香港教育大學
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A Project entitled

"Effect of 8-week weight training program on rope skipping performance of continuous double under"

Submitted by

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Declaration

I, *Kung Ching Yan* declare that this research report represents my own work under the supervision of *Dr. Sun Fenghua*, and that it has not been submitted previously for examination to any tertiary institution.

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Abstract

Background: Rope skipping is an aerobic sport, one of the tricks called double under has been used by many athletes because of the endurance characteristics. As weight training could improve in endurance sports, it may also be effective in double under. *Purpose:* This study was to examine the effect of an 8-week weight training program on rope skipping performance in double under in secondary school students. *Methods:* Forty secondary school students were recruited in the study and be divided into two groups: an experimental group (EXP) (n=20) and a control group (CON) (n=20). Both groups continued their normal training, while the EXP attended two additional weight training sessions per week for 8 weeks. The program included using the phase of fundamental endurance (1 - 3 weeks), functional endurance I (4 - 6 weeks), and functional endurance II (7 - 8 weeks) by using the barbell. All participants were examined in pre-test and post-test using rope skipping continuous double under test (DUT), push-ups test (PUT), sit-ups test (SUT), and repeated squat test (RST). *Results:* Compared with the pre-test, there were significant improvements in post-test in EXP. Including DUT (EXP: 71.9 ± 29.2 vs. 104.9 ± 30.1, p = 0.029) (CON: 76.55 ± 32.51 vs. 81.9 ± 32.29, p = 0.120), PUT (EXP: 35.9 ± 7.4 vs. 43.6 ± 6.3, p = 0.029) (CON: 35.55 ± 6.57 vs. 38.80 ± 5.64, p = 0.08), SUT (EXP: 28.7 ± 8.6 vs. 45.1 ± 8.4, p = 0.001) (CON: 31.90 ± 8.97 vs. 35.00 ± 9.56, p = 0.198), and RST (EXP: 36.9 ± 5.2 vs. 44.9 ± 5.3, p = 0.00) (CON: 34.75 ± 5.50 vs. 36.9 ± 5.12, p = 0.001).

Conclusion: These results show that an 8-week weight training program may improve performance of continuous double under and muscular endurance in secondary students.

Keywords: Rope Skipping, Weight Training, Endurance

Table of content

1. Introduction

Rope skipping is preferred as a common cardiorespiratory training in both fitness and athletic programs. It is associated with health benefits, such as higher bone density or lower depressive symptoms (Ha et al., 2017). In the past, people were interested in rope skipping as it was a method to improve physical fitness and health (Miyaguchi, Sugiura, & Demura, 2014). Till now, it becomes a traditional warm-up method that contains aerobic activity and used by universal sports recently. Different rope skipping programs had also appeared and was a part of sports training routines (Miyaguchi, Sugiura, & Demura, 2014). As it was a common and useful training for the improvement in different sports, the volleyball players involved rope skipping training program because it settled to shoulder strength (Duzgun et al., 2010), soccer players trained rope skipping as additional practice in soccer (Trecroci et al., 2015) and the basketball players with rope skipping training was popular because of the anaerobic characteristics (Orhan, 2013). Besides, some of the schools had also implemented rope skipping as a scheme for primary and secondary students since it could improve their health-related quality of life (Ha et.al., 2015). Rope skipping was an attractive physical activity in school-based by considering the aspect of price, characteristics, and space. A recent study found that the participants spent more time in MVPA in the school-based intervention, which concluded rope skipping training in PE lesson (Ha et al., 2017). Thus, there are closely relationship about rope skipping program and adolescents. In addition to the warm-up, extra training, and physical scheme in school, it was included in the physical education program. It was a superb physical activity for helping students to meet the physical activity standard in national (Heumann & Murray, 2015). With continuous development in sports, it became a dependent sport that

included systematic training and competition, such as the judgment of tricks, skills, and difficulty.

As the popularity of rope skipping was increasing gradually, more people discovered its benefits (Miyaguchi, Sugiura, & Demura, 2014). For example, it is considered one of plyometric training for improving our muscle power and stiffness (García-Pinillos et al., 2020). Also, it had a positive goal in orientation (Albers, 2018), gained higher levels of bone mineral density (Ha & Ng, 2017), and improved in balance and coordination (Trecroci et al., 2015). It is not only a rope skipping skill that enhances motor skill development but also improves cardiorespiratory endurance (Heumann & Murray, 2015). However, the biomechanical studies of rope skipping were limited. It has been researched from the aspects of physiology (Jones, Squires, & Rodahl, 1962), psychology (Albers, 2018), specific sports training (Trecroci et al., 2015), and the systematic competitive judging system (Heumann & Murray, 2015). Recently, there is a growing concern about rope skipping as it is regarding its characteristics such as competition and dependence (Bruce, Moull & Fischer, 2017).

One of the most symbolic tricks of rope skipping called ‘double under’has been recognized by coaches and athletes in competition. The definition of ‘double under’ means rotate the rope nearby the body and under feet twice times when jumping. Evaluating continuous double under is referred to perform as much as possible you can (Bruce, Moull & Fischer, 2017). Over 80 % time of athletes were used double under in the freestyle competition. Many students in primary school, secondary school, or the college had learned it in the Physical Education lesson (Ha et al., 2015) and it was a trick for all sports athlete, as the runners and soccer players as they may use rope skipping for training their endurance (Trecroci et al., 2015). Also, elite athletes used

rope skipping to be an alternative training as it improved explosive power and jumping ability (Shek, Fong & Hong, 2005). Thus, it is an important trick to everyone.

Yet, practice in endurance sports may cause fatigue easily. Sports training results in body metabolic, molecular variations, and hormonal, which could increase the level of power that could be continued by a muscle and maintain the exercise intensity (Bogdanis, 2012). However, some athletes or participants did not receive organized training and they felt fatigued after it. So, they cannot perform well although they were hard work for the training. The previous study showed that enduring exercise in football could lead to a decline in muscle generation because of fatigue (Reilly, Drust & Clarke, 2008). Koblbauer et al (2014) expressed that there was also a kinematic fluctuation like trunk inclination during the training in novice runners when they felt tired. Thus, we cannot overlook those negative effects. As continuous double under belongs to the ability in endurance, participants might cause fatigue when they repeat it. Fatigue might produce acute adaptation and affect the performance in sports, which could absolutely increase injury risk (Hooper et al., 2014). So, a weight training program may be one of the methods which could delay fatigue and improve the performance of rope skipping continuous double under.

