THE ANTHROPOMETRIC AND PHYSICAL FITNESS PROFILE OF ELITE ADOLESCENT SPRINTERS AGED 13 TO 18 IN HONG KONG

BY

TING WAI TING

09005234

AN HONOURS PROJECT SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF ARTS

IN

PHYSICAL EDUCATION AND RECREATION MANAGEMENT (HONOURS)

HONG KONG BAPTIST UNIVERSITY

April, 2012

HONG KONG BAPTIST UNIVERSITY

30th April, 2012

We hereby recommend that the Honours Project by Mr. TING WAI TING entitled "The anthropometric and physical fitness profile of elite adolescent sprinters aged 13 to 18 in Hong Kong" be accepted in partial fulfillment of the requirements for the Bachelor of Arts Honours Degree in Physical Education And Recreation Management.

Dr. Tong Kwok Keung, Tom	Prof. Chow Bik Chu
Chief Adviser	Second Reader

DECLARATION

I hereby declare that this honours project "The anthropometric and physical fitness profile of elite adolescent sprinters aged 13 to 18 in Hong Kong" represents my own work and had not been previously submitted to this or other institution for a degree, diploma or other qualification. Citations from the other authors were listed in the references.

TING WAI TING

30th April, 2012

ACKNOWLEDGEMENTS

First of all, I would like to express my deepest gratitude to my chief advisor, Dr. Tong Kwok Keung, for his valuable advices and professional suggestions and guidance throughout the project period. Special appreciation is given to Prof. Chow Bik Chu, for being my second reader.

In addition, I would like to give thanks to the staff of Dr. Stephen Hui Research Centre for Physical Education and Wellness for their profession advices in using the measuring tools. Finally, I would like to express special thanks to all subjects for their sincere participation in the study.

____

TING WAI TING

Department of Physical Education

Hong Kong Baptist University

Date: 30th April, 2012

Abstract

From the previous studies, most of the studies are focused on anthropometric and physical fitness profile of senior sprinters. Similar studies for Hong Kong junior sprinters are definitely lacking or even none. Therefore, this study was decided to establish the anthropometric and physical fitness profile of elite adolescent sprinters aged 13 to 18 in Hong Kong. 22 male elite adolescent sprinters from different secondary schools athletics team who entered the 100m or 200m final in inter-school athletics competition in Hong Kong, aged 13 to 18 in grade A, B, C, were invited to participate in this study (Grade A: age, 17.43±0.54 years, height, 172.93±4.95 cm, weight, 62.84±7.24 kg; Grade B: age, 15.38±0.52 years, height, 171.88±7.10 cm, weight, 58.61±4.35 kg; Grade C: age, 13.29±0.49 years, height, 168.57±6.05 cm, weight, 55.19±4.97 kg). Circumference of chest, waist, hip, thigh, calf, shoulder width, length of lower extremity, thigh and calf were measured. Standing long jump, single leg hop and hip flexibility were also assessed. Pearson correlation analysis found that thigh circumference ($r=-0.554$, $p<0.05$), chest circumference ($r=-0.578$, $p<0.05$), shoulder width ($r=-0.51$, $p<0.05$), fat free mass ($r=-0.576$, $p<0.05$), age ($r=-0.744$, $p<0.05$) and weight ($r=-0.465$,

$p<0.05$), generated capabilities to be negatively correlated to 100m sprint performance. The BMI of almost all aged groups (13-17) in elite adolescent sprinters group were lower than normal junior population group except the group of aged 18. Elite adolescent sprinters relatively had lower body fat percentage, lower fat mass and higher fat free mass than normal adolescent population.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURES PAGE

Chapter 1

INTRODUCTION

A rapid movement from one place to another place is required in many athletic activities, especially in sprint running (Kukolj, Ropret, Ugarkovic & Jaric, 1999; Pinero et al., 2010). Sprinting is an ancient event in athletics starting in the first Greece Olympic Game and it is a human ability to perform a maximum running velocity (Haneda, Enomoto, Hoga & Fujii, 2003). In addition, sprint can be divided into five phases including start, acceleration, transition, maximal running velocity and deceleration (Cunha, 2005; Niels, 2005). In the development of sprinting events, there are outdoor and indoor competitions in track and field athletics recently. The outdoor competition of sprinting includes 100m, 200m, 400m, 4x100m and 4x400m relays and the indoor competition of sprinting consists of 50m, 60m, 200m, 400m, 4x200m and 4x400m relays. Running is a kind of basic human movements. How fast the human being can perform has been a concern for a long period. Many researchers tried to obtain a prediction to the sprinting performance and attempted to find the relationships between sprint performance and different kinds of tests (Cunha, 2005).

In 1951, Hong Kong Amateur Track and Field Association was established. Athletics was first publicly promoted and competitions were held in the same year. Hong Kong Schools Sports Federation was established in 1997 and superseded the three former schools sports organization. This Federation is responsible for current secondary and primary schools sports programs and related issues in different districts. Inter-school Athletics Competition is one of the sports programs and holds every year. In secondary school section, each school has maximum two representatives to participate in different track and field events in specific grade A, B and C. Almost schools in Hong Kong have athletics team and they are enthusiastically to take part in the Inter-schools Athletics Competition. If the school wins the overall prize, the school' reputation will become better. Under this circumstance, the school is willing to promote athletics and the selection of representatives is fundamental. However, the studies of anthropometric and physical fitness profile of local outstanding junior sprinters are lacking. The selection of representatives can only rely on the result of school sports day. Therefore, in this study, we would like to evaluate the anthropometric and physical fitness profile of Hong Kong outstanding sprinters in secondary schools athletics team.

Statement of the Problem

Different levels of physical and performance characteristics have been used as indicators of success in sport (Onyewadume, Amusa and Owolabi, 2004). Nowadays, most of the studies are focused on anthropometric and physical fitness profile of male senior sprinters whose age is above 20 from South Africa, Europe, Middle East and Asia. Some researchers such as Kumagai et al. (2000), Onyewadume et al. (2004), Almuzaini and Fleck (2008), Kale, Asci, Bayrak and Acikada (2009) and Habibi et al. (2010), separately focused on different dimensions or variables including the limb length, bone width, skinfold thickness, percentage of body fat, somatotype and anaerobic power in the profile studies of sprint athletes. In addition, several studies were focused on the relationship between different jumping tests and sprinting performance (Habibi et al., 2010; Almuzaini & Fleck, 2008; Kale et al., 2009). However, the resemble findings are really scarce in Hong Kong. Moreover, there are not much similar studies designed for junior sprinters exclusively. The study of the anthropometric and physical fitness assessment is also important to junior sprinters.

Purpose of study

The main purpose of this study is to establish the anthropometric and physical fitness profile of elite adolescent sprinters aged 13-18 in Hong Kong. It provides scientific information for further studies and potential use in sprinting field.

Significance of Study

Based on the anthropometric and physical fitness characteristics of elite adolescent sprinters aged 13 to 18 in Hong Kong, an individual's strengths and weaknesses can be identified. All data can label as health condition prediction of junior sprinters for preventing the sport-specific injuries and enhancing self-awareness.

In addition, the anthropometric and physical fitness profile is also able to help local junior sprinters, coaches and teachers to have better understanding and scientific information in order to analysis the current training structure, and adopt or develop other training method for improving the sprint performance.

Moreover, the findings of this study would provide meaningful information to compare with other countries' and places' junior sprinters. The comparison is able to discover the advantages and disadvantages of junior sprinters in different countries and places. All circumstance expose in this study may facilitate the further research on selection of potential sprinters in Asia or in Hong Kong.

Chapter 2

REVIEW OF LITERATURES

The review of literatures was mainly divided into five sections: (1) Factors affecting sprint performance, (2) anthropometry, (3) body composition, (4) muscular fitness and (5) summary.

Factors Affecting Sprint Performance

Sprint involves performing at a very high intensity that can only be maintained within a short duration and typically less than 60 seconds (Stokes, Nevill & Hall, 2005). Sprint performance depends on different parameters. One parameter ameliorated may improve the whole performance (Cunha, 2005). Kale et al. (2009) stated that successful sprint performance requires good starting ability, highest maximal running velocity and the endurance of that velocity capacity. Similarly, some researchers stated that the sprint performance was determined by the acceleration ability, the magnitude of maximal speed and speed maintenance against the onset of fatigue (Ross, Leveritt & Riek, 2001; Bret, Rahmani, Dufour, Lacour & Messonnier, 2002).

Besides, some research studies founded that sprint running horizontal velocity is the product of step length and step rate (Hunter, Marshall & Mcnair, 2004; Kale et al., 2009). In addition, Hunter et al. (2004) indicated that there is a negative interaction between the step length and step rate. If there is an increase in step length, the step rate will decrease and vice versa. The resemblance findings were shown by Zhou and Zan (2009), found that the stride length and stride frequency were correlated negatively. On the contrary, Luo (2009) found that sprinters can increase the stride length and stride frequency synchronously during the acceleration phase. He discovered that beginner can synchronously increase the stride length and stride frequency in the acceleration period (0m to 15m). Athletes in advanced level increased the stride length and stride frequency simultaneously in the acceleration period (0m to 25m). World elite athletes also had an increase in stride length and stride frequency simultaneously in the acceleration period (0m to 30m). Moreover, Hunter et al. (2004) indicated that the very high stride length and stride frequency achieved by elite sprinters may only be possible by using a high horizontal and low vertical of takeoff when performing sprinting.

In addition, Kale et al. (2009) showed that those elite sprinters performed by optimal step length and step rate during the maximum running velocity in sprinting. He also stated that shorter contact time in each step results in better sprint performance. The similar finding was shown by Zhang and Li (2004), mentioned that the interaction between stride length and stride frequency depended on the factors of body shape of each person, genetics, level of training and sprinting technical quality. Athletes should reasonably adjust their mode of stride length and stride frequency upon their personal characteristics in order to enhance the sprint performance.

Furthermore, Li, Chen and Zhai (2007) found that all-range stretch hand and swing arm action in sprinting prompted a larger stride length in biomechanics. Kumagai et al. (2000) indicated that sprinters have relatively high percentage of fast twitch muscle fibers in the leg muscles. He also found that the longer fascicle length is related to better sprinting performance. The resemblance finding conducted by Onyewadume et al. (2004) showed that successful sprinters have a high percentage of fast twitch fibers and able to generate very large power outputs very rapidly. Besides, the external environment can also affect the sprint performance. The influence of each condition can be ranked by humidity, pressure and temperature. The impact of wind condition toward 100m and 200m is amplified for head-winds but dampened for tail-winds (Mureika, 2003; Mureika, 2006).

