honours Degree in Physical Education And Recreation Management.

_____________________              _____________________

Dr. Louie Hung Tak Lobo             Prof. Chow Bik Chu
Chief Adviser                        Second Reader
I hereby declare that this honours project “Effect of 4-Week Plyometric Training on Vertical Jump in Secondary Volleyball Players” represents my own work and had not been previously submitted to this or other institution for a degree, diploma or other qualification. Citations from the other authors were listed in the references.

_______________________

Wong Yee Ki

24th APRIL, 2015

ANKNOELWDGEMENTS
First of all, I would like to express my deepest gratitude to my chief advisor, Dr. Louie Hung Tak Lobo for his kindness and generous guidance, valuable advice, and encouragement throughout the whole project. I would also like to express my appreciation to Prof. Chow Bik Chu for being my second reader.

Moreover, my sincere thanks must give to my volleyball coach, for his arrangement, cooperation and his help of that 4-week program. The program would not be that success without his help. In addition, I would like to give my thanks to my secondary school Physical Education teachers for their support and encouragement.

Last but not least, the special gratitude goes to all of the participants in my program for their enthusiastic participation.

_______________________

Wong Yee Ki

Department of Physical Education

Hong Kong Baptist University

Date: 24th APRIL, 2015

ABSTRACT
This study investigated the effect of 4-week plyometric training on vertical jump in secondary volleyball players. There were 24 volleyball players from H.K.M.L.C. Queen Maud Secondary School participated in this study. 12 of them involved into the training program and 12 of them were selected as control group. The experimental group was required to completed a set of plyometric training, which twice a week and last for 4 weeks. For evaluating the jumping ability of the subjects, Countermovement Jump test and Countermovement Jump test with arm swings were conducted before and after the training program. Heart rate, blood pressure and weight changes were also the indicators to find out the other effects of plyometric training.

Throughout the training program, there was a significant improvement of vertical jump after experimental group completing the 4-week plyometric training. And the experimental group's improvement was obviously better than control group. Experimental group also had a significant weight loss, the reduction of diastolic blood pressure and heart rate. However, the systolic blood pressure did not have any significant mean difference. To sum up, plyometric training is useful to improve vertical jump, cardiovascular responses and weight loss.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
</tbody>
</table>
Statement of the Problem..........................3
Purpose of the Study..............................3
Significance of the Study........................4

2. REVIEW OF LITERATURE..........................5
   Biomechanics of Vertical Jump.................6
   Factors affect Vertical Jump..................7
   Benefits of Plyometric training...............8
   Plyometric Training Progression.............9
   Instruments of vertical jumps.............11
   Summary........................................11

3. METHODS.............................................12
   Subjects........................................13
   Instruments....................................13
   Procedures......................................14

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis</td>
<td>16</td>
</tr>
<tr>
<td>Training Program</td>
<td>17</td>
</tr>
<tr>
<td>Definition of terms</td>
<td>17</td>
</tr>
</tbody>
</table>
Chapter 1

INTRODUCTION

Volleyball, as is well known that is one of the famous team sports in Hong Kong, even in the world. In a volleyball game, it involves 12 players in total and 6 players in each team. It includes receivers, hitters, middle hitters, liberoes and setters. They play in an 18m long and 9m wide court and with the height of 2.43m net for the men’s competition, and 2.24m height for the women. Players require to performance different skills and abilities, like jumping, agility, power, balance, etc., and require lots of energy during a match.

According to Pandy and Zajac (1991) and Van Soest et al. (1993), jumping ability, particularly in vertical jump is vital in different sports. Having a higher Vertical Jump is beneficial to the successful performance of athletes, especially for the basketball and volleyball players. In a 2-3 hours volleyball match, attacking, blocking, serving and even playing the ball involves considerable amount of jumping. Based on Pandy’s study report, it reported that the setters can make about 269 jumps in one match. For the middle players, they need to jump around 223 times. The outside hitters jumps 197
times, and the right-side hitters make 128 jumps, which has an average of 194 jumps during just one match. It is obvious showed that jumping ability is especially important in volleyball, no matter it required to jump high or jump lots of times. Players with higher vertical jump and better jumping ability can have a better performance in the volleyball match.

Many coaches believe that the development of inferior limbs’ maximum force and resistance force are essential to increase the elevation of the center of gravity in vertical jump. For enhancing the vertical jump ability, lots of coaches and players consider to use the plyometric training to strengthen the lower limbs muscle. Most of the coaches combine different training program instead of just using the plyometric training. The popular combinations are plyometric training with weight training and plyometric training with aerobic exercises. For the plyometric training, it includes different jumping exercises, like squat jump, lateral jump, box jump, hops, bounding and so on. It involves an immediate eccentric muscle contraction and rapidly followed by concentric contraction, which shortening the muscle in a very short period of time. This training helps to develop
the strength of muscles in the lower body to generate high speeds and power in order to increase the height of vertical jump.