Increasing endurance was usually considered an essential thought in weight training programs. It is a well-known concept in sports and was suitable for sports that contain the elements of strength, endurance, and strength power. It has been shown to increase different modes of exercise endurance. One of the effective ways was using high repetitions with low weight training, it could increase endurance performance (Denadai et al., 2017). So, when the repetition increase, the modification from strength to endurance would grow gradually. Guglielmo, Greco & Denadai (2009) stated that many studies had added weight training programs into concurrent

training that could improve endurance performance after 4 – 6 weeks (Guglielmo, Greco & Denadai, 2009). Since continuous double under is an endurance activity, an 8-week weight training program added in regular rope skipping training may be an effective method for improving its performance.

Weight training program brought some benefits to the athlete. Guglielmo, Greco & Denadai (2009) reported that it brought improvement for the running economy endurance runners. The result showed that weight training protocol achieved a maximal strength of leg muscles, it could improve their running performance after 4 weeks weight training program. Koninckx, Van Leemputte & Hespel (2010) also discovered that weight training could increase the maximal power production in cycling. It could improve their sprint power output in the 30 minutes test on an isokinetic bicycle ergometer at 120 rpm. Also, the potential of a weight training program could improve endurance performance in road cycling. As a consequence, proper weight training might result in an improvement in sports performance, power output, and production.

Almost the whole part of body muscle had been involved in rope skipping double under. The specific muscle includes the shoulder, core, quadriceps, and calve muscle. The level of muscle endurance affected body fatigue. As jumpers developed proper shoulder muscle endurance could maximize their performance, it helped to maintain rope turning continuously (Bruce, Moull & Fischer, 2017). Also, core endurance was most significant in different sports because it could ensure spine stability for injury prevention (Faries & Greenwood, 2007). During prolonged exercise, it was also important to spinal stability. The lower body supported the landing force, not only the whole-body weight but also the momentum. Therefore, improving the above specific muscle through weight training may profit rope skipping performance.

As rope skipping continuous double under need to jump repeatedly, it required certain muscle endurance for supporting our jump. Weight training has a strong relationship in muscular endurance, and it is good for improving our rope skipping double under. Studies have shown that it is related to sports performance and power output (Guglielmo, Greco & Denadai, 2009). Trained muscles allow power production, to support the whole body and delay fatigue. However, not all the studies had found the results successfully. For example, the study had no significant improvement after the weight training program in cyclists because the experimental group had performed the resistance training program and weight training program at the same time, which may interrupt the weight training program in this study. Thus, the study cannot settle the effects between pre-test and post-test.

At present, less is currently known for the effect of weight training on rope skipping performance due to a lack of studies in this area. Because of the limited studies, the purpose of this study was to examine the effect of an 8-week weight training program on rope skipping performance, specifically the continuous double under in secondary students. It was hypothesized that secondary students would improve their rope skipping performance in continuous double under after an 8-week weight training program.

1.1 Purpose of study

- To examine the effect of an 8-week weight training program on rope skipping performance of continuous double under in secondary school students.
- To find out which muscle groups improved in secondary school students after the 8-week training.
- To find out why they should use the additional weight training program in their training rather than participating the normal rope skipping training.

2. Literature review

The importance of weight training

Weight training has been shown to improve the physical elements of strength, endurance, and speed. It could increase skeletal muscle growth and reduce the injury risk, it has meaningful advantages for the athlete when they participated in sports (Hooper et al., 2014). For increasing the physical qualities, athletes should perform weight training consistently. Thus, it could increase muscle mass and improve sports performance (Koninckx, Van Leemputte & Hespel, 2010). The previous study had proved that the results of weight training could improve the performance in cycling (Koninckx, Van Leemputte & Hespel, 2010) and running endurance (Guglielmo, Greco & Denadai, 2009). In these studies, both of their experimental group who participated in weight training programs had significant improvement in their training. So, weight training was important to athletes.

The principle of weight training program on muscle endurance

Set up a weight training program must consider the acute training variables. Participants would have a significant improvement when they had enough training intensity, volume, and resting time. For improving weight training program effectiveness, three fundamental thoughts should be included, like variation, progressive endurance, and specificity (Saeterbakken et al.,2018). When we combined those concepts into a weight training program, it may generate a benefit for the athletes. Sports performance would be improved through a progressive weight training program. Thus, we should design directional training for the athletes.

Weight training intensity

Weight training intensity had been discovered by many studies. It was the same as the program load, and it had been proposed as an important training variable for training muscle endurance and training effectiveness (Denadai et al., 2017). 1RM is the most weight that people can lift once for exercise. Most of the weight training intensity is shown as a percentage of 1 RM. Also, it was related to the repetitions with the specific load of the training (Petrofsky & Laymon, 2004). Normally, there were three ranges of repetitions, including low repetitions (1 to 5 repetitions), moderate repetitions (6 -12 repetitions), and high repetitions (>15 repetitions) (Denadai et al., 2017). As many people thought muscular endurance would gain after the weight training program, one of the effective ways has been shown in the previous study, it stated that using ≥15 repetitions and a load of ≤50 %1RM in the training of each exercise was effective in the program (Denadai et al., 2017).

Weight training volume

Weight training volume was the exercise load, repetitions, and total sets. The training volume for each training session may be different (Saeterbakken et al.,2018). However, it may base on different targets of the weight training program. Regarding muscular endurance, using high repetitions with low weight training could increase endurance performance (Denadai et al., 2017). Although there was not a high volume of weight training, it could maximize muscular endurance.

Weight training for the specific muscle

Training for the specific muscle could support sports performance. There was some evidence to prove that the selected weight training had a strong correlation to the performance (Bruce, Moull & Fischer, 2017). The selected weight training program plays an important role in maximizing muscular endurance. Focus on the characteristics of rope skipping, shoulder, core, quadriceps, and calve muscle would be used in the sports (Bruce, Moull & Fischer, 2017). When we designed a weight training program, we should target these muscles.

Resting period during weight training

The rest periods were indicated the time between each set of weight training. There is 3 difference basic range of resting period, including 30 seconds, 1, and 2 minutes (Ghaderi et al., 2012). Base on the range of resting periods in weight training, there would have a diverse effect on muscular endurance. When weight training with loads between 50-90% 1RM, 3 to 5 minutes resting period allowed to have more repetition to be completed. A short resting period may produce metabolic stress, participates would feel tired easily (Ghaderi et al., 2012). Overall, the training outcome was related to the resting period, and we should control it and achieve the training target.

Metabolic stress of weight training

There was serval negative response of weight training. However, when we control the load and repetitions of weight training, the negative response was limited. Metabolic stress may contribute to muscle adaptation. The previous study had shown that it would increase lactate production, decreased pH, and phosphocreatine depletion (Caterisano et al., 2018). Compare to the control group, the weight training group increase blood lactate double after they had the

weight training. Thus, the participants may feel tired after the weight training (Reilly, Drust & Clarke, 2008). Moreover, a seriously overloaded weight training program was harmful to the athlete. For example, it would decrease muscle generation and decrease sports performance. Thus, we should concentrate on the workload and the posture of the athlete when they do the weight training.