Anthropometry

Anthropometric measurements such as age, height, weight, body composition, width, circumferences and limb length measurements would be investigated in the study. Measurements should be selected according to the purposes of studies (Malina, 1988). In addition, age is one of the factors affecting various sports performance. Sprint performance during children and adolescents period depends on growth and maturation (Villanueva et al, 2011). Besides, height may play an important role in athletic success (Niels, 2005). Shorter sprinters have relatively lower movement resistance or inertia moment and advantageous in acceleration particularly (Onyewadume et al., 2004). Niels (2005) pointed out that taller sprinters have relatively longer lower limbs and enable to have longer step length. Siris (1986) indicated that the medium height of world elite sprinters is 177.9cm. However, Niels (2005) stated that there is no optimal height for sprinters, but there are an optimal range exclude sprinters who are very tall or very short in stature.

Moreover, anthropometry refers to the measurement of the size and proportion of the human body (Heyward, 2002; Malina, 1988). Kumar (2006) indicated that sports talent spotting is a trend throughout the world. Besides, Villanueva et al. (2011) reported that there is positive relationship between anthropometric characteristics and both sprint performance and repeated-sprint performance. Furthermore, particular anthropometric measurements are pre-requisites for good athletic performance in various sports (Kukolj et al., 1999; Habibi et al., 2010). Similarly, Mirkov, Kukolj, Ugarkovic, Koprivica and Jaric (2010) pointed out that anthropometric measurement is important for early talent selection. However, Kukolj et al. (1999) stated that the measurements of anthropometry, muscular strength and power are poor predictors of the performance of initial acceleration and maximum speed phase during the sprinting.

Body Composition

World Health Organization (WHO) has recommended body mass index (BMI) to the public and there are body weight classifications including underweight, normal, overweight and obesity. BMI was a measurement of relative weight and calculated as weight in kilograms divided by height in meters squared [kg/m^2]. Actually BMI is easy to calculate and obtain, and enable an unbiased comparison between short and tall population groups. In Asian population, less than 18.5 kg/m^2 is underweight; 18.5-23 kg/m^2 is normal; 23-27.5 kg/m^2 is overweight; and 27.5 kg/m^2 or above is obesity (WHO, 2004). In addition, a high BMI among children, young adults, older adults and elderly is associated with potential health risks like cardiovascular disease (CVD), morbidity and mortality (WHO, 2004; Kyrolainen, Santtila, Nindl & Vasankari, 2010; Freedman, Katzmarzyk, Dietz, Srinivasan & Berenson, 2010). Moreover, BMI highly correlates with body fat percentage (WHO, 2004). However, the body mass consists of fat mass and fat free mass. BMI is limited to distinguish the portion between body fatness and lean tissue. A large muscle mass can result in high BMI even though the body fatness is not excessive (Freedman et al., 2010; Heyward, 2002; Adams & Beam, 2008; Abernethy, Old, Eden, Neill & Baines, 1996; Niels, 2005). Skinfold thickness, air displacement plethysmography, bioelectrical impedance and dual energy X-ray absorptiometry (DXA) are more accurate estimation of body fatness (Freedman et al., 2010). However, there is a possibility to have an error in skinfold thickness measurement and likely increase with the estimation of body fatness if the measurer is not familiar with the measurement (Heyward, 2002; Freedman et al., 2010; ACSM, 2010).

In addition, body composition is strongly associated with physical fitness. Young men in overweight and obesity group have poor explosive power, aerobic fitness and muscle endurance (Kyrolainen et al., 2010). Similarity, So and Choi (2010) stated that obese group had higher blood pressure and weaker cardiovascular function than normal group. The fitness level of obese group is lower than the normal group involving power, balance and cardiorespiratory endurance. Besides, there is an inverse relationship between excess body weight and sprinting performance (Pinero et al., 2010; Onyewadume et al., 2004). Onyewadume et al. (2004) also mentioned that excess body fat can decrease acceleration of sprint due to extra body mass loading. Moreover, Pinero et al. (2010) pointed out that overweight and obese group children have poor sprint performance in 20m, 30m and 50m test due to extra load in body weight like to perform a weight-bearing task. To improve sprint performance of children, control or reduce the body weight may be a useful method to achieve the goal. So and Choi (2010) also indicated that the body of obese people become less sensitive and the scope of everyday activities are limited. Furthermore, Onyewadume et al. (2004) mentioned that sprinters have relatively high percentage of muscle mass owing to genetic factors and training effect, and the somatotype of majority successful sprinters have tended to be predominantly mesomorphic. Generally, the athletes in track events of athletics have low body fat mass in norm. High in body fat mass can influence the track events performance.

Muscular Fitness

Physical fitness has been defined as a measure of how well one performs physical activity. In other words, it can also be labeled as body movement produced by muscle action that increases energy expenditure (Kyrolainen et al., 2010). Physical fitness can be divided into health-related physical fitness and motor-related physical fitness. Health-related physical fitness includes muscular strength, muscular endurance, cardiorespiratory endurance and flexibility. Motor-related physical fitness consists of agility, power and balance (Heyward, 2002; So & Choi, 2010). Besides, Deane, Chow, Tillman and Fournier (2005) also indicated that muscular strength is one of the elements of physical fitness.

Different sports are required to have resistance training in order to improve the muscular strength. Although quadriceps, hamstrings and calf muscles are chiefly responsible for propelling the body forward during running and jumping exercise, hip flexor muscles also contribute to bring the free leg forward and upward during the sprinting in recovery phase. However, hip flexor muscles training was ignored or neglected by athletes and coaches.

In addition, Kale et al. (2009) stated that jump power is the best indicator of sprinting ability. The lower limb power capability can be evaluated by the jump tests and they provide valid assessments of muscular power. Besides, some research studies showed that there is a high correlation between the leg power and sprint ability by using horizontal and vertical jump displacements as an indirect power measurement (Habibi et al., 2010; Bret et al., 2002). Moreover, Habibi et al. (2010) found that the jump assessment of single leg hop for distance is strongly related to the sprinting performance (r=-0.76). In addition, Pinero et al. (2010) indicated that standing long jump test as a predictor to assess the lower body muscular strength is better than the vertical jump test. Standing long jump test is time efficient, practical, and lower in cost and equipment requirements and it could be considered as a general index of youth' muscular fitness. Furthermore, some researchers showed that the standing long jump ability with both sprinting acceleration and sprinting velocity have significant correlation (Peterson, Alvar & Rhea, 2006; Almuzaini & Fleck, 2008; Kale et al., 2009).

Moreover, flexibility has been generally defined as the range of motion available in joints or group of joints that allows normal and unimpaired function (Wang, Whitney, Burdett & Janosky, 1993; Luttgens & Hamilton, 1997; Jenkins & Beazell, 2010). Besides, Jenkins and Beazell (2010) stated that flexibility is an individual variable, joint-specific, inherited characteristic that influences by age, gender and ethic group. Similarly, Wang et al. (1993) showed that gender, age, muscle size and warm up are the factors contributing to flexibility. The flexibility of females in hip abduction, flexion and extension are better than males associating with anatomy factors. He also pointed out that strength training caused muscle hypertrophy and limited the flexibility development. In addition, proper stretching can increase range of motion in particular joints in order to produce the optimum running performance and reduce the risk of injuries (Blazevich, 2001; Jenkins & Beazell, 2010).

However, Blazevich (2001) stated that excessive stretching and flexibility may cause an increase in injuries and a decrease in performance.

Summary

As observed above, the success of a sprinter was determined by different physiological characteristics. Anthropometry, body composition and muscular fitness are the general assessments on the elite sprinters. However, the previous studies were just focused on the senior sprinters and there was in lack of scientific information about the junior sprinters. In Hong Kong, the related research on sprinter is very scarce.

Chapter 3

METHOD

The method in this study was separated into the following sections: (a) subjects; (b) procedures; (c) anthropometry; (d) body composition; (e) muscular fitness and (f) sprint performance in official competition.

Subjects

Eighteen outstanding male junior sprinters, aged 13-19 (Grade A, B, C athletes), were volunteered to participate in this study. The subjects were invited from different districts including Tsuen Wan, Kwai Tsing, North district, Kowloon, Hong Kong Island and Sai Kung. Nine secondary schools representatives of athletics team were involved in this study. Prior to the participation, participants were fully informed of the purpose of the study, benefit of the study and possible risks associated with the test. Informed Physical Activity Readiness Questionnaire (PAR-Q) and informed consent forms were provided to all participants and guardians to sign.

Procedures

In this study, there were total three main components assessed to the outstanding junior sprinters consisting of anthropometric measurement, body composition indirect estimation and muscular fitness assessment. Anthropometric measurement including height, weight, skinfold thickness at two sites, shoulder width, chest circumference, waist circumference, hip circumference, lower extremity length, thigh length and calf length. Besides, standing long jump test, single leg hop for distance test, hip flexibility (flexion and extension) test were the field tests. Anthropometric measurement would be taken first. After that, a sufficient warm up session would be given to participants about 15 minutes and then hip flexibility (flexion and extension) test would be performed. Standing long jump test and single leg hop for distance test were also going to assess. Between each field test, there was 5 minutes break to all participants. The measurements and the field tests were conducted in one day to each school.

Anthropometry

Body height and weight

The body height of the sprinters was measured by a wall mounted stadiometer at mid inspiration. The subjects were required to take off the shoes, stand straight with foot together and touch the wall with back, buttocks and both heels. The measurer should lower the ruler until it touches the vertex firmly instead of exerting extreme pressure. The height was assessed to the nearest 0.1cm. The body weight was recorded by electronic weighing scale, to the nearest 0.1kg. The subjects dressed in minimal clothing and were instructed to stand in an erect posture with eyes looking front horizontally. The subjects stood in the centre of the scale platform without shoes. 0.3kg of the clothes weight was deducted from the body weight (Eston & Reilly, 2001).

Body mass index (BMI) calculation

Body Mass Index (BMI) was calculated as weight/height squared [kg/m^2] (Pinero et al., 2010).

