JASMINE SONG WEN HUI INCLINED TREADMILL SPRINT TRAINIG & PLYOMETRIC EXERCISE IN IMPROVING SPRINT PERFORMANCE

COMPARISON BETWEEN INCLINED TREADMILL SPRINT TRAINING AND PLYOMETRIC EXERCISE IN IMPROVING SPRINT PERFORMANCE AMONG HEALHTY YOUNG ADULTS

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DECEMBER 2022

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By

JASMINE SONG WEN HUI

A Research project submitted to the Department of Physiotherapy,
Faculty of Medicine and Health Sciences,
Universiti Tunku Abdul Rahman,
in partial fulfillment of the requirements for the degree of Bachelor of Physiotherapy (HONOURS)

December 2022

COMPARISON BETWEEN INCLINED TREADMILL SPRINT TRAINING AND PLYOMETRIC EXERCISE IN IMPROVING SPRINT PERFORMANCE AMONG HEALTHY YOUNG ADULTS

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ABSTRACT

Background and Objective:

Improving sprint performance helps in allowing athletes that utilizes explosive sprint such as track and field, soccer, and basketball to have a greater advantage. Therefore, the effect of intervention that can improve sprint performance should be studied on. Besides, there are limited studies in comparing inclined treadmill sprint training and plyometric exercise among healthy young adults in sprint performance in Malaysia. The objective of the study is to compare inclined sprint training and plyometric exercise in improving sprint performance in improving sprint performance among healthy young adults.

Methods:

A quasi-experimental design will be used as the research design. The population will be done through quota sampling and will be screen using questionnaire. The participants will be randomly assigned to two groups. 10-meter dash, vertical jump test and standing long jump test are used to assess the sprint performance. Statistical analysis will be done using SSPS software and Microsoft excel.

Results:

In the inclined treadmill sprint group, there is significant improvements in standing long jump test, vertical jump test and 10-meter dash ($p<0.05$) respectively. On the other hand, plyometric exercise significant improvement in both vertical jump test and 10-meter dash ($p<0.05$) except standing long jump ($p>0.05$). There is no significant difference between inclined treadmill sprint and plyometric exercise in improving sprint performance among healthy young adults through analyzing the vertical jump test, peak power and 10-meter dash ($p>0.05$) while standing long jump ($p<0.05$) being the only outcome measure that is significant.

Conclusion:

This study concluded the effect of both inclined treadmill sprint and plyometric exercise are significant in improving sprint performance which are the standing long jump, vertical jump test and 10-meter dash over a period of 4 weeks. However, there is no significant difference found between both intervention group.

Keywords: Inclined Treadmill Sprint, Plyometric Exercise, Sprint performance, Standing Long Jump Test, Vertical Jump Test, 10 Meter Dash, Young Healthy Adults

ACKNOWLEDGEMENTS

With the completion of this research project, I would like to express my deepest gratitude firstly to all the participants who participate in the project with full cooperation without whom none of this would be possible. I really appreciate the time and effort you have provided.

Next up, I would like to acknowledge the assistance and guidance my supervisor, Ms Premala a/p Krishnan, has provided me all the way back from the proposal preparation till now.

Lastly, I would like to thank my family and friends for all their support and understanding towards me throughout this process of producing the research project.

APPROVAL SHEET

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This Research project entitled "**<u>COMPARISON BETWEEN INCLINED TREADMILL SPRINT TRAINING AND PLYOMETRIC EXERCISE IN IMPROVING SPRINT PERFORMANCE AMONG HEALTHY YOUNG ADULTS</u>**" was prepared by JASMINE SONG WEN HUI and submitted as partial fulfilment of the requirements for the degree of Bachelor of Physiotherapy (HONOURS) at Universiti Tunku Abdul Rahman.

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PERMISSION SHEET

It is hereby certified that **JASMINE SONG WEN HUI** (ID No: **19UMB03720**) has completed this Research project entitled "COMPARISON BETWEEN INCLINED TREADMILL SPRINT TRAINING AND PLYOMETRIC EXERCISE IN IMPROVING SPRINT PERFORMANCE AMONG HEALTHY YOUNG ADULTS under the supervision of MS PREMALA A/P KRISHNAN(Supervisor) from the Department of Physiotherapy, Faculty of Medicine and Health sciences.

Yours truly,

(JASMINE SONG WEN HUI)

DECLARATION

I hereby declare that the Research project is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

Name: JASMINE SONG WEN HUI

Date: 24 DECEMBER 2022

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LIST OF ABBREVIATIONS

SSC	Stretch Shortening Cycle
Vmax	Velocity Max
IPAQ-SF	International Physical Activity Questionnaire Short Form
PAR-Q	Physical Activity Readiness Questionnaire
UTAR	Universiti Tunku Abdul Rahman
HEPA	Health-enhancing physical activity
M	Mean
SD	Standard deviation
n	Frequency

Chapter 1

INTRODUCTION

1.1 Chapter Overview

This chapter outlines the background of the research, giving a broad context regarding the research before moving on to the importance and relevance, research objectives and hypothesis and operational definition of terms used in the research.

1.2 Background Study

1.2.1 Sprinting

The title “the world's fastest human” is bestowed through breaking and setting the world record in the 100-meter sprint of the Olympic Games. There has been a dramatic progression in improving sprint performance as technology and training methods began to advance with a combination of improved footwear, sprinting techniques and running surfaces (Haugen et al., 2019). For example, a 0.7% mean performance improvement when the bending stiffness of the sprint shoes has carbon fiber plates inserted beneath the sock liner in the 20-40 m interval of 40-m sprints which concluded that the shoes help improve sprinting ability (Stephanyshin & Fusco, 2004). A rougher floor surface can negatively affect sprint performance (Haugen & Buchheit, 2016). Sprinting ability is also an important indicator for performance among long-distance runners that are elite in their field as there is a significant correlation between 10,000 m races and 100-m sprint time (13.3[0.7] s; $r=.68$, $P = .014$), 400-m sprint time (56.6 [2.7] s;$r=.69$, $P=.013$), and running economy (55.5 [3.9] $mL \cdot kg^{-1} \cdot min^{-1}$;$r=.59$, $P=.045$). Improving sprint performance is beneficial to various sports as being quicker means it is more advantageous to an athlete since it means that one will reach the ball at a quicker speed compared to the opponent (Stolen et al., 2005). Hence, increasing the anaerobic fitness qualities of the players is what needs to be considered when planning their training program.

The sprint-oriented training model was found to be as beneficial as endurance training in healthy and aging (Kusy et al., 2015). However, there is some difference in each training model. Long-term sprint-oriented training maintains improving bone mineral density, muscle mass, neuromuscular function and training adherence more effectively compared to endurance training(Kusy et al., 2015). The sprint model of lifelong physical activity should be taken into consideration as an alternative for maintaining recommended levels of essential health characteristics with aging in a healthy active person(Kusy et al., 2015).

1.2.2 Biomechanics of Sprinting

Sprinting is a type of anaerobic exercise, otherwise known as an exercise that consumes energy by breaking down glucose without using oxygen (Chertoff, 2018). Sprinting is influenced by various biomechanical variables such as technique, force production, reaction time, muscle structure and neural factors (Mero, Komi & Gregor, 1992). Sprinting includes a phase regarding quick acceleration phase continued with a velocity maintenance phase. The sprinters will have the upper body to be positioned in a forward-tilted position to direct the ground reaction forces more horizontally. According to Thomas (2017), in sprint events, the maximal running speeds are attained by generating a high force output, in other words, producing a high vertical ground reaction force over short contact times. The lower limb muscle strength and explosive power also play an important part in facilitating sprint performance.

1.2.3 Muscles used in Sprinting

The main contributor of braking and support during the braking phase of stance is the quadriceps whereas the main contributor during the propulsion phase in facilitating propulsion and support is the tricep surae (Hamner et al., 2010). During the part of propulsion in the stance phase during sprinting, hamstrings play an important role in producing a forward ground reaction force (Howard et al., 2018).

In the braking phase otherwise known as the early stance phase, co-contraction of the agonistic and antagonistic muscles occurs to facilitate stabilization. For example, the hamstrings and calves' co-contracts simultaneously with tibialis anterior and rectus femoris respectively (Howard et al., 2018). During the flight phase, the hamstrings and calves show minimal activity during knee flexion whereas the rectus femoris is active in the early swing phase and eccentrically contracts to execute hip extension and knee flexion. As the gait progresses to the late swing phase, the rectus femoris activates as the legs extend to prepare for ground contact. Rectus femoris is concluded to play a more important role as a knee extensor as opposed to a hip flexor (Thieme et al., 1987). Besides, the tibialis anterior also activates during the early swing phase to position the foot in a dorsiflexed position until it reaches the late swing phase as it prepares for ground contact. It plays the role of stabilizing accompanied by the activation of the calves during the braking phase.

Through analyzing the EMG peak time, it can be seen which muscles work the most in each phase. The knee extensors and gastrocnemius presented a stance peak from 98.8-100% in almost all strides (Guidettil et al., 1996). In the stance phase, the peak of EMG activity ranged between 67.6-100% with all muscles which are the vastus medialis, rectus femoris, bicep femoris, gastrocnemius and tibialis anterior being activated (Guidettil et al., 1996). In the stance phase, bicep femoris EMG activity was recorded to be 56%. In the initial swing phase, the rectus femoris and tibialis anterior experience peak activation (Guidettil et al., 1996). During the terminal swing phase of activation, a high frequency of occurrence ranging from 73.2-100% was observed in the hamstring, knee extensors, and calf muscle. (Guidettil et al., 1996). Maximum activity is shown in knee extensors and gastrocnemius in all strides with a percentage ranging from 88.8-98.5%, whereas the hamstring muscle, bicep femoris muscle to be more specific and tibialis anterior has an EMG activity of 44% (Guidettil et al., 1996).

1.2.4 Plyometric Exercise

Through stretch-shortening cycle exercises, fast eccentric resistance exercises and high-velocity resistance training, the type II muscle fibres can be amplified. Hence, training exercises that require external resistance factors are useful in improving acceleration speed (Dawes, 2012).

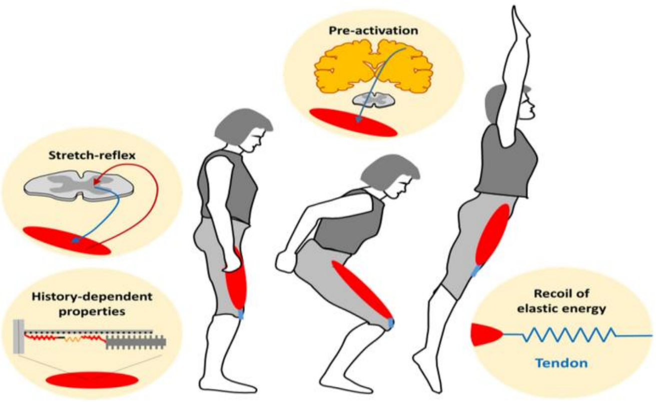

Figure 1: Potential mechanisms contributing to the performance-enhancing effect of in vivo muscle-tendon unit stretch-shortening cycles (Seiberi et al., 2021).

There are three phases of plyometric exercise which are the eccentric pre-stretch, amortization phase and concentric shortening phase (Davies et al., 2015). The first phase of the plyometric exercise is the eccentric pre-stretch phase or pre-loading. The neurophysiological biomechanical response is used to describe the muscle spindle of the muscle-tendon unit and tissues that are non-contractile are stretched within the muscles during the eccentric pre-stretch phase (Davies et al., 2015). Some studies concluded that the eccentric pre-stretch enhances the resultant contraction of the concentric muscle (Bosco et al., 1981, 1982; Bosco & Komi, 1979). The three stretch variables which are the amount of the stretch, length of the stretch and pace of the stretch are the predictors for the pre-stretch phase. Manipulating any of the variables previously stated would impact significantly the energy stored during the eccentric pre-stretch motion.

The next phase in the SSC is the amortization phase which is used to describe the duration from the end of the eccentric pre-stretch towards the beginning of the concentric muscle action otherwise usually known to be the electromechanical delay phase of plyometrics (Davies et al., 2015). As the muscle spindle fibres move from eccentric to concentric, there would be a time delay as there is a force generation and acceleration of muscular contraction follow by the elastic recoil in direction of the plyometric movement pattern to overcome the negative work of the eccentric pre-stretch (Cavanagh & Komi, 1979). It is a key phase for the performance of plyometric as it is found that it is more effective and powerful and can be achieved through a shorter amortization phase as stored energy can be used more efficiently in the transition. Potential energy can be lost due to a longer amortization phase which leads to a greater need for concentric forces applied to complete a set of movements (Heinecke, 2021).