Hybrid pedagogical approach

The hybrid model was a new pedagogical approach, which combined face to face instruction and online instruction. The mixed-mode pedagogy was used in research recently, and it was used most in the United States. It could be an opportunity to instruct the students without any conflict at transport, place, and time (O'Byrne & Pytash, 2015). The elasticity of hybrid learning, and pedagogical approach could be a great method in the modern world.

The considerations of hybrid learning

Hybrid learning required students learning to be self-regulating and continuously. Many things would disturb them when they received information from online learning. Also, there may have more challenges compared to traditional learning (O'Byrne & Pytash, 2015). Adding the technology into the path of learning did not equal more motivation. Thus, the online mode of pedagogy should be a clear goal and should affect the students' motivation.

3. Methods

3.1 Participants

A total of forty healthy secondary students (20 males and 20 females, age: 15.5 ± 1.3, height: 159.3 ± 17.8 cm, weight: 59.6 ± 20.1 kg, experience year: 5 ± 2.1 years) with at least 2 years rope skipping experience (about 2 days per week) and within 12 to 17 years old were volunteered to take part in this study. Participants were recruited from two different secondary schools. They were divided into two groups, and each consist of 20 participants from the same secondary school (EXP: n = 20; CON: n = 20). All participants completed a PAR-Q form to determine they were suitable for taking part in the experiment or safely participate in this study. Potential participants were excluded if they had participated in weight training within the past six months. All participants received a briefing session with written information about the study procedure, potential risks and benefits. A consent form was signed and finished before the experiments. Ethical approval of this research was obtained from the Human Research Ethics Committee of the Education University of Hong Kong.

Table 1. Physical characteristics and experience background of participants in EXP and CON.

	EXP (n=20)	*CON (n=20)*
Age (years)	15.3 ± 1.3	15.6 ± 1.2
Height (cm)	161.9 ± 7.4	159 ± 4.1
Weight (kg)	56.3 ± 9.6	60.8 ± 6.6
Experience year (years)	4.8 ± 1.9	5.2 ± 2.2

Values are presented by mean ± SD; Experimental group, n = 20; Control group, n = 20; No significant results in any data between EXP and CON (p>0.05).

3.2 Study design

The research design was a case-control design. It was hoped that the experiment continued fairly. Participants with matched physical criteria and background were assigned to two groups: an experimental group (EXP) and a control group (CON). Since the experimental group and control group came from different secondary school and need to keep secret about this study. Thus, they did not know what was happening in the other group or interfered with each other. Due to the uncertain situation of COVID-19 in Hong Kong, the study used a hybrid mode to continue the experiment. The study had considered the difference between face-to-face instruction and online instruction. However, the hybrid model may be a potential method and it was fair to everyone. The study continuously 50% of time used face to face instruction, and 50% of time used online instruction. In weight training, periodization provides a good system with splitting the training process in specific time periods (DeWeese, et al., 2013). To realize the effectiveness of the weight training program on the performance of continuous double under, and refer the pervious study, EXP completed an 8-week weight training program, which included using the phase of fundamental endurance (1 - 3 weeks), functional endurance I (4 - 6 weeks), and functional endurance II (7 - 8 weeks) by using the barbell. All participants continued their regular training (2 days per week) while the EXP attended two additional weight training sessions per week for 8 weeks. During the 8-week experiment period, all participants cannot receive other weight training programs and rope skipping training. To ensure the experiment progress smoothly throughout the 8-week experiment period, all participants were required to record the training time and activity in their training log.

3.3 Instrument

The jump rope was used by participants for performing continuous double under. 40 of jump rope was used for the pre-test, training, and post-test in 8 weeks of this research. To calculate the jump rope results, 1 counter was needed in the pre-test and post-test. Besides, barbells and yoga mats were used in the weight training program. Since only the experimental group used these instruments, 20 barbells and yoga mats were enough in each weight training item. Heart rate (HR) measures and rate of perceived exertion (RPE) are becoming increasingly popular for monitor endurance performance responses (Buchheit, 2014). To monitor the training response of participants, 40 heart rate monitor (H7 heart rate sensor, Polar, Finland) and 1 rate of perceived exertion (Borg RPE scale) were used in the experiment period. A body composition monitor (Omron HBF-375) was used in pre-test and post-test. Consent forms were given to two different secondary schools, 40 participants or/ and their parents.

3.4 Procedure

The flow chart of the experiment is shown in Figure 1, the whole experimental period took 8 weeks to finish. Two groups were compulsory to attend an online briefing session before the pre-test. The content of the briefing session included the flow of experiments, training methods, the rules of the experiment, and the test. Thus, they were accepted on familiar with the procedures and requirements of all tests.

All participants were required to complete two trials of rope skipping continuous double under test (DUT), one push-ups test (PUT), one sit-ups test (SUT), and one repeated squat test (RST) in both pre-test and post-test sessions. To avoid affecting DUT performance due to fatigue, both

groups followed the test order: (1)DUT (2)PUT (3)SUT and (4)RST. All participants took 15 minutes to rest after the first and second trials of DUT and a 5-minute recovery period between each following test (Figure 2). Moreover, the experimental group test 1 RM in the exercise of chess press, wrist curl, plank T, bent-over row, goblet squat, and lunge in the pre-test, which is face to face mode. Thus, it could be easy to arrange suitable weight training for them. All the tests took place in a space and around an hour. Heart rate (HR) and rate of perceived exertion (Borg RPE scale) were measured their training response.

Figure 1. Flow of the experiment.

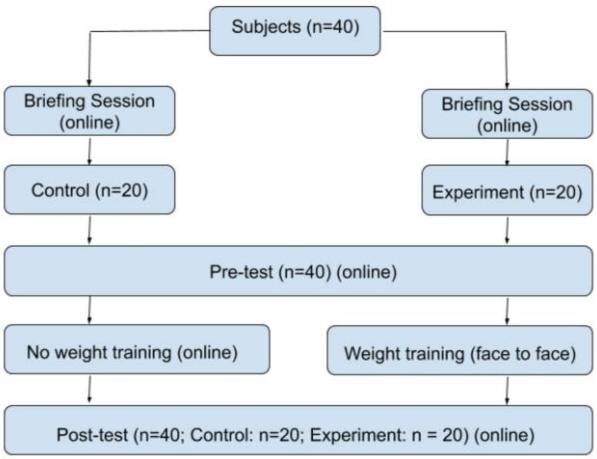
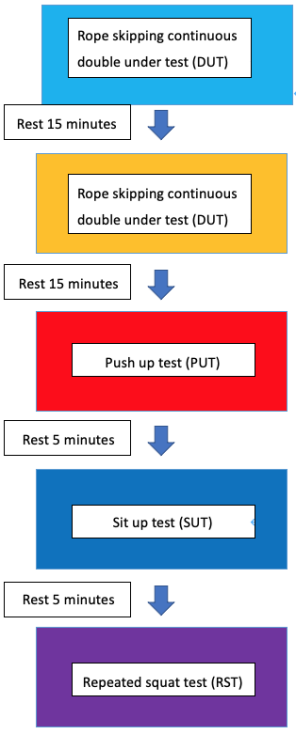


Figure 2: Pre-test/Post-test order



The DUT was the main test of the experiment since it aimed at realizing the effectiveness of the continuous double under. It was straightly related to the performance of endurance because it could generate fatigue in a certain period (Bruce, Moull & Fischer, 2017). It was used to test the rope skipping performance and the endurance level in rope skipping participants.