Skinfold thickness measurement at two sites

Slaughter et al. method (1988) was used to estimate percentage of body fat from combination of two sites of skinfold thickess (triceps and medial calf). These two sites of skinfold thickness were measured on the right side of the participants’ body (see Figure 1 and Figure 2). Participant was agreed to go shirtless for the measurements. Then, the test measurer pinched the skinfold, at about 1 cm proximal to the marked site by using thumb and index finger. The jaw points of the Harpenden caliper (Lafayette Instrument, USA) placed on the marked site at a depth of about half the distance between the crest of the fold and the base of the normal skin perimeter (Adams & Beam, 2008).

In addition, the test administrator maintained a firm grip on the skinfold while reading the gauge of the skinfold caliper within four seconds to the closest 0.1mm. The test administrator made three circuits of skinfold measurement and recorded for each site during each circuit. The medium value would be used for analytical purposes (Adams & Beam, 2008).

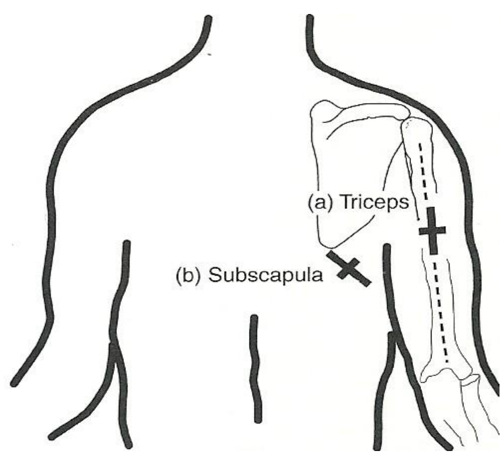

Figure 1. Site and measurement of triceps skinfold site

a.) Triceps skinfold (see Figure 1)

When using a tape for measurement, distance between inferior margin of olecranon process and lateral projection of acromial process is measured on lateral aspect of arm with 90° elbow flexion. A midpoint is marked. The fold is vertical and parallel to the line of the upper arm. The subjects were instructed to stand with their arms hanging loosely at their side (Harrison et al., 1988).

b.) *Calf skinfold. (see Figure 2)*

The fold is vertical and lifted at level of maximal calf circumstance on medial aspect of calf with 90° flexion of knee and hip (Harrison et al., 1988).

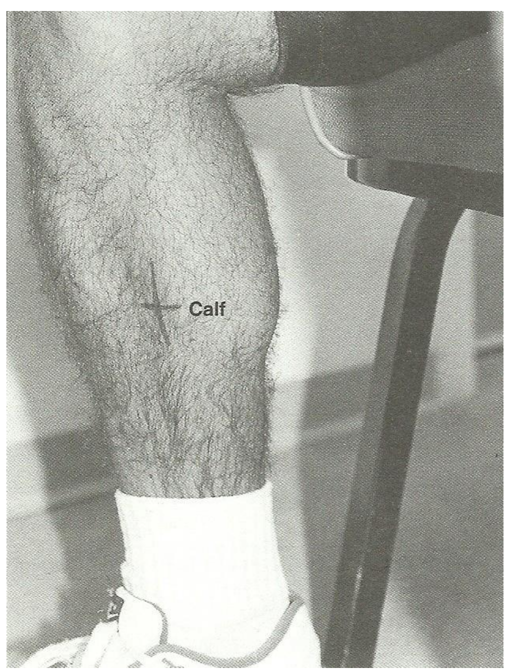

Figure 2. Calf skinfold

Shoulder width

Subjects were required to stand in an erect position with arms hanging loosely at their side and eyes-front. Anthropometer (LAFAYETTE Instrument Company, Indiana) was used to measure the shoulder width of the subjects. The anthropometer was applied to the lateral borders of acromion processes. The width was read to the nearest 0.1cm and taken from the rear (Wilmore et al., 1988).

Chest circumference

The measuring tape (Michigan company, USA) was applied snugly around the torso at the level of forth costo-sternal joints. The subjects were instructed to stand straight with both feet at shoulder width. The measurement was in horizontal plane and recorded to the nearest 0.1cm (Callaway et al., 1988).

Waist circumference

The tape was applied snugly around the narrowest part of torso. The subjects were instructed to stand upright with both feet at shoulder width. The measurement was in horizontal plane and recorded to the nearest 0.1cm (Callaway et al., 1988).

Hip circumference

The tape was applied snugly around the maximum posterior extension of buttocks. The subjects were instructed to stand upright with arms at the side and both feet together. The measurement was in horizontal plane and recorded to the nearest 0.1cm (Callaway et al., 1988).

Waist to hip ratio (WHR)

The equation of waist to hip ratio (Ghosh & Kendra, 2007) is as follow:

WHR = waist circumference (cm) / hip circumference (cm)

Thigh mid circumference

The tape was applied snugly around the midway between the inguinal crease and the proximal border of the patella (see Figure 3). The measurement was in horizontal plane on the right leg and recorded to the nearest 0.1cm (Callaway et al., 1988).

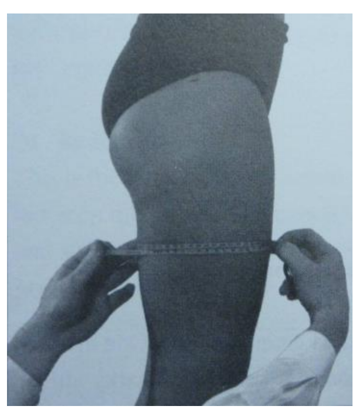

Figure 3. Thigh (mid) circumference

Calf circumference

The tape was applied snugly around the maximum girth of calf muscle. The subjects were instructed to sit with back erect (see Figure 4). The measurement was in horizontal plane on the right leg and recorded to the nearest 0.1cm (Callaway et al., 1988).

Figure 4. Calf circumference

Lower extremity length

A measuring tape was used to measure the lower extremity length. The lower extremity length can be defined as the distance from the tibiale laterale landmark to the floor (Norton et al., 1996). In other words, it was the distance between the greater trochanter of femur and the floor. The subjects were instructed to stand erect without shoes.

Thigh length

To measure the thigh length, an anthropometer was used. Thigh length was the distance from the trochanterion to the tibiale laterale (Norton et al., 1996). In other words, it was the distance between the lateral condyle of femur and greater trochanter of femur (see Figure 5). The subjects were instructed to stand straight with the right side facing to the measurer.

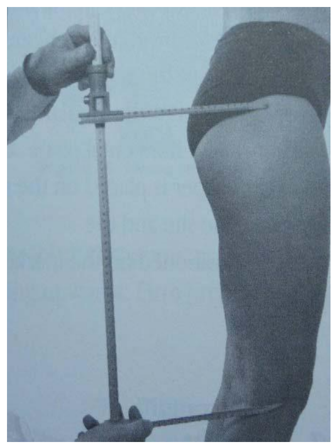

Figure 5. Thigh length

Calf length

For the calf length measurement, an anthropometer was used. The calf length was the distance between the tibiale mediale and sphyrion tibiale landmark (Norton et al., 1996). In other words, it was the distance between the medial condyle of tibia and the medial malleolus of tibia (see Figure 6). The subjects were instructed to seat with the right ankle cross over and rest on the left knee.

Figure 6. Calf length

Body Composition

Percentage body fat and fat free mass calculation

As mentioned before, the equation described in the Slaughter et al. method (1988) was used to estimate percentage of body fat from combination of two sites of skinfold thickess (triceps and medial calf). As subject is male, the corresponding equations below were used:

$$\% \text{ Fat} = 0.735 \text{ X } (\text{Sum of Skinfold}) + 1.0 \qquad \text{Eq. 1}$$

Where: SFF = Sum of two skinfold sites;

% Fat = Percent body fat

Another calculation method of fat free mass is as follow:

$$\text{Fat free mass} = \text{Body mass} - (\text{Body mass x } \% \text{ Fat}) \qquad \text{Eq. 2}$$

Muscular Fitness

Hip flexibility (hip flexion)

A goniometer (Baseline® measurement instruments) was used to assess the active hip flexion. The subjects were instructed to lie on the table in a supine position. The right leg was going to assess. The right knee can bent during the active hip flexion. The opposite leg should still contact with the table. When the maximal amplitude of a movement is reached, this maximal amplitude was then read and recorded. The landmarks are the tip of the greater trochanter and the lateral femoral epicondyle. The goniometer was kept with the red scale left of the subject (the needle is then at zero degree at the start of the motion), in line with the longitudinal axis of the thigh oriented on both landmarks (Eston & Reilly, 1996). The measurement was in sagittal plane (see Figure 7). Three trials were conducted and the average of the two closest result as central value.

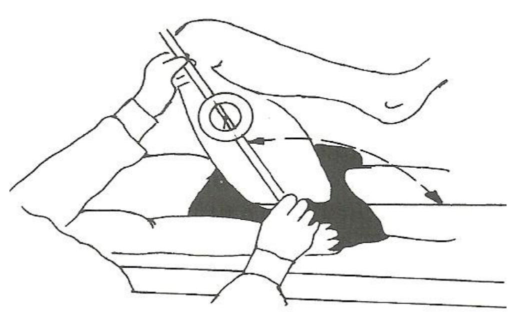

Figure 7. Hip flexion

Hip flexibility (hip extension)

A goniometer was used to assess the active hip extension. The subjects were instructed to lie on the table in a prone position. The right leg was going to assess. The right knee should extend during the active hip extension. The opposite leg should still contact with the table. The goniometer was placed on the lateral midline of pelvis as the stationary arm, and the moving arm should place on the lateral midline of femur. The landmarks are the tip of the greater trochanter and the lateral femoral epicondyle. The goniometer was kept with the red scale left of the subject (the needle is then at zero degree at the start of the motion), in line with the longitudinal axis of the thigh oriented on both landmarks (Eston & Reilly, 1996). The measurement was in sagittal plane (see Figure 8). Three trials were conducted and the average of the two closest result as central value.

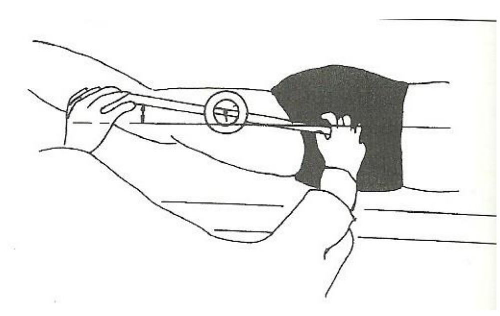

Figure 8. Hip extension

Standing long jump test

The standing long jump required the subjects to stand behind the starting line with feet together. Subjects were instructed to push off vigorously and jumped forward as far as possible. They were allowed to hold their arms loosely by their side and swing to assist the jump. The jump was completed with both feet landing on the floor (Habibi et al., 2010; Almuzaini & Fleck, 2008; Kale et al., 2009). The distance was measured from the take-off line to the point where the back of the heel nearest to the take-off line lands on the floor to the nearest 1cm (Pinero et al., 2010). The maximal explosive muscular power of lower limb was assessed. The test was repeated three times and the best result was retained.

