RELATIONSHIP BETWEEN SELECTED ANTHROPOMETRIC MEASURES OF 
LOWER LIMBS AND ANAEROBIC POWER IN UNIVERSITY STUDENTS

BY

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We hereby recommend that the Honours Project by Ms Yuen Hei Man entitled “Relationships Between Selected Anthropometric Measures of Lower Limbs and Anaerobic Power in University Students” be accepted in partial fulfillment of the requirements for the Bachelor of Arts Honours Degree in Physical Education And Recreation Management.

__________________________    _______________________
Dr. Tom Tong                   Dr. Louie Hung Tak, Lobo

Chief Adviser                  Second Reader
DECLARATION

I hereby declare that this Honours Project "Relationships Between Selected Anthropometric Measures of Lower Limbs and Anaerobic Power in University Students" represents my own work and had not been previously submitted to this or institution for a degree, diploma or other qualification. Citations from the other authors were listed in the references.

________________________________________

Yuen Hei Man

30th April, 2013
ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my chief advisor, Dr. Tom Tong, for his valuable advices and professional suggestions and guidance throughout the project period. Special appreciation is given to Dr. Louie Hung Tak, Lobo, for being my second reader.

In addition, I would like to give thanks to the staff 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.

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Date: 30th April, 2013
Abstract

Anaerobic power is an important element in many sports but it is difficult to find out with simple apparatus. This study aimed to investigate the relationship between the selected anthropometric measures of limb lower and anaerobic power in university students. Thirty-one female subjects (n=31) from the Hong Kong Baptist University who aged between 18 and 26 participated in the study. (Age: 21.45±1.95 years; Height: 160.39±5.51 (cm); Weight: 54.42±6.12 (kg); %body fat: 25.02±3.57%) The study included a anthropometric measurement of five sites in the lower limbs (Thigh length; Calf length; Mid-thigh circumference; Calf circumference; Ankle circumference) and the Wingate Anaerobic Test. No significant relationships were found between all the selected anthropometric measures and anaerobic power using Pearson correlation analysis (P>0.05). The result suggested that there were only small correlation between the selected anthropometric measures and the anaerobic power.
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Chapter 1

Introduction

Anaerobic power is an important and crucial factor for many sports events. An anaerobic activity is defined as energy expenditure that uses anaerobic metabolism (without the use of oxygen) for less than 90 seconds, utilizing an exhaustive effort. (Zupan et al., 2009) People always want to know their anaerobic power in advance so that they can choose the most suitable event to participate. Furthermore, with the ability to estimate the anaerobic power, coaches could find out potential athletes. Long from the past, different field tests and laboratory tests were established to estimate athletes’ anaerobic power.

The Wingate Anaerobic Test (WAnT) is one of the most commonly-used tests for determining anaerobic power of lower limbs. Beam and Adams (2010) reported that the WAnT have a significant level of validity and reliability. According to Zupan et al. (2009), the WAnT measures lower-body peak power,
anaerobic capacity and the fatigue index that indicate the reduction of power. Abernethy, Hanrahan, Kippers, Mackinnon and Pandy (2005) defined that anthropometry is the science about Measurement of the size, proportions and composition of the human body. They also stated that in most cases it is directly measured, and thus the shape of the body segment can be indicated. Wang, Thornton, Kolesnik and Proespn JR (2006) defined anthropometry as a simple reliable method for quantifying body size and proportions by measuring body length, width, circumference (C), and skinfold thickness (SF).

In this research, I have selected a few anthropometric measures and determine their relationships with the anaerobic power.

**Statement of Problem**

The purpose of this study is to investigate the relationship between the selected anthropometric measures of lower limbs and anaerobic power in university students in Hong
Kong.

According to Kim, Cho, Jung and Yoon (2011), 72% of anaerobic energy contribution depends on PCr in skeletal muscle, which is directly affected by fat-free mass (FFM) or muscle mass (MM) of body composition. According to Mastrangelo et al. (2004), both mid-thigh circumference and FFM are independent predictive variables to anaerobic especially on absolute peak power and absolute mean power.

According to Martin, Spenst, Drinkwater and Clarys (1990), muscle mass and mid-thigh circumference, muscle mass and calf circumference were correlated. Apart from that, Aouadi et al. (2012) found that volleyball players with longer lower limb length have higher anaerobic power. Therefore, I believe that there would be a relationship between selected anthropometric measures of lower limbs and anaerobic power.

However, just knowing the anaerobic power is not enough. The ultimate goal is to successfully predict anaerobic power without directly testing it as the Wingate Anaerobic test is an exhausting test. Therefore, I would like to investigate
whether anthropometric variables of lower limbs would affect the anaerobic power as they are easy to measure. I would also like to find out the best linear combination of anthropometric variables for predicting the anaerobic power.

**Hypothses**

1) There would be a positive relationship between the selected anthropometric measures of lower limbs and peak anaerobic power.

2) There would be a positive relationship between the selected anthropometric measures of lower limbs and mean anaerobic power.

**Significance of study**

It is time-consuming for coaches to pick up potential athletes with good anaerobic power using Wingate Anaerobic Test each time. With this study, coaches might discover potential athletes with anthropometric measures, which are inexpensive, convenience and user-friendly.
Chapter 2

Review of Literature

Anaerobic power is one of the important elements for being successful in different sports, especially for those include jumping, such as volleyball and basketball. This review concerns on anaerobic power and involve five sessions: 1) Anthropometry and sports performance. 2) Biological factors affecting anaerobic power. 3) Non-biological factors affecting performance of Wingate Anaerobic Test. 4) Factors Affecting Performance of Wingate Anaerobic Test. 5) Summary.