Before the DUT in the pre-test session, all participants received the same kind of jump rope. They could adjust the length of the rope. However, there were specific length ratios of the rope: 1 (body height): 0.5-0.6 (jump rope length) since the rope's mass and length were manipulated the performance of rope skipping (Bruce, Moull & Fischer, 2017). Also, they had 15-minute practice time for familiarizing the jump rope.

During the DUT, participants stood on an area (2m x 2m), which was marked by themselves before the test and had a DUT. Judges would stop counting the results when participants moved out of the designated area. However, counting would continue until they entered the area. 1 participant participated in the DUT and the other participants waited for the trial by using zoom. Each participant tested 2 times in the DUT, and they were recorded by the judges by using the counter. After the test, the score of continuous double under was marked for each trial.

Test for muscular endurance also included the PUT, SUT, and RST. The PUT was designed to measure the performance of arm and shoulder extensor muscles (Esco, Olson & Williford, 2010). It was a typical measurement for the upper body muscular endurance (Seo et al., 2013). Yet, the SUT was aimed to measure the abdominal and hip flexor muscles (Parfrey et al.,2008) and the RST was a measure of the knee flexor and extensor muscles (Vaara et al., 2012). Three test reliability has been stated to be high among young adults (Ryman Augustsson et al., 2009).

Before those tests, all participants have informed of the correct posture. To complete PUT, participants located their hands about 10 – 20 cm wider than shoulder-width and kept a horizontal spinal position. They should keep their knee flexed about 90° with their feet raised up and also bent their elbows until their chest was roughly 12 cm from the mat (Esco, Olson &

Williford, 2010). To complete SUT, participants need to face up and lay on a mat, with a horizontal position with their knees bent. Participants should cross their arms at the chest level, their hands should put on the opposite shoulders (Parfrey et al.,2008), they should flex their trunk until the elbow touches the thighs. To perform the RST, participants stood with feet shoulder-width apart, the knee within a line with the ankle, and hands out for balance. Also, bend the knees and drop hips down and back. Knees should reach about 90°. During the three tests, all participants will be performing the maximum number of repetitions within 60 seconds and the correct posture will be counted by the test helper.

The weight training program should include the training 2-3 times per week for at least 4 weeks (Denadai et al., 2017). Chess press and wrist curl are commonly used in upper body exercise. Plank T and Bent-over row are used in core and back. Goblet squat and lunge are usually used in the lower body. All of the weight training is focused on the muscle used in rope skipping (Wong & Hong, 2004). The program contains 3 parts: fundamental endurance (3 weeks), functional endurance I (3 weeks), and functional endurance II (2 weeks). The purpose of the fundamental endurance phase is to increase basic muscular strength and the functional endurance phase I and II is to increase muscular endurance of the body (Saeterbakken et al.,2018). Details of weight training program design are presented in Table 2.

The weight training program was completed 2 training sessions per week, each session included 6 exercise and about 30 minutes duration of time. Each training session were instructed by a training instructor. The experimental group was required to attend a minimum of 80 % of the weight training sessions for a valid training quantity and they were needed to have a heart rate monitor and RPE for monitoring their body status.

Table 2. Weight training program design

Exercise Protocol	Reps/Time	Load	Sets	Equipment
Warm- up Exercise				
Running	5 minutes	/	1	/
Week 1-3 (Fundamental Endurance)				
Upper body: Chest press	20	20% 1RM	2	Barbell
Upper body: Wrist curl	20	20% 1RM	2	Barbell
Core: plank T	20	20% 1RM	2	Barbell
Back: Bent-over row	20	20% 1RM	2	Barbell
Lower body: Goblet squat	20	20% 1RM	2	Barbell
Lower body: Lunge	20	20% 1RM	2	Barbell
Week 4-6 (Functional Endurance I)				
Upper body: Chest press	25	25% 1RM	3	Barbell
Upper body: Wrist curl	25	25% 1RM	3	Barbell
Core: plank T	25	25% 1RM	3	Barbell
Back: Bent-over row	25	25% 1RM	3	Barbell
Lower body: Goblet squat	25	25% 1RM	3	Barbell
Lower body: Lunge	25	25% 1RM	3	Barbell
Week 7-8 (Functional Endurance II)				
Upper body: Chest press	30	30% 1RM	4	Barbell
Upper body: Wrist curl	30	30% 1RM	4	Barbell
Core: plank T	30	30% 1RM	4	Barbell
Back: Bent-over row	30	30% 1RM	4	Barbell
Lower body: Goblet squat	30	30% 1RM	4	Barbell
Lower body: Lunge	30	30% 1RM	4	Barbell

Base on this previous situation, I designed the participants cannot perform the other training program which could improve their rope skipping performance. Besides, I was preferred to use the barbell in rope skipping training since it is adaptable. Caterisano et.al (2018) stated that although there was some difference between the combined weight training program and barbell training, both barbell training and combined weight training could also improve power over a

5-week training period. Yet, endurance weight training was stated as using ≥15 repetitions and a load of ≤50 %1RM in the training of each exercise (Denadai et al., 2017). Thus, my study was followed by this principle in the endurance weight training program.

3.5 Statistical analysis

The data analysis was completed with IBM SPSS Statistics (version 26, IBM Corp). The outcome measures were the variables of DUT, PUT, SUT and RST, and all the subjective measures. All data were presented as mean ± SD. Two-way (Group X Time) repeated measures analysis of variance (ANOVA) was used to analyze the differences between the two groups (CON and EXP) from pre-test and post-test. Normality was checked the baseline data of the participants by using histogram and Kolmogorov-Smirnov Test, and homogeneity of variance assumption was checked by using Levenes' Test. The significance level was set at $p \leq 0.05$.