Single leg hop for distance test

The single leg hop for distance required the subjects to begin standing on the designated testing leg with their toe behind the starting line. Their arms were permitted to hold loosely by their side during the test. Subjects were instructed to jump as far forward as possible and land on both feet (Habibi et al., 2010). The distance was measured from the take-off line to the point where the back of the heel nearest to the take-off line lands on the floor to the nearest 1cm (Pinero et al., 2010). The maximal explosive muscular power of lower limb was assessed. The test was repeated three times and the best result was retained. Both legs were tested respectively.

Sprint performance in official competition

The 100m and 200m performance taken into account was completed during an outdoor Inter-school Athletics Competition (2011-2012) in different divisions. The performance on 100m and 200m was measured with a fully automatic photo finish electric system (accuracy ± 0.01 second).

Definition of terms

For a better understanding of this study, the terms that would be used commonly were defined as follow:

Grade A sprinters

Refer to 2011 to 2012 Inter-school Athletics Competition guideline, Grade A sprinters were operationally defined as the sprinters born in 1992 to 1994.

Grade B sprinters

Refer to 2011 to 2012 Inter-school Athletics Competition guideline, Grade B sprinters were operationally defined as the sprinters born in 1995 to 1996.

Grade C sprinters

Refer to 2011 to 2012 Inter-school Athletics Competition guideline, Grade C sprinters were operationally defined as the sprinters born in 1997 to 1998.

Junior sprinters

Junior sprinters were operationally defined as the sprinters aged 19 or below.

Senior sprinters

Senior sprinters were operationally defined as the sprinters aged 20 or above.

Elite sprinters

Elite sprinters were operationally defined as the sprinters who can enter the 100m or 200m final in 2011 to 2012 Inter-schools Athletics Competition.

Maximal explosive muscular power

Maximal explosive muscular power required an all-out effort to perform a task during a very short period (Lazzer, Pozzo, Rejc, Antonutto & Francescato, 2009).

Seasonal best

Seasonal best was operationally defined as the best performance of athletes within a particular season or a year.

Personal best

Personal best was operationally defined as the best performance of athletes within any periods.

Step length

Step length is the horizontal distance between the touchdown point of one foot to that of the following touchdown for the opposite foot (Hunter et al., 2004).

Step rate

Step rate is the number of step finishing in a unit of time (Hunter et al., 2004).

Hip flexion

Hip flexion is the motion of the femur move straightly and anteriorly toward the pelvis from any point in sagittal plane (Floyd, 2007).

Hip extension

Hip extension is the motion of the femur move straightly and posteriorly away the pelvis from any point in sagittal plane (Floyd, 2007).

Delimitations

The study was delimited to the followings:

1. There were total 22 male elite adolescent sprinters who were the secondary school athletics team representatives.
2. All subjects were aged 13 to 18.
3. The time spent for testing each subject was approximately 30 to 40 minutes.
4. The anthropometric measurement and three field tests were finished in one day to each school, unless they were unable to take and finish the tests because of any illness or injury.

Limitations

The following limitations were understood for the purpose of interpreting this study:

1. The data of tests were collected in different dates and time.

2. The performance of the subjects might vary according to their different daily lifestyle and physical activity level.
3. The study could not control the underlying variables such as injuries, sickness or tiredness.
4. The effort and motivation of the subjects in performing the hip flexibility assessment, standing long jump test and single leg for distance test were uncontrollable which might influence the results of the study.

Statistical analysis

All collected data were reported as mean and standard deviation. The Statistical Package for the Social Science 15.0 for windows (SPSS 15.0) software would be used to analyze the Minimum and maximum values of variables. The descriptive statistics would be also calculated by the SPSS. Pearson correlation production moment coefficient of correlation (r) was used to examine the correlation between anthropometric variables, muscular fitness variables and sprinting performance in official competition. An alpha level of $p<0.05$ indicated statistical significance.

Chapter 4

ANALYSIS OF DATA

This chapter was divided into two main sections including the results and discussions. In each section, it was generally divided into six dimensions, they are (1) Background information of sprinters, (2) Sprint performance, (3) Anthropometry, (4) Body composition, (5) Muscular fitness and (6) Correlation between sprint performance and the measured and calculated variables.

Results

Background information of sprinters

The background information of sprinters was shown in table 1.

Table 1. *Background information of sprinters (N=22)*

Variables	Numbers of subjects
Grade A	7
Grade B	8
Grade C	7

In grade A, 3 subjects had 0 to 2 years training experience; 3 subjects had 5 to 6 years training experience; 1 subject had 7 to 8 years training experience. Besides, 1 subject had one day training every week; 6 subjects had four days training every week. Moreover, 1 subject had 120 minutes for each training section; 6 subjects had 180 minutes for each training section.

In grade B, 1 subject had 0 to 2 years training experience; 4 subjects had 3 to 4 years training experience; 3 subjects had 5 to 6 years training experience. In addition, 3 subjects had two days training every week; 4 subjects had three days training every week; 1 subject had four days training every week. Besides, 1 subject had 120 minutes for each training section; 6 subjects had 180 minutes for each training section; 1 subject had 240 minutes for each training section.

In grade C, 3 subjects had 0 to 2 years training experience; 3 subjects had 3 to 4 years training experience; 1 subject had 5 to 6 years training experience. Moreover, 5 subjects had two days training every week; 2 subjects had three days training every week. Furthermore, 2 subjects had 90 minutes for each training section; 5 subjects had 180 minutes for each training section.

Sprint performance

The sprint performances of Grade A elite sprinters were shown in table 2.

Table 2. *Sprint performance of Grade A elite sprinters (N=7)*

Variables	Minimum	Maximum	Mean	±SD
100m PB (s)	10.93	11.96	11.35	0.36
100m SB (s)	11.13	12.10	11.44	0.36
200m PB (s)	22.44	24.11	23.01	0.62
200m SB (s)	22.47	24.11	23.02	0.63

In addition, the sprint performances of Grade B elite sprinters were shown in table 3.

Table 3. *Sprint performance of Grade B elite sprinters (N=8)*

Variables	Minimum	Maximum	Mean	±SD
100m PB (s)	11.39	12.35	11.84	0.28
100m SB (s)	11.39	12.50	11.97	0.38
200m PB (s)	23.32	25.50	24.45	0.72
200m SB (s)	23.40	25.50	24.55	0.66

Moreover, the sprint performances of Grade C elite sprinters were shown in table 4.

Table 4. *Sprint performance of Grade C elite sprinters (N=7)*

Variables	Minimum	Maximum	Mean	±SD
100m PB (s)	12.14	12.59	12.42	0.16
100m SB (s)	12.14	12.90	12.53	0.28
200m PB (s)	24.98	27.21	26.12	0.80
200m SB (s)	24.98	27.21	26.12	0.80

Anthropometry

The physical characteristics of grade A elite sprinters were shown in table 5.

Table 5. *Physical Characteristics of Grade A elite sprinters (N=7)*

Variables	Minimum	Maximum	Mean	±SD
Age	17	18	17.43	0.54
Height(cm)	165	179.5	172.93	4.95
Weight(kg)	54	75	62.84	7.24
BMI	19.26	23.67	20.96	1.52
Shoulder width (cm)	39.30	42.50	40.91	1.21
Circumference (cm)				
- Chest	81.75	94.50	88.48	4.02
- Waist	67.75	76.25	71.26	3.22
- Hip	83.00	96.40	89.61	4.77
- Thigh	46.90	57.45	52.45	3.70
- Calf	33.40	38.50	36.18	1.88
Length (cm)				
- Lower extremity	80.50	91.50	84.91	3.73
- Thigh	31.40	39.80	35.57	2.52
- Calf	31.30	36.40	34.03	1.79

In addition, the physical characteristics of grade B elite sprinters were shown in table 6.

Table 6. *Physical Characteristics of Grade B elite sprinters (N=8)*

Variables	Minimum	Maximum	Mean	±SD
Age	15	16	15.38	0.52
Height(cm)	161	180	171.88	7.10
Weight(kg)	53	65	58.61	4.35
BMI	17.56	21.61	19.86	1.17
Shoulder width (cm)	38.70	41.40	40.13	0.82
Circumference (cm)				
- Chest	81.10	92.10	85.59	3.58
- Waist	67.10	75.25	69.68	2.83
- Hip	84.00	94.00	87.58	2.95
- Thigh	47.90	53.65	50.76	1.79
- Calf	33.80	37.20	35.57	1.10
Length (cm)				
- Lower extremity	82.10	91.00	86.46	3.45
- Thigh	31.80	38.20	36.28	2.40
- Calf	29.30	38.00	34.90	2.84

Besides, the physical characteristics of grade C elite sprinters were shown in table 7.

Table 7. *Physical Characteristics of Grade C elite sprinters (N=7)*

Variables	Minimum	Maximum	Mean	±SD
Age	13	14	13.29	0.49
Height(cm)	158	176	168.57	6.05
Weight(kg)	48	63	55.19	4.97
BMI	18.34	20.57	19.40	0.99
Shoulder width (cm)	34.70	41.10	37.53	2.16
Circumference (cm)				
- Chest	76.75	84.90	80.63	2.86
- Waist	63.30	72.35	68.36	3.23
- Hip	79.80	88.50	84.86	3.43
- Thigh	45.25	51.00	48.58	2.09
- Calf	32.90	38.60	34.70	1.94
Length (cm)				
- Lower extremity	77.60	90.00	83.91	4.50
- Thigh	32.30	37.10	34.17	2.00
- Calf	32.30	37.20	34.37	2.08

Body composition

The body composition of Grade A sprinters was shown in table 8.

Table 8. *Body composition of Grade A elite sprinters (N=7)*

Variables	Minimum	Maximum	Mean	±SD
Body fat %	8.69	14.85	11.11	2.57
Fat mass	4.78	10.07	7.03	2.07
Fat free mass	46.96	64.93	55.81	6.03
Waist-hip ratio	0.76	0.82	0.80	0.02

Moreover, the body composition of Grade B sprinters was shown in table 9.