Anthropometry and Sports Performance

In the past studies, anthropometry has been considered as an important factor affecting sports performance that investigation. According Norton and Olds (1996), stature is a crucial factor in sports, and the key determinant of success of many sports is the height. For example, the height of
athletes in basketball, high jump and volleyball are significantly higher than the non-athletes. They also noted that in swimming, sprint swimmers are taller than long distance swimmers in both male and female because the former involves relatively more start, turn and stretch for the finish.

Nevertheless, they are some sports that encourage small stature. Watts, Joubert, Lish, Mast and Wilkins (2003) and Norton et al. (1996) had found that rock and hill climbers would possess a relatively small stature. Watts et al. (2003) added that they have high handgrip to mass ratio, low body mass and low sums of skinfolds. Climbers also have higher ape indexes (arm span to height ratio) which have positive influence on climbing performance. Norton et al. (1996) pointed that small stature allowed athletes to have advantages in acceleration and agility.

Apart from stature, they also stated another characteristic observed from various sports -- the sitting height to stature ratio. It indicated the relative length of
the legs to the stature. Relative short trunks can be in sports that jumping is required. Norton et al. (1996) explained that smaller ratio can reduce the projected frontal area which is an additional source of resistance to movement, and thus increase the trunk stability.

**Biological Factors Affecting Anaerobic Power**

**Body mass**

In this category, past studies have focused on the body mass which usually expressed in terms of fat-free mass (FFM) and the percentage of body fat (%BF). Norton et al. (1996) found that the athletes related to strength-dependent events have the highest values for body mass. Crawford et al. (2011) stated that it is generally accepted that the increase in body mass implied an increase in both FFM and strength. Nevertheless, they added that muscle strength did not increase proportionally with total body mass. In addition, Kim, Cho, Jung and Yoon (2011) also reported that anaerobic
power was closely correlated with increase in FFM and
mass (MM). Similarly, Ali et al. (2012) concluded that body
composition (subjects’ height, body weight, body mass index
(BMI) and percentage of body fat (%BF) were included) and
somatotype are important in anaerobic and sprint performance.
However, according to Crawford et al. (2011), if the increase
in body weight is due to increase in body fat, then physical
fitness is compromised.

Norton et al. (1996) pointed that in sports requiring
explosive power, body fat of athletes are lower than average
as excess body fat would increase body mass and decrease
acceleration. Similarly, Dogan and Raschka (2011) found that
soccer players contain lower body-fat than sports students.
Likewise, Kim et al. (2011) stated that fat mass decreased
when the level of Judoists’ improved, whereas FFM, MM and
total body water increased. However, they also proposed that
the tendencies differences of FFM and MM between groups are
due to the muscle fibers inside them.
**Fiber Types**

Apart from body mass, previous studies also found that the types of fiber of the athlete are another important factor affecting the anaerobic power. Coyle, Costill and Lesmes (1979) found that muscle performance is influenced by skeletal muscle fiber composition. Ahmetov, Vinogradova and Williams (2012) agreed that muscle fiber composition would affect the ability to perform anaerobic exercise. Likewise, Komi, Rusko, Vos and Vihko (1977) indicated that muscle fiber composition (percentage of fast-twitch fibers) was related to the anaerobic performance capacity of the whole body. They also suggested that a high percentage of fast-twitch fibers might be a prerequisite for the triumph of athletes in certain power events. Similarly, Faial et al. (2007) found that there were significance differences in Absolute Anaerobic Power Unit (UPAA) between sprinters (238.19 ±27.47 UCIA) and long distance runners (125.85±31.2 UCIA) (mean± S.D.). In this case, sprinters represent fast-twitch fibers composition while the long distance runners represent slow-twitch fibers
composition.

In addition, Bosco, Komi, Tihanyi, Fekete and Apor (1983) suggest that power performance and muscle fiber composition are more related when the velocity of movement increases. Ahmetov, Vinogradova and Williams (2012) agreed that muscle fiber composition would affect the ability to perform anaerobic exercise.

**Heritability**

Apart from body mass and types of fiber heritability was also found to be a crucial factor that affects athlete’s anaerobic power. Arden and Spector (1997) pointed 50-80% of inter-individual variation in lean body mass is affected by genetic factors. Ahmetov et al. (2012) also indicated that muscle fiber composition is determined by both genotype and environment. Maridaki (2006) found that most heritability index for anaerobic parameters was high, implying a strong genetic influence. Likewise, Costa et al. (2012) pointed that genetic influence would affect athletic performance. They
found that around 30-90% of anaerobic power and capacity is affected by genetic factors. On the other hand, Calvo et al. (2002) suggested that the overall heritability of explosive power is high although that of anaerobic capacity is low.

**Uses of the Wingate Anaerobic Test for Anaerobic Power Determination**

According to Inbar, Bar-Or and Skinner (1996), there were different types of anaerobic tests and were grouped as very brief tests (lasting 1-10s) and brief tests (lasting 20-60s). Wingate anaerobic test (WAnT) is a brief test which consists of 20s, 30, and 45s protocols. They also added that WAnT is “the most-tested test” but it was not found to be superior to others anaerobic tests. On the other hand, Beneke, Pollmann, Bleif, Leithauser and Hutler (2002) found that the use of anaerobically deliver energy was more than previous estimation in WAnT. They also concluded that WAnT metabolism is highly anaerobic.
Regarding the test, Zupan et al. (2009) stated that the WAnT measures lower body peak power, anaerobic capacity and fatigue index. Inbar et al. (1996) pointed that WAnT which conducted under standardized environmental conditions a high correlation coefficients ranged between 0.89 and 0.99, which means WAnT was a highly reliable task. Apart from that, Hachana et al. (2012) examined the test-retest reliability of a 15s WAnT to a standardized 30s WAnT and found that the 15s test is also a highly reliable anaerobic power test. In addition, Inbar et al. (1996) pointed out that WAnT was a valid test for anaerobic performance under controlled, standardized conditions. Similarly, Sands et al. (2004) stated that WAnT has merit validity and reliability.