The last phase will be the concentric shortening phase which can be also referred to as the resultant power production performance phase. This final phase results from various interactions involving the biomechanical response involving the elastic properties of pre-stretched muscles. The three phases work together to perform plyometric movement which can be used to enhance muscle power performance (Davies et al., 2015).

1.2.5 Inclined Training

Incline running involves different biomechanics of the lower limb compared to level running. The incline running condition results in a higher frequency of stride and decreased stride length compared to level running (Swanson & Caldwell, 2000). Besides, there is a greater proportion of duration spent in stance during the stride cycle in contrast to level running. Furthermore, the flexion angles of the hip, knee and ankle were significantly increased to maintain similar foot placement as level running (Swanson & Caldwell, 2000). In the swing phase, it also had been concluded that there is a significantly shorter swing phase duration due to the greater stride frequency (Swanson & Caldwell, 2000). This leads to a dramatically greater muscular loading with a larger hip ROM and velocities of flexor and extensor. During inclined running, the ability to produce force during the concentric phase is improved due to the increased pre-activation of muscles of the lower limb muscles as the extensor muscles experience the stretch-shortening cycle of early stance. In addition, the hip flexors that had improved muscular loading that occurs during incline running caused running speed to be enhanced (Swanson & Caldwell, 2000).

1.2.6 Importance and Relevance

Training of the lower limb is common in sports as most of it involves a lot of lower body movement which includes body control, strength, power, agility, and endurance so that the lower limb can perform better during competition. Sprinting is commonly associated with sprinters and runners, however, various other sports such as basketball, rugby and badminton also involve sprinting which can be crucial in a game. Improving sprint performance is beneficial to various sports as being quicker means it is more advantageous to an athlete since it means that one will reach the ball at a quicker speed compared to the opponent (Stolen et al., 2005). The anaerobic fitness qualities of a player are the most decisive moments in phases of goal scoring or defending in a competition. (Faude et al.,2012). Most scoring players in football play straight sprints (n = 161, 45% of all analysed goals, $P<0.001$) followed by jumps (n = 57, 16%), rotations and change-in-direction sprints (n = 22, 6%each) which shows that power and speed abilities are important in decisive moments in goal scoring (Faude et al., 2012)

1.2.7 Concluding Remarks

In a nutshell, this study is conducted to determine the effectiveness of inclined treadmill sprint and plyometric exercise each as a sole exercise on jumping distance, jumping height and sprint speed using outcome measures. The significant difference between inclined treadmill sprint and plyometric exercise can also be concluded through data and inferential analysis for hypothesis testing.

1.3 Research Objectives

1. To determine the effectiveness of inclined sprint training in improving sprint performance among healthy young adults.

2. To determine the effectiveness of plyometric exercise in improving sprint performance among healthy young adults.

3. To compare inclined sprint training and plyometric exercise in improving sprint performance among healthy young adults.

1.4 Hypothesis

H0i): Inclined sprint training has no significant effect in improving sprint performance among healthy young adults.

H1i): Inclined sprint training has a significant effect in improving sprint performance among healthy young adults.

H0ii) Plyometric exercise has no significant effect in improving sprint performance among healthy young adults.

H1ii) Plyometric exercise has a significant effect in improving sprint performance among healthy young adults.

H0iii) There is no significant difference between inclined treadmill sprint and plyometric exercise among healthy young adults.

H1iii) There is a significant difference between inclined treadmill sprint and plyometric exercise among healthy young adults.

1.5 Operational definition

a) Plyometric exercise refers to exercise training that increases muscular power by utilizing the speed and force of various motions (Robinson, 2020). In this study, front cone hops, lateral cone hops, standing jump and reach, lateral jumps over barriers, alternate bounding, diagonal cone hops, cone hops with 180-degree turn, cone hops with a change of direction sprint and single-leg vertical jumps are used as a plyometric training program.

b) Inclined sprint training refers to running in short bursts that are high intensity and are performed at top speed at an inclination. In this study, the participants will be sprinting on a treadmill. The workout consists of sprinting at a vertical incline of 8% and the number of sprints is progressively increased from 6 times to 12 times at the end of the week.

c) Sprint performance refers to determining how successful or good the action of sprinting is.

d) Sprinting refers to moving over a certain distance at top speed for a short period (Merriam-Webster, n.d.).

e) Healthy young adults refer to people who are between the ages 18-26 that does not have any underlying cardiovascular diseases or acute musculoskeletal, neurological, or orthopedic/musculoskeletal disorder (Bonnie et al., 2015)

f) The targeted Heart Rate after moderate-intensity physical activity would be 64% to 76% of the maximum heart, whereas the target heart rate would be 77% and 93% of the maximum heart rate after vigorous-intensity physical activity (Karvonen & Vuorimaa, 1988).

1.6 Structure of research

In this research paper, Chapter 1 is covering the background of the study including the research questions, research objectives, and importance and relevance of the study. Chapter 2 brings up the literature review done on the relevant titles and themes of past studies. Chapter 3 included the methodology of the research which discusses the research design, sampling design, research instrument and procedure of data collection in the research. Chapter 4 is followed subsequently to present the results collected after analysing through descriptive and inferential analysis as well as hypothesis testing. Chapter 5 concludes by featuring a discussion of the findings from the studies, limitations of the studies and recommendations for future studies.

1.7 Rationale

There are different types of specific sprint training methods. Which are specific and non-specific. Specific training is resisted sprinting such as inclined sprinting whereas non-specific training is a plyometric exercise. A systematic review and meta-analysis done by Eraslan et al., (2021), investigated that there is preliminary evidence that plyometric training can increase sprint performance in adolescent overhead athletes. According to Kavaliaukas et al., (2017), it has been reported that incline training sessions of 6 weeks twice weekly can improve aerobic and anaerobic performance measures.

Much literature had been done on the different exercises to improve sprint performance. A study done on plyometric exercise have a small sample size. Furthermore, Besides, to my knowledge, there is also limited research regarding the effects of inclined sprint training using a treadmill on sprint performance. In addition, Sáez de Villarreal et al., (2012) hsuggested that future studies can be done by trying to equate the same workloads when comparing groups. Besides, a scoping review is done suggesting the different future directions in plyometric jump training research that more research is needed among females, youth and individual sports due to insufficient studies (~24.0, ~37.0, and ~12.0% of overall studies respectively) and also identify the dose-response relationship following plyometric training is needed as there is insufficient coverage on the effect size values and training prescription (~34.0 and ~55.0% of overall studies, respectively (Ramirez-Campillo et al., 2018).

This study aims to compare the effect between inclined sprint training and plyometric exercise in improving sprint performance among healthy young adults. Both plyometric exercise and inclined sprint training exercises are important in developing the physical capabilities of athletes even though the mechanisms are different. However, a justification for which exercise can improve sprint performance effectively is needed. Coaches and trainers would need to formulate an exercise plan suitable for the athlete in a certain timeframe that is most effective in improving the physical capabilities of the athlete. Furthermore, in the case of bad weather, both exercises are suitable indoor which provides options to the coaches. Both exercises are also easy to access for all people who wish to increase their physical capabilities. They can also incorporate exercises done during the experiment in the future if they wish to.

The effectiveness of each exercise program will be done by conducting a 10-meter dash, vertical jump test and broad jump test. The test is chosen as there is a correlation between the test and sprint performance. 10-meter dash, vertical jump test and standing long jump test will be conducted. Comparison between the two exercises will be done by comparing the result of how much improvement of the sprint time and explosive power in the subject in each exercise.

1.8 Scope of Study

The study will be conducted in Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus. The study will involve full time university students studying in UTAR, Sungai Long Campus, age 18 to 26 years old. The university students that will be chosen are those who live a physically active lifestyle who have an interest in sprinting, track and field, badminton, and basketball. Sprint speed will be assess using a 10-meter dash. Muscle power will be determined through broad jump test and vertical jump height test.

1.9 Problem Statement

Much literature had been done on the different exercises to improve sprint performance. To my knowledge, study done on plyometric exercise mostly recruited athletes. Athletes had received a higher volume of training prior to the study; hence the results might be affected due to the physiological adaptations in the lower limb. The sample size they recruited are also smaller. There is also research conducted on comparing the effect different training protocols in short sprints acceleration kinematics, but there is limited study in comparing sprint training and plyometric exercise in sprint performance in longer distance (Lockie et al., 2012). Besides, to my knowledge, there is also limited research regarding the effects of inclined sprint training using treadmill on sprint performance. In addition, according to Sáez de Villarreal et al., 2012, he suggested that future studies can be done by trying to equate same workloads when comparing groups.

Chapter 2

LITERATURE REVIEW

2.1 Chapter overview

This chapter outlines the different literature that have been written in previous articles and journals which provides the draft for the research project.

2.1 Sprint Performance

Maximum sprint performance depends on different factors as it is a multifactorial phenomenon, such as muscle power, maximum dynamic strength, rate of force development and anaerobic power (Cronin & Hansen, 2005; Majumdar & Robergs, 2011). A cross-sectional study had researched on identifying the best predictors of maximum running speed among different strength-power exercise and tensiomyography (TMG) parameters (Loturco et al., 2019). Their result had shown that in both loaded and unloaded conditions, the faster athletes can perform better in the assessment in strength-power. Different studies had been extensively reported that there are strong associations between power and speed (Cronin & Hansen, 2005; Loturco et al., 2015; Young et al., 1995). Hence, I will be using exercises that helps to improve muscle power in my study and compare both exercise in their effects in improving sprint performance.

Vertical jump performance, standing long jump performance and 10-meter dash are found to be correlated in assessing sprint performance. According to previous study, high vertical jump performance is highly associated with sprinting over various distances such as from 10 to 60m (Comfort et al., 2014; Loturco et al., 2019; Smirniotou et al., 2008). Besides according to Baccarini & Booth, 2008, standing long jump appears to be related in assess the sprint performance. In addition, 10 metre dash is used to test and determine the acceleration and can be a reliable indicator for agility, speed and quickness. Hence, vertical jump test, standing long jump test and 10 metre dash will be used in assessing the sprint performance among healthy young adults.

2.2 Motorized Treadmill vs Overground Training

A meta-analysis and systematic review analysis of cross-over studies done by Van Hooren et al., (2019) to compare between motorized treadmill and overground running in their biomechanical outcomes. The findings of the study indicate that motorize treadmill can be comparable with overground running in terms of their biomechanics, but they are still aspects that differ from each other (Van Hooren et al., 2019). For example, the stiffness of the surface, experience and comfort, insufficient motor power, belt dimensions restriction and mechanical model that is compliant, different air resistance at higher running speed and altered speed perception. Hence, consideration would need to be taken when assessing the results.

According to a study done by Dorgor et al., (2020) to investigate the effects of overground training and motorized treadmill on body composition. Dorgor et al., (2020) had found that overground sprint training had result in a greater improvement in performance, but they still mentioned that motorized treadmill can still be a beneficial alternative. Hence, future research is needed how significant motorized treadmill can be used as an alternative training method in improving sprint performance as opposed to overground training.

Thus, research would need to be done in determining the training protocols and effectiveness of using motorized treadmill for sprint training to determine whether using treadmill can be a beneficial alternative to overground sprinting in improving sprint performance.

2.3 Effects of Inclined Sprint Training in Improving Sprint Performance

There are different sprint training methods that can be implemented in improving sprint performance over various distance. According to Rumpf et al. (2016), specific sprint training is beneficial in reducing sprint times, but non-specific training can still for supplement speed development for all distance. Hence, specific sprint training which is inclined treadmill sprint training will be used.

According to Kavaliaukas et al., (2017), it has been reported that incline training sessions of 6 weeks twice weekly is able to improve aerobic and anaerobic performance measures. A study had been done on combined sprint interval, plyometric, and strength training among adolescent soccer players (Ferley et al., 2020). The sprint interval training they implemented uses treadmill with different grades and levels. According to Ferley et al., 2020, they had concluded that level and inclined-based sprint interval training in combination of plyometric training and strength training improved measures of speed, change of direction, strength, and anaerobic capacity among a group of adolescent soccer players significantly. The result from this study is the combination of inclined-based sprint interval training with plyometric training and strength training. Hence, it is needed to investigate and compare the sole effect of inclined-based sprint interval training and plyometric training to know the significance of them in improving sprint performance as a single training. Besides, they had used adolescent soccer players that has a lack of reporting on the biological ages of the subject. Besides, athletes have other exercises in addition with the exercise done during the experiment which would affect the result of the study. Thus, a different population which are recreational players as they are a population that have a limited study on sprinting performance and only instruct them to do only the experimental exercises.