Statement of problem

There are lots of studies and researches conducted in the foreign countries to examine that plyometric training can improve vertical jump. However, there are no specific or similar studies about plyometric training for the volleyball players in Hong Kong. With a different physical characteristics and lifestyle between Hong Kong and foreign countries, it was wondered how the plyometric training can improve the vertical jump ability of secondary volleyball players in Hong Kong and see whether the plyometric training can also help with their physiological changes.

Purpose of the study

The purpose of this study is to investigate the effect of plyometric training exercise on the secondary volleyball players, and to test whether the plyometric training can improve other physiological changes, like Heart Rate, Blood Pressure and the weight of those players.
Significance of the study

Vertical jump is important for considerable sports, no matter team sports or individual sports, no matter track and field, racket sports or ball games. Every year, there will be substantial competitions held by the schools, The Hong Kong Schools Sports Federation, Leisure and Cultural Services Department and other parties. Every school and coach wants to improve the players’ performance and wants them to get a better result during those competitions. The importance and the effect of the plyometric training will be investigated in this study. If the training has a significant improvement for the secondary volleyball players, then it is possible to implement to other sports and improve the player’s jumping ability. It is hoped that these findings can facilitate more coaches to use this plyometric training program in the future.

Chapter 2

REVIEW OF LITERATURE

Vertical jump is an essential component in the volleyball. If a player can jump higher and jump with
more frequencies, that player can have higher chances to block and spike the ball successfully, which players can have better performance and good result of the game. There was a study by Piucco and Santas (2009), they reported that there was a volleyball championship competition, and there were statisticians analyzing volleyball players' jumping statistic. The result was that the setters made around 64 jumps, 47 jumps for the middle players and 31 jumps for the outside players.

For improving the vertical jump, most of the coaches and researchers start considering using plyometric training for their teams. This study was aimed at finding out the effect of the plyometric training to the vertical jump. In this chapter, the review of literature of this study is divided into following sections: (1) Biomechanics of Vertical Jump, (2) Factors affect Vertical Jump, (3) Benefits of Plyometric training, (4) Plyometric Training Progression, (5) Instruments for Vertical Jumps, and (6) Summary.

**Biomechanics of Vertical Jump**

Vertical jump is a complex movement involving different parts of the body. Jump usually characterized
as ‘ballistic’ movements. Jumping involved in three parts, which one muscle group starts first, then continued by no muscle activation and lastly reduced the movement speed by the opposite muscle group. (Roger, 2007). To simplify the action of vertical jump, Jan and Jandran (2007) analyzed the parts of the vertical jump. First of all, vertical jump required a process of take-off, then, is the flight and lastly is landing. According to Brian (1998) and Roger, in the first stage of starting position, which means the body posture just standing upright, it involves hip and knee flexion, and dorsiflexion at the ankle. The driving force is provided at the gravity. Then, followed by the preparation phase, which means lowering the body, this action stored the elastic energy in the eccentrically contracting muscles. In the take-off phase, the hip extended first, then immediately followed by the knee extension and ankle plantar-flexion. The leg muscles will change from eccentric to concentric. This phase can drive the body upwards vertically. Different articles have showed that the lower body part is the main and important element to drive the body upward. That means if people have higher lower limbs strength, they have higher ability to jump high and jump better.
Factors affect Vertical Jump

Vertical jump can be affected by several of biomechanical, physiological and anthropometric factors, such as muscle mass, flexibility, age, weight, height, the muscle strength and so on. (Abidin & Adam, 2013) The vertical velocity of the center of gravity at take-off phase could determine the jumping height. The mass of the subject and the strength of the muscle affected the velocity and can change the speed of driving the body upward. Nahydiya and Mohd stated that leg power is one of the contributing factors to the height of vertical jump. The vertical jump height increased if the leg power was stronger. However, there was a study by Harley in 2002 showed that greater quadriceps muscle strength did not have a positive relationship with jump higher. Besides, the swing and the strength of the arms and shoulder can generate a higher jump height. It is obvious to show that human body composition and physiological characteristics are the factors that affect the jump height. Also, several studies reported that the amount of training may be related to the height of jumping. If players do more training about jumping, the height of the vertical jump would be higher than other players.
Benefits of Plyometric training

Plyometric training means the muscles had a rapid and powerful contraction and followed by a high-intensity eccentric contraction. According to American College of Sports Medicine, it mentioned that plyometric training is a safety, beneficial and interesting physical activity. To considering the benefits given by the plyometric training, to commence with, due to the plyometric training requires stretch and shortening the same muscle in the short period of time, therefore, it can help to increase the movement speed and increase the ability to produce muscle power.

Secondly, plyometric training can help for the bone development. According to Medhat (2010), he did a plyometric training research related to the bone density. The result showed that regular plyometric training can increase the bone mineral density by around 13% and it also can help to prevent bond injures up to 42%.

If the training is regularly progressed, it needs a great deal of energy. It can help to control weight and burn lots of calories. Besides, plyometric training requires a great amount of jumping, moving, bouncing and
hopping movements. It is kinds of aerobic activities. Thus, it can increase fitness and cardiovascular functions. According to Hamid et al. (2013), they found out that plyometric training can help to reduce Systolic blood pressure, diastolic blood pressure and heart rate. Hamid et al. (2014) showed that high workload of plyometric training has greater increases than low workload in rate-pressure product. Therefore, cardiovascular responses can be improved by plyometric training.