**Factors Affecting Performance of Wingate Anaerobic Test**

Even though the relation between WAnT power indices anaerobic performance was quite high (Inbar et al., 1996), there are different factors that may affect the performance
in WAnT. According to Inbar et al. (1996), warm up consistently can improved mean power (MP) by 7%. Likewise, Crowley, Garg, Lohn, Someren and Wade (1991) also indicated the importance of muscle temperature to performance in sprinting exercise. On the other hand, Souissi et al. (2010) pointed that short warm-up will alter Wingate test performance in the afternoon.

Besides warm up, according to Peveler, Punders and Bishop (2007) and Peveler and Green (2011), saddle height would affect the performance of WAnT. Both of the studies found that setting the saddle height with 25° to 35° knee angle is better than using 109% of inseam. Preveler et al. (2007) stated that using a lower saddle height (>35°) would lead to a loss in power. Preveler et al. (2011) added that peak power at a 25° knee angle were significantly higher than 109% of inseam. On top that, both studies suggested that a 25° to 35° knee angle could prevent injury. Preveler et al. (2011) specified that the use of 25° knee angle could provide optimal performance and also prevent injury.
Summary

Previous studies have shown that anthropometry and sports performance are related. However, there is lack of scientific evidence showing the relationship between the anthropometric measures of lower limb and anaerobic power. Besides, different studies have proved that body mass and fiber types would affect anaerobic power of the individuals. Although there is little evidence showing that body mass, fiber type and the anthropometric measures of lower limbs are related, but logically, longer lower limbs implied relatively more body mass and fiber type. The researcher should try to find that the relationship between anaerobic power and the anthropometric measures of lower limb.
Chapter 3

Method

Subjects

The research included 30 female university students as subject. They were all aged within 18 to 25 years old with suitable health status and sports background. Participants were fully informed of the aim and the procedure of the test. They were also informed by the researcher of the possible risk of the test. They had signed the consent form and PAR-Q form voluntarily before the test starts. They had to undergo some anthropometric measures of lower limb in the selected and finish the Wingate Anaerobic Test.

Testing Procedure

Before the start of the test, participants had to sign the PAR-Q form that proved the subjects health status allowed her to do the test. Then, they had to sign up the consent form voluntarily that showed they have fully understood the aim
and the procedure of the test. The subject’s body height would be measured by the \textbf{stadiometer} and subject’s body weight and percentage of body fat would then be measured by the body composition analyzer.

The selected anthropometric measures were first conducted in the laboratory of Dr. Stephen Hui Research Centre for Physical Recreation and Wellness. All of the measures be conducted on the right hand side of the body. Each anthropometric variables would be measured for two times and the average value of it was recorded. This could ensure the accuracy of the measurements. There were totally five for measurement which were thigh length, calf length, circumference, calf circumference and ankle circumference. After the measurement, the subject would stay in the center and do the Wingate Anaerobic Test. A five-minute warm up would be performed on the Monark ergometer, and then the subject would perform the actual test on the Lode ergometer. After the test, some cool down activities were followed. The subject could leave afterwards.
Definition of Terms

Anaerobic power

It is defined as energy expenditure that uses anaerobic metabolism (without the use of oxygen) that lasts less than 90 seconds, utilizing an exhaustive effort. (Zupan et al., 2009)

Anthropometry

It is defined as the science about measurement of the size, proportions and composition of the human body. Abernethy, Hanrahan, Kippers, Mackinnon and Pandy (2005)

Operational Definition of Terms

Lower limbs

It was defined as the legs of the human body in this study.

University students

It was defined as young adults studying in Hong Kong Baptist University aged between 18 and 26 years old.
**Delimitation**

The study was delimited to the followings:

1) The subjects were delimited to 31 female students studying in the Hong Kong Baptist University with sports background.

2) All of the subjects were aged within 18 and 26 years old.

3) The Wingate Anaerobic Test and the anthropometric measurement were carried out in the laboratory of Dr. Stephen Hui Research Centre for the Physical Recreation and Wellness of Hong Kong Baptist University

4) The Wingate Anaerobic Test and the anthropometric measurement were conducted on the same day.

**Limitation**

The study was limited by the following factors:

1) The sample size of the test was too small (N=31), thus the result of this study could not have good generalization.

2) The subject may not use all of their effort in doing the Wingate anaerobic test.
Measurement

Anthropometric Measurements

A sliding caliber was used to measure the length of the selected sites of lower limb. The book Anthropometrica edited by Norton K. and Olds T. was used as reference and were supported by the International Society for the Advancement of Kinanthirpometry (ISAK). Norton et al. (1996) had noted the point for measuring thigh and calf's lengths and circumference.

Direct measurement of the segments’ length would be conducted. All measurements would be measured to the nearest 0.1 cm.

1) Thigh Length

It was defined as ‘the distance from the trochanterion to the tibiale laterale’, which was the distance between the lateral condyle of the femur and greater trochanter. Their right side of the segment should be measured.
2) Calf Length

It was defined as 'the length between tibiale mediale and sphyrion tibiale, which was the distance between the lateral malleolus of the fibula and the lateral condyle of the tibia. The subject should be seated on a chair with right ankle crossed over and resting one the left knee.