Table 9. *Body composition of Grade B elite sprinters (N=8)*

Variables	Minimum	Maximum	Mean	±SD
Body fat %	7.81	16.12	10.57	2.51
Fat mass	4.44	10.48	6.24	1.85
Fat free mass	47.71	56.94	52.37	3.40
Waist-hip ratio	0.77	0.83	0.80	0.02

Furthermore, the body composition of Grade C sprinters was shown in table 10.

Table 10. *Body composition of Grade C elite sprinters (N=7)*

Variables	Minimum	Maximum	Mean	±SD
Body fat %	9.75	16.46	12.35	2.53
Fat mass	4.68	9.55	6.89	1.91
Fat free mass	43.22	53.51	48.29	3.53
Waist-hip ratio	0.79	0.82	0.81	0.01

Muscular fitness

The muscular fitness of Grade A sprinters was shown in table 11.

Table 11. *Muscular fitness of Grade A elite sprinters (N=7)*

Variables	Minimum	Maximum	Mean	±SD
Standing Long Jump(m)	2.36	2.69	2.51	0.11
Single leg hop (m)				
- left leg	2.02	2.39	2.15	0.13
- right leg	1.93	2.41	2.14	0.17
Hip flexibility (°)				
- flexion	94.5	117	103.36	9.61
- extension	18	39.5	25.64	7.08

In addition, the muscular fitness of Grade B sprinters was shown in table 12.

Table 12. *Muscular fitness of Grade B elite sprinters (N=8)*

Variables	Minimum	Maximum	Mean	±SD
Standing Long Jump(m)	2.15	2.86	2.46	0.21
Single leg hop (m)				
- left leg	1.84	2.26	2.04	0.13
- right leg	2.02	2.26	2.10	0.07
Hip flexibility (°)				
- flexion	95	109	99.81	4.65
- extension	17.5	25.5	21.50	2.56

Furthermore, the muscular fitness of Grade C sprinters was shown in table 13.

Table 13. *Muscular fitness of Grade C elite sprinters (N=7)*

Variables	Minimum	Maximum	Mean	±SD
Standing Long Jump(m)	1.75	2.64	2.35	0.28
Single leg hop (m)				
- left leg	1.77	2.23	2.02	0.14
- right leg	1.70	2.15	2.03	0.15
Hip flexibility (°)				
- flexion	90	107	101.29	6.33
- extension	15	39.5	24.21	8.39

Correlation between 100m sprint performance and the measured and calculated variables

The Pearson correlation between the 100m sprint performance and the measured and calculated variables were computed and shown in table 14.

Table 14. Pearson correlation between the 100m sprint performance and the measured and calculated variables (N=22)

Variables	*r*	p
Height	-0.356	0.104
Weight	-0.465*	0.029
Age	-0.744*	0.000
BMI	-0.335	0.128
Waist to hip ratio	0.364	0.096
% body fat	0.307	0.164
Fat mass	0.072	0.749
Fat free mass	-0.576*	0.005
Shoulder width	-0.510*	0.015
Circumference:		
-Chest	-0.578*	0.005
-Waist	0.166	0.461
-Hip	0.349	0.111
-Thigh	-0.554*	0.007
-Calf	-0.415	0.055
Length:		
-Lower extremity	-0.186	0.406
-Thigh	-0.200	0.373
-Calf	-0.099	0.660
Standing long jump	-0.394	0.070
Single leg hop		
-Left leg	-0.249	0.263
-Right leg	-0.237	0.288
Hip flexibility		
-Flexion	-0.233	0.296
-Extension	-0.286	0.197

* Correlation is significant at the 0.05 level (2-tailed)

A large amount of measured and calculated variables including height, body mass index, waist to hip ratio, body fat percentage, fat mass, waist circumference, hip circumference, calf circumference, lower extremity length, thigh length, calf length, standing long jump, single left leg hop, single right leg hop, hip flexion and hip extension were not significant correlated with 100m seasonal best performance of sprinters. However, there was a negative correlation between thigh circumference and 100m seasonal best performance of sprinters ($r=-0.554$, $p<0.05$). Besides, there was a negative relationship between chest circumference and 100m seasonal best performance of sprinters ($r=-0.578$, $p<0.05$). In addition, a negative correlation between shoulder width and 100m seasonal best performance of sprinters was found ($r=-0.51$, $p<0.05$). Moreover, fat free mass was significant correlated negatively with 100m seasonal best performance of sprinters ($r=-0.576$, $p<0.05$). Furthermore, there was a negative correlation between age and 100m seasonal best performance of sprinters ($r=-0.744$, $p<0.05$). Also there was a negative correlation between weight and 100m seasonal best performance of sprinters ($r=-0.465$, $p<0.05$).

Discussions

This discussion chapter was generally divided into three aspects; they are (1) Sprint performance, (2) Anthropometry, (3) Body composition and (4) Muscular fitness.

Sprint performance

In Hong Kong, aged 13 to 14 elite sprinters within this research have a 100m personal best resulting in average 12.42 seconds which is slower than the foreign elite sprinters in the same age group resulting in average 11.64 seconds in 100m personal best (Siris, 1986). In addition, the foreign elite sprinters aged 17 to 18 can perform average 11.15 seconds in 100m as their personal best performance (Siris, 1986). Hong Kong elite sprints in the same age group within this research can perform with mean 11.35 seconds in 100m as their personal best which is slower than the foreign elite sprinters. Different sprint performance may be interpreted as distinctive race, training method and sprint technique.

Anthropometry

A study on the prediction of sprint potential focused on the height and weight of junior sprinters aged 13 to 17 at different performance level of 100m (Siris, 1986). The comparison between the local and foreign junior sprinters in anthropometric indicator was shown in table 15. To compare with foreign junior sprinters, the local junior sprinters who can perform 100m within average 12.4 to 14 seconds were taller and heavier than the foreign junior sprinters in the same range of performance qualification. However, the local junior sprinters who can perform 100m within average 11.6 to 12.3 seconds group and average 11.1 to 11.5 seconds group were shorter and lighter than the foreign junior sprinters. In my findings, there was a negative correlation between weight and 100m sprint performance (r=-0.465, $p<0.05$). As weight increased, the time to accomplish 100m may be shorter. Sprinters with lower in weight have less muscle mass so as too weak. But sprinters with higher in weight may hinder to accelerate owing to take higher force with a large mass (Niels, 2005). It was not likely that sprinters with very high weight can perform faster in 100m, but instead there may be an optimal range of weight in sprinters.

Table 15. The comparison between the local (N=22) and foreign (N=23) junior sprinters in anthropometric indicator at different performance level of 100m

Subscale	Nationality	Performance Qualification (sec.)		
		12.4-14.0s	11.6-12.3s	11.1-11.5s
Height(cm)	Local	168.57±6.05	171.88±7.1	172.93±4.95
	Foreign	165±1.67	177.7±0.79	177.5±1.39
Weight(kg)	Local	55.19±4.97	58.61±4.35	62.84±7.24
	Foreign	52.1±2.16	66.3±1.09	68.8±1.35

In addition, there was a significant negative relationship between age and 100m sprint performance in my findings (r=-0.744, $p<0.05$). The coefficient of determination (r^2) is 0.55 meaning that 55 percent of variability in 100m sprint performance is due to different ages. In junior sprinters with aged 13 to 18, they were within the period of adolescence growth. Older adolescent can perform faster in 100m than younger adolescent. Besides the training effect, junior sprinters may run faster due to the muscular and bone development in puberty period. After this period, they entered another period of aging or maturation. Metabolism, muscle mass and bone density were decreased gradually. Therefore, the negative relationship between age and sprint performance is likely just within the puberty period. Interestingly, most anthropometric measurements in this finding revealed poor or insignificant correlation with 100m sprint performance. However, chest circumference (*r*=-0.578, p<0.05), thigh circumference (*r*=-0.554, p<0.05) and shoulder width (*r*=-0.51, p<0.05) were negatively correlated with 100m sprint performance. But still there was in lack of statistical strength to identify those anthropometric measurements as predictors of 100m sprint performance.

Education Bureau (2010) in Hong Kong cooperated with a large amount of Hong Kong secondary schools to conduct a research about Hong Kong secondary school students' physical fitness and create norm tables by age groups. Table 16, 17, 18, 19, 20 and 21 were shown the group of aged 13, 14, 15, 16, 17 and 18 in anthropometric comparison respectively. The BMI of both elite junior sprinters group and normal junior population group were within the normal range (18.5-23 kg/m^2) in Asian population. The BMI of almost all aged groups (13-17) in elite junior sprinters group were lower than normal junior population group except the group of aged 18. Niels (2005) pointed out that there was a tendency toward less weight and BMI among sprinters than among normal population.

In addition, it is still unclear that taller sprinters possessing longer lower limbs have superiority to sprint and acceleration performance. But it is the fact that longer lower limb would lead an increase in step length and may lead to a decrease in step rate (Hunter, 2004; Habibi et al., 2010).