**Plyometric Training Progression**

According to Avery (2011), the writer suggested some of the guidelines for doing the plyometric training. For example, the training should start with one set of low-intensity exercises, then two to three sets of six to ten repetitions of much higher intensity exercises. Also, the training should only two to three times per week. It suggested that players should start from easier to complex exercises, add repetitions gradually in order to make the training more demanding, and perform the repetitions from slow at first, then learn to do them in a quicker way. Besides, the study divided the plyometric exercises into three main groups: Jumps without apparatus
(for beginners), jumps over apparatus (good for developing maximum take-off phase) and jumps in and off apparatus (required to jump up and down of the boxes).

On the other hands, recovery is also a critical thing in the program in order to developing a higher power of muscle and longer muscular endurance. There should be enough rest time between different sets of exercises and different days of training. With a proper recovery period, it can prevent the injuries by fatigued muscles.

**Instruments of vertical jumps**

There are a few instruments to measure the vertical jump height, for the basic way, instructors can use the wall and required the subjects to use chalk to draw on the wall. Also, the Vertec is another instrument to measure the height of vertical jump. Vertex is visible and easy to interpret. Besides, the vertical jump performance can measure by a resistive platform (Ergojump or Kistler) which connected to a timer. It can record the flight time and calculated the jump height. Nowadays,
there are developing many other methods to record the height of jump.

**Summary**

Vertical Jump is mainly using the lower body parts muscle. The concentric of the muscle drive the body move upward. Many studies showed that biomechanical, physiological and anthropometric factors can affect the performance of the vertical jump. The strength of lower body muscle has a positive relationship with the vertical jump performance. Therefore, many coaches are focusing to use plyometric training to strengthen the lower limbs muscle. Plyometric training not only can speed up the muscle contraction, it also can strengthen the bones, control weights and improve the cardiovascular responses. Although plyometric training is a safe training, it is important for coaches and players to follow the guidelines of having plyometric training. It is vital that it should provide enough rest time for the recovery of muscle. Participants should avoid doing training when having fatigued muscle in order to prevent injury. Coaches can use different methods to record the progression of the training and the performance of their players’ vertical jump ability. For the advancement of
the technology, there are lots of technologies and measurements can calculate the height and the time of the vertical jump.

**Chapter 3**

**METHOD**

The purpose of this study was to investigate the changes of vertical jump performance when the secondary volleyball players involving in a 4-week plyometric training program. This chapter of the study will be presented in the following parts: (1) Subjects, (2) Instruments, (3) Procedures, (4) Hypothesis, (5) Training Program, (6) Definition of terms, (7) Delimitations, (8) Limitations, and (9) Method of analysis.

**Subjects**

There were 6 male and 6 female H.K.M.L.C. Queen Maud Secondary volleyball team players involved in the 4-week plyometric training. Also, other 6 male and 6 female in the same team were the subjects of control group. All subjects aged between 12 and 17.

**Instruments**
A Physical Activity Readiness Questionnaire (PAR-Q) form and an informed consent form were administered to all the subjects. Subjects were required to fill up the form before they participate in this study, which to ensure they are well-known of the study and they do not have any physically problems and diseases with their body.

A valid measuring tape was used to measure the height of vertical jump during the study. Subjects were required to use the chalk to draw on the wall. All data of the jumping heights were recorded in their individual record form. In this study, there was only one researcher to hold and record all the information during the pretest, posttest and the 4-week plyometric training program.

**Procedures**

At the beginning of the test, all subjects were well-known the purpose, potential risks and benefits of this study. A PAR-Q form and an informed consent form was administered and filled by all subjects before the test. After introduced the test, there were 4 categories of the test: (1) Basic Individual Physical Characteristics, (2) Warm-up exercise, (3) Countermovement Jump Test, and (4)
Countermovement Jump with arm swing Test. All tests would be held on the same day with the same condition.

**Basic Individual Physical Characteristics**

Body weight, body height, heart rate, blood pressure would be measured in this part. Body weight was measured by the electronic weight scale provided by the school. Body height was recorded by the measuring tape, which on the wall in the school. Heart rate and blood pressure were measured by the electronic sphygmomanometer (A&D Medical UA-631).

**Warm-up Exercise**

Subjects were given 10 minutes for keeping their body ready for the test, which suggest them to jog, to run and to stretch during these 10 minutes.

**Countermovement Jump Test**

Firstly, subjects needed to stand in the side way of the wall and got ready for the trials. Subjects took a chalk within their fingers with the hand that near the wall. Then, they needed to keep their feet flat on the ground and perform a vertical jump. They were required to jump vertically as high as possible and used the chalk to mark their highest point. Every subject had three trials.
After all subjects finished their first trial, then subjects performed the second trial, which ensured all the subjects had enough rest time between trials and prevent muscle fatigue.