Anthropometry tape was used to measure the girths of the selected sites. Norton et al. (1996) had also indicated how to measure the circumferences of different selected body segment. They mentioned that the tape should be held at right
angles to the body segment during the measurement and the
tension of the tape should be constant.

Figure 2. Measurement of Calf Length

3) Thigh circumference (mid)

The measurement was taken at the right thigh of the subject,
perpendicular to the long axis of it. The subject should be
in an elevated position, standing erect with the feet
apart and mass distributed equally on both feet. The measurer
should align the eyes with the tape to obtain accurate
measurement.
4) Calf circumference (maximum)

The maximum circumference of the calf was found by the researcher by using the middle fingers to manipulate the tape. The subject should be in an elevated position, standing erect with the weight equally distributed on both feet.
5) Ankle Circumference

The ankle circumference was measured at the narrowest superior to the sphyrion tibiale. The tape was manipulated up and down to ensure the minimal circumference was obtained.

Figure 5. Measurement of Ankle Circumference

**Wingate Anaerobic Test Protocol**

The protocol was suggested by Beam and Adams (2010) for testing the anaerobic power of the lower limb.

There were 4 distinct time period during the test: 1) warm-up, 2) recovery interval, 3) Wingate Test, 4) cool down.

The resistance of the ergometer was determined by the
weight of the subject. The equation for the leg ergometer is:

\[
\text{Force (kg)} = \text{Body Weight (kg)} \times 0.075
\]

Subject was required to warm-up for 5 minutes on the ergometer before the actual test. The warm-up included five all-out sprints for 4-6 second duration. This aimed to increase subject’s performance and prevent injuries such as muscle strain.

After the warm up, subject was required to perform some stretching for 2-5 minutes. This time period would allow the subject to recovery from the warm-up session, but still had a significant level of body temperature and blood flow.

Afterwards, the actual Wingate Anaerobic Test could be carried out. The test would last for 30s and subject was required to use all of his/her effort. Absolute and relative anaerobic peak and mean power would be calculated by the computer.

Finally, there was a cool-down session that allows the subject to ride slowly on the ergometer. Some stretching should be performed too.
**Data Analysis**

Statistical analysis was performed with the Statistical Package for Social Science (SPSS 18.0). The descriptive statistics of each variable such as mean, variance and standard deviation were calculated. Those five selected anthropometry variables (thigh length, calf length, thigh circumference and calf circumference) were correlated the relative peak power derived from the WAnT. The Pearson correlation coefficient (r) was used to state the relationships between the independent variables and the anaerobic power. Multiple regression was used to determine the best linear combination of each variable for predicting the relative anaerobic power. The 0.05 level of significance was used for all statistical tests.
Chapter 4

Data Analysis

Results

Thirty-one female students with sports background aged between 18 to 26 years old who are studying in the Hong Kong Baptist University were invited to participate in this study. The purpose of this study was to investigate the relationship between selected anthropometric measures of lower limbs and anaerobic power in university students. Based on the result, the researcher also tried to find out the best linear combination of different variables for predicting the anaerobic power through multiple regression analysis. The researcher would measure subjects’ selected anthropometric sites of length and circumference of their lower limb they had to participate in a 30 second Wingate Anaerobic Test.

All tests for statistical significance were standardized at an alpha level of $P < 0.05$, and all results were expressed in form of range, mean and ±SD while $n=31$. 
In these 31 subjects, they were specialized in 14 sports: Badminton (n=1); Basketball (n=3); climbing (n=1); cross country (n=3); fencing (n=2); gymnastic (n=1); handball (n=2); soccer (n=7); squash (n=1); swimming (n=2); table tennis (n=2); tennis (n=1); volleyball (n=2); woodball (n=3).

The following table had summarized the physical characteristics of the subjects. (n=31)

Table 1. Descriptive statistic of the physical characteristic of all subjects (n=31)

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Mean</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>18-26</td>
<td>21.45</td>
<td>±1.95</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>146.5-170</td>
<td>160.39</td>
<td>±5.51</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>41.7-69</td>
<td>54.42</td>
<td>±6.12</td>
</tr>
<tr>
<td>%Body Fat</td>
<td>19-33.7</td>
<td>25.02</td>
<td>±3.57</td>
</tr>
</tbody>
</table>

In these 31 university female subjects with sports background, the average age of them were 21 years old, the average height were 160.39cm, the average weight were 54.42kg and their average percentage of body fat were 25.02%.
Table 2. Descriptive statistic of the anthropometric measures of selected lower limb sites for all subjects (n=31)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Range</th>
<th>Mean</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thigh Length (cm)</td>
<td>30.65-40.6</td>
<td>35.67</td>
<td>±2.65</td>
</tr>
<tr>
<td>Calf Length (cm)</td>
<td>29.1-36.5</td>
<td>32.88</td>
<td>±1.84</td>
</tr>
<tr>
<td>Mid-thigh circumference (cm)</td>
<td>44.25-56.85</td>
<td>49.37</td>
<td>±2.91</td>
</tr>
<tr>
<td>Calf Circumference (cm)</td>
<td>31.75-40.75</td>
<td>35.50</td>
<td>±2.02</td>
</tr>
<tr>
<td>Ankle Circumference (cm)</td>
<td>18.55-23</td>
<td>20.62</td>
<td>±1.13</td>
</tr>
<tr>
<td>Calf-to-thigh length Ratio</td>
<td>0.79-1.09</td>
<td>0.93</td>
<td>±0.072</td>
</tr>
</tbody>
</table>

In average, the subjects have an average thigh length 35.67cm and an average calf length of around 32.88cm. The subjects' average mid-thigh circumference, calf circumference and ankle circumference were 49.37cm, 35.5cm and 20.62cm.