Table 16. Anthropometric comparison between Hong Kong elite junior sprinters (N=5) and Hong Kong normal junior population (N=464) in aged 13

Variables	Group	Mean ± SD
Height(cm)	Hong Kong elite	166.8±6.06
	Hong Kong normal	162.02±7.45
Weight(kg)	Hong Kong elite	55.2±5.89
	Hong Kong normal	52.73±11.93
BMI	Hong Kong elite	19.79
	Hong Kong normal	20.09

Table 17. Anthropometric comparison between Hong Kong elite junior sprinters (N=2) and Hong Kong normal junior population (N=502) in aged 14

Variables	Group	Mean ± SD
Height(cm)	Hong Kong elite	173±4.24
	Hong Kong normal	166.8±7.16
Weight(kg)	Hong Kong elite	55.15±3.04
	Hong Kong normal	56.01±11.7
BMI	Hong Kong elite	18.42
	Hong Kong normal	20.13

Table 18. Anthropometric comparison between Hong Kong elite junior sprinters (N=5) and Hong Kong normal junior population (N=492) in aged 15

Variables	Group	Mean ± SD
Height(cm)	Hong Kong elite	171.8±8.29
	Hong Kong normal	169.66±5.98
Weight(kg)	Hong Kong elite	58.48±4.34
	Hong Kong normal	59.4±12.58
BMI	Hong Kong elite	19.86
	Hong Kong normal	20.64

Table 19. Anthropometric comparison between Hong Kong elite junior sprinters (N=3) and Hong Kong normal junior population (N=474) in aged 16

Variables	Group	Mean ± SD
Height(cm)	Hong Kong elite	172±6.25
	Hong Kong normal	170.6±5.76
Weight(kg)	Hong Kong elite	58.83±5.35
	Hong Kong normal	60.39±11.89
BMI	Hong Kong elite	19.85
	Hong Kong normal	20.75

Table 20. Anthropometric comparison between Hong Kong elite junior sprinters (N=4) and Hong Kong normal junior population (N=413) in aged 17

Variables	Group	Mean ± SD
Height(cm)	Hong Kong elite	172.63±5.94
	Hong Kong normal	171.55±5.6
Weight(kg)	Hong Kong elite	61.23±5.47
	Hong Kong normal	62.49±10.54
BMI	Hong Kong elite	20.51
	Hong Kong normal	21.23

Table 21. Anthropometric comparison between Hong Kong elite junior sprinters (N=3) and Hong Kong normal junior population (N=602) in aged 18

Variables	Group	Mean ± SD
Height(cm)	Hong Kong elite	173.33±4.51
	Hong Kong normal	170.86±5.87
Weight(kg)	Hong Kong elite	65±10
	Hong Kong normal	62.18±10.17
BMI	Hong Kong elite	21.55
	Hong Kong normal	21.30

Body composition

As it is mentioned before, Education Bureau (2010) conducted a research about Hong Kong secondary school students' physical fitness and created norm tables by age groups. By using the data from Education Bureau for calculation, the body fat percentage, fat mass and fat free mass were outputted. The comparison between elite junior sprinters and normal junior population were shown in table 22. Some researchers (Onyewadume et al., 2004; Kumagai et al., 2000) indicated that athletes generally have lower body fat percentage than normal population which is also occurred in my findings. Person who has higher percentage of body fat will lead to poorer muscular strength and power per unit of body mass. Therefore, they may run slower in sprint due to lower fat free mass (Pinero et al., 2010). In my study, there was a negative correlation between 100m sprint performance and fat free mass ($r=-0.576$, $p<0.05$). To compare with normal junior population group, the elite junior sprinters have relatively higher fat free mass and relatively lower fat mass. However, limited data on body composition of elite junior sprinters was in this study. Body composition may be one of the indicators to spot sprint potential but further studies are required to strengthen this viewpoint.

Table 22. Body composition comparison between Hong Kong elite junior sprinters and Hong Kong normal junior population at different age group

Age	Group	% body fat (%) Average	Fat mass (kg) Average	Fat free mass (kg) Average
13	Hong Kong elite	12.57	7.06	48.14
	Hong Kong normal	18.64	9.83	42.9
14	Hong Kong elite	11.79	6.48	48.67
	Hong Kong normal	17	9.52	46.51
15	Hong Kong elite	11.1	6.57	51.91
	Hong Kong normal	16.6	9.86	49.54
16	Hong Kong elite	9.69	5.7	53.13
	Hong Kong normal	16.36	9.88	50.51
17	Hong Kong elite	10.2	6.18	55.04
	Hong Kong normal	16.07	10.04	52.45
18	Hong Kong elite	12.32	8.17	56.83
	Hong Kong normal	15	9.33	52.85

**Note: Group aged 13 (Elite: N=5 ; Normal N=464)*
Group aged 14 (Elite: N=2 ; Normal N=502)
Group aged 15 (Elite: N=5 ; Normal N=492)
Group aged 16 (Elite: N=3 ; Normal N=474)
Group aged 17 (Elite: N=4 ; Normal N=413)
Group aged 18 (Elite: N=3 ; Normal N=602)

Muscular fitness

Maud and Cortez-cooper (1995) indicated that the normal range of hip flexion and hip extension in normal population was 121 degree and 12 degree respectively. In my findings, the average range of hip extension in grade A, B and C elite adolescent sprinters in Hong Kong were greater than normal junior population resulting in 25.64±7.08 degree, 21.5±2.56 degree and 24.21±8.39 degree respectively. However, the average range of hip flexion in grade A (103.36±9.61 degree), B (99.81±4.65 degree) and C (101.29±6.33 degree) elite adolescent sprinters in Hong Kong were lower than normal junior population. Poor flexibility has a higher rate of injury no matter in athletes or non-athletes. Therefore, adequate stretching and flexibility training for athletes is utmost importance in order to prevent injury and improve sports performance (Jekins and Beazell, 2010).

Besides, Education Department of People's republic of China (2011) established a norm table for different form students in China about China students' physique health. As

Hong Kong is a part of China, this norm is valuable and selected for evaluation. The standing long jump of Hong Kong elite junior sprinters was shown in table 23. According to the norm table of standing long jump performance in China, there were total four categories including excellent, good, pass and fair. Referring to this norm table, Hong Kong F.2 elite junior sprinters were labeled as "excellent" category, F.3 elite junior sprinters were labeled as "good" category, F.4 elite junior sprinters were labeled as "excellent" category, F.5 elite junior sprinters were labeled as "good" category and F.6 elite junior sprinters were labeled as "excellent" category. Elite junior sprinters have jumped relatively longer than normal junior population. Standing long jump assessment is performed with a rapid contraction and in a high velocity of lower limb muscles. The higher portion of leg muscle mass, the greater distance jumped in standing long jump (Kale et al., 2009). This assessment may be one of the indicators to discover the talent junior sprinters. Although there was a weak negative correlation between 100m sprint performance and standing long jump performance ($r=-0.394$, $P>0.05$) in my findings, still it had a reference value.

Table 23. Standing long jump performance of Hong Kong elite junior sprinters at different form in secondary schools

Form	Standing long jump (m) Average
F.2 (N=8)	2.34
F.3 (N=2)	2.32
F.4 (N=5)	2.55
F.5 (N=5)	2.49
F.6 (N=2)	2.57

In addition, Kale et al. (2009) also stated that improved ability of horizontal jumping increases the range of motion of lower legs for flight phase of sprint step. Moreover, a research conducted by Habibi et al. (2010) revealed that single left and right leg hop for distance was significantly related to 10m sprint performance from a block start (r=-0.74 $p<0.05$ and r=-0.76, $p<0.05$ respectively). Unfortunately, no data on 10m sprint performance from a block start are available in my findings. Further studies on this dimension are required. Also a weak negative relationship between 100m sprint performance and single left and right leg hop for distance was found in this study (r=-0.249, $p>0.05$ and r=-0.237, $p>0.05$ respectively). But still single leg hop training cannot be neglected in 100m sprint training as to improve the acceleration phase. Better understanding of training method in jumping can assist the sprinting coaches and athletes to improve the sprint performance. Under this circumstance, horizontal jump training should be involved in 100m sprint training for improving the sprint performance.

Furthermore, as it was mentioned before, the range of hip flexion of elite junior sprinters in this study were lower than the normal population. Some researchers (Armiger & Martyn, 2009; Floyd ,2007) stated that the hip flexion motion was performed by a complex network of muscles, ligaments, tendons and bones. Hip flexors were a group of muscles including iliopsoas, pectineus, rectus femoris and sartorius. Hip flexors were responsible for moving the legs upward and forward. Also hip flexors were one group of the muscles participating in the sprinting action. However, hip flexors stretching and training were rarely emphasized in 100m training programs. Deane et al. (2005) indicated that hip flexor training can improve the sprint acceleration phase. Also Guskiewicz et al. (1993) stated that there was an improvement in sprint speed if the hip strength increased. Therefore, hip flexors stretching and training were recommended to instill into sprint training. Figure 9 and 10 were the hip flexors stretching exercise that elite junior sprinters can do. Figure 11 was the hip flexion exercise with resistance that elite junior sprinters can perform.

Jenkins and Beazell (2010) pointed out that hip flexors stretching (Figure 9) in a posterior pelvic tilt can activate the right gluteal as well as to facilitate iliopsoas stretch. Each subject should vaguely felt in anterior thigh during this type of stretching. In addition, Blazevich (2001) stated that this flexibility training (Figure 10) can improve the stretch on the hip flexors and also knee extensors while preventing stretch in the muscles that stabilize the pelvis. In this exercise, each subject is often felt both in the lateral and anterior musculature of hip and also in the patellar connective tissue. Moreover, Deane et al. (2005) indicated that each subject can perform 10 repetitions in one set of strength training for hip flexors (Figure 11) and with total 2 sets for each leg. Coaches and sprinters can consider to add the above exercise and training in order to improve the hip flexion flexibility and the hip flexors strength.

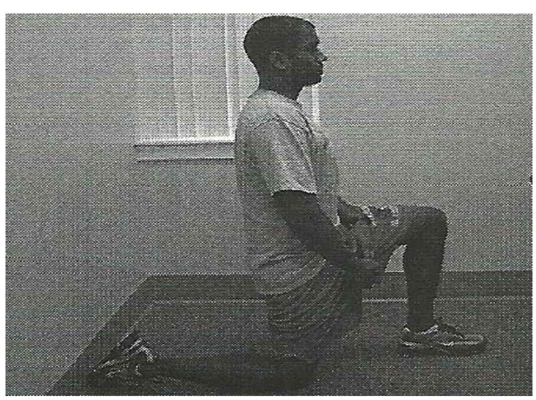

Figure 9. Hip flexors stretching

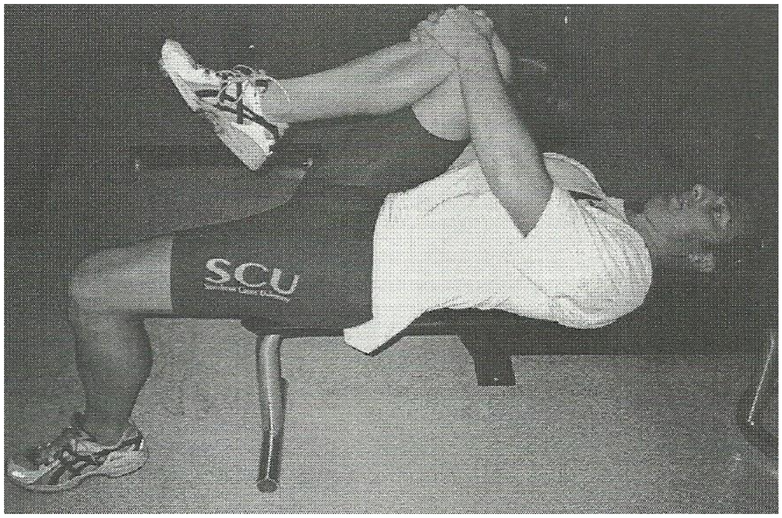

Figure 10. Hip flexors and knee extensors stretching by surpassing and lying in a supine position

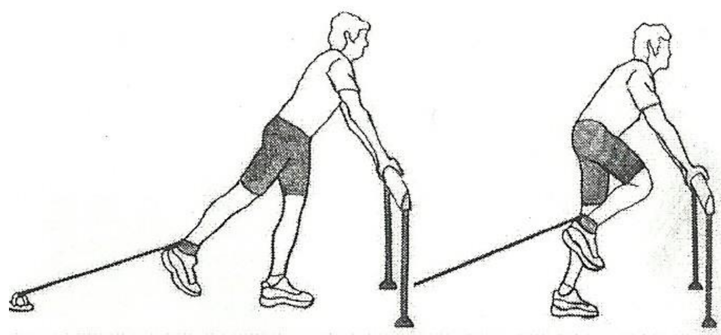

Figure 11. Hip flexion exercise by using elastic band as resistance

Chapter 5

SUMMARY AND CONCLUSION

Summary of results

The present study was decided to establish the anthropometric and physical fitness profile of elite adolescent sprinters aged 13 to 18 in Hong Kong and provide scientific information for further studies and potential use in sprinting field.