**Countermovement Jump with arm swing Test**

In this part, the test was similar to the countermovement jump test. Subjects needed to start from a straight position and kept arms straight and parallel to the ground. Then, they needed to bend their legs and generated a full arm swing while jumping for maximal height. Subjects needed to use chalk to touch the wall when they were at the highest point. Three trials were tested in this Countermovement Jump with arm swing Test. Also, the second and third trial began after all the subjects finished the previous trial.

**Hypothesis**

The following of hypothesis were stated in this study:

1. There will be a significant difference of vertical jump between pretest and posttest of the 4-week plyometric training.
2. Students who involve in the 4-week plyometric training will have result of a better vertical jump than those students who have not receive the training.

3. There will be an improvement on heart rate of the subjects between pretest and posttest of the 4-week plyometric training.

4. There will be an improvement on blood pressure of the subjects between pretest and posttest of the 4-week plyometric training.

5. There will be a significant weight loss of the subjects after the 4-week plyometric training.

**Training Program**

The plyometric training program is 4-week and underwent two days, which are Tuesday and Friday. The program started in March, 2015. Subjects needed to involve in this training approximately one hour after school during their regular volleyball training. The first week of training intensity would be low to moderate, which let subjects’ muscle familiar with the training. The second week’s intensity would increase to moderate and high, and high intensity in the third week. The final week would be the highest intensity, which required the
subjects to perform the maximal effort in the last training week.

Definition of terms

These terms were defined operationally for this study in the following:

Plyometric Training

Plyometric exercise was from Europe. It was first referred as "jump training". According to Dr. Andreo A. Spina, plyometric is some exercises which enable muscles to reach its maximum strength in a very short period of time. This speed-strength ability is called power. Therefore, some people called plyometric exercise as "power training" exercise. Plyometric involves a concentric muscular contraction and immediately followed by an eccentric contraction of the same muscle group.

Vertical Jump

According to Vishaw, Amandeep and Sandeep (2015), Vertical jump (VJ) performance is one of the best indications of lower limbs muscle power. Vertical Jump is the ways to rise own body center of gravity higher in the vertical plane. This mainly uses the one’s muscle.
Secondary Volleyball Players

The students who are studying in the secondary school and are one of the members of school volleyball team were the subjects in this study.

Heart Rate

It is the speed of the heartbeat. The unit of heartbeat is beats per minute (bpm). According to the National Institute of Health, the normal resting heart rate for adults is 60-100 bpm. For the elite athlete, their heart rate may be around 40-60 bpm.

Blood Pressure

Blood pressure is the pressure of the blood flow in the arteries. It is usually measured by sphygmomanometer. Blood pressure usually recorded as two numbers, one is systolic blood pressure, which means the pressure in the arteries that the heart needs to pump out blood during each beat. And another number is called diastolic blood pressure. It means the pressure that the heart relaxes before the next beat. It should be normally less than 120/80 mmHg.
Delimitations

The following delimitations were set for this study:

1. The subjects are delimited to male and female volleyball players aged from 12 to 17.
2. Total of 24 subjects were participated in this study, which the ratio of male and female is half and half.
3. Countermovement Jump (CMJ) and Countermovement Jump with arm swing (CMJA) were carried out as vertical jump tests in the H.K.M.L.C. Queen Maud Secondary School.
4. Due to the Vertec was too expensive and difficult to get. In this study, a measuring tape on the wall that provided by the secondary school was used to replace the Vertec.

Limitations

The limitations of the study were listed as follows and should be considered before interpreting the results:

1. This study was limited by the small sample size (N=24).
2. Activities or exercise in daily time of the subjects other than the training program are not controlled.
3. All the subjects were voluntary involved in this training program. Participants may be not fully attend all training sessions due to different reasons, like sickness, work of study or others.
4. The performance of the participants might be varied due to their effort to this program and their genetic factors.

**Method of analysis**

A paired t-test and two-way ANOVA was used to examine the effect of 4-week plyometric training in this study. There will be pretest and posttest between 2 groups (experimental groups and control groups). The Statistical Package for Social Science (SPSS) was used to analyze all data. When analyzing the data of this study, the level of significance was set as $P < 0.05$.

**Chapter 4**

**ANALYSIS OF DATA**

In this study, the purpose was to find out the effect of the 4-week plyometric training for the teen volleyball players, whether the program had a significant result on that experimental group. Therefore, there was a control group in this study and compared the result before and after of 4-week training program. Furthermore, the study aimed to investigate whether the training program would
help for the improvement of heart rate and blood pressure rate, and have a weight loss. There will be divided into two parts in the followings, results and discussion.

Results

Descriptive Statistics

24 volleyball players were invited to participate in this study. 12 of them were in the experimental group and 12 were in the control group. Each group had the same number of male and female. Those 24 players aged at 14.7 (SD= 1.4). Their mean height was 166.2 cm (SD= 7.7) and the mean weight was 59kg (SD= 9.5). And in the posttest, the weight had been measured again; the mean weight was 58.6kg (SD= 9.4). The subjects’ physical characteristics distribution was shown in Table 1.