The calf-to-thigh length ratio, which is calculated by calf length divided by thigh length, has a minimum value of 0.79, a maximum value of 1.09 and an average of 0.9255.
Table 3. Descriptive statistic of the relative power for all subjects (n=31)

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Mean</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Peak Anaerobic power (W/kg)</td>
<td>4.6-7.9</td>
<td>6.44</td>
<td>±0.79</td>
</tr>
<tr>
<td>Relative Mean Anaerobic power (W/kg)</td>
<td>6.8-12.2</td>
<td>9.73</td>
<td>±1.18</td>
</tr>
</tbody>
</table>

From the Wingate Anaerobic test, the subjects' relative peak anaerobic power and relative mean anaerobic power can be found. The average of relative peak anaerobic power was 6.44, while the minimum value was 4.6 and the maximum value was 7.9.
Figure 6.

Result of Wingate Anaerobic test – Peak anaerobic power (W)

The above graph has shown the tendencies of the subjects in Wingate Anaerobic Test and expressed in peak anaerobic power. Bear in mind that this graph showed the peak anaerobic power (W) but not relative peak anaerobic power (W/kg). However, from the graph, we could still see that after reaching their peak power within 5 second, their peak anaerobic power would fall inevitably.
The relationship of the selected anthropometric measures and the anaerobic power was computed. Pearson Correlation was calculated by SPSS. The following tables have shown the Pearson correlation coefficient, the coefficient of Determination and the significant value in 2-tailed:

Table 4. Pearson correlation of coefficient between measured anthropometric length and relative peak anaerobic power (n=31)

<table>
<thead>
<tr>
<th>Relative Peak Anaerobic Power (W/kg)</th>
<th>r</th>
<th>r²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thigh Length (cm)</td>
<td>0.267</td>
<td>0.071</td>
<td>0.146</td>
</tr>
<tr>
<td>Calf Length (cm)</td>
<td>0.287</td>
<td>0.082</td>
<td>0.118</td>
</tr>
</tbody>
</table>

No correlation, P >0.05
Table 5. Pearson correlation of coefficient between measured anthropometric circumference and relative peak anaerobic power (n=31)

<table>
<thead>
<tr>
<th>Relative Peak Anaerobic Power (W/kg)</th>
<th>r</th>
<th>r²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-thigh Circumference (cm)</td>
<td>0.221</td>
<td>0.049</td>
<td>0.232</td>
</tr>
<tr>
<td>Calf Circumference (cm)</td>
<td>-0.076</td>
<td>0.006</td>
<td>0.685</td>
</tr>
<tr>
<td>Ankle Circumference (cm)</td>
<td>-0.087</td>
<td>0.008</td>
<td>0.642</td>
</tr>
</tbody>
</table>

No correlation, P >0.05

Table 6. Pearson correlation of coefficient between measured anthropometric length and relative mean anaerobic power (n=31)

<table>
<thead>
<tr>
<th>Relative Mean Anaerobic Power (W/kg)</th>
<th>r</th>
<th>r²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thigh Length (cm)</td>
<td>0.076</td>
<td>0.005</td>
<td>0.682</td>
</tr>
<tr>
<td>Calf Length (cm)</td>
<td>-0.193</td>
<td>0.037</td>
<td>0.298</td>
</tr>
</tbody>
</table>

No correlation, P >0.05
Table 7. Pearson correlation of coefficient between measured anthropometric circumference and relative mean anaerobic power (n=31)

<table>
<thead>
<tr>
<th>Relative Peak Anaerobic Power (W/kg)</th>
<th>r</th>
<th>r²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-thigh Circumference (cm)</td>
<td>-0.079</td>
<td>0.006</td>
<td>0.672</td>
</tr>
<tr>
<td>Calf Circumference (cm)</td>
<td>-0.272</td>
<td>0.074</td>
<td>0.139</td>
</tr>
<tr>
<td>Ankle Circumference (cm)</td>
<td>-0.173</td>
<td>0.030</td>
<td>0.298</td>
</tr>
</tbody>
</table>

No correlation, P >0.05

Table 8. Pearson correlation of coefficient between calculated calf-to-thigh length ratio and relative anaerobic power (n=31)

<table>
<thead>
<tr>
<th>Calf-to-thigh length Ratio</th>
<th>r</th>
<th>r²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Peak Anaerobic Power (W/kg)</td>
<td>0.059</td>
<td>0.003</td>
<td>0.754</td>
</tr>
<tr>
<td>Relative Mean Anaerobic Power (W/kg)</td>
<td>-0.235</td>
<td>0.055</td>
<td>0.204</td>
</tr>
</tbody>
</table>
No correlation, P > 0.05

The Pearson correlation of coefficient (r) and the coefficient of determination (r²) were very small, which means the correlations were weak and the variance explained the relationships were small. The correlation between relative anaerobic power and different variables were not significant (P>0.05). The following scatter-plotted graph illustrated the relationships between each variable and the relative anaerobic power for all participants (n=31).