Adding inclination to treadmill sprinting is also a great way in adding in resistance and increase the intensity of the exercise. Traditionally, uphill sprinting is one of the ways in doing sprint in an inclined angle. Uphill sprinting involves sprinting up a surface that is steep such as sprinting on a slope. Treadmill sprinting is also one of the ways to do inclined sprinting exercises as depending on the model of the treadmill, inclination and declination can be set according to your choice. The difference between uphill sprinting and treadmill sprinting is that treadmill offered a controlled environment whereas being outside will force you to battle with the nature elements such as facing wind resistance and rain. Hence, treadmill will be used to facilitate a control environment for sprint training.

According to Slawinski et al., (2008), inclined ground sprint running was suggested to be beneficial in specific acceleration phase of sprint start and help in reducing hamstring activation throughout maximal sprint session. The study population is focused in adult population, hence there is a need to do a study on the effect of inclined sprinting among young adults as they physiology make up and metabolism are not the same. Besides, a study has been conducted in determining the effect of uphill and downhill training method in improving the maximum sprint speed (Paradisis et al., 2009). The study studies on effect of the combination of both uphill and downhill training, hence, it does not generalize the conclusion that inclined sprinting as a sole training exercise can improve sprint speed. There are also not many article that focus on solely inclined sprint training on the effectiveness of improving sprint performance. Thus, there is a need in investigating the inclined sprint training in improving sprint performance among healthy young adults.

2.4 Inclination and Duration of Treadmill

In stance phase, the stride frequency and percentage of stride spent were significantly higher in inclined speed running (1.78hz; 32.8%) compared to level speed running (1.39 Hz; 28.8%) condition (Swanson & Caldwell, 2000). Aside from that, all range of motion in extensor joint was greater for inclined speed running during push-off phase(Swanson & Caldwell, 2000). There is also a greater average generation of power and energy during hip flexion and extension during swing phase during inclined speed running (Swanson & Caldwell, 2000). By having an average resultant treadmill reaction force during stance must be roughly match the body weight to counteract the forces of gravity to maintain a consistent centre of mass position above the treadmill(Swanson & Caldwell, 2000). Hence, it was concluded that key mono- and bi-articular muscles receive greater muscular loading from inclined treadmill sprint during swing and stance phases (Swanson & Caldwell, 2000).

A study has been done to compare short bouts and long bouts of inclined treadmill running among distance runner which spans over 6 weeks. It has been concluded that both groups of intervention were able to improve significantly in all their test conducted; furthermore, short bouts of inclined treadmill running has a more significant improvement in lactate threshold and time-to-exhaustion at various conditions including 80%Vmax and 20% grade despite the inclined treadmill running in long bout consists of a longer duration and more interval of running ($p<0.05$) (Ferley et al., 2016). Besides, they stated that a sprint-like treadmill is more effective in enhancing a crucial factor that affect long distance running performance and better a preparing individual to run on courses of different varieties (Ferley et al., 2016).

A study assessing the electromyographic activity of the gluteus medius, rectus femoris, hip adductors, vastus lateralis, gluteus maximus, bicep femoris, medial hamstring and medial gastrocnemius during different inclination and speed (Wall-Scheffler et al., 2010). The 4 levels of inclination which are 0%, 5%, 10% and 20% has been shown to have significantly impacted the lower limb muscles ($p<0.03$). However, only bicep femoris and vastus lateralis continue to increase in activity when running up a slope and shown similar activity pattern during stance phase (Wall-Scheffler et al., 2010). Vastus lateralis is related significantly with hip internal rotation when walking or running in different inclined slopes ($r=-0.660$, $p<0.01$) (Salim et al., 2012). Rectus femoris on the other hand has increase dramatically throughout the beginning of stance and again at the beginning of the swing during level and inclined surface(Wall-Scheffler et al., 2010) Gluteus medius also shown muscle activity in some interactions in incline above 0% ($p=0.041$) and has higher activity especially in stance phase (Wall-Scheffler et al., 2010). Medial hamstring had also shown activity when 4 level of inclines are assessed ($p = 0.015$) (Wall-Scheffler et al., 2010).

2.5 The Effects of Plyometric exercise In Sprint Performance

Plyometric training is a sort of exercise training that improve muscle power by utilizing the speed and force of various movements (Davies et al., 2015). A few examples of plyometric training are running, jumping, throwing, hopping, and kicking. Usually, athletes can include plyometric training to ramp up the difficulty or versatile their exercise program (Davies et al., 2015). Plyometric training also does not require much equipment which is assessable. Furthermore, aside of being a standalone exercise, plyometric exercise can also be combined with other exercise program to further improve the strength, explosive power of muscle and agility of the athlete (Davies et al., 2015). Plyometric training makes use of the stretch-shortening cycle (SSC) through using an eccentric movement that is swiftly followed by a concentric movement (Davies et al., 2015). To increase the resultant force production and generate more tension, the plyometric movement employs the pre-stretch of the muscle tendon unit length-tension curve (Davies et al., 2015).

A systematic review and meta-analyses concluded that plyometric training shows that there is a small to moderate positive effect on sprint performance among healthy adults that are athletes or recreationally active (Oxfeldt et al., 2019). However, most of the literature they reviewed on has plyometric exercise incorporated into a multicomponent physical conditioning program which complicated the interpretation of studies as it cannot be ruled out that the positive effect from the intervention is due to a larger training volume or plyometric intervention as a sole exercise. Furthermore, there is a diverse training frequency, volumes and exercises being studied on which results in no optimal plyometric program exists (Oxfeldt et al., 2019). Besides, studies show heterogeneity proposed careful interpretation of the available information provided (Oxfeldt et al., 2019) In addition, a scoping review is done suggesting the different future directions in plyometric jump training research that more research is needed among females, youth and individual sports due to insufficient studies (~24.0, ~37.0, and ~12.0% of overall studies respectively) and also identify the dose-response relationship following plyometric training is needed as there is insufficient coverage on the effect size values and training prescription (~34.0 and ~55.0% of overall studies, respectively (Ramirez-Campillo et al., 2018).

Plyometric exercises have been an integral component in strengthening and late phases of rehabilitation programs. This type of exercise is among the various exercises that can assist in power development, a foundation in athlete which can enhance their performance of their sport (Davies et al., 2015). Plyometric exercise should be following the principle of progressive overload when determining the training intensity, exercise selection and volume(Davies et al., 2015). For example, lower intensities exercise should be introduced first, such as doing less complex exercise techniques, single-joint exercises then progressing to higher intensities such as doing more complex exercise techniques and multi-joint exercises (Davies et al., 2015).

A pilot study had been conducted done by Poomsalood and Pakulanon to assess the effect of 4-week plyometric training on agility, speed and muscle power in the leg among male university basketball players. They were able to conclude that the training group speed, agility and muscle power had a higher speed and agility compared to the control group (p = .003 and .001, respectively). However, limitation is presented as they mentioned that the significance differences in leg muscle power were not found due to the study being a pilot study and had only included male participants. Hence, there is a need for research to be conducted by including more participants and include female participants.

According to Sáez de Villarreal, et al. (2012), it was found that there is sprint performance is nonsignificant greater when plyometrics were performed in combination with other type of exercises such as weight training and electrostimulation. A study has been compared between plyometric training and strength training and it has been concluded that plyometric exercise is more beneficial in improving linear sprint, vertical jump, linear sprint and COD performance (Pardos-Mainer, 2021). Furthermore, according to López Ochoa (2015), a 4 weeks 8 session plyometric training can provide positive effects such as improving the capability in performing acceleration in the distance of 30 metres, enhance explosive strength, power, and maximum strength of the muscle. In this study, only 18 sedentary students are recruited, and it suggested to have future studies of having a larger sample size. Thus, a larger sample size would be recruited to have a more accurate average values and able to identify outliers in the data while providing a smaller error margin.

However, there is one authors had not shown improvement in sprint times with plyometric exercise. According to Furthermore, according to Sáez de Villarreal et al. (2013), incorporating plyometric exercise with full-squat, loaded countermovement jumping and parallel-squat results in light increase in displacement velocity and sprint performance. Hence, there is still a need to conduct research in determining the training protocols of plyometric training and the effectiveness of plyometric training as a sole training exercise in improving sprint performance by assessing the significance of improving sprint time and muscle power.

2.6 Effect of BMI on Sprint Performance

Body Mass Index (BMI) is commonly a tool in health care practice in that uses both weight and height to estimate weight status in relation to potential risk. According to the classification by Centres for Disease, Control and Prevention (CDC), BMI that is < 18.5 is underweight, BMI that is 18.5 to <25 is healthy weight, BMI that is 25.0 to <30 is overweight and finally BMI that is 30.0 or higher is in the obesity range.

A study had been conducted to assess the percentile values for six different sprint tests among 2.708 Spanish children age between 6 to 17.9 years. It had been concluded in this study that both underweight children and adolescent per have similar sprint performance, whereas overweight and obese group performed worser then their counterpart (Castro-pin et al., 2009). The author from this study suggested to control or reduce the weight to help in improving the sprint performance among adolescence (Castro-pin et al., 2009).

Furthermore, the relationship between body mass and running and jumping performances among young basketball players are assessed is examined. The study main finding was that there is an association of body mass status with running and jumping performance in young basketball players which there is negative correlation of BMI with running and jumping performances (Nikolaidis et al., 2015). Through the study, overweight players were determined to have the worst performance in running (sprint and endurance) and jumping (Pmean and CMJ) in U-12 and worst endurance in U-18 ($p<0.05$) (Nikolaidis et al., 2015).

There is also a study conducted to study the association between and health-related physical fitness among Chinese college students. Their study included standing long jump and 50-m sprint as a test for physical fitness (Silva et al., 2019). The result suggested that the relation between BMI and physical fitness was non-linear which also concluded that normal weight college students generally had a better physical fitness compared to obese, overweight, and underweight students, especially in males (Silva et al., 2019).

Hence, in this study, participants of the same BMI which are normal BMI (18.5kg/m^2-24.9kg/m^2) will be recruited to reduce bias.

2.7 Anthropometric Characteristics Affecting Sprint performance

Field Test of Performance and their relationship to age and anthropometric parameters were studied among adolescent handball players. It was concluded that there is moderate to very large univariate relationship between the performance in upper limb and lower limb muscles and the anthropometric characteristics of male handball players especially the body mass, height, and lower limb length (Hammami et al., 2019). There is significant correlation between standing height and 5-30 m sprint ($p<0.001$)

(Hammami et al., 2019). Height of volleyball players are also reported to have significant relationship with their jump performance (Aouadi et al., 2012). Besides, taller players have a significantly higher anaerobic power as opposed to their counterparts ($p<0.05$) (Kru¨ger et al., 2014)

Regarding jump distance, is has been found that there were no significant correlations anthropometry such as height, shank length, shank circumference, thigh circumference, leg length and body weight with jump scores. ($r<0.49$) (Wu et al., 2003). However, it was concluded that the take-off speed and take-off angle determine the jump distance and creating a 90-degree knee initial angle with free arm motion allows the longest distance in standing long jump (Wu et al., 2003). This is due to time of force applied on the muscle increased when the knee is bend 90 degrees resulting in a higher vertical and horizontal impulse(Wu et al., 2003). Hence, proper technique is needed to be taught among participants during pre-test session.

Thus, the height of the participants will be set as 160-175cm to include both male and female and still ensure the mean height between both interventions are similar.

Chapter 3

METHODS

3.1 Chapter overview

This chapter will outline the research methodology used in this study by mentioning the research design, sampling design, research instrument and procedure in detail.

3.2 Research Design

The research design used in this study is a quasi-experimental design with randomization of 1:1 allocation rate. It will be two arms as there are two interventions being given to the participants.

3.3 Research Setting

The experiment study location will be in the Physiotherapy Centre, KA345 and UTAR gym at Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus. The corridor of KA block 1st floor will be used as pre-test location for the doing 10-meter dash, vertical jump test. This location is chosen as the population chosen will be university students in UTAR. Besides, the tools and equipment such as treadmill and cones are available in the Physiotherapy Centre. Participants will be recruited at KA block and KB block of UTAR Sungai Long Campus. The participants of focus are students of UTAR who are still active in their academics during the time of their recruitment.

3.4 Participants Characteristics

The targeted population for this study is healthy young adults of a height of 160 cm -175 cm in UTAR who have an interest in track and field, badminton, or basketball. Physically active students that are under the category are recruited and had done resistance training in the lower limb before. Both male and female healthy student and those who had not experienced any lower limb injury or surgery were recruited. The eligibility of students are based on the inclusion and exclusion criteria of written below.