Table 1

Descriptive data: Physical Characteristics of the subjects (N= 24)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>12</td>
<td>17</td>
<td>14.7</td>
<td>±1.4</td>
</tr>
<tr>
<td>Weight Pre-test (kg)</td>
<td>43.3</td>
<td>79</td>
<td>59</td>
<td>±9.5</td>
</tr>
<tr>
<td>Weight Post-test (kg)</td>
<td>42</td>
<td>77</td>
<td>58.6</td>
<td>±9.36</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>153.5</td>
<td>181</td>
<td>166.2</td>
<td>±7.7</td>
</tr>
</tbody>
</table>
Following the Physical Characteristics measurements, there were several tests conducted. In the pre-test, the mean heart rate was 95.8 bpm (SD= 15.4). The blood pressure rate was 117/79 mmHg (SD= 12/9). In the post-test, the mean heart rate was 91.9 bpm (SD= 13.5). The blood pressure rate was 114/71 mmHg (SD= 10/8). The distribution of heart rate and blood pressure was shown in Table 2.

Table 2

*The pre-test and post-test result: Heart Rate and Blood Pressure Rate (N= 24)*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate Pre-test (bpm)</td>
<td>65</td>
<td>129</td>
<td>96</td>
<td>±15</td>
</tr>
<tr>
<td>Heart Rate Post-test (bpm)</td>
<td>64</td>
<td>123</td>
<td>92</td>
<td>±14</td>
</tr>
<tr>
<td>Blood Pressure Rate Pre-test (mmHg)</td>
<td>93/60</td>
<td>135/99</td>
<td>117/79</td>
<td>±12/9</td>
</tr>
<tr>
<td>Blood Pressure Rate Post-test (mmHg)</td>
<td>95/60</td>
<td>131/89</td>
<td>114/71</td>
<td>±10/8</td>
</tr>
</tbody>
</table>

**Inferential Statistics**

A two-way ANOVA and the paired t-test were used for testing the hypotheses that set in the beginning of the study. The scores of the average jump height of Counter
movement jump (CMJ) and the Counter movement Jump with arm (CMJA) were used for the hypotheses testing.

The first hypothesis was that there would be a significant difference of vertical jump between pretest and posttest of the 4-week plyometric training. The second hypothesis was that students who involved in the 4-week plyometric training would have a better result of vertical jump than those students who did not receive the training. Lastly, there would be an improvement on heart rate and blood pressure and a weight loss of subjects after 4-week plyometric training.

Subjects needed to preform 1 time standing reach height, 3 times of Counter movement Jump (CMJ) and 3 times of Counter movement Jump with arm swing (CMJA). The mean standing reach height was 214.5 cm (SD= 10.9). In the pre-test, the mean height of average counter movement jumps was 256.5 cm (SD= 17) and the mean height of average counter movement jumps with arm swing was 262.3 cm (SD= 18.6). In the post test, 258.4cm (SD= 18.2) and 264.4cm (SD= 18.9) were the mean height of average counter movement jumps and average counter movement jumps with arm swing.
Table 3

*Standing Reach Height of experimental group, the pre-test and the post-test result of CMJ and CMJ with arm swing (N= 12)*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing Reach Height (cm)</td>
<td>196</td>
<td>238</td>
<td>214.5</td>
<td>±10.9</td>
</tr>
<tr>
<td>CMJ Pre-test (cm)</td>
<td>230</td>
<td>290</td>
<td>256.5</td>
<td>±17</td>
</tr>
<tr>
<td>CMJ Post-test (cm)</td>
<td>229</td>
<td>291</td>
<td>258.4</td>
<td>±18.2</td>
</tr>
<tr>
<td>CMJ with arm Pre-test (cm)</td>
<td>235</td>
<td>289</td>
<td>262.3</td>
<td>±18.6</td>
</tr>
<tr>
<td>CMJ with arm Post-test (cm)</td>
<td>237</td>
<td>299</td>
<td>264.4</td>
<td>±18.9</td>
</tr>
</tbody>
</table>

By using the Paired t-test to testing the significance of the first hypotheses, the mean CMJ test after the 4-week plyometric training was significantly (t= -2.55, p= .03) difference than the mean CMJ test before the 4-week plyometric training at the .05 level of significance. To considering the CMJA test, there was a more significant result (t= -6.68, p= .00) came out. It shows than the 4-week plyometric training could have better improvement on both tests, especially in the CMJA test; the improvement was much obvious.

Table 4
Paired t-test for average Counter movement Jump Heights and Average Counter movement Jump with arm Swing Heights of experimental group (N= 12)

<table>
<thead>
<tr>
<th>Test 1: CMJ &amp; CMJ_post</th>
<th>N</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>-2.55</td>
<td>.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test 2: CMJA &amp; CMJA_post</th>
<th>N</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>6.68</td>
<td>.00</td>
</tr>
</tbody>
</table>

*p < .05, two-tailed.

For testing the second hypotheses of whether experimental group had a higher jumping height than the control group, a two-way ANCOVA was used. There was significant (F= 6.31, p= .02) mean differences of CMJ test between experimental group and control group. For the CMJA test, it also had a significant (F= 14.85, p= .00) mean differences between experimental group and control group. The experimental group had better jumping results on both CMJ and CMJA tests after 4-week training program than the control group at the .05 level of significance.