The research hypotheses “There would be a positive relationship between the selected anthropometric measures of lower limbs and peak anaerobic power.” and “there would be a positive relationship between the selected anthropometric measures of lower limbs and mean anaerobic power.” were rejected. The null hypotheses “There would be no relationship between the selected anthropometric measures of lower limbs and peak anaerobic power.” and “there would no positive relationship between the selected anthropometric measures of lower limbs and mean anaerobic power.” were accepted.
Figure 7. Scatterplot of the relationship between relative peak anaerobic power and measured anthropometric length

This figure has illustrated the relationship between relative peak anaerobic power and measured anthropometric length for all participants (n=31). Measured anthropometric length included thigh length and calf length. The Pearson correlation coefficient of thigh length and calf length were $0.267 (r=0.267)$ and $0.287 (r=0.287)$. The coefficient of determination of thigh length and calf
were 0.071 ($r^2=0.071$) and 0.082 ($r^2=0.082$), which means only 7.1% and 8.2% of variance explained by the relationship. The significant value (2-tailed) were 0.146 and 0.118 respectively. Therefore, there were no significant correlation between measured anthropometric length and the relative peak anaerobic power ($p >0.05$)

Figure 8. Scatterplot of the relationship between relative peak anaerobic power and measured anthropometric circumference
This figure has illustrated the relationship between relative peak anaerobic power and measured anthropometric circumference for all participants (n=31). Measured anthropometric circumference included mid-thigh circumference, calf circumference and ankle circumference. The Pearson correlation coefficient of mid-thigh circumference, calf circumference and ankle circumference were 0.221 (r=0.221), -0.076 (r=-0.076) and -0.087 (r=-0.087). The coefficient of determination of them were 0.049 (r²=0.049), 0.006 (r²=0.006) and 0.008 (r²=0.008), which means only 4.9%, 0.6% and 0.8% of variance explained by the relationship. The significant value (2-tailed) were 0.232, 0.685 and 0.642 respectively. Therefore, there were no significant correlation between measured anthropometric circumference and the relative peak anaerobic power (p >0.05).
Figure 9. Scatterplot of the relationship between relative peak anaerobic power and calf-to-thigh ratio

This figure has illustrated the relationship between the relative peak anaerobic power and calf-to-thigh ratio for all participants. The Pearson correlation of coefficient was 0.059 (r=0.059) and the coefficient of determination was 0.003(r2=0.003), which means only 0.3% of variance explained by the relationship. The significant value (2-tailed) was 0.754. Therefore, there was no significant correlation between the calf-to-thigh length ratio and the relative peak anaerobic power (p >0.05).
Figure 10. Scatterplot of the relationship between relative mean anaerobic power and measured anthropometric length

This figure has illustrated the relationship between relative mean anaerobic power and measured anthropometric length for all participants (n=31). Measured anthropometric length included thigh length and calf length. The Pearson correlation coefficient of thigh length and calf length were 0.076 (r=0.076) and -0.193 (r=-0.193). The coefficient of determination of thigh length and calf length were 0.006 (r2=0.006) and 0.037 (r2=0.037), which means only 0.6% and 3.7% of variance explained by the relationship. The
significant value (2-tailed) were 0.682 and 0.298 respectively. Therefore, there were no significant correlation between measured anthropometric length and the relative mean anaerobic power (p > 0.05)

Figure 11. Scatterplot of the relationship between relative mean anaerobic power and measured anthropometric circumference

This figure has illustrated the relationship between relative mean anaerobic power and measured anthropometric
circumference for all participants (n=31). Measured anthropometric circumference included mid-thigh circumference, calf circumference and ankle circumference. The Pearson correlation coefficient of mid-thigh circumference, calf circumference and ankle circumference were -0.079 (r=-0.079), -0.272 (r=-0.272) and -0.173 (r=-0.173). The coefficient of determination of them were 0.006 (r²=0.006), 0.074 (r²=0.074) and 0.030 (r²=0.030), which means only 0.6%, 7.4% and 0.3% of variance explained by the relationship. The significant value (2-tailed) were 0.672, 0.139 and 0.298 respectively. Therefore, there no significant correlation between measured anthropometric circumference and the relative peak anaerobic power (p >0.05).
Figure 12. Scatterplot of the relationship between relative mean anaerobic power and calf-to-thigh length ratio.

This figure has illustrated the relationship between calf length and relative mean anaerobic power for all participants. The Pearson correlation of coefficient was -0.235 (r=-0.235) and the coefficient of determination was 0.055 (r²=0.055), which means only 5.5% of variance explained by the relationship. The significant value (2-tailed) was 0.204. Therefore, there was no significant correlation between calf length and the relative peak anaerobic power (p >0.05).
The relationship between the relative anaerobic power and the selected anthropometric measures were not significant (\(p>0.05\)). The coefficient of determination of the selected anthropometric variables (\(r^2\)) was small, which means only a small variance explained the relationship.

As a result, the hypotheses “There would be a positive relationship between the selected anthropometric measures of lower limbs and peak anaerobic power.” and “There would be a positive relationship between the selected anthropometric measures of lower limbs and mean anaerobic power.” were rejected.

The null hypotheses “There would be no relationship between the selected anthropometric measures of lower and peak anaerobic power.” and “there would be no positive relationship between the selected anthropometric measures of lower limbs and mean anaerobic power.” were accepted.
Multiple Regression Analysis

As all of the variables did not show a significant correlation with the anaerobic power, the researcher cannot generate any linear combination for predicting the relative anaerobic power from selected anthropometric measures.

**Discussion**

The purpose of this study was to investigate relationship between selected anthropometric measures of lower limbs and anaerobic power in university students in Hong Kong. The researcher also tried to find out the best linear combination for predicting the relative anaerobic power from selected anthropometric measures. This part of discussion was divided into three parts: 1) Relationship between relative anaerobic power and selected anthropometric measures of lower limb. 2) Reason for the insignificant result of the study. 3) Factors affecting the result of the test.
1) Relationship between relative anaerobic power and selected anthropometric measures of lower limb

The significant value of the relative peak anaerobic power were 0.146 (thigh length), 0.118 (calf length), 0.232 (mid-thigh circumference), 0.685 (calf circumference), 0.642 (ankle circumference) and 0.754 (calf-to-thigh length ratio) respectively. On the other hand, the significant value of relative mean anaerobic power were 0.682 (thigh length), 0.298 (calf length), 0.672 (mid-thigh circumference), 0.139 (calf circumference), 0.298 (ankle circumference) and 0.204 (calf-to-thigh length ratio) respectively.