Inclusion Criteria

1. UTAR students who are at the age of 18-26 years old.

2. Physically active students, under the category of HEPA (health-enhancing physical activity)

3. Students who had done resistance training in the lower limb before (Potach, 2004)

4. Students who have an interest in track and field, badminton, or basketball and have a height of 160 cm – 175 cm.

Criteria for HEPA active:

(a) vigorous-intensity activity for at least 3 days and achieve at least minimum 1500 MET- minutes/week

(b) 7 or more days of any combination of walking, moderate -intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week

Exclusion criteria

1. Student who have cardiovascular diseases or acute musculoskeletal, or orthopedic disorder (Prieske et al., 2018)

2. Student who had any lower limb surgery in the past 6 months

3. Hypertension (resting systolic arterial blood pressure (BP) >140/90 mmHg)

4. Smoking

5. Student who have a BMI of below 18.5 or over 25.

3.5 Sampling Method

Sampling method used in this study was quota sampling method. Quota sampling method is used to select the participants that reach the selection criteria of the population.

3.6 Sample Size

The participants that are the focus of recruitment are UTAR students who are active in their academics during the time of participation. The sample size will be calculated using G*Power software version 3.1.9.4. T test family will be used and means difference between two dependent means (matched pairs) is chosen as statistical test. The alpha error problem will be 0.05 with a power of 0.8. The minimum total sample size is 27. A 20% dropout rate (attrition) is considered; hence 34 students will be recruited with 17 people in each group.

3.7 Research instrument

There are five components used in the instrument, which were consent form, demographic data and screening form, Personal Data Protection notice, International Physical Activity Questionnaire (IPAQ-SF) and instruments used for the experiment.

3.7.1 Form

There are four sections of the forms needed to be filled in by the participants. In the first section, a consent form is included to for participant to indicate their will to participate in the study. A brief introduction and description of purpose regarding the research, procedure, duration, and benefits and risk of the study. The contact number and email were given in the case if the participant wishes to contact the researchers. Next, Personal Data Protection notice is included to indicate the participants acknowledgement and agreement towards the research. In the second section, the demographic data such as Name, Age, Gender, Race, Year of study, Contact number, height, and weight. The BMI of the students are calculated using the height and weight is taken. The screening of exclusion criteria such as whether the participants have an interest in track and field, badminton, soccer, or basketball and resistance training of the leg. In the third section, it includes the screening assessment which consisted of IPAQ-SF and PAR-Q is used ensure participant meet the inclusion criteria of this study.

The International Physical Activity Questionnaire short form (IPAQ-SF) was used to assess the physical activity level of the participants. This is to check whether the participants fit the inclusion criteria of the study. Only HEPA active students of UTAR are recruited as they meet the inclusion criteria of the study. According to the IPAQ-SF, the criteria for HEPA active are i) vigorous-intensity activity for at least 3 days and achieve at least minimum 1500 MET- minutes/week OR ii) 7 or more days of any combination of walking, moderate -intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week.

The PAR-Q is used to screen for evidence of risk factors during moderate physical activity and reviews family history of disease and disease severity. Hence, candidates that are suitable for exercise testing and prescription can be recruited by filling out the questions present in PAR-Q,

3.7.2 Tools

Plyometric uses cones and barriers hence a total of 12 cones and 2 barriers are prepared to act as an obstacle during the exercise. The cones are used to execute front cone hops, diagonal cone hops, cone hops with sprints and lateral cone hops. Whereas barriers are used in executing lateral barrier hops. The stopwatch of the phone is used to measure the sprint time during 10-meter dash. Measuring tape is used to measure the distance for 10-meter dash, vertical jump test and standing long jump test. Cellophane Tape is used to mark the starting line and finishing line. The tape is also used to mark for vertical jump test and standing long jump test. Treadmill BH LK-G6700 Pro Action which is the treadmill in the Physiotherapy centre is used for incline sprint training. The validity of Vertical Jump Test is found to be (r=0.99, p=0.001) with intra-evaluator reproducibility (r=0.99, p=0.001) and for inter-evaluator reproducibility (r=1.0, p=0.001), hence can be concluded the Sargent Jump test to be valid and reproducible for measuring explosive strength (de Salles et al., 2012). The test-retest reliability for 10 m sprint test was found (ICC = 0.87) (Gabbett et al., n.d.).

3.8 Procedure

Participants will be recruited from different faculties in Universiti Tunku Abdul Rahman (UTAR), Sungai Long campus if they meet the inclusion criteria. The study is conducted in the Physiotherapy centre at UTAR KA block. The procedure and detail of the research will be brief to the participants, and they will be asked to fill in the consent form, personal data protection statement and questionnaire to get their consent, screen and obtain their demographic data. The participants will be assigned to two different groups through drawing lots. Both groups will be doing the exercise training program twice a week for 4 weeks. The participants will be advised to avoid strenuous physical activity, in addition to the intervention of study during the of the experiment.

Before starting the exercise, a 10 min of warm-up, including jogging, side shuffles, high knee exercises, lunges (forward and lateral), squats, and submaximal vertical jumps is done for the participants (Lum et al., 2016). Jogging is done for 5 minutes, whereas side shuffles, high knee exercises, lunges, squats, and submaximal vertical jumps are done for 3 sets and 15 repetitions. The cool down exercise will be straight walking for 5 minutes and static stretching of the lower limb muscle which are glutes, psoas, hamstring, quadriceps, calfs and adductors for 5 minutes.

Pre-Test

The participants will be doing pre-test at the beginning of the study. The pre-test is done 24-48 hours prior to the first training to ensure the pre-test done will not cause fatigue during the programme. Practice will be given to the participants before the testing for them to familiarize the movement. Standing long jump test, vertical jump test and 10-meter dash will be done. 10 meter-dash will be done twice, whereas vertical jump test and standing long jump test will be done three times. 2 minutes of rest will be given after each test. Data will be recorded down.

Standing long jump test

The standing long jump test will be conducted at a corridor at KA block. The participants will be in a standing position behind the starting line. The jump will be commenced by instructing the participants to swing their arms and bend their knees to provide the maximum propulsion forward. A two-foot take-off and landing will be used. The participants will need to jump as far as possible and be able to land on both feet without falling backwards. The participants will be doing the test three times and the longest distance will be recorded. The correlation of standing long jump test with sprinting is 20.81(Loturco, 2015).

The horizontal jump assessments (r = -0.73 to -0.86) is found to be reliable. (Maulder & Cronin, 2005).

Vertical Jump Test

The vertical jump test otherwise known as Sargent Jump test will be conducted in the stairway as the wall is high enough. Cello tape will be used to facilitate the reading of the vertical jump test by placing it on the tip of the participant middle finger. The participants will be instructed to be in a standing with arm extended above their head. The elbow should not be flexed, and the feet should be in contact with the ground. The participants are instructed to mark the highest point they can reach using their fingers. The standing reach height is measured first. Then, the participate would need to stand away from the wall and vertically jump as high as they can. The participant will then need to do a semi-squat and flex their hands to jump and mark the highest point they can reach. When jumping, the participants need to keep their knee in total extension as they reach for the highest point. The participants will be performing three jumps and highest jump will be taken. The validity is found to be (r=0.99, p=0.001) with intra-evaluator reproducibility (r=0.99, p=0.001) and for inter-evaluator reproducibility (r=1.0, p=0.001), hence can be concluded the Sargent Jump test to be valid and reproducible for measuring explosive strength (de Salles et al., 2012).

10-meter dash

Participants will get ready themselves on the starting line in four point starting stance. '3-2-1-Go' will be counted for the participants. The participants will accelerate maximally towards the finish line when 'Go' is shouted. The finishing time will be recorded to the nearest 2 decimal places once the participant crosses the finishing line. After the participant runs for three times, the average time will be taken to the nearest 2 decimal places. The test-retest reliability for 10 m sprint test was found (ICC = 0.87) (Gabbett et al., n.d.).

Performance Testing for Inclined Treadmill Group

A performance testing will be done for the inclined treadmill group to check for Vmax. The treadmill incline grade is set to be 1% grade and the participants are asked to complete a 2-min run on the treadmill which is counted as a stage. After each 2-minute completion of the treadmill, a 30 second pause is given to the participant to rest. The treadmill speed is then increased by 0.8 km/hr for each. Vmax is the speed when the participant can complete at least 90s of the 2-min stage; if less then 90s of the 2-min stage, the Vmax will be defined as the treadmill speed in the previous stage (Ferley et al., 2016).

The first group will be doing an inclined sprint training program. The participants will have a trial run on the treadmill for 2 times and the safety clip of the treadmill will be clip on the participants throughout the training. The program is using a treadmill in the physiotherapy centre. The treadmill the study will be using is Treadmill BH LK-G6700 Pro Action. The inclined treadmill protocol is by Ferley et al., 2016. The rest duration which is 65% HR max from the experiment is 1-2 minutes. Week will be separate to two days. The first session of each week will be running on the treadmill that have 10.0% treadmill grade and run at Vmax, whereas the second session of each week will be running on the treadmill that have 1.0% treadmill grade and run at 65% Vmax.

The second group will be doing plyometric exercise program. The plyometric exercise will be conducted in a progressive manner where it increases in intensity ask the week progresses. 2 sessions of plyometric exercise are prescribed to the participants. The subjects will be performing each task with maximum effort. For front cone hops, lateral cone hops, lateral jump over barriers, alternate bounding, diagonal cone hops, cone hops with 180 degree turn and cone hops with change of direction sprint, a work-to-rest ratio of 1:5 is recommended. For single-leg vertical jump and standing jump, 5 seconds of intraset rest interval and 2 minutes of rest interval interset are given.

Figure 2: Inclined Treadmill Sprint

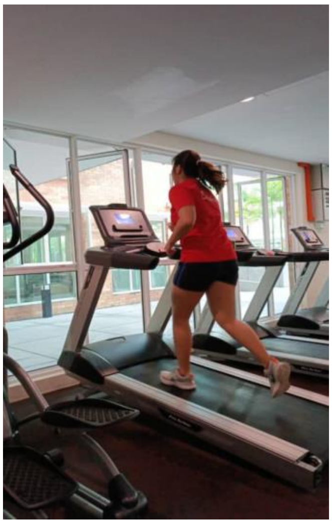

Figure 3: Different Plyometric exercise

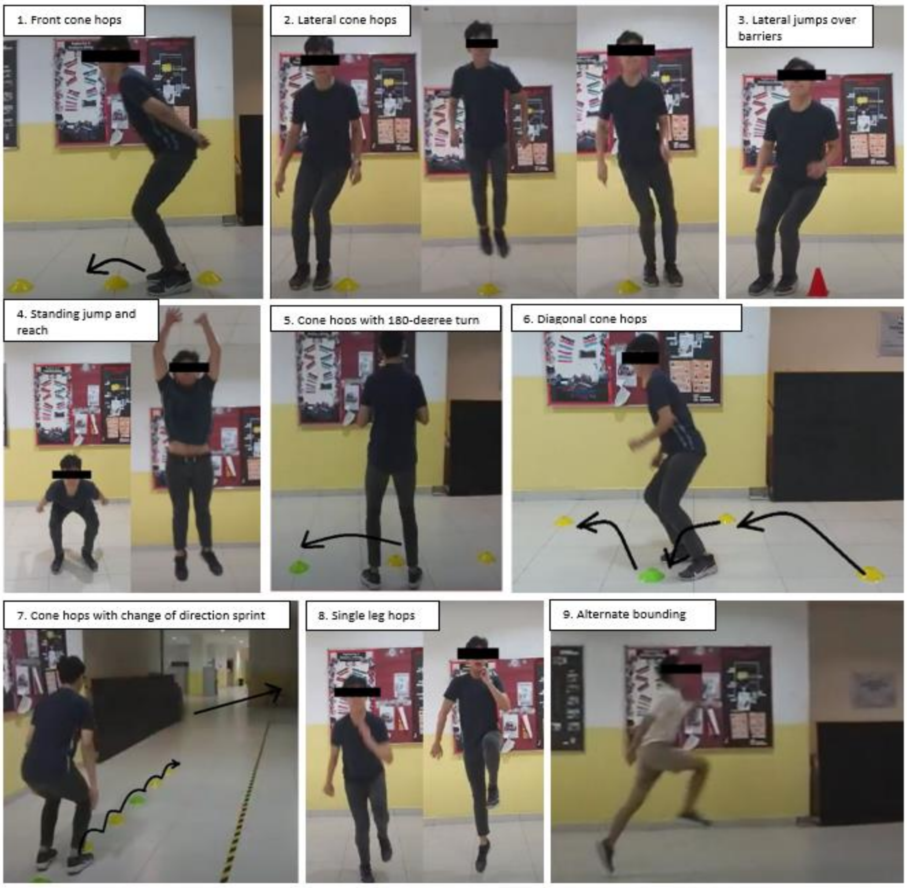

Table 3.1 Inclined Treadmill Protocol

	$Sessions·Wk^{-1}$	$Bouts·Session^{-1}$	Intensity	Treadmill Grade	Work Duration	Rest Duration
INC_{Short}						
Weeks 1–2	2	10	Vmax	10.0%	30 s	65% HRmax
	1	1	65% Vmax	1.0%	30 min	NA
Weeks 3–4	2	12	Vmax	10.0%	30 s	65% HRmax
	1	1	65% Vmax	1.0%	30 min	NA

Note. Retrieved from “Incline Treadmill Interval Training: Short vs. Long Bouts and the Effects on Distance Running Performance” by Ferley et al., 2016, *Journal of Sports Medicine*, *37*(12), 958–965 (https://pubmed.ncbi.nlm.nih.gov/27479460/).