To further analyzing the difference between experiential group and control group, for the CMJ test, the improvement of experimental group was 2.08 cm (SD= 0.38) and 0.75cm (SD= 0.38) for the control group. For
the CMJA test, the improvement of experimental group was 3.12 cm (SD= 0.38) and 1.08 cm (SD= 0.38) for the control group. These were showed in Figure 1 and 2.

Figure 1
The improvement height on CMJ test between experimental group and control group
Lastly, considering whether the 4-week plyometric training program could improve other aspects, the study used the weight, Heart rate and blood pressure as indicators by using the paired t-test to test. There were significantly differences in the weight changes \( (t = 2.83, p = .02) \), diastolic blood pressure \( (t = 4.44, p = .00) \), and the heart rate \( (t = 1.38, p = .02) \) before and after the 4-week training program at the .05 level of significance. However, there were no significant \( (t = 1.86, p = .09) \) difference in the systolic blood pressure before and
after the 4-week training program at the .05 level of significance.

Table 5

*Paired t-test for Weight, Blood pressure and Heart Rate of experimental group (N= 12)*

<table>
<thead>
<tr>
<th>Test</th>
<th>Pre-test &amp; Post-test</th>
<th>(N)</th>
<th>(t)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1: Weight</td>
<td>12</td>
<td>2.83</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Test 2: Systolic Blood Pressure</td>
<td>12</td>
<td>1.86</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Test 3: Diastolic Blood Pressure</td>
<td>12</td>
<td>4.44</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Test 4: Heart Rate</td>
<td>12</td>
<td>1.38</td>
<td>0.02</td>
<td></td>
</tr>
</tbody>
</table>

\(*p < .05, \text{two-tailed.}\)

**Discussion**

The purpose of the study was to investigate the effect of plyometric training exercise on the secondary volleyball players, and to test whether the plyometric training can improve other physiological changes, like weight, Heart Rate and Blood Pressure of those players. There will be divided into three parts: (1) The Effect of the plyometric training to Hong Kong secondary volleyball
players, (2) The changes of physiology by the plyometric training, and (3) The factors affecting the result of the plyometric training in this session.

The Effect of the plyometric training to Hong Kong secondary volleyball players

According to the 4-week plyometric training program result of the pre-test and the post-test, the program was obviously useful to improve the vertical jump of the subjects. Most of the subjects who involved in the training program could increase 1cm to 6cm of the jumping height. The possible reasons that enhanced the vertical jump were the strength of leg power of subjects had increased via the 4-week training program. Also, the training program required subjects to jump continuously and learn different jumping methods, thus it might refine their jumping mechanics. They might learn how to utilize the body mechanism to generate a higher jump.

There were lots of similar results that did in the foreign countries. Most of their studies were 6 weeks and with a longer time of trainings. Their results were more obvious and had a considerable growth increase, such as a similar study conducted by Soundara and Pushparajan in
2010 and Kent et al. (1992). They examined a vertical jump increase of around 8 to 10cm. In this study, it was only 4 weeks program and length was only around 1 hour. But there were also had an improvement among the subjects, therefore, it is no doubt that the plyometric program was useful not only in the foreign countries but also for the Hong Kong people.

The changes of physiology by the plyometric training

According to the result of weight, heart rate and diastolic blood pressure, there were significant differences between pre-test and the post-test. Firstly, for the weight changes, the subjects generally had the weight loss. The reason was they had an extra training period for 1 hour and twice a week. The exercises involved high intensive and caused to burn calories. It increased the energy expenditure of the subjects. Therefore, if the subjects maintain their energy intake as normal day and with higher energy expenditure during these 4 weeks, there will have an energy deficit. Thus, it could have a weight loss. To sum up, plyometric training with the proper intensity and training time could have a result of weight loss.
Secondly, for the heart rate and blood pressure, there were different researches showed that exercise regularly can improve the cardiovascular system, which mean it can improve the blood pressure and the function of the heart. According to Hamid, et al. (2012), Hamid, et al. (2013), and Gokulakrishnan, D., & Pushparajan, A. (2014), they found out that plyometric training can have a significant reduction in blood pressure. In this study, the heart rate and the diastolic blood pressure had an improvement after 4-week plyometric training, but systolic blood pressure had not got a positive response to the program. It is no doubt that there will improve the body physiological response with a proper plyometric training. However, there were lots of limitations and reasons that influenced the result of the test in this study that caused this negative result of systolic blood pressure.

The factors affecting the result of the plyometric training

Subject's background.

There are 24 of subjects in this study. All of them were selected by the coach of the volleyball team and all of them were the member of the volleyball team. For the
control group, although they did not participate in the program, most of them still had a slightly improvement after 4-week of the pre-test. The possible reason was that they had regular training sessions every week. And more importantly, their coach provided extra workouts for them, which was a bit similar to the plyometric training. It is hard to control their exercise pattern. Therefore, the difference between the experimental group and control group might be affected.