As a result, there were no significant correlation between the relative power and any selected anthropometric measures of lower limbs

2) Reason for the insignificant result of the study.

The researcher aimed to find out the relationship between anaerobic power and the selected anthropometric measures of the lower limb, and find out the best linear combination of
different measured variables for predicting anaerobic power in a less-consuming and simple way. Relative peak anaerobic power and relative mean anaerobic power were chosen. This was aimed to increase the fairness of the study. As the relative anaerobic power is calculated from power divided by body weight, it could eliminate the weight differences from subjects so that the measurements were standardized and the result could be compared between subjects of different size.

From the study, no significant correlations were found. The reasons for the insignificant result of the study were believed as below:

Different past studies had proved that muscle mass and percentage of body fat are main factors affecting anaerobic power. According to Martin et al. (1990), muscle mass and mid-mid-thigh circumference and calf circumference were correlated. However, according to Crawford et al. (2011), if the increase in body weight is due to increase in body fat, then physical fitness is compromised. In this study,
subjects’ percentage of body fat also had significant
correlation with mid-thigh circumference ($r=0.714$, $p=0.000$)
and calf circumference ($r= 0.570$, $p=0.001$).

So, by just measuring anthropometric length and
circumference is not the best method for predicting
anaerobic power because it cannot tell whether the percentage
of body fat weigh more or the percentage of muscle mass weigh
more in the lower limb.

As anaerobic power is affected by multiple factors not
a single factor, anaerobic power cannot be simply predicted
from measuring length and circumference of lower limb.
Therefore, no significant correlations were found in this study.

The variable that is closest to have significant
correlation with relative peak anaerobic power is the
length ($r=0.287$, $r^2=0.082$, $p=0.118$). The variable that is
closest to have significant correlation with relative
anaerobic power is the calf circumference ($r=-0.272$, $r^2=0.074$,
$p=0.139$)
3) Factors affecting the result of the test

1) Selection of subjects

Since most of the subjects (n=29) are majoring in Physical Education and Recreation Management or Sport and Recreation Studies, while the others (n=2) are university sports team member with other majors, most participants have regular exercise background. Even though subjects included different age, height, weight and different type of specialized sports, their background were not heterogeneous enough with respect to Wingate anaerobic test. Therefore, most of them had similar result on the test. To improve the situation, it is better to include a diversity of non-athletes, recreational athletes and elite athletes.

2) Measuring errors

For the anthropometric measurements, according to Norton et al. (1996), the subject should be present with minimal clothing, which means swimming customs are ideal for ease of
access to all measurement sites. However, the subjects in this study were asked to wear shorts and t-shirts. Therefore the access to the measurement site might be affected. Moreover, even though the measuring errors from the tape and caliper were minimized, they were still likely to exist. On top of that, the identification of the body landmark would directly affect the accuracy of the measurement.

For the Wingate anaerobic test, the tension of Monark ergometer for warm up was loosen inevitably when the number of subjects increased. Consequently, it led to the increase in resistance in the ergometer. As a result, the 5-minutes warm up required more strength and power to finish it. Even though enough time was given to each subject after warm up to ensure that they were ready for the actual test, the warm up with increased resistance would still affect the accuracy of the result.
3) Selection of sites

Only the length and circumference of lower limb were measured in the test. Other anthropometric measures that might affect the Wingate anaerobic test result such as skinfold thickness and flexibility were not measured in this study.

4) Different types of specialized sports of subjects

All subjects have their own specialized sports: Badminton (n=1); Basketball (n=3); climbing (n=1); cross country (n=3); fencing (n=2); gymnastic (n=1); handball (n=2); soccer (n=7); squash (n=1); swimming (n=2); table tennis (n=2); tennis (n=1); volleyball (n=2); woodball (n=3). Inbar et al. (1996) stated that athletes with anaerobic specialty would have significantly higher absolute and relative peak power. Therefore, as there were anaerobic type and aerobic types of specialized sports, the correlation made between anaerobic power and anthropometric measures might be affected.
5) Daily variance after school

As the Wingate anaerobic test is a high intensity test, it required the subject to have good mental and physical state to finish it.

Therefore, the daily activities of the subject would cause daily variances which affect the result. For example, as most of the subjects took part in the study in the afternoon after class, or if the subjects sleep late on the day before the test, she might not able to perform her best because of tiredness. Other than that, if the subject is too full or hungry, the test result would be affected too.

6) Familiarity with apparatus

Wingate anaerobic test required subjects to perform a 30-second anaerobic test on an ergometer, which is a actually a cycling apparatus. However, some of the subjects were not get used to the small seat and its hardness of the lode ergometer during the test, which might affect their
performance.

Besides, the toe stirrups were also important in the test. Inbar et al. (1996) pointed out that after using the toe stirrups, a pushing or pulling force can be exerted on the pedal throughout the full cycle. However, the stirrups were broken during the research period and tape was used to replace them. Even though all subjects' foot was held tightly by the tape, result might still be slightly affected.

7) Subjects’ effort motivation

Since the Wingate anaerobic test is an exhausted and high intensity test, it required the subjects’ utmost effort to finish it. However, it was impossible to control how hard they perform in the test and test result might be affected.