Table 3.2: Plyometric Training Program

Training week	Training volume (Foot contacts)	Plyometric drill	Sets × Repetitions	Training intensity
1	100	- Front cone hops	3 × 12	Low
		- Lateral cone hops	3 × 12	Low
		- Standing jump and reach	4 × 7	Low
2	120	- Lateral cone hops	3 × 10	Low
		- Standing jump and reach	5 × 6	Low
		- Lateral jump over barriers	3 × 10	Moderate
		- Alternate bounding	3 × 10	Moderate
3	140	- Diagonal cone hops	3 × 8	Low
		- Lateral jump over barriers	3 × 8	Moderate
		- Cone hops with 180 degree turn	4 × 8	Moderate
		- Cone hops with change of direction sprint	4 × 8	Moderate
		- Single-leg vertical jump	4 × 7	High
4	120	- Diagonal cone hops	3 × 10	Low
		- Cone hops with 180 degree turn	3 × 10	Moderate
		- Cone hops with change of direction sprint	3 × 12	Moderate
		- Single-leg vertical jump	4 × 6	High

Note. Retrieved from “Effects of 4-week plyometric training on speed, agility, and leg muscle power in male university basketball players: A pilot study” by Poomsalood & Pakulanon, 2015, *Kasetsart Journal - Social Sciences, 36*(3):598-606.(https://www.researchgate.net/publication/298836618_Effects_of_4-week_plyometric_training_on_speed_agility_and_leg_muscle_power_in_male_university_basketball_players_A_pilot_study)

Criteria of termination of exercise will be when the patient is fatigue, have light headedness, confusion, ataxia, dyspnea, or nausea. The participants will be given time to rest until they no longer have shortness of breath.

The participants will be doing post-test at the end of the study. The testing will be done after 2 days of the last training session. 10-metre-dash, vertical jump test and standing long jump test will be done. 10 metre-dash will be done twice, whereas vertical jump test and standing long jump test will be done three times. 1 minutes of rest will be given after each test. The data will be recorded.

All the data are recorded in a table and both results are compared to determine if there is any improvement in sprint speed, jump height and jump length. Besides, it is to also to compare the effectiveness between two exercises in improving the sprint performance.

3.9 Data analysis

Data analysis was conducted through IBM SPSS software statistics version 26. To assess the difference of mean score of pre-test and post-test on sprint performance through using standing long broad jump, vertical jump test and 10-meter dash, paired sample t-test is used after testing the normality of the data. Besides, independent t-test was used in comparing the effects of inclined treadmill sprint and plyometric exercises on sprint performance. The effect of each demographic characteristics has on sprint performance among healthy young adults in UTAR are also tested using independent t-test.

3.10 Ethical approval

This study is subjected to ethical approval by the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman (UTAR). Informed consent from the participants is obtain before commencing the experiment. The participants will also be informed about the details and effect of the experiment. Data confidentiality is also upheld by keeping the information of the participants confidential.

Chapter 4

RESULTS

4.1 Chapter overview

This chapter will be presenting the findings collected during the data collection phase of this research project. The demographic information are presented first followed by the outcomes of the inferential tests continued on with hypothesis testing. A summary of the findings will be stated, and the tabulation of data will be included at the conclusion of each component. A total of 45 participants were recruited, 2 participants were excluded as they do not meet the inclusion criteria and 5 participants drop off due to an injury sustained from external factors outside of the intervention conducted for the research. All participants recruited were given consent for data processing.

Descriptive statistics will be used to report the frequency, frequency percentage, mean and standard deviation of the demographic data of participants which are the age, gender, race, BMI, and year of study. Then, normality test will be used to determine whether the data is normally distributed or not. Paired T test will be used to assess the significance of inclined treadmill sprint and plyometric exercise in improving sprint performance by analysing the pre-test and post-test of each outcome measures. Next, Independent T test will be used to assess the significant difference between inclined treadmill sprint and plyometric exercise in improving sprint performance based on the difference between pre-test and post-test.

4.2 Demographic of population

This section will be presenting the demographic characteristics of the participants using descriptions, graphs and a table that will be summarising the whole section.

There are 19 students in each intervention group. Referring to Table 4.1, the age range in this study is 18-22 years old. The greatest number of people in inclined treadmill sprint group have the age of 21 years old is 8(42.1%). It is then followed by age 20 years old which has a total of 7(36.8%) and age 22 years old of 2(10.5%). Both age 18 years old and 19 years old has the same number of people in the group which is a total of 1(5.3%). On the other hand, the greatest number of people in plyometric exercise have the age of 20 years old which is a total number of 3(15.8%) which is then followed by age 19 years old 5(26.3%). Both age 22 years old and 18 years old have the same number of people in plyometric exercise which are 3(15.8%). Participant that are 22 years old are the least in plyometric exercise group 1(5.3%). The mean and standard deviation in age of participants in inclined treadmill sprint and plyometric exercise are (M = 20.47, SD = 0.96) and (M=19.79, SD = 1.27) respectively.

The majority gender in both intervention group are male have a total of 15(78.9%), whereas the female with a total of 4(21.1%) in both intervention groups. All participants in inclined treadmill sprint Chinese, having a total number of 19(100.0%) people, on the other hand, the majority participants in plyometric group are Chinese, having a total number of 18(94.7%) people with only one Indian participant 1(5.3%). All participants have normal BMI in both interventions having a total of 19(100.0 %) in each group respectively. The mean and standard deviation of BMI in this study is 21.73 and 2.13 respectively.

In inclined treadmill sprint group, Year 2 students has the greatest number of participants by having a total of 7(36.8%), followed by Year 3 students having a total number of 6(31.6%) and Year 1 students totalling to be 5(21.1%). Both Foundation and Year 4 students have equal number of people by having only 1(5.3%) person. On the other hand, Year 1 students have the greatest number of participants by having a total of 8(42.1%) followed by Year 2 students 7(36.8%) people then foundation students having 3(15.8%) people and Year 4 students of 1(5.3%) people.

Table 4.1: Demographic of Population

	Inclined Treadmill Sprint n=19		**Plyometric Exercise n=19**	
Demographic data	n (%)	M (SD)	n (%)	M (SD)
Age		20.47		19.79
18	1(5.3)	(0.96)	3(15.8)	(1.27)
19	1(5.3)		5(26.3)	
20	7(36.8)		7(36.8)	
21	8(42.1)		1(5.3)	
22	2(10.5)		3(15.8)	
Gender				
Male	15 (78.9)		15 (78.9)	
Female	4 (21.1)		4 (21.1)	

Race				
Chinese	19 (100)		18 (94.7)	
Indian	0 (0)		1 (5.3)	
BMI		21.75 (2.30)		21.73 (2.13)
Normal	19(100.0)		19(100.0)	
Year of study				
Foundation	1(5.3)		3(15.8)	
1	5(21.1)		8(42.1)	
2	7(36.8)		7(36.8)	
3	6(31.6)		0(0.0)	
4	1(5.3)		1(5.3)	

4.4 Inferential analysis

Paired sample t-test and independent t-test are the inferential analysis used in this research to assess the research objectives and hypotheses. A brief description of the test utilised will be written in each section followed with the test's findings and tabulation of results. IMB SPSS Statistic version 26 was used to analyse the results.

4.3 Test of Normality

To test for Normality, Shapiro-Wilk is used in this study According to Table 4.2, beside the age of participants ($p<0.05$) being not normal, the pre-test and post-test values of both intervention p value are more than 0.05, which indicates the results obtained is normal.

Table 4.2: Test of Normality using Shapiro-Wilk

	Shapiro-Wilk		
	Statistic	**df**	**Sig**
Inclined Treadmill Sprint			
Age	0.877	19	0.019
Standing Long Jump Pre-test	0.934	19	0.203
Standing Long Jump Post-test	0.916	19	0.095
Vertical Jump Test Pre-test	0.949	19	0.377
Vertical Jump Test Post-test	0.934	19	0.206
10 Meter Dash Pre-test	0.935	19	0.215
10 Meter Dash Post-test	0.957	19	0.519
Plyometric Exercise			
Age	0.891	19	0.033
Standing Long Jump Pre-test	0.933	19	0.193
Standing Long Jump Post-test	0.962	19	0.620
Vertical Jump Test Pre-test	0.945	19	0.321
Vertical Jump Test Post-test	0.959	19	0.623
10 Meter Dash Pre-test	0.962	19	0.550
10 Meter Dash Post-test	0.962	19	0.612

p>0.05

4.4 Paired T test

To determine if the mean score obtained during the pre-test and post-test for the same set of participants in the outcome measure differs, a paired sample t-test is carried out.

The mean in pre-intervention of standing long jump distance in inclined treadmill sprint group is reported to be 190.83cm (SD=11.97cm) whereas the post-intervention mean is reported to be 202.80cm (SD=33.02cm). According to Table 4.3, there is significant difference being reported between pre-intervention and post-intervention in improving standing long jump distance in inclined treadmill sprint group ($p=0.003$, $p<0.05$). The data is presented have a 95% confidence interval (CI) [-19.30, -4.65]. On the contrary, the mean in pre-intervention of standing long jump distance in plyometric exercise group is reported to be 200.06cm (SD=44.16cm). whilst the post-intervention mean is reported to be 199.47cm (SD=37.63cm). There is no significant difference between pre-intervention and post-intervention in standing long jump distance in plyometric exercise group ($p=0.888$, $p>0.05$). A 95% confidence interval, CI [-8.08, 9.25] is reported through data analysis.

Table 4.3: Results of Paired sample t-test for Standing Long Jump

	Standing Long Jump				
	Pre-test (cm) M (SD)	**Post-test (cm) M (SD)**	**Diff**	**t**	**Sig**
Inclined Treadmill Sprint (n=19)	190.83 (38.87)	202.80 (33.02)	11.97	-3.43	0.003
Plyometric Exercise (n=19)	200.06 (44.16)	199.474 (37.63)	0.59	0.143	0.888

p value <0.05

Based on Table 4.4, the mean vertical jumping height in inclined treadmill sprint group for the pre-intervention is reported to be 45.88cm (SD=12.15cm) whereas the mean in post-intervention is reported to be 50.80cm (SD = 11.57cm). As observed in the table below, there is a significant difference in pre-intervention and post-intervention vertical jumping height of inclined treadmill sprint. ($p<0.001$, $p<0.05$). A 95% confidence interval, CI [-6.91, -2.92] is reported. The mean vertical jumping height in plyometric exercise for the pre-intervention is 50.26cm (SD=15.04cm) while the mean in post-intervention is reported to be 50.26cm (SD=13.74cm). There is significant difference between pre-intervention and post-intervention reported on vertical jump height in plyometric exercise based on Table 4.4. ($p=0.009$, $p<0.05$). A 95% confidence, CI [-4.81, -0.79] is reported.