Twenty two male elite adolescent sprinters aged 13 to 18 from ten secondary schools in different districts of Hong Kong were invited to be the subjects in this study. Different components including anthropometric measurement, body composition calculation and muscular fitness assessment were conducted in this finding. The anthropometric measurement and three field tests were finished in one day to each school. All collected data were analyzed by Statistical Package for the Social Science 15.0 for windows (SPSS 15.0). Pearson correlation production moment coefficient of correlation (r) was used and the significant level of 0.05 was set.

The results of this study were summarized as follows:

1. There was a negative correlation between thigh circumference and 100m seasonal best performance of sprinters (r=-0.554, p<0.05, N=22).

2. There was a negative relationship between chest circumference and 100m seasonal best performance of sprinters (r=-0.578, p<0.05, N=22).

3. A negative correlation between shoulder width and 100m seasonal best performance of sprinters was found (r=-0.51, p<0.05, N=22).

4. Fat free mass was significant correlated negatively with 100m seasonal best performance of sprinters (r=-0.576, p<0.05, N=22).

5. There was a negative correlation between age and 100m seasonal best performance of sprinters (r=-0.744, p<0.05). 6. There was a negative correlation between weight and 100m seasonal best performance of sprinters (r=-0.465, p<0.05).

7. The BMI of almost all aged groups (13-17) in elite adolescent sprinters group were lower than normal junior population group except the group of aged 18.

8. Elite adolescent sprinters relatively had lower body fat percentage, lower fat mass and higher fat free mass than normal adolescent population.

Conclusion

The related research on adolescent elite sprinters in Hong Kong is very scarce. This anthropometric and physical fitness profile study provided useful scientific information and reference for evaluating the junior elite sprinters and may be used as potential spotting in Hong Kong. This research can also be aroused the awareness of junior sprinters and athletics continuous development in Hong Kong.

Recommendations for further studies

1. The sample size should be extended in order to enlarge the representativeness of the research.
2. The research could be more representative if the subjects won medals in inter-school athletics competition recruiting from different districts.
3. Female adolescent elite sprinters could be included in this study so that it could also benefit to female.
4. The test should conduct in pre-season period, which could minimize the uncontrollable variables like competition and injury that would be affected the testing schedule.

BIBLIOGRAPHY

Adams, G. M. & Beam, W. C. (5th Ed.). (2008). *Exercise physiology: laboratory manual*. Boston: McGraw-Hill.

Almuzaini, K. S. & Fleck, S. J. (2008). Modification of the standing long jump test enhances ability to predict anaerobic performance. *Journal of Strength and Conditioning Research, 22*(4), 1265-1272.

American College of Sports Medicine.(6th Ed.).(2009). *ACSM's resource manual for guidelines for exercise testing and prescription*. Philadelphia: Lippincott Williams & Wilkins.

Armiger, P. & Martyn, M. A. (2009). *Stretching for functional flexibility*. Philadelphia: Lippincott Williams & Wilkins.

Blazevich, A. J. (2001). Flexibility training for sprint runners. *Strength and Conditioning Journal, 23*(4), 42-49.

Bret, C., Rahmani, A., Dufour, A. B., Messonnier, L. & Lacour, J. R. (2002). Leg strength and stiffness as ability factors in 100m sprint running. *Journal of Sports Medicine and Physical Fitness, 42*(3), 274-281.

Callaway, C. W., Chumlea, W. C., Bouchard, C., Himes, J. H.,Lohman, T. G., Martin, A. D., Mitchell, C. D., Mueller,W. H., Roche, A. F., & Seefeldt, V. D.(1988). Circumferences. In T.G., Lohman, A.F., Roche, & R., Martorell (Eds), *Anthropometric standardization reference manual* (pp. 39-54). Champaign, IL: Human Kinetics.

Cunha, L. (2005). The relation between different phases of sprint run and specific strength parameters of lower limbs. *International Symposium on Biomechanics in Sports, 23*, 183-186.

Deane, R. S., Chow, J. W., Tillman, M. D. & Fournier, K. A. (2005). Effects of hip flexor training on sprint, shuttle run, and vertical jump performance. *Journal of Strength and Conditioning Research, 19*(3), 615-612.

Education Bureau. (2010). *Hong Kong secondary school students' physical fitness norm tables*. Retrieved January 15, 2012, from http://cd1.edb.hkedcity.net/cd/pe/tc/rr/pfs/sec_09_10_e.pdf

Eston, R. & Reilly, T. (2nd Ed.). (2001). *Kinanthropometry and exercise physiology laboratory manual: tests, procedures and data [volume 1: Anthropometry]*. London ; New York : Routledge.

Floyd, R. T. (16th Ed.). (2007). *Manual of structural Kinesiology*. Boston: McGraw-Hill.

Freedman, D. S., Katzmarzyk, P. T., Dietz, W. H., Srinivasan, S. R. & Berenson, G. S. (2010). The relation of BMI and skinfold thockness to risk factors among young and middle-aged adults: the Bogalusa heart study. *Annals of Human Biology, 37*(6), 726-737.

Ghosh, A. & Kendra, P. C. (2007). Comparison of anthropometric, metabolic and dietary fatty acids profiles in lean and obese dyslipidaemic Asian Indian male subjects. *European Journal of Clinical Nutrition, 61*, 412-419.

Guskiewicz, K., Lephart, S. & Burkholder, R. (1993). The relationship between sprint speed and hip flexion extension strength in collegiate athletes. *Isokinetics & Exercise Science, 3*(2), 111-116.

Habibi, A., Shabani, M., Rahimi, E., Fatemi, R., Najafi, A., Analoei, H. & Hosseini, M. (2010). Relationship between jump test results and acceleration phase of sprint performance in national and regional 100m sprinters. *Journal of Human Kinetics, 23*, 29-35.

Haneda, Y., Enomoto, Y., Hoga, K., & Fujii, N. (2003). Changes in running velocity and kinetics of the lower limb joints in 100m sprint running. *Japanese Journal of Biomechanics in Sports & Exercise,*7(3), 193-205.

Harrison, G. G., Buskirk, E. R., Carter, J.E., Johnston, F. E., Lohman, T. G., Pollock, M. L., Roche, A. F. & Wilmore, J. (1988).Skinfold thickness and measurement technique. In T.G., Lohman, A.F., Roche, & R., Martorell (Eds), *Anthropometric standardization Reference Manual* (pp. 55-70). Champaign, IL: Human Kinetics.

Heyward, V. H. (4th Ed.). (2002). *Advanced fitness assessment and exercise prescription.* Champaign, IL: Human Kinetics.

Hunter, J. P., Marshall, R. N., & Mcnair, P. J. (2004). Interaction of step length and step rate during sprint running. *Medicine & Science in Sports Exercise*, *36*(2), 261-271.

Kale, M., Asci, A., Bayrak, C. & Acikada, C. (2009). Relationships among jumping performances and sprint parameters during maximum speed phase in sprinters. *Journal of Strength and Conditioning Research, 23*(8), 2272-2279.

Jenkins, J. & Beazell, J. (2010). Flexibility for runners. *Clinics in Sports Medicine, 29*(3), 365-377.

Kukolj, M., Ropret, R., Ugarkovic, D. & Jaric, S. (1999). Anthropometric, strength, and power predictors of sprinting performance. *Journal of Sports Medicine and Physical Fitness, 39*(2), 120-122.

Kumagai, K. Abe, T., Brechue, W. F., Ryushi, T., Takano, S. & Mizuno, M. (2000). Sprint performance is related to muscle fascicle length in male 100-m sprinters. *Journal of Application Physiology, 88*, 811-816.

Kumar, H. (2006). Age changes in speed of running during 30 meter sprint running. *Journal of Exercise Science and Physiotherapy, 2*, 92-95.

Kyrolainen, H., Santtila, M., Nindl, B. C. & Vasankari, T. (2010). Physical fitness profiles of young men associations between physical fitness, obesity and health. *Journal of Sports Medicine, 40*(11), 907-920.

Lazzer, S., Pozzo, R., Rejc, E., Antonutto, G. & Francescato, M. P. (2009). Maximal explosive muscle power in obese and non-obese prepubertal children. *Clinical Physiology and Nuclear Medicine, 29*(3), 224-228.

Lee, S. M. & Piazza, S. J. (2009). Built for speed: musculoskeletal structure and sprint ability. *Journal of Experimental Biology, 212*, 3700-3707.

Li, L., Chen, Y, J., Zhai, F. M., & Cui, B. T. (2007). All-range stretch hand and swing arm for 100m sprinters. *Shandong Sports Science & Technology*, *29*(3), 26-27.

Malina, R. M.(1988).Physical anthropology. In T.G., Lohman, A.F., Roche, & R., Martorell (Eds), *Anthropometric Standardization Reference Manual* (pp. 99-102). Champaign, IL: Human Kinetics.

Maud, P. J. & Cortez-Cooper, M. Y. (1995). Static techniques for the evaluation of joint range of motion. In P. J. Maud, & Foster, C. (Eds.), *Physiological assessment of human Fitness* (pp. 221-243). Champaign, IL: Human Kinetics.