4. Results

All participants (n = 40) were completed in both pre-test and post-test. No significant differences were found between two groups (EXP vs. CON) in height (161.9 ± 7.4 vs. 159 ± 4.1 cm; p = 0.349), weight (56.3 ± 9.6 vs. 60.8 ± 6.6 kg; p = 0.312), experience year (4.8 ± 1.9 vs. 5.2 ± 2.2 years; p = 0.496) and double under test (DUT) performance (71.95 ± 29.20 vs. 76.55 ± 32.51; p = 0.640). There was also no difference was perceived in the training hours per week excluding the weight training in EXP.

Table 3 presented a summary of the test results in both pre-test and post-test. It showed that the results of DUT, PUT, SUT, and RST were significant in the experimental group. (DUT: p = 0.029; PUT: p = 0.029; SUT: p = 0.001; RST: p = 0.000) Also, only the result of RST was significant in the control group (RST: p = 0.001).

Table 3. Summary of the result in pre-test and post-test.

	Pre-test	Post-test
Double Under Test (DUT)		
EXP	71.95 ± 29.20	103.7 ± 32.19*
CON	76.55 ± 32.51	81.9 ± 32.29
Push-Ups Test (PUT)		
EXP	35.90 ± 7.36	43.65 ± 6.27*
CON	35.55 ± 6.57	38.80 ± 5.64
Sit-Ups Test (SUT)		
EXP	28.70 ± 8.63	45.10 ± 8.38*
CON	31.90 ± 8.97	35.00 ± 9.56
Repeated Squat Test (RST)		
EXP	36.90 ± 5.23	44.9 ± 5.37*
CON	34.75 ± 5.50	36.9 ± 5.12*

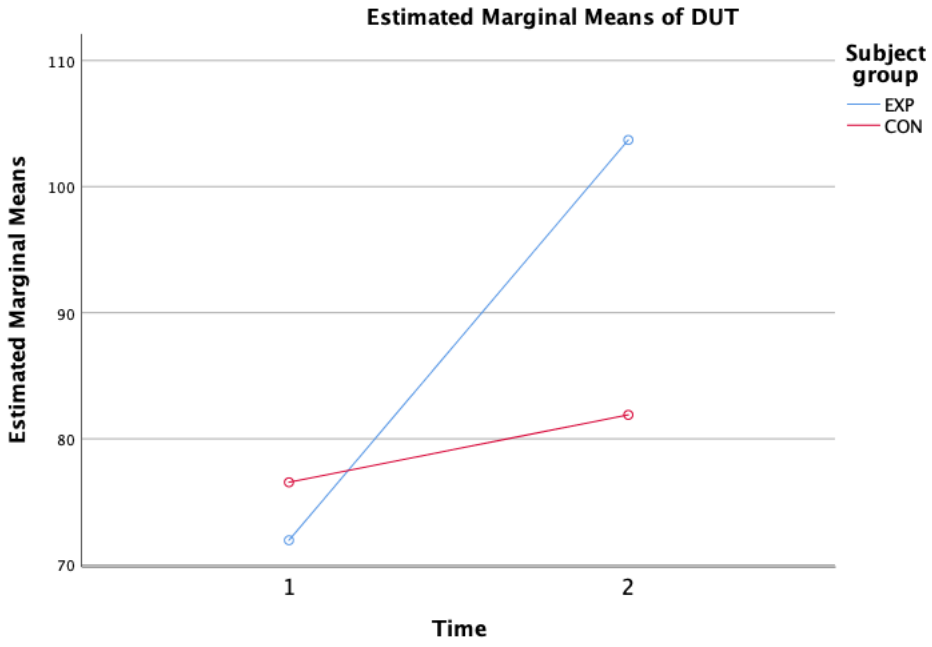
EXP: Experimental group, n = 20; CON: Control group, n = 20

*P< 0.05 in pre-test vs post test

Double Under Test (DUT) in experimental group and control group

The result of the Double Under Test (DUT) improved in the experimental group after an 8-week weight training program (pre-test vs. post-test: 71.95 ± 29.20 vs. 103.7 ± 32.19, p = 0.029, figure 3). However, it did not receive any significant results in control group (pre-test vs. post-test: 76.55 ± 32.51 vs. 81.9 ± 32.29, p = 0.120). Two-way repeated measures ANOVA was used to examine whether the weight training program can improve rope skipping performance of continuous double under. There was a statistically significant interaction effect (group x time) or group effect in two-way repeated ANOVA (F (1,38) = 74.766, p = 0.00).

Figure 3. The changes of DUT in two group.

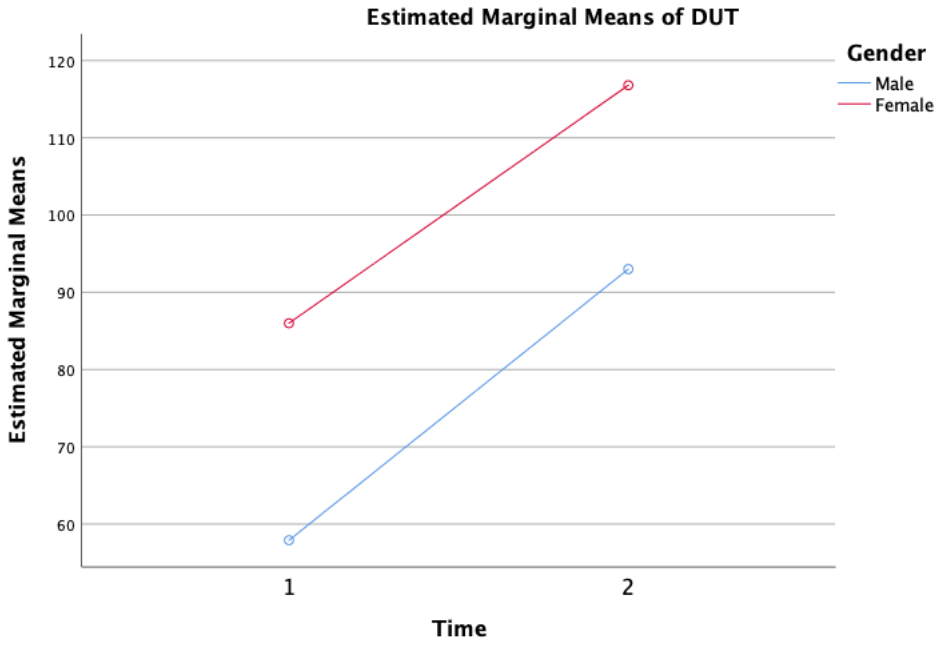


DUT: Double Under Test; EXP: Experimental group, n=20; CON: Control group, n=20

Gender difference in Double Under Test (DUT) in experimental group

The result of the Double Under Test (DUT) improved in the experimental group after an 8-week weight training program (female pre-test vs. post-test: 79.45 ± 31.2 vs. 97.7 ± 37.34, p = 0.00; male pre-test vs. post-test: 69.05 ± 29.82 vs. 89.55 ± 28.47, p = 0.00). Two-way repeated measures ANOVA was used to examine whether the weight training program can improve rope skipping performance of continuous double under. There was a statistically significant interaction effect (group x time) or group effect in two-way repeated ANOVA (F (1,46.225) = 0.777, p = 0.39).