Table 4.4: Results of Paired sample t-test for Vertical Jump

	Vertical Jump				
	Pre-test (cm) M (SD)	**Post-test (cm) M (SD)**	**Diff**	**t**	**Sig**
Inclined Treadmill Sprint (n = 19)	45.88 (12.15)	50.80 (11.57)	-4.92	-5.181	0.000
Plyometric Exercise (n = 19)	50.26 (15.04)	53.06 (13.74)	-2.80	-3.433	0.009

p value <0.05

According to Table 4.5, the mean in pre-intervention of 10-meter dash in the inclined treadmill sprint group is found to be 2.64s (SD=0.36s) while the mean in post-intervention is found to be 2.45s (SD=0.27s). There is significant difference between the pre-intervention and post-intervention in sprint speed for 10-meter dash in inclined treadmill sprint group ($p=0.007$, $p<0.05$). A 95% confidence interval, CI [0.06, 0.33] is reported. Next, the mean in pre-test of 10-meter dash in the pre-intervention of plyometric exercise group is reported to be 2.47s (SD=0.25s) while on the other hand, the post-test means of 10-meter dash is reported to be 2.35s (SD=0.20s). Similarly, there is significant difference being reported between pre-intervention and post-intervention of sprint speed in plyometric exercise group ($p=0.035$, $p<0.05$). A 95% confidence interval, CI [0.01, 0.23] is reported.

Table 4.5: Results of Paired sample t-test for 10 Meter Dash

	10 Meter Dash				
	Pre-test (s) M (SD)	**Post-test (s) M (SD)**	**Diff**	**t**	**Sig**
Inclined Treadmill Sprint (n = 19)	2.64 (0.36)	2.45 (0.27)	0.20	3.08	0.007
Plyometric Exercise (n = 19)	2.47 (0.25)	2.35 (0.20)	0.12	-2.282	0.035

p value <0.05

4.4.3 Independent T test

Firstly, independent T test is used to compare the difference in both intervention groups and determine the mean difference of gender in each intervention groups. This test is conducted to determine whether if the intervention influence the participants who are being assessed. After the data are thoroughly explained, a summary table will be at the end of each section with a closing summary for the significant independent t-test findings.

The significant difference between the effect of inclined treadmill sprint and plyometric exercise on sprint performance is tested through Independent T test. The mean difference is the difference between pre-test and post-test of jump distance obtained by conducting standing long jump test. As presented in Table 4.6, the mean difference of the jumping distance for inclined treadmill sprint and plyometric exercise is 12.56. A 95% confidence interval, CI

[1.61,23.52] is reported. The table shows that there is significant difference between the effect of inclined treadmill sprint and plyometric exercise on jump distance ($p=0.026$, $p<0.05$).

Furthermore, the comparison data between two intervention group on vertical jump test is analysed. The mean difference is the difference between pre-test and post-test of jump height obtained by conducting vertical jump test. According to Table 4.6, the mean difference of the jump height between inclined treadmill sprint and plyometric exercise is reported to be 2.12 with a 95% confidence interval, CI [-0.62, 4.84] reported. Based on the table, there is no significant difference between the effect of inclined treadmill sprint and plyometric exercise on jump height ($p=0.125$, $p>0.05$).

Finally, the data of 10-meter dash is also analysed. The mean difference is the difference between pre-test and post-test of sprint speed obtained by conducting 10-meter dash. The mean difference of the sprint speed in inclined treadmill sprint group and plyometric exercise group is -0.08. Similarly, there is no significant difference between the effect of inclined treadmill sprint and plyometric exercise on sprint speed ($p=0.355$, $p>0.05$).

Table 4.6: Mean difference of Standing Long Jump, Vertical Jump and 10-meter Dash between two groups

	Inclined Treadmill Sprint difference M (SD)	**Plyometric Exercise difference M (SD)**	**Diff**	**t**	**Sig**
Standing Long Jump (cm)	11.97 (15.20)	-0.59 (17.98)	12.56	2.326	0.026
Vertical Jump (cm)	4.92 (4.14)	2.80 (4.17)	2.12	1.570	0.125
10 Meter Dash (s)	-0.12 (0.25)	-0.23(0.34)	-0.08	-0.937	0.355

p value <0.05

4.5 Independent T test on Gender

The next independent t-test was carried out to test the effect of gender on the jump distance of both interventions. According to Table 4.7, the mean difference of jump distance of male is 11.68cm (SD=16.75) whereas the female group has a mean difference of 13.08cm (SD=8.69cm). The difference on jump distance between both gender is statistically insignificant (p=0.876, p>0.05) with a 95% confidence interval, CI [-19.95, 17.16]. In addition, the mean difference in jump distance in plyometric exercise group among male is -2.85cm (SD=18.37cm) whereas the female mean difference of jump distance is 7.90cm (SD=15.58cm), Similarly, the jump distance between both gender in plyometric exercise reported that no significant difference is observed. (p=0.301, p>0.05). The difference is also statistically insignificant with a 95% confidence interval, CI [-32.02, 10.51].

Table 4.7 Results of Independent t-test for Gender in Standing Long Jump

	Standing Long Jump (cm) Mean Diff (SD)		Diff	t	Sig
	Gender				
	Male	**Female**			
Inclined Treadmill Sprint	11.68 (16.75)	13.08 (8.69)	-1.40	-0.159	0.876
Plyometric Exercise	-2.85 (18.37)	7.90 (15.58)	-10.75	-1.067	0.301

p value <0.05

In addition, the effect of gender on the jump height of both interventions is analysed. According to Table 4.8, the mean difference of male in jumping distance in inclined treadmill sprint group is 4.67cm (SD=4.40cm) whereas female has a mean difference of 5.83cm (SD=3.33cm). There is no significant difference between male and female in jump height in inclined treadmill sprint. (p=0.634, p>0.05). A 95% confidence interval, CI [-6.17, 3.87] is reported. In addition, the mean difference in jumping height in plyometric exercise group among male is 2.54cm (SD=4.54cm) whereas there is a mean difference of 3.78cm (SD=2.54cm) among females. Similarly, there is no significant difference between both gender group (p value = 0.613, p>0.05). A 95% confidence interval, CI [-6.29, 3.82] is reported.

Table 4.8 Results of Independent t-test for Gender in Vertical Jump

	Vertical Jump (cm) Mean Diff (SD)		Diff	t	Sig
	Gender				
	Male	**Female**			
Inclined Treadmill Sprint	4.67 (4.40)	5.83 (3.33)	-1.15	-0.484	0.634
Plyometric Exercise	2.54 (4.54)	3.78 (2.54)	-1.24	-0.515	0.613

p value <0.05

Lastly, the effect of gender on sprint speed improvement of both interventions is analysed. According to Table 4.8, the mean difference of male in sprint speed in inclined treadmill sprint group is -0.17s(SD=0.30s) while female has a mean difference of -0.32s(SD=0.16s). There is no significant difference observed between male and female in sprint speed improvement (p= 0.357, p>0.05). A 95% confidence interal, CI [-0.19,0.49] is reported. In addition, the mean difference in sprint speed in plyometric exercise group among male is -0.12s (SD=0.28s) which is the same as female -0.12s (SD=0.12s) but having different standard deviation. There is no significant difference between male and female in sprint speed improvement for plyometric exercise group (p=0.987, p>0.05). A 95% confidence interval, CI [-0.21,0.21] is reported.

Table 4.9 Results of Independent t-test for Gender in 10 Meter Dash

	10 Meter Dash (s) Mean Diff (SD)		Diff	t	Sig
	Gender				
	Male	**Female**			
Inclined Treadmill Sprint	-0.17 (0.30)	-0.32 (0.16)	0.152	0.948	0.357
Plyometric Exercise	-0.12 (0.28)	-0.12 (0.12)	-0.002	-0.016	0.987

p value <0.05

4.6 Hypothesis Testing

H0i): Inclined sprint training has no significant effect in improving sprint performance among healthy young adults.

H1i): Inclined sprint training has a significant effect in improving sprint performance among healthy young adults.

The paired sample t-test was conducted to determine the significant effect of inclined sprint training in improving sprint performance. The confidence level is set as a=0.05. If the p value is <0.05, the null hypothesis will be rejected whereas if the p value is >0.05, the null hypothesis will be failed to reject.

The standing long jump, vertical jump and 10-meter dash has a p value <0.05 (p=0.003, p<0.001, p=0.007) respectively. Hence, null hypothesis is rejected. In conclusion, inclined sprint training has a significant effect in improving sprint performance among healthy young adults.

H0ii) Plyometric exercise has no significant effect in improving sprint performance among healthy young adults.

H1ii) Plyometric exercise has a significant effect in improving sprint performance among healthy young adults.

The paired sample t-test was conducted to determine the significant effect of inclined sprint training in improving sprint performance. The confidence level is set as a=0.05. If the p value is <0.05, the null hypothesis will be rejected whereas if the p value is >0.05, the null hypothesis will be failed to reject.

The vertical jump, anerobic power and 10-meter dash has a p value <0.05 (p=0.009, , p=0.035) respectively but standing long jump has a p value >0.05 (p=0.888). Hence, null hypothesis is rejected. In conclusion, plyometric exercise has a significant effect in improving sprint performance among healthy young adults.

H0iii) There is no significant difference between inclined treadmill sprint and plyometric exercise among healthy young adults.

H1iii) There is a significant difference between inclined treadmill sprint and plyometric exercise among healthy young adults.

The paired sample t-test was conducted to determine the significant effect of inclined sprint training in improving sprint performance. The confidence level is set as a=0.05. If the p value is <0.05, the null hypothesis will be rejected whereas if the p value is >0.05, the null hypothesis will be failed to reject.

The vertical jump and 10-meter dash has a p value of >0.05 (p=0.125, p=0.355) whereas p value of standing long jump <0.05 (p=0.026). Hence, null hypothesis failed to reject. There is no significant difference between inclined treadmill sprint and plyometric exercise among healthy young adults.

Chapter 5

DISCUSSION

5.1 Chapter Overview

This chapter discusses the findings of the study and compares the results with previous studies. The improvements of standing long jump test, vertical jump test and 10-meter dash in both interventions will be discussed accordingly. This is then followed by limitation of the study and recommendation.

5.2 General findings of the Study

The purpose of this study is to compare inclined treadmill sprint and plyometric exercise in improving sprint performance which are speed, horizontal jump distance and jump height among healthy young adults. Besides, the effect of each intervention are analyse to determine whether there are significant improvement on each outcome measures. The result in the study shows that both inclined treadmill sprint and plyometric exercise improved the sprint performance significantly among healthy young adults. In the inclined treadmill sprint group, there is significant improvements in all 4 outcome measures which are standing long jump test, vertical jump test and 10-meter dash ($p<0.05$) respectively. On the other hand, plyometric exercise significant improvement in both vertical jump test and 10-meter dash ($p<0.05$) however there is no significant improvement in the standing long jump ($p>0.05$). Furthermore, there is no significant difference between inclined treadmill sprint and plyometric exercise in improving sprint performance among healthy young adults through analyzing the vertical jump test, peak power and 10-

meter dash ($p>0.05$) while standing long jump ($p<0.05$) being the only outcome measure that is significant.

5.3 Effect of Inclined Treadmill Sprint on-Sprint Performance

Firstly, not much of previous studies had studied on the effect of inclined treadmill training on standing long jump. However, uphill running is similar in running on a treadmill with inclination. There had studies done previously on the effect of uphill running on jump performance. After 8 weeks of training among the training group that underwent uphill running, statistically significant changes are observed with a medium effect size on standing broad jump among prepubertal children (Jaimes et al., 2021). The mentioned study had a different population compared to the current study as being prepubertal children and another as young adults and the mentioned study did not state the inclination of the hill used to conduct uphill running. Hence, the chosen population results can be added in as relevant data for future studies.

Moreover, the findings from this research are found to be in line with existing data regarding vertical jump. There are statistically significant changes in vertical jump height by having a large effect size after uphill running (Jaimes et al., 2021). The experiment is statistically significant due to having a large sample size of 63 people. Apart from that, another study had similar finding of this research which supported that uphill running training program is strongly proven to improve jump height after 8 weeks of running with progressive intensity on 30-degree elevation of treadmill (Singh, 2011).

Besides, the finding of this research is agreement with previous studies on this topic. There is significant improvement in the sprint time among professional hockey players after completing 4 week of uphill repeated sprinting training (Jakeman et al., 2016.) According to Kavaliauskas et al., (2017), an uphill sprinting of running 10 times 10 seconds sprint on an inclination of 7% gradient can improve the sprint speed of soccer players. The present study included more participants by having a total of 38 participants compared to the study mentioned previously which recruited 14 male soccer players. Uphill running has been demonstrated to provide in greater activation of lower limb muscle which are the adductors (83±8%), gluteal group (79 ±11%), bicep femoris (79 ± 7%), gastrocnemius (76 ±15%) and vastus group (75 ±13%), each playing crucial role in contributing the braking phase and propulsion phase of sprinting (Sloniger et al., 1997). Individuals running on the treadmill need to produce sufficient resultant on the treadmill bet to counteract the speed of the treadmill and the gravity force (Brown, 2002). High-speed incline, the adaptation in the muscles results in an increase muscle activation of the lower extremity resulting in a larger mechanical load on the hamstring (Gregory, M et al., 2007).