Mirkov, D. M., Kukolj, M., Ugarkovic, D. Koprivica, V. J. & Jaric, S. (2010). Development of anthropometric and physical performance profiles of young elite male soccer players: a longitudinal study. *Journal of Strength and Conditioning Research, 24*(10), 2677-2682.

Mureika, J. R. (2003). Modeling wind and altitude effects in the 200m sprint. *Canadian Journal of Physics, 81*, 895-910.

Mureika, J. R. (2006). The effects of temperature, humidity, and barometric pressure on short-sprint race times. *Canadian Journal of Physics, 84*, 311-324.

Niels, U. (2005). Anthropometric comparison of world-class sprinters and normal populations. *Journal of Sports Science and Medicine, 4*, 608-616.

Norton, K., Whittingham, N., Carter, L., Kerr, D., Core, C. & Jones, M. M. (1996). Measurement techniques in Anthropometry. In K. Norton & T. Olds (Eds.), *Anthropometrica: a textbook of body measurement for sports and health courses (pp. 27-76)*. Sydney, Australia: UNSW Press.

Onyewadume, I. U., Amusa, L. O. & Owolabi, E. O. (2004). Physique, anaerobic power and pulmonary measures of botswana track athletes. *Kinesiology, 36*(2), 250-259.

Peterson, M. D., Alvar, B. A. & Rhea, M. R. (2006). The contribution of maximal force production to explosive movement among young collegiate athletes. *Journal of Strength and Conditioning Research, 20*(4), 867-873.

Pinero, J. C., Montesinos, J. L. G., Keating, X. D., Mora, J., Sjostrom, M. & Ruiz, J. R. (2010). Percentile values for running sprint field tests in children ages 6-17 years: influence of weight status. *Research Quarterly for Exercise and Sport, 81*(2), 143-151.

Pinero, J. C., Ortega, F. B., Artero, E. G., Rejon, M. J. G., Mora, J., Sjostrom, M. & Ruiz, J. R. (2010). Assessing Muscular strength in youth: usefulness of standing long jump as a general index of muscular fitness. *Journal of Strength and Conditioning Research, 24*(7), 1810-1817.

Ross, A., Leveritt, M., & Riek, S. (2001). Neural influences on sprint running. *Sports Medicine, 31(*6), 409-425.

Siris, P. (1986). How to predict sprint potential. *Modern Athlete & Coach, 24*(4), 13-15.

So, W. Y. & Choi, D. H. (2010). Differences in phycial fitness and cardiovascular function depend on BMI in korean men. *Journal of Sports Science and Medicine, 9*, 239-244.

Stokes, K., Nevill, M. & Hall, G. (2005). Age is an important determinant of the growth hormone response to sprint exercise in non-obese young men. *Hormone research, 65*(2), 57-61.

Villanueva, A. M., Buchheit, M., Kuitunen, S., Douglas, A., Peltola, E. & Bourdon, P. (2011). Age-related differences in acceleration, máximum running speed, and repeated-sprint performance in young soccer players. *Journal of Sports Sciences, 29*(5), 477-484.

Wang, S. S., Whitney, S. L., Burdett, R. G. & Janosky, J. E. (1993). Lower extremity muscular flexibility in long distance runners. *Journal of Orthopaedic & Sports Physical Therapy, 17*(2), 102-107.

Wilmore, J. H., Frisancho, R. A., Gordon, C. C., Himes, J. H., Martin, A. D., Martorell, R., & Seefeldt, V. D. (1988). Body breadth equipment and measurement techniques. In T.G., Lohman, A.F., Roche, & R., Martorell (Eds), *Anthropometric standardization reference manual* (pp. 27-38). Champaign, IL: Human Kinetics.

World Health Organization. (2004). Appropriate body-mass index for asian populations and its implications for policy and intervention strategies. *The Lancet, 363*, 157-163.

Zhang, B. R., & Li, Y. B. (2004). Factors influencing the pace length and pace frequency in short-distance running. *Journal of Langfang Teachers College, 20*(4), 62-64.

Zhou, H., & Zan, X. M. (2009). On the influent factors for boulter's success inspirations from the 29th Olympic games man 100 meters finals. *Journal of PLA Institute of Physical Education, 28*(2), 38-41.

全國學生體質健康標準數據管理中心 (2011)。中國學生體質健康標準評分表。檢索自2012年1月15日，從http://www.csh.edu.cn/csphw/press/biaozhun.html

APPENDIX A

Informed Consent for adolescent sprinters

The purpose of the fitness testing is to evaluate physiological profile including anthropometric measurement, body composition, flexibility and muscular fitness.

I understand that I am responsible for monitoring my own condition throughout the tests, and should any unusual symptoms occur, I will cease my participation and inform the instructor.

In signing this consent from, I, ______________________ (Name of Participant), affirm that I have read this form in its entirety and that I understand the description of the testing procedures and the risks and discomforts, and having had an opportunity to ask questions that have been answered to my satisfaction.

________________________	________________________
(Signature of participant)	(Date)
________________________	________________________
(Person administering tests)	(Date)

APPENDIX B

中學生田徑運動員體能測試參加者同意書

閣下正被邀請參與一個關於香港中學生田徑運動員的研究，其研究目的是收集運動員身體素質的資料。其資料可能將會有助於日後選材之用。

研究包括以下測試：

- 皮下脂肪
- 髖關節柔韌性
- 立定跳遠
- 立定單足跳遠
- 量度:
  1)肩寬　2)胸圍　3)腰圍　4)臀圍　5)大腿粗幼度
  6)小腿粗幼度　7)大腿長度　8)小腿長度　9)下肢長度

風險評估

當進行測試時，可能會潛在不適和危險。當參加者在研究期間有任何不適，應立即通知有關研究人員。如需要額外藥物治療，有關費用將由參加者負責。若進行研究中參加者有任何受傷，將不會獲得任何金錢上的賠償。

參予條款

參加者是義務參與是項研究，若參加者於中途退出，將不需承擔任何懲罰。當參加者進行研究期間，要求退出，亦不需負上任何責任或損失。如果參加者中途退出，其數據將交回他本人或可要求銷毀。

*本人 ________________________ 已細閱及明白上述內容，並同意參加是次研究。

_________________________　　　　_________________________
(實驗對象簽署)　　　　(日期)

_________________________　　　　_________________________
(研究人員簽署)　　　　(日期)

APPENDIX C

Physical Activity Readiness Questionnaire (PAR-Q)

PAR-Q is designed to help you. For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

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

YES	NO	
☐	☐	1. Has your doctor even said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2. Do you feel pain in your chest when you do physical activity?
☐	☐	3. In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7. Do you know of any other reason why you should not do physical activity?

I, ___________________________ (Name of Participant), have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

_____________________________ _________________________

(Signature of participant) (Date)

APPENDIX D

體能活動適應能力問卷 (PAR-Q)

經常進行體能活動不但有益身心，而且樂趣無窮，因此，愈來愈多人開始每天多做運動。對大部分人來說，多做運動是很安全的。不過，有些人則應在增加運動量前，先行徵詢醫生的意見。
在進行測驗之前，請回答以下７題問題。普通常識是回答這些問題的最佳指引。
請仔細閱讀下列問題，然後誠實回答：
請答「是」或「否」。

是	否	
□	□	1. 醫生曾否說過你的心臟有問題，以及只可進行醫生建議的體能活動？
□	□	2. 你進行體能活動時會否感到胸口痛？
□	□	3. 過去一個月內，你曾否在沒有進行體能活動時也感到胸口痛？
□	□	4. 你曾否因感到暈眩而失去平衡，或曾否失去知覺？
□	□	5. 你的骨骼或關節(例如脊骨、膝蓋或髖關節)是否有毛病，且會因改變體能活動而惡化？
□	□	6. 醫生現時是否有開血壓或心臟藥物（例如water pills）給你服用？
□	□	7. 是否有其他理由令你不應進行體能活動？

*如果在上述問卷中有一個或以上「是」的答案，即表示參加者的身體狀況可能不適合參加有關活動。

本人 _______________ (姓名)已閱悉、明白並填妥本問卷。本人的問題亦已得到圓滿解答。

____________________ ____________________
(實驗對象簽署) (日期)

APPENDIX E

Data Collection Form

Name :________________________(Chinese) ______________________ (English)

Date of Birth: ______(day)/_______(month)/________(year)

Age: ________________

Height: ________________(cm) Weight: ______________(kg)

Regular training of sprint: 0-2 / 3-4 / 5-6 / 7-8 / 9-10 / 11 or above years

Grade of inter-school athletics competition: _____________

100m PB:______________(s) 100m SB: ______________(s)

200m PB:______________(s) 200m SB: ______________(s)

Times of training: __________(days/ week) __________ (minutes / day)

Anthropometry

Skinfold:

- Triceps: Trial1________Trial2_______Trial 3_______ Average__________(mm)
- Calf: Trial1________Trial2 _______Trial 3_______ Average__________(mm)

Width:

- Shoulder: Trial1__________ Trial 2__________ Average__________(cm)

Circumference:

- Chest: Trial1__________ Trial 2__________ Average__________(cm)
- Waist: Trial1__________ Trial 2__________ Average__________(cm)
- Hip: Trial1__________ Trial 2__________ Average__________(cm)
- Thigh: Trial1__________ Trial 2__________ Average__________(cm)

- Calf: Trial1__________ Trial 2__________ Average__________(cm)

Length:

- Lower extremity: Trial1__________ Trial 2__________ Average__________(cm)

- Thigh: Trial1__________ Trial 2__________ Average__________(cm)

- Calf: Trial1__________ Trial 2__________ Average__________(cm)

Body Composition

% Fat (Boys) = 1.0 + (0.735 x Sum of Skinfold)

Percentage of body fat: ___________(%)

Fat mass: ____________(kg)

Fat Free mass: ____________(kg)

Muscular fitness

Standing Long Jump: Trial1________Trial2_______Trial 3_______Best_______(m)

Single Leg Hop (left): Trial1________Trial2_______Trial 3_______Best_______(m)

Single Leg Hop(right): Trial1________Trial2_______Trial3_______Best_______(m)

Flexibility

Hip Flexion:

Trial1_______Trial2_______Trial 3_______ Two closest average________(°)

Hip Extension:

Trial1_______Trial2_______Trial 3_______ Two closest average ________(°)