Figure 4. The changes of PUT in female and male in experimental group.

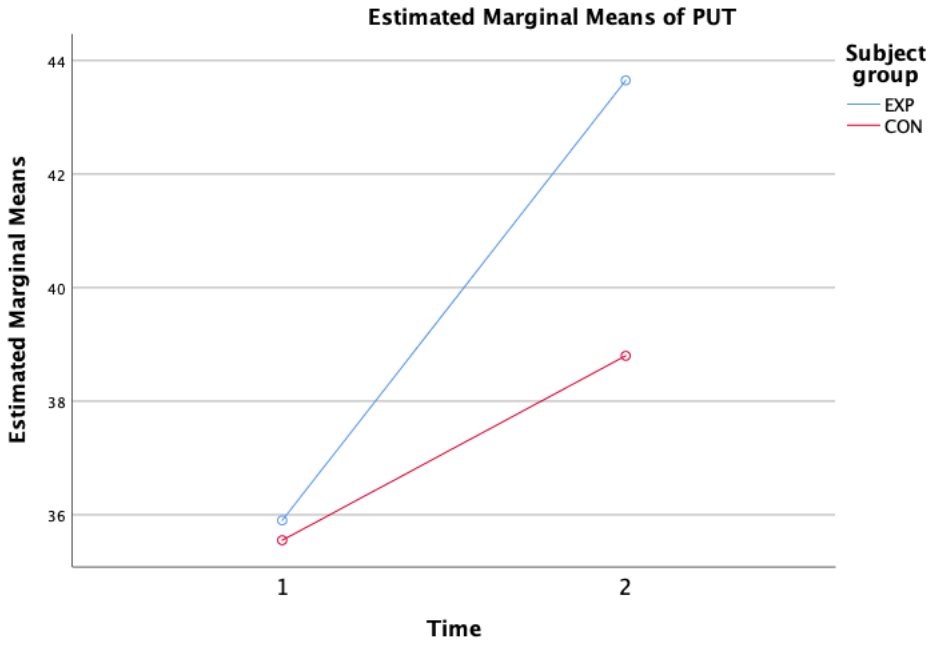


PUT: Push-Ups Test; Male, n=10; Female, n=10

Push Up Test (PUT) in experimental group and control group

Compared with the pre-test, the mean post-test of Push Up Test score increased in experimental group after 8-week weight training program (pre-test vs. post-test: 35.90 ± 7.36 vs. 43.65 ± 6.27, p = 0.029, figure 3). However, it was not significant in control group ((pre-test vs. post-test: 35.55 ± 6.57 vs. 38.80 ± 5.64, p = 0.08). Furthermore, there was an interaction effect (group x time) or group effect in two-way repeated ANOVA (F (1, 38) = 15.915, p = 0.295).

Figure 5. The changes of PUT in two group.

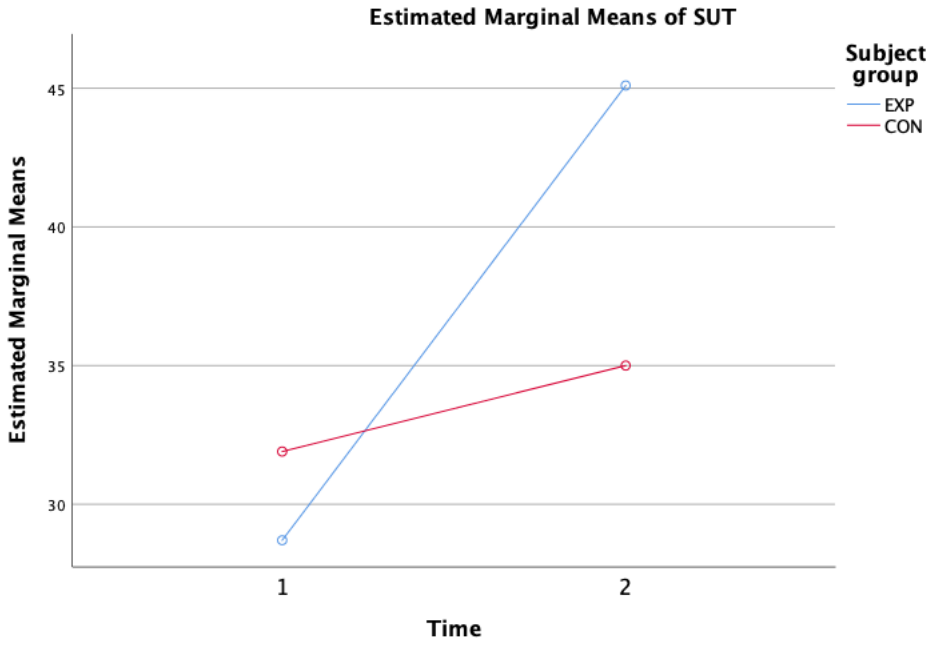


PUT: Push-Ups Test; EXP: Experimental group, n=20; CON: Control group, n=20

Sit Up Test (SUT) in experimental group and control group

The results SUT scores improved significantly in experimental group after the 8-week weight training program (pre-test vs. post-test: 28.70 ± 8.63 vs. 45.10 ± 8.38, p = 0.001, figure 4). But, not in control group (pre-test vs. post-test: 31.90 ± 8.97 vs. 35.00 ± 9.56, p = 0.198). Furthermore, there was a statistically significant group x time interaction (F (1,38) = 50.298, p = 0.047).

Figure 6. The changes of SUT in two group.