The incline running condition results in a higher frequency of stride and decreased stride length compared to level running (Swanson & Caldwell, 2000). Besides, there is a greater proportion of duration spent in stance during the stride cycle in contrast to level running. Furthermore, the flexion angles of the hip, knee and ankle were significantly increased to maintain similar foot placement as level running (Swanson & Caldwell, 2000). In the swing phase, it also had been concluded that there is a significantly shorter swing phase duration due to the greater stride frequency (Swanson & Caldwell, 2000). This leads to a dramatically greater muscular loading with a larger hip ROM and velocities of flexor and extensor. This then increases the muscle strength in the lower limb. During inclined running, the ability to produce force during the concentric phase is improved due to the increased pre-activation of muscles of the lower limb muscles as the extensor muscles experience stretch-shortening cycle of early stance (Swanson & Caldwell, 2000). In addition, the hip flexors that had improved muscular loading that occurs during incline running causes running speed to be enhanced (Swanson & Caldwell, 2000).

5.4 Effect of Plyometric Exercise on Sprint Performance

The findings from this research consistent with different past research which have proposed the idea that plyometric training can improve sprinting ability. The finding of this study coincides with previous study which stated that there is no remarkable improvement shown in the explosive parameters used in the study such as standing long jump after 16 weeks of plyometric exercise ($p>0.05$) (Vassil & Bazanovk, 2012). Nevertheless, there is also research that contradicts with the study result. Long-jump performance had shown to improve substantially among elite basketball players after 6 weeks, 2 sessions per week of plyometric training consisting of unilateral and horizontal jumps (Gonzalo-Skok et al., 2019). It is speculated that there is no significant improvement in the horizontal jump distance due to the plyometric exercise used in this study being designed according to the playstyle of basketball which involves mostly jumping vertically and sprinting. Another possible explanation that plyometric provides a weaker effect on improving jumping distance could be due to the specificity nature of plyometric training and optimizing muscle stimulation during the exercises (Saéz et al., 2012). In addition, both vertical and horizontal motion is required in standing long jump which results in the complexity of the exercise (Saéz et al., 2012).

There is an agreement between the vertical jump result obtained in this study and result studied by Asadi (2011) who concluded that there is a significant improvement in vertical jumping among male students who are in college after a set of fixed plyometric exercises which are depth jump and countermovement jump for 6 weeks. A high-intensity plyometric program can positively affect the sprint performance after training for 6 weeks (Asadi & Arazi, 2012). Furthermore, Verma et al. (2014) concluded that 6 weeks of plyometric training brought about significant improvement among untrained students. Kotzaminidis (2006) findings also coincides with the study revealing that there is positive effect of plyometric training on vertical jumping performance. The improvements in vertical jump from this study could be attributed due to the enhanced muscle coordination and stronger muscle power through neural adaptations in the nervous system by utilizing the SSC which is a mechanism used in plyometric exercise (Arazi et al., 2014).

Furthermore, sprinting ability is enhanced after 4 weeks of plyometric training. Plyometric training had found to improve the sprint time after training for 6 weeks on sand (Asadi 2011). These findings also supported a conclusion by Kotzamanidis (2006) who stated in the study that a 20-session consisting of 10-week x 2 sessions per week of plyometric training leads to significant improvement in sprinting. Sprint performance is also impacted positively through high-intensity plyometric program after a training of 6 weeks (Asadi & Arazi, 2012). It is likely due to the incorporation of sprint specific plyometric exercise and jumps with horizontal displacement in the program providing greater horizontal acceleration which helps in sprint performance gains (Sáez de Villarreal, et al., 2012).

Plyometric exercise uses SSC to strengthen the muscle allowing improve explosive power in the lower limb. During plyometrics, an important role is played by the contractile component of the actin and myosin with coordination of the sarcomere in motor control and development of force (Davies et al., 2015). The physiological length-tension curve of the muscle-tendon unit is used during pre-stretch face to enhance the ability of the muscle fibre in helping to generate more tension and resultant force production (Davies et al., 2015). Then, when the concentric action of the muscles occurs, the greatest power is produced during plyometrics which explained the reason the amoritization phase is critical to produce optimum development of power in a muscle (Davies et al., 2015). According to Davies et al., (2015), Recruitment of voluntary contractions of skeletal muscles such as the fast twitch fibres of

IIa, IIb which are crucial in power development occurs through high intensity and high speed of plyometric exercise.

5.5 Comparison between Inclined Treadmill Sprint and Plyometric Exercise on Sprint Performance

Research that has been done regarding the comparison between inclined treadmill sprint and plyometric exercise has been observed to be not widely explored. The findings in these results indicates that there is no significant difference between inclined treadmill sprint and plyometric exercise in improving sprint performance among healthy young adults especially in the vertical jump and 10-meter dash. However, there is significant difference found between inclined treadmill sprint and plyometric exercise in improving the horizontal jump distance.

The result could be theorized due to plyometric being a more specific exercise (Saéz et al., 2012). A plyometric exercise consisting of more horizontal jumps can be beneficial in improving the results of jump distance (Saéz et al., 2012). In addition, both vertical and horizontal motion is required in standing long jump which results in the complexity of the exercise (Saéz et al., 2012). Moreover, incline running satisfy the requirements of being a high-velocity and sport-specific training. Previous study had documented there is increased step length and reduced contact times when accelerating (Rumpf et al., 2016). Inclined ground running is also suggested to be beneficial in specific acceleration phase of sprint start which can be assessed in 10-meter dash as it measures the individual to accelerate (Slawinski et al., 2008).

Plus, there is several confounding factors needed to be taken note for this study. By addressing the confounding factors needed to be taken note of in this study, allows future direction in assessing the sprint performance to limit the potential bias. The between-groups difference with respect of standing long jump may be linked due to the complexity nature of the technique of the take-off angle and jump technique (Wu et al., 2003). The take-off speed and take-off angle determine the jump distance and creating a 90-degree knee initial angle with free arm motion allows the longest distance in standing long jump (Wu et al., 2003). Even though the proper techniques have been taught, participants had trouble in landing properly due to the smooth surface on the floor where the pre-test and post-test takes place resulting in the participants are unable to jump to their full potential.

Besides, although there had been effort done to equal the training intensity in each group by having both interventions conducted within 2 session per week, the training intensity and training volume between interventions is not calculated due to each intervention being selected from separate articles. Hence, there might be a possibility that one of the interventions having a higher intensity.

Furthermore, manual timing is used in this study to assess the sprint time in 10 metre dash which may be a confounding factor due to human error.

Very high ICC values (0.99) and small mean errors (0.04-0,05) had been observed among manual timing and electronic timing to collect data. However, fully automatic systems, high speed video, dual-beamed photocells and laser guns are most accurate in monitoring sprint performance (Haugen & Buchheit, 2016). Hence, in the case where electronic timing devices are present, it is more recommend instead of hand-held timing.

However, a few strengths in this study needs to be taken account. The sample size for this study is comparably greater than other similar studies done on this topic as a total of 38 participants were recruited to participate in this study. Vassil & Bazanovk, (2012) had recruited 21 volleyball players to investigate the effect of plyometric on sprint performance, Kavaliauskas et al., (2017) had recruited 14 male soccer players to study the effectiveness of an in-season uphill sprint training programme on soccer on the physical characteristics among soccer players while only 10 subjects were recruited in the study done by Poomsalood & Pakulanon, (2015) to study the effect of 4 weeks plyometric on speed, agility and leg muscle power. Furthermore, most intervention in previous study done included the usual training which may affect the results in their study. Nonetheless, participants in this study are advised to not do any exercise other than the intervention exercise in this study to ensure the result true to the effectiveness of the exercise prescribed.

Although the results were unable to generalized to elite athlete, there is emphasize on the population recruited in this study being highly athletic due to the fact they are all HEPA active students according to the IPAQ-SF. What's more, the results in sprint performance are in line with trained athletes. Jakeman et al., (2016), investigated the effects uphill running on sprint performance among trained hockey player concluding it to be effective. Hence, it can be concluded that similar findings can be obtained among novice or moderately trained athletes who have a similar age and characteristics.

Lastly, as the effect of each intervention had on sprint performance had been studied, a combination of both inclined treadmill sprint and plyometric exercise can be explored in the future to determine the effects of the intervention.

5.6 Effect of Demographic Characteristics in Sprint Performance Improvements

The findings from this study concludes that there is no significant difference found between gender and sprint performance improvements of all four outcomes for plyometrics exercise and inclined treadmill sprint. This contradicts with previous studies as male had more gains in compared to women in vertical jump (Saé et al., 2009). However, the findings of sprint performance adaptations such as sprint speed are reported to be similar in men and women after plyometric training (Saéz et al., 2012) This suggest that plyometric training induced adaptations in male and female independently after training (Andrade & Henríquez-Olguín, 2014).

No significant difference was observed in this study regarding the effect of gender may be due gender the large gender difference and having unequal number of male and female in each intervention group. A previous study done to assessed to validity and reliability of the standing long jump included equal amounts of male and female (n=30) had reported a high degree of inter-rate between both groups (Rahman et al., 2021). Besides, there is also significant difference ($p<0.001$) being depicted between male and female groups in vertical jump test score when 40 males and 40 females are recruited (Dalui et al., 2014). Moreover, significant difference between genders were reported among age 15 years old or older in their running speeds, concluding that the span between gender increases after they passed the age of 15 year ($p<0.05$) (Papaiakovou et al., 2009). Hence, more female participants are needed to be recruited for the result to be significant. But a difficulty in recruiting female participants during the study should be noted since most female students are sedentary. As human ages, physical activity decreases among male and female which may be due to a behavioural or psychological factors (Thompson et al., 2003). Males are also found to be more active compared to females, however specific answers as to the phenomenon had not been discovered (Thompson et al., 2003).

In addition, the BMI for this study were not assessed due to only normal BMI participants were recruited for this study. A study conducted by (Nikolaidis et al., 2015), main finding was that there is an association of body mass status with running and jumping performance in young basketball players which there is negative correlation of BMI with running and jumping performances Through the study, overweight players were determined to have the worst performance in running (sprint and endurance) and jumping (Pmean and CMJ) in U-12 and worst endurance in U-18 ($p<0.05$) (Nikolaidis et al., 2015). Silva et al., (2019 concluded the relation between BMI and physical fitness was non-linear which also concluded that normal weight college students generally had a better physical fitness compared to obese, overweight, and underweight students, especially in males (Silva et al., 2019). Hence, in this study, participants of the same BMI which are normal BMI (18.5kg/m^2-24.9kg/m^2) will be recruited. The height of the participants was fixed to be the height of the participants will be set as 160-175cm to include both male and female. it was concluded that there is moderate to very large univariate relationship between the performance in upper limb and lower limb muscles and the anthropometric characteristics of male handball players especially the body mass, height, and lower limb length (Hammami et al., 2019). There is significant correlation between standing height and 5-30 m sprint ($p<0.001$) (Hammami et al., 2019). Height of volleyball players are also reported to have significant relationship with their jump performance (Aouadi et al., 2012). Regarding jump distance, is has been found that there were no significant correlations anthropometry such as height, shank length, shank circumference, thigh circumference, leg length and body weight with jump scores. ($r<0.49$) (Wu et al., 2003). Hence, there is a need to take note of that the height will be affecting the vertical jump and sprint acceleration in this study.

Furthermore, the age of the participants was not studied on due to the small age range of the participants recruited in the studies. The age group of the participants recruited for this study is under the young adult category which have and age between 18-26. However, most of the participants recruited are between the age of 18-22, which may be due to the recruitment of the participants occurs in the university where majority of the students are in that age range. Aside from that, the normality of the pre-test and post-test of each intervention are reported to be normal, which means that they are normally distributed.

5.7 Limitations of Study

It is important to discuss the limitations present in the study which may influence the results of the current study. Several issues were detected that may have impact the result of the study.

First, the research studies only recruited young adults from one institution only which is UTAR. Hence, the result is unable to represent the whole population of young adults. Besides, it is not a randomized control trail as it does not include control group. Furthermore, even though the findings are non-significant regarding the effect of gender in each intervention in improving sprint performance, it may be affected due to the unequal number of males and females present in each group.

Besides, there is another limitation due to the recall bias of participants physical activity. An IPAQ-SF is required to be filled up by participants which requires the participants to recall their physical activity level of the past 7 days due to the structure of the questions. Recalling of the event might pose some inaccuracies resulting in the physical status of the participants being affected.