Moreover, for the subjects in the experimental group, some of them did not really have an obvious improvement. The reason was some of them did not attend all the training sessions. Besides, some of the girl subjects were not put lots of effort during the training. They did not fully perform the whole jumping movements. Besides, every subject had different physical responses to the training program, some might have higher responses. Thus, the improvement among subjects might have a huge difference due to the above reasons.

Measuring Errors.

Firstly, the measuring tape in the secondary school was old and a little bit worn. It affected the accuracy
to receive data. The study used the same blood pressure and heart rate instrument to measure, but the result might inaccurate due to different situations. Subjects might involve in exercise, sick, nervous before measuring heart rate and blood pressure. Due to the time limit of the testing day, although time was provided to the subjects to calm themselves, it stills not enough to let their heart rate and blood pressure to recover to the resting period. Thus, it might affect the accuracy of the data collection.

Chapter 5

SUMMARY AND CONCLUSION

In this chapter, the result summary and the study's conclusion will be briefly descriptive in the following. Also, there will be some recommendations introduced for the future study.

Summary of the results

The study was designed to investigate the effect of plyometric training exercise on the secondary volleyball players, and to test whether the plyometric training can improve other physiological changes, like weight, Heart Rate and Blood Pressure of those players.
There were 24 secondary volleyball players selected to participate in this study. In this study, the subjects were divided into two groups, experimental group, which involved in a 4-week plyometric training, and control group. Each of the group had 6 male and 6 female. All the tests and training program conducted in the H.K.M.L.C. Queen Maud Secondary School. Subjects needed to attend a pre-test and post-test. Each of the subjects needed to preform 3 times of Counter Moment Jump and 3 times of the Counter Moment Jump with arm swing. The basis physical characteristics, like weight and height, and the heart rate and blood pressure rate were measured before the jumping test. The results were concluded in the following.

1. Those 24 players aged between 12 and 17. Their mean height was 166.2 cm (SD= 7.7) and the mean pre-weight was 59kg (SD= 9.5); the mean post-weight was 58.6kg (SD= 9.4).

2. There was a significant improvement of vertical jump by the CMJ test \( t = -2.55, p = .03 \) and CMJA test \( t = -6.68, p = .00 \) after the 4-week plyometric training.
3. The experimental group had better jumping results on both CMJ test ($F = 6.31, p = .02$) and CMJA tests ($F = 14.85, p = .00$) after 4-week training program than the control group.

4. The weight changes ($t = 2.83, p = .02$), diastolic blood pressure ($t = 4.44, p = .00$), and the heart rate ($t=1.38, p = .02$) had a significant difference after the 4-week training program. But, the systolic blood pressure ($t = 1.86, p = .09$) have no significant mean difference.

**Conclusion**

In this study, it showed that the plyometric training is useful for enhancing the vertical jumping ability. Also, it can enhance the heart rate and blood pressure. Understanding more about how to increase the vertical jump and the physiological functions of the volleyball players can help the coaches to set a better and comprehensive training program for the players, which can help the team achieve a better performance in the competition.

**Recommendations for further study**
1. The future study can investigate other aspects that related to the plyometric training. It is no double that plyometric training not only enhances the vertical jump, heart rate and blood pressure, but also the core muscle, cardiovascular system, etc. Therefore, it is possible to find out the relationships between plyometric training and other aspects.

2. For the jumping test, in order to receive more accurate data, there should not only a demonstration to the subjects, but also let subjects have trials to perform the movement of the test first. Otherwise, it may affect the result of the test.

3. For the suture study, the plyometric program can have a longer length. 4-week training is not a short period but it is much better to hold longer weeks that can arrange more exercises to subjects and increase the intensity stage by stage.

4. In this study, there is only recruited one secondary school and only volleyball players. The future study can consider different types of school, and several of sports players to participate in the study.
REFERENCES


Plyometric Training for Children and Adolescents. (n.d.). Retrieved from
https://www.acsm.org/docs/current-comments/plyometrictraining.pdf?sfvrsn=4


APPENDIX A

Consent Form to Participants

Dear Student,

Effect of 4-week Plyometric Training on Vertical Jump in Secondary Volleyball Players

I am Wong Yee Ki, from Hong Kong Baptist University Physical Education and Recreation Management. I am going to complete my Honors Project on the topic that mentioned above.

All of the participation in this test is voluntary. You can withdraw and discontinue the participation at any time without penalty. In this study, there will be some physical activities during the test. If you feel uncomfortable in any way during the test, you can stop the test anytime. There are some measurements in the following:

Basic Individual Physical Characteristics

Countermovement Jump Test with 3 trials

Countermovement Jump with arm swing Test with 3 trials

The test will last approximately 45 minutes. All data will be recorded during the test. All information obtained in this study will be used for research purpose.
only. Your personal information will not be identified by any reports.

For any further information of this study, please feel free to contact Wong Yee Ki by phone 90644640.