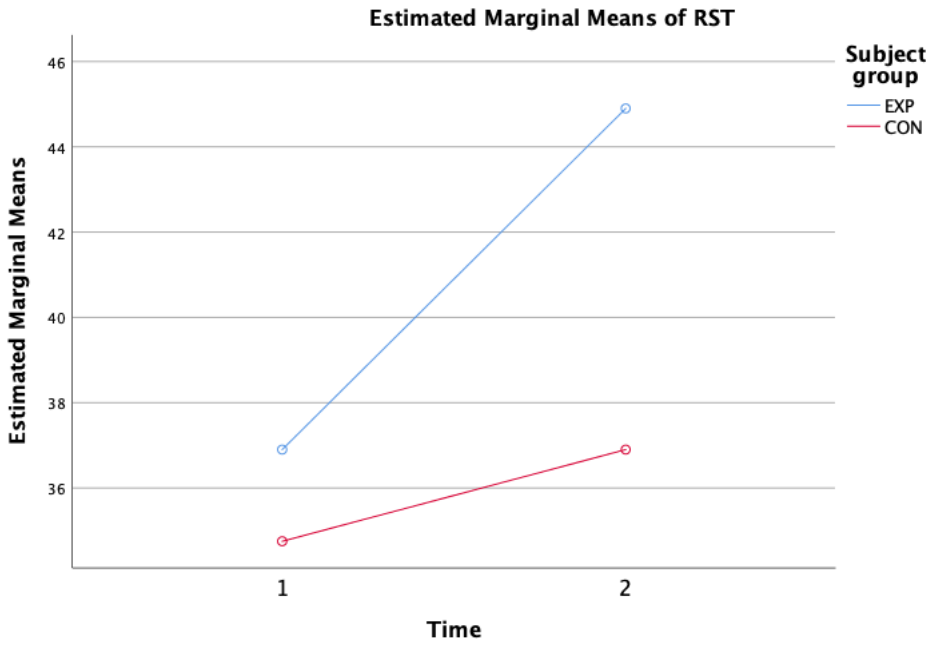


SUT: Sit-Ups Test; EXP: Experimental group, n=20; CON: Control group, n=20

Repeated Squat Test (RST) in experimental group and control group

The results of the Repeated Squat Test (RST) showed significant scores between the experimental group and control group by using two-way repeated measures ANOVA. Compare the pre-test results, the mean of post-test repeated squat test improved in both experimental group and control group (EXP: pre-test vs. post-test: 36.90 ± 5.23 vs. 44.9 ± 5.37, p = 0.000; CON: pre-test vs. post-test: 34.75 ± 5.50 vs. 36.9 ± 5.12, p = 0.001, figure 5) Furthermore, there was a statistically significant group x time interaction (F (1,38) = 50.298, p = 0.047).

Figure 7. The changes of RST in two group.



RST: Repeated Squat Test; EXP: Experimental group, n=20; CON: Control group, n=20

5. Discussion

The main finding of this research is that an 8-week weight training program may improve muscular endurance and the performance of continuous double under. To compare some pointers with the pre-test, DUT score, PUT score, SUT score, and RST score were increased in EXP after the additional weight training program. However, only the RST score was improved in CON.

The main reason for the success in increasing the performance of continuous double under because of the weight training program design. Weight training program involved the periodization and overall concept of training, the phase of fundamental endurance and functional endurance is the concept of periodization and subsequent programming, such as the exercise selection, volume, and intensity (DeWeese, et al., 2013). It is a logical, sequential method in weight training. Since many coaches used a large volume in weight training simultaneously, athletes cause fatigue easily and they could not achieve the best performance (Issurin, 2010). Thus, I try to increase the volume step by step and follow the goal of the periodization phase. The weight training could benefit the double continuous under because it could strengthen the muscular endurance, which is related to the characteristics of continuous double under.

Continuous double under requires muscular endurance such as the mass of the muscle to constantly contract and against resistance for a long period (Guglielmo, Greco & Denadai, 2009). As it required to jump as much as possible you can, muscular endurance support is the main theme in this exercise. In this study, it aimed at finding the changes in continuous double under, the DUT is preferred to measure the difference in continuous double under after 8 weeks

of the weight training program. As the muscular endurance could maintain and provide certain support for the body, it could maintain the exercise intensity (Bogdanis, 2012). Pre-test and post-test were applied in both groups. However, the control group did not receive and practice the weight training program in that period. Thus, the main intervention was the weight training program, and it may redirect changes in secondary school participants. A previous study showed that the subject squat lower after fatigue and they need to recruit more leg muscles to maintain the jumping frequency (Wong & Hong, 2004). So, a weight training program would increase their leg muscle and improve their jumping status. This study found that the post-test DUT score was significantly higher than the score in the pre-test in the experimental group (EXP) (Figure 2). To compare the pre-test the score of continuous double under in experimental group (EXP) and control group (CON), the percentage differences in the post-test score of continuous double under were + 44.1% and + 7.0% respectively. This shows that the experimental group (EXP) improved the most when comparing the control group (CON). Although both groups improved after 8-week training, the control group did not experience a weight training program, which may lead to a difference in the score of continuous double under in DUT. This finding is consistent with some of the similar previous studies, the well-trained athletes were improved their muscular endurance and vertical jumping ability after a 12-week weight training program, also they did not increase the total body mass. However, the group who did not participate in the weight training program did not receive an improvement in vertical jumping ability (Rønnestad et al., 2004). And another study stated that the muscle strength and the time of weight training program increased linearly for the participate in cycle ergometry. To compare with the weight training group, no weight training group only increased endurance by 23 min per week, which less than the weight training group approximately 18.6 min per week (Petrofsky & Laymon, 2004). Also, the weight training guided to an improvement

in running economy, especially the performance between 1,500 and 10,000 m distance (Alcaraz-Ibañez & Rodríguez-Pérez, 2017). Therefore, it seems that weight training is a great tool for improving muscular endurance, and also for the continuous double under. It is a better training method for the secondary school rope skipping participants.

There is no significant difference between gender in the double under test (DUT) in the experimental group. Weight training could improve endurance performance when they participate in 8-week training (Guglielmo, Greco & Denadai, 2009). There was some evidence to prove that both female and male improve their performance after the selected weight training (Bruce, Moull & Fischer, 2017). Thus, they have all improved the continuous double under since weight training could improve endurance performance.

The other purpose of the present study was to investigate the effect of 8-week weight training on muscle influence and effectiveness. The push-ups test (PUT), sit-ups test (SUT), and repeated squat test (RST) were typical measurement for body muscular endurance (Seo et al., 2013), three tests are valid and reliable as they have been tested in young adults (Ryman Augustsson et al., 2009). Push-ups test and sit-ups test have also been tested the physical characteristics of the young football player (Boyacı & Afyon, 2017).

The PUT performance was improved significantly in the experimental group but not in the control group (Figure 3). It showed that improvement after weight training. The PUT data implement that the arm and shoulder extensor muscles in the experimental group were well trained during the additional 8-week weight training to compare with the control group. A recent study revealed that increase weight loads progressively could achieve desired muscle

endurance in adolescents (Myers, Beam & Fakhoury, 2017). Therefore, it is achievable that weight training could improve the desired muscle group and its endurance. Yet, the CON did not receive a significant result in this item. This finding is consistent with the previous study, the experimental group who experienced the jumping exercise did not receive muscle strength in the arm (Sandstedt et al., 2013). Thus, it may not improve the score in the pre-test of PUT. The research suggested that using weight training in the training could also decrease sports-related injury and increase bone strength index (Myers, Beam & Fakhoury, 2017).

Moreover, the SUT for pre-test and post-test were practical in the experimental group (EXP) and control group (CON). This study found that the post-test data in SUT increased in EXP when they compared to the pre-test. The percentage difference in the SUT post-test increased by 57.1%. However, it did not show a significant result in CON. This result is consistent with the previous study, in which more trunk and head movement after jumping fatigue and the participants were unable to maintain the movement (Wong & Hong, 2004). SUT aimed to measure the abdominal and hip flexor muscles (Parfrey et al.,2008), plant T and bent-over row could increase the muscle in the core and back. When comparing the CON, they did not receive any training for the abdominal. Thus, the EXP have better SUT results.

The RST was significantly improved in both the experimental group (EXP) and control group (CON). Continuous double under required lower leg muscle and upper leg muscle, such as calf, quadriceps, and hamstrings, whenever the participants train rope skipping, those muscles could be trained (Wong & Hong, 2004). However, for those who joined the weight training program, they could gain more opportunity to train their muscle, especially the leg muscle and quadriceps. So, we could see the EXP have the faster progress results in the post-test.

There is some limitation in this study. First, the project used a hybrid model, which may affect the reliability of the pre-test and post-test data. As all the participants have taken different places during the pre-test and post-test, it may not fair to everyone. Second, there are fewer studies about kinematics in rope skipping, which may limit the application of the study. Despite there are some limitations in the study, the results may provide a useful reference for athletes and residents. Third, there are different rope skipping ability in my participants, especially there are discrepancy of continuous double under in female and male. Further studies are required to clarify how the heart rate affect the students in rope skipping performance, because weight training could change the heart rate performance in rope skipping. Also, the studies could invest how important for the weight training program in rope skipping. Studies may change the intervention pattern, such as the experimental group only participate weight training program and the control group continuous rope skipping training for 8-weeks.

6. Conclusion

In conclusion, an 8-week weight training program may improve the performance of continuous double under and muscular endurance in secondary students. Also, the weight training program should aim at additional training in rope skipping.

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Appendices:

A. Training log

Date	Time of training	Total of hours	Name of training	Location

B. Consent form (for parent)

THE EDUCATION UNIVERSITY OF HONG KONG

Department of Health and Physical Education

CONSENT TO PARTICIPATE IN RESEARCH

Effect of 8-week weight training program on rope skipping performance of continuous double under

I _____ hereby consent to my child participating in the captioned research supervised by Dr. Sun Fenghua, Bob and conducted by Kung Ching Yan, who are students of Department of Health and Physical Education in The Education University of Hong Kong.

I understand that information obtained from this research may be used in future research and may be published. However, our right to privacy will be retained, i.e., the personal details of my child will not be revealed.

The procedure as set out in the **attached** information sheet has been fully explained. I understand the benefits and risks involved. My child's participation in the project is voluntary.

I acknowledge that we have the right to question any part of the procedure and can withdraw at any time without negative consequences.

Name of participant _____

Signature of participant _____

Name of Parent or Guardian _____

Signature of Parent or Guardian _____

Date _____

INFORMATION SHEET

Effect of 8-week weight training program on rope skipping performance of continuous double under

You are invited to participate with your child in a project supervised by Dr. Sun Fenghua, Bob and conducted by Kung Ching Yan, who are students of the Department of Health and Physical Education in The Education University of Hong Kong.

The introduction of the research

A) The aims of the research are to examine the effect of an 8-week weight training program and find out the better training method on rope skipping performance of continuous double under in secondary school students.

B) Since you are study in the secondary school and participated in a rope skipping team, you are invited to participate in this study.

The methodology of the research

A) Participants: 40 participants will include in this study and I will ask for their contact email and phone in the beginning of the experiment.

B) Procedure of the research: As all participants are below 18 years old, students or/ and parents' approval will be completed before participating in this research. Participants with matched physical criteria and background will be assigned to two groups: a control group (CON) and an experimental group (EXP). Participants in the EXP will complete an 8-week weight training program, which includes using the flexible barbell. All participants will continue their regular rope skipping training (2 days per week) while the EXP attend two additional weight training sessions per week for 8 weeks. All participants will be required to complete two trials of rope skipping continuous double under test (DUT), one push-ups test (PUT), one sit-ups test (SUT), and one repeated squat test (RST) in both pre-test and post-test sessions. All the test will take place in the school hall and will take around an hour.

C) Potential benefits: Each participant will receive a $50 Wellcome coupon of reimbursements.

The potential risks of the research

Participate may feel muscular fatigue and injury when they do the exercise incorrectly. Thus, warm-up and continuous monitor will be adopted to avoid these risks. In the weight training program, participate will have 5 minutes running warm-up session, it can help get the body ready, such as increase muscle flexibility to make greater range of motion and with less muscle pain. Participates need to have a heart rate (HR) monitor and rate of perceived exertion (RPE) for monitoring their performance in their training session to avoid over fatigue. Also, each training sessions will be instructed by a training instructor. It could minimize the muscle fatigue and injury.

Your child's participation in the project is voluntary. You and your child have every right to withdraw from the study at any time without negative consequences. All information related to your child will remain confidential and will be identifiable by codes known only to the researcher.

Describe how results will be potentially disseminated

The result will be presented by the board presentation.

If you would like to obtain more information about this study, please contact Kung Ching Yan at telephone number or their supervisor Dr. Sun Fenghua, Bob at telephone number

If you or your child have/ has any concerns about the conduct of this research study, please do not hesitate to contact the Human Research Ethics Committee by email at hrec@eduhk.hk or by mail to Research and Development Office, The Education University of Hong Kong.

Thank you for your interest in participating in this study.

Kung Ching Yan
Principal Investigator

C. Consent form (for student)

THE EDUCATION UNIVERSITY OF HONG KONG

Department of Health and Physical Education

CONSENT TO PARTICIPATE IN RESEARCH

Effect of 8-week weight training program on rope skipping performance of continuous double under

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I understand that information obtained from this research may be used in future research and may be published. However, my right to privacy will be retained, i.e., my personal details will not be revealed.

The procedure as set out in the **attached** information sheet has been fully explained. I understand the benefits and risks involved. My participation in the project is voluntary.

I acknowledge that I have the right to question any part of the procedure and can withdraw at any time without negative consequences.

Name of participant _____

Signature of participant _____

Date _____

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Describe how results will be potentially disseminated

The result will be presented by the board presentation.

If you would like to obtain more information about this study, please contact Kung Ching Yan at telephone number or their supervisor Dr. Sun Fenghua, Bob at telephone number

If you have any concerns about the conduct of this research study, please do not hesitate to contact the Human Research Ethics Committee by email at hrec@eduhk.hk or by mail to Research and Development Office, The Education University of Hong Kong.

Thank you for your interest in participating in this study.

Kung Ching Yan
Principal Investigator