Furthermore, manual timing is used in this study to assess the sprint time in 10 metre dash which may be a limitation due to human error. Very high ICC values (0.99) and small mean errors (0.04-0,05) had been observed among manual timing and electronic timing to collect data. However, fully automatic systems, high speed video, dual-beamed photocells and laser guns are most accurate in monitoring sprint performance (Haugen & Buchheit, 2016).

Lastly, due to the majority population in UTAR is Chinese students, most of the participants are of the same race are Chinese having the percentage of 99%. Hence, the results can only represent people of Chinese descent as other races are grossly underrepresented.

There is a limitation encounter in this study as only male football player is recruited which means that the result cannot be applied on the opposite gender due to the different morphological differences. It is theorized that running uphill will encounter resistance from gravity which allows improvement in jump height (Singh, 2011).

5.8 Recommendations for Future Studies

In future studies, more female participants should be recruited to be able to study the relationship between gender and sprint performance, hence determine if gender effect the improvements on sprint performance. Besides, vital signs such as blood pressure was measured before and after each intervention. A decrease in blood pressure is observed in both inclined treadmill sprint group and plyometric exercise group after the intervention. Hence, future studies can investigate the effect of inclined treadmill sprint and plyometric exercise on the same group on blood pressure.

In addition, future studies can be done to determine whether improvement can be derived from inclined sprint training through different variations of inclination, frequency, volume, duration, and periodization of training. Inclusion of more female in the study would be recommended to investigate the effect of each intervention of sprint performance. A larger inclusion of different race can be done in the future to address the racial distribution of the study.

The long-term effects of each exercise should also be studied in the future to see how each training will fare in the long run. This is to further examine how each intervention will affect the sport performance if the training continues for a longer period. For example, a longitudinal study can be conducted to observe the effects of the intervention.

Chapter 6

CONCLUSION

This study concluded the effect of both inclined treadmill sprint and plyometric exercise are significant in improving sprint performance which are the standing long jump, vertical jump test and 10-meter dash over a period of 4 weeks. However, there is no significant difference found between both intervention group.

Most of the inclined treadmill intervention of previous study is done to investigate the endurance performance on long distance runners, hence the result from this study also provided crucial data that the mentioned intervention is beneficial in improving the sprint performance and muscle power of individuals. Even though there are no significant differences found for the sprint performance between both interventions, these results can provide a guide for coaches and athletes seeking improvement on the related parameters. What’s more, the protocols used in the study can be added into literature to help in solidifying the optimal parameters, frequency and duration of each intervention.

Furthermore, it will be interesting to see future studies being conducted on the effect of cardio workout such as inclined treadmill sprint on blood pressure. In addition, a greater number of female participants can be recruited to investigate the relationship between gender on sprint performance. Due to not much inclined treadmill sprint training protocols had been designed, the running frequency, duration and inclination of treadmill can be further explored in the future. Lastly, as the effect of each intervention had on sprint performance had been studied, hence the long-term effect or a combination of both inclined treadmill sprint and plyometric exercise can be explored in future studies.

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APPENDIX I-ETHICAL FORM

UNIVERSITI TUNKU ABDUL RAHMAN
Wholly Owned by UTAR Education Foundation (Company No. 578227-M)

Re: U/SERC/224/2022

4 November 2022

Mr Muhammad Noh Zulfikri Bin Mohd Jamali
Head, Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
Universiti Tunku Abdul Rahman
Jalan Sungai Long
Bandar Sungai Long
43000 Kajang, Selangor

Dear Mr Muhammad Noh,

Ethical Approval For Research Project/Protocol

We refer to your application for ethical approval for your students' research project from Bachelor of Physiotherapy (Honours) programme enrolled in course UMFD3026. We are pleased to inform you that the application has been approved under Expedited Review.

The details of the research projects are as follows:

24.	Effectiveness of Continuous Moderate-Intensity Training and Mindfulness Meditation on Blood Pressure and Resting Heart Rate Among Physically Inactive Pre-Hypertensive Young Adults	Wan Cai Hui		
25.	Comparison between Inclined Treadmill Sprint Training and Plyometric Exercise in Improving Sprint Performance Among Healthy Young Adults	Jasmine Song WenHui	Ms Premala a/p Krishnan	
26.	Effect of Pilates-Based Exercise on Young Adults with Patellofemoral Pain	Jesslyn Ng Jee Cheng		
27.	Association Between Quadriceps Angle and Hamstring Flexibility with Knee Injuries Among Weight Lifters	Teh Wei Ze	Ms Ambusam a/p	

The conduct of this research is subject to the following:

(1) The participants' informed consent be obtained prior to the commencement of the research;

(2) Confidentiality of participants' personal data must be maintained; and

(3) Compliance with procedures set out in related policies of UTAR such as the UTAR Research Ethics and Code of Conduct, Code of Practice for Research Involving Humans and other related policies/guidelines.

(4) Written consent be obtained from the institution(s)/company(ies) in which the physical or/and online survey will be carried out, prior to the commencement of the research.

Kampar Campus : Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
Tel: (605) 468 8888 **Fax**: (605) 466 1313
Sungai Long Campus : Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor Darul Ehsan, Malaysia
Tel: (603) 9086 0288 **Fax**: (603) 9019 8868
Website: www.utar.edu.my

Should the students collect personal data of participants in their studies, please have the participants sign the attached Personal Data Protection Statement for records.

Thank you.

Yours sincerely,

Professor Ts Dr Faidz bin Abd Rahman
Chairman
UTAR Scientific and Ethical Review Committee

c.c Dean, M. Kandiah Faculty of Medicine and Health Sciences
Director, Institute of Postgraduate Studies and Research

APPENDIX II – Informed consent

<u>Research Participant Information Sheet</u>

Universiti Tunku Abdul Rahman

Faculty of Medicine and Health Sciences

Department of Physiotherapy

Bachelor of Physiotherapy (Honours)

Information Sheet to Participate in the Study

Comparison between Inclined Treadmill Sprint Training and Plyometric Training in Improving Sprint Performance Among Healthy Young Adults

Student Investigator: Jasmine Song Wen Hui

Department: Faculty of Medical and Health Sciences (FMHS)

Course Name and Course Code: UMFD 3026 Research Project

Year and Semester: Y3T2

Course Coordinator: Mr Avanianban Chakkarapani

You are being asked to volunteer for this research study that is being conducted as part of the requirement to complete the above-mentioned course, UMFD 3026 Research Project.

Please read this information sheet and contact me to ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study

Comparison is done as both exercises are different in increasing sprint performance. Sprint training is a specific exercise whereas plyometric exercise is non-specific. Through this research, students would be able to make gain knowledge regarding which exercise is more effective in increasing sprint performance and be able to make an inform decision based on it. They can also incorporate exercises done during the experiment in the future. Besides, the results obtain from this study can help coaches, gym goers and gym professional trainers in determining which is more suitable according to the equipment availability the benefits of the exercise towards them. The population is chosen as university students who are healthy and is active as there are categorize as healthy young adult. The sprint performance will be access using 10 meter dash, vertical jump test and standing long jump test. Approximately 30 students will be recruited and assigned randomly into two groups.

Procedures

If you agree to be in this study, after signing the consent form, fill in the questionnaire and pass the screening test, you will be asked to draw lots to assign you to one of two groups. One group will be performing inclined treadmill sprint training while another group will be performing plyometric exercise.

Before commencing the study and completion the study of four weeks, you will be asked to fill in questionnaire to screen whether you are suitable for this study. Pre-test and post-test will be done 48 hours prior and after the training by doing 10-meter dash, vertical jump test and standing long jump test. Practice sprint and jumps will be given before the study to familiarize with the movement.

10 minutes of dynamic stretching and static jogging will be done before exercise and 5 minutes of static stretching will be done after exercise.

Incline Treadmill Sprint Training

You will be sprinting on a treadmill. Practice sprinting on the treadmill will be given. You will be sprinting on the treadmill at 10.0% grade at Vmax 10-12 times for 30s and 1.0% at 65%Vmax for 1 time for 30 minutes.

Plyometric Exercise

You will be doing different sets of front cone hops, lateral cone hops, standing jump and reach, lateral jumps over barriers, alternate bounding, diagonal cone hops, cone hops with 180-degree turn, cone hops over the period of 4 weeks. Each time a new plyometric exercise is introduce, you will be taught on the correct techniques on how to perform it safely.

Length of Participation

The study will be 2 visits for a total of 4 weeks. The exercise will be done approximately 45 minute-1 hour.

Risks and Benefits

Benefits: Gaining knowledge regarding the different training protocols that can be used in improving sprint training. Aside from that, it will help you in strengthening your legs. Overall, strengthening and cardiovascular training can be achieved.

Risk: Possible injury such as muscle cramps, muscle strain and tendonitis might occur.

Confidentiality

No information that will make it possible to identify you, will be included in any reports to the University or in any publications.

Research records will be stored securely, and only approved researchers will have access to the records.

Voluntary Nature of the Study

Participation in this study is voluntary. If you withdraw or decline participation, you will not be penalized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at any time.

Contacts and Questions

If you have any questions, clarifications, concerns or complaints, about the research, the researcher conducting this study can be contacted at 013-8681006, jasminesong15@1utar.my

The course coordinator, Mr Avanianban Chakkarapani can be contacted at avanianban@utar.edu.my, 0122672457

, concerns, or complaints

about the research and wish to talk to someone other than individuals on the research team or

Please keep this information sheet for your records.

Research Participant Consent Form

Universiti Tunku Abdul Rahman

Faculty of Medicine and Health Sciences

Department of Physiotherapy

Bachelor of Physiotherapy (Honours)

Consent Form to Participate in the Study

Comparison between Inclined Treadmill Sprint Training and Plyometric Training in Improving Sprint Performance Among Healthy Young Adults

Student Investigator: Jasmine Song Wen Hui

Department: Faculty of Medical and Health Sciences (FMHS)

Course Name and Course Code: UMFD 3026 Research Project

Year and Semester: Y3T2

Course Coordinator: Mr Avanianban Chakkarapani

I have read the provided information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have, has been answered to my satisfaction. I understand that I will be given a copy of this form, and the researcher will keep another copy on file. I consent voluntarily to be a participant in this study.

Name of Participant: ___________________________________

IC No: ________________________ Date: _________________

APPENDIX III - Demographic data

DEMOGRAPHIC DATA

If you are:

1. UTAR students who are at the age of 18-26 years old.

2. Physically active students

3. Students who had done resistance training in the lower limb before (Potach, 2004)

3. Students who have an interest in track and field, badminton, or basketball

You are welcome to participate in this study.

Participation

This research study requires you to complete the questionnaire given. It will take 10-15 minutes to complete the questionnaire. Your participation in this study is completely voluntary. Withdrawal from this study is allowed at any time. The decision to withdraw will not influence your relationship with the researcher.

Benefits and risks

There are no known benefits or risks to the participant.

1. Name: _______________

2. Age: ___________

3. Gender:

- o Male
- o Female

4. Race:

- o Chinese
- o Malay

- Indian
- Others: _____

5. Height: _____cm

6. Weight: _____kg

7. Year of Study:
   - Foundation
   - Year 1
   - Year 2
   - Year 3
   - Year 4
   - Others

8. Handphone number: _________

APPENDIX IV – Participation screening

1. Do you have an interest in track and field, badminton, soccer or basketball?

- Yes
- No

2. Do you do any resistance training of the leg? (Eg. Squat, bench press, deadlift)

- Yes
- No

APPENDIX V- IPAQ Short form

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

APPENDIX VI-PAR-Q

2022 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ **OR** high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ______	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it **does not limit your current ability** to be physically active. **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow Global Physical Activity Guidelines for your age (https://www.who.int/publications/i/item/9789240015128).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION
If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ______________________ DATE ______________

SIGNATURE ______________________ WITNESS ______________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______________________

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

01-11-2021

APPENDIX VII-TURNITIN REPORT

COMPARISON BETWEEN INCLINED TREADMILL SPRINT TRAINING AND PLYOMETRIC EXERCISE IN IMPROVING SPRINT PERFORMANCE AMONG HEALHTY YOUNG ADULTS

by Jasmine Song Wen Hui

Submission date: 23-Dec-2022 06:58PM (UTC+0800)
Submission ID: 1986153896
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Word count: 15003
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COMPARISON BETWEEN INCLINED TREADMILL SPRINT TRAINING AND PLYOMETRIC EXERCISE IN IMPROVING SPRINT PERFORMANCE AMONG HEALHTY YOUNG ADULTS

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