According to Karaba-Jakovljević, Popadic-Gacesa, Grujic, Barak and Drapsin (2007), the parameters from Wingate Anaerobic Test increased significantly with verbal encouragement. Therefore, verbal motivation was given
throughout the test and a can of coke was given to each subject after the test to replenish their blood glucose level immediately.

Chapter 5

Conclusion

Summary of Results

This study was designed to examine the relationship between anaerobic power and the selected anthropometric measures of lower limb in university student. 31 subjects took part in the test and their measured anthropometric length, circumference and the result of Wingate Anaerobic Test were recorded. The data were analyzed by Statistical Package of Social Science (SPSS) and Pearson Coefficient of Correlation was used. The 0.05 level of significance was used for all statistical tests.

The common variance of relative peak anaerobic power and different variables were as follows: Thigh length (7.1%, $r^2=0.071$), calf length (8.2%, $r^2=0.082$), mid-thigh
circumference (4.9%, $r^2=0.049$), calf circumference (0.6%, $r^2=0.006$), ankle circumference (0.8%, $r^2=0.008$) and calf-to-thigh ratio (0.3%, $r^2=0.003$).

The common variance of relative mean anaerobic power and different variables were as follows: Thigh length (0.6%, $r^2=0.006$), calf length (3.7%, $r^2=0.037$), mid-thigh circumference (0.6%, $r^2=0.006$), calf circumference (7.4%, $r^2=0.074$), ankle circumference (3.0%, $r^2=0.030$) and calf-to-thigh ratio (5.5%, $r^2=0.055$).

Therefore, from the study, the correlations between anaerobic power and the anthropometric measures of lower limb were weak, and no significant correlations were found.

**Recommendations for Further Study**

1) A larger sample size should be obtained with a greater diversity of subjects. For example, male, non-athletes and elite athletes should be also included to increase the representativeness of the study.
2) Other anthropometric measures such as skinfold thickness and flexibility should be included and correlated to anaerobic power as well in the study to improve its comprehensiveness.

3) In order to ensure subjects have a good mental and physical state, it is recommended to perform the test in the morning in which their states are the best.
References


Appendix A

Consent Form of Wingate Anaerobic Test

I have been informed that the purpose of this test is to determine my anaerobic power. I understand that I will undergo an anaerobic cycling test in the Dr. Stephen Hui Research Centre for Physical Recreation and Wellness. I will continue until I decide to stop, or any signs or symptoms of cardiopulmonary or metabolic disease found during the test.

I have been informed that the test last for around 6 minutes. I understand that I have to cycle during the test, and use maximal effort during the actual test. I understand that I am responsible for monitoring my own condition during the exercise test and should any unusual symptoms occur, I would cease my participation and inform the tester of my symptoms if I know there is a risk of certain abnormal changes occurring during or following exercise.

After performing the test, I will be benefited to know more about my anaerobic power and physical fitness status. Knowing these can help you to choose a most suitable sport to participate.

I have been informed that the records of this study will be kept private. In any sort of report we make public, no information, which makes it possible to identify me, will be included. Should I have any questions afterwards, I would be available to contact Hei Man Yuen (6157 4377).

I understand that my participation is strictly voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

In signing this consent form, I affirm that I have read this form in its entirety and that I understand the nature of the testing procedure. I also affirm that my questions regarding the exercise program and procedures have been answered.

Subject’s name: ____________________  Subject’s Signature: ________________
Date: ______________________________
Witness of the subjects obtaining consent
Witness’s name: ____________________  Witness’s Signature: ________________
Date: ______________________________
Appendix B

Data Collection Form

Personal Information

Name of Subject______________________________
Gender_____
Age_____
Height ________ cm
Body Weight ________ kg
% Body Fat ________%
Date of testing______________________________
Starting Time______________________________
Specialized Sports__________________________

Record of Scores

Section 1: Selected Anthropometric Measurement

<table>
<thead>
<tr>
<th>Measurement Site</th>
<th>First Measure</th>
<th>Second Measure</th>
<th>Average Value</th>
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</thead>
<tbody>
<tr>
<td>Thigh Length</td>
<td>cm</td>
<td>cm</td>
<td>cm</td>
</tr>
<tr>
<td>Calf Length</td>
<td>cm</td>
<td>cm</td>
<td>cm</td>
</tr>
<tr>
<td>Mid-thigh Circumference</td>
<td>cm</td>
<td>cm</td>
<td>cm</td>
</tr>
<tr>
<td>Calf Circumference</td>
<td>cm</td>
<td>cm</td>
<td>cm</td>
</tr>
<tr>
<td>Ankle Circumference</td>
<td>cm</td>
<td>cm</td>
<td>cm</td>
</tr>
</tbody>
</table>

Section 2: Wingate Test

Resistance: ______kg x 0.075 = ______kp

(kp x 10 = N) ________N

Absolute Peak Anaerobic Power:______W

Relative Peak Anaerobic Power:______W kg⁻¹

Absolute Mean Anaerobic Power:______W

Relative Mean Anaerobic Power:______W kg⁻¹
PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

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

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

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

1. Have you ever had 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 (for example, back, knee or hip) 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?

YES to one or more questions

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

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

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:
- Start becoming more physically active—begin slowly and build up gradually. This is the safest and easiest way to go.
- Take part in a fitness appraisal: this is an excellent way to determine your basic fitness so that you can plan the best way for you to be active. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 140/90, talk with your doctor before you start becoming much more physically active.

Important Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity and if it results after completing this questionnaire, consult your doctor prior to physical activity.

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

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

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

NAME ____________________________

SIGNATURE ____________________________

SIGNATURE OF PARENT ____________________________

OR GUARDIAN (for participants under the age of majority) ____________________________

WITNESS ____________________________

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

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