Thank You.
Yours sincerely,

Wong Yee Ki
Date:

____________________  ______________________
Signature                         Date

I,_____________________________, understand that my involvement of this study is voluntary, and I know my name will be kept confidential. And I can quite the test any time and have the right to ask for the completed report.
APPENDIX B
Data Collection Sheet

Name of subject: _____________ Examiner: _____________
Age: _____ Gender: Male / Female Date: ________

Body Weight: ___________kg
Body Height: ____________ cm
Heart Rate: ________bpm
Blood Pressure: ________mm Hg
Standing Reach Height: _____________ cm

<table>
<thead>
<tr>
<th>Test</th>
<th>1st Trial (cm)</th>
<th>2nd Trial (cm)</th>
<th>3rd Trial (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMJ</td>
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<tr>
<td>CMJ with arm</td>
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APPENDIX C

Physical Activity Readiness

PAR-Q & YOU
(A Questionnaire for People Aged 15 to 69)
(Revised - Feb 2011)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly. Check YES or NO.

<table>
<thead>
<tr>
<th>YES</th>
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</tbody>
</table>

Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

Do you feel pain in your chest when you do physical activity?

In the past month, have you had chest pain when you were not doing physical activity?

Do you lose your balance because of dizziness or do you ever lose consciousness?

Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?

Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want - as long as you start slowly and build up gradually. Or you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active - begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal - this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

NO to all questions

DELA Y BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever - wait until you feel better; or
- if you are or may be pregnant - talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer "YES" to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

Source of the PAR-Q: The Canadian Society for Exercise Physiology

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

Signature: ____________________________

Identity Certificate No.: ____________________________

Date: ____________________________

Witness: ____________________________

Signature of Parent or Guardian: ____________________________

(for participants under the age of majority)

Note: 1. The information provided on this form will only be used for the application for use of Leisure and Cultural Services Department's Fitness Rooms and enrolment of recreation and sports activities. For correction of or access to personal data collected by means of this form, please contact staff of the enrollment counter/department.

2. If you answer "yes" to one or more questions in the "PAR-Q & YOU", your physical condition may not be suitable for taking part in the activity concerned. For safety's sake, you should consult a doctor in advance and produce a medical certificate upon enrolment or hire of fitness equipment to prove that you are physically fit for taking part in the activity. If you fail to produce a medical certificate, you must submit the completed Declaration upon enrolment or hire of fitness equipment.

3. If you fail to submit the "PAR-Q & YOU", your application for enrolment of recreation and sports activities or use of Leisure and Cultural Services Department's Fitness Rooms will not be processed. This physical activity clearance is valid for one year from the date it is completed. Registered fitness room users have to re-submit a new questionnaire after the valid period expired.

This physical activity clearance becomes invalid if your condition changes so that you would answer YES to any of the seven questions.
Applicants aged 70 or above must sign the following declaration

**Declaration** (Please mark a “✓” in one of the following boxes)

I hereby declare that:

☐ 1. I am a frequent participant in physical activities and am capable of participating in this activity. Therefore, I do not need to produce any medical certificate to prove that I am able to participate in this activity. The Leisure and Cultural Services Department shall not be liable for any injury or death I may suffer in this activity. I understand that if I have any doubts about my ability, I should consult a doctor before taking part in the activity.

☐ 2. I am not a frequent participant in physical activities. However, I have been examined by a doctor and certified as physically fit for participating in this activity. A copy of the medical certificate is attached for reference.

Signature of Applicant : ______________________

Name of Applicant (Block Letters) : ______________________

Date : ______________________
APPENDIX D

Training Program

1st Week – Tuesday
2X20 Feet Ankle Hops
2X20 Side to side Jump
2X20 Hip-twist ankle hops
2X20 Split Squat Jumps
2X6 Standing Jump and Reach
2X6 Squat Jump

1st Week – Friday
2X20 Feet Ankle Hops
2X20 Side to side Jump
2X10 Rim Jumps
2X10 Jump to box
2X20 Single leg push-offs from box
2X20 Lateral box push-offs

2nd Week – Tuesday
3X20 Side to side Jump
2X10 Rim Jumps
2X20 Lateral box push-offs
2X20 Single leg push-offs from box
3X3 Double leg Hops
3X10 Front box Jump

2nd Week – Friday
2X15 Rim Jumps
3X20 Single leg push-offs from box
2X20 Lateral box push-offs
1X5 Standing triple Jump
1X10 Squat Jumps
2X6 Depth Jump

3rd Week – Tuesday
3X20 Side to side Jump
2X30 Hip-twist ankle hops
3X10 Standing Jumps over barrier
2X10 Front box Jump
3X5 Double leg hops
3X10 Rim Jumps

3rd Week – Friday
3X10 Lateral Cones Hops
3X10 Jump over cones
3X10 Alternating push offs
3X6 Depth Jump
2X6 Squat Jump
3 Zigzag hops

4th Week – Tuesday
2X8 Double Leg butt kick
3 Alternative Leg Diagonal Bound
3X15 Alternative push offs
4X10 Standing Jumps over barrier
2X10 Rocket Jump
3X10 Split Jump

4th Week - Friday
3X8 Double Leg butt kick
4 Alternative Leg Diagonal Bound
3X5 Squat Jump
3X6 Double leg hops
2X10 Rocket Jump
3X10 Split Jump

This plyometric training program was modified from: