INTERCHANGEABILITY AMONG THE UPPER
BODY TESTS OF MUSCULAR STRENGTH AND
ENDURANCE

BY

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We hereby recommend that the Honors Project by Mr. Yiu Hoi Ching entitled “Interchangeability among the Upper Body Tests of Muscular Strength and Endurance” be accepted in partial fulfillment of the requirements for the Bachelor of Arts Honors Degree in Physical Education and Recreation Management.

________________________  _______________________
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29th April, 2011
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______________________________
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ABSTRACT

Muscular strength and endurance are important component in health fitness. Many test batteries include upper body strength and endurance tests in it. The commonly used upper body strength and endurance tests are Pull-up test, Push-up test, Modified Pull-up test, Modified Push-up test and Flexed Arm Hang test. Most of the test batteries will include one of the above tests and some of may provide several options for the practitioner without any explanation. This study was designed to examine the interchangeability between the upper-body strength and endurance tests, including Pull-up test, Modified Pull-up test, Flexed Arm Hang test, and Push-up test by assessing the correlation between the test results among them. Twenty Males were participated in this study (age, 22.8±1.28 years; height, 1.73±0.65 m; weight, 150.7±12.44 lbs). Subjects were asked to perform the five upper-strength and endurance tests in a specific sequence. It was found that there were significant correlations between the performance of Pull-up test and Modified Pull-up test (r=0.87; p<0.05); Pull-up test and Flexed Arm Hang test (r=0.74; p<0.05); Modified Pull-up test and Flexed Arm Hang test (r=0.70; p<0.05); Push-up test and Pull-up test (r=0.48, p<0.05); Push-up test and Modified
Pull-up test ($r=0.69$, $p<0.05$). But there were no significant correlation between the subject’s performance of Push-up test and that of Flexed Arm Hang test shown in this study ($r=0.33$, $p>0.05$). According to the finding, it suggests that the four upper body muscular strength and endurance test couldn’t be used interchangeably.
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Chapter 1

INTRODUCTION

Muscular strength and endurance are one of the health-related physical fitness components (ACSM, 2003). McManis, Baumgartner, & Wuest (2000) mentioned that the level of muscular strength and endurance affects an individual’s ability to perform daily functions and various physical activities throughout the life span. Upper-body strength and endurance are also considered important for performing functional and daily activities as well as preventing injury and osteoporosis.

Because of the importance of upper-body strength and endurance, Engelman & Morrow (1991) pointed out that test developers make continuous efforts to develop different upper-body fitness tests and include them in test batteries. So that the physical educators can use muscular fitness test scores to document health related physical fitness. There are many test batteries developed by different associations and available for the physical educators. Most of them include test items designed to measure upper body muscular strength and/or muscular endurance (AAHPERD, 1988; Chrysler Fund-Amateur Athletic Union[CE-AAU], 1987; Institute for Aerobics Research[IAR], 1987; PCPFS, 1987). In most of the test batteries, there will be one upper body muscular fitness
test included, but some of them may provide several options for the practitioner, such as, the FITNESSGRAM® health-related physical test battery, which was developed by the CIAR (1999) and is currently endorsed by the American Alliance for Health, Physical Education, Recreation and Dance [AAHPERD], provides the following field tests for the practitioners: (a) the traditional pull-up test, (b) the modified pull-up test, (c) the 90° push up test, and (d) the flexed-arm hang test. Although the practitioner may choose to use either of the tests, the Push-up test is recommended.

According to AAHPERD (1988); CF-AAU (1987); PCPFS (1987), PU and FAH are the most commonly used field tests as measurements of upper-body strength and endurance. But, Ross, Pate, Delpy, Gold, and Svilar (1987) argued that Modified Pull-up test and Pull-up test are more acceptable field tests for upper-body strength and endurance, because they can provide a better range of scores. Baumgartner, Oh, Chung, Hales (2002); Clemons, Duncan, Blanchard, Gatch, Hollander, Doucet (2004) also pointed out that modified push-up test is commonly used to measures upper-body strength and endurance.

Statement of Problem

Many test batteries include one upper-body strength and endurance tests among the Push-up test, Pull-up test, Modified Pull-up test and Flexed Arm Hang test, or provide several
options for the practitioners without any explanation.

Zhu (1998) pointed out that if tests are used interchangeably, tests must be equivalent. Different tests may involve different muscle groups. According to Pat Manocchia’s Anatomy of Exercise: [A Trainer’s Guide to Your Workout], Pull-up involves biceps brachii, brachioradialis, latissimus dorsi, posterior deltoid, rhomboid, teres major and trapezius. For Push-up, it involves deltoideus, coracobrachialis pectoralis major, pectoralis minor and triceps brachii. So a subject may get a high score in Push-up test but a low score in Pull-up test, because he/she has a very strong pectoralis major.

Sherman & Barfield (2006) pointed out that if tests are not consistent in classification, problems can occur when using test scores to classify whether the subject are in a health fitness zone.

**Purpose of Study**

The purpose of the study was to examine the interchangeability between the upper-body strength and endurance tests, including Pull-up test, Modified Pull-up test, Flexed Arm Hang test, and Push-up test by assessing the correlation between the test results among them.

**Significance of Study**

Mahar and Rowe (2008) pointed out that for researches, the
Aims of fitness tests are to (a) determine the association between fitness and other health outcomes, (b) evaluate the effectiveness of training programs designed to increase fitness, and (c) determine the prevalence of adequate levels of fitness in defined population groups. In school settings, fitness tests are used to (a) provide individualized feedback to students about their fitness levels, (b) make recommendations for increasing or maintaining current fitness levels, (c) educate students about physical activity and fitness, and provide information to help determine the effectiveness of physical education programs.

Among the test manuals available for selection, there are four commonly used upper-body strength and endurance tests, which are Pull-up test, Modified Pull-up test, Flexed Arm Hang test, and Push-up test. Test manuals usually include one of these tests in their test battery without explanation on the selection. Also the test manuals usually don’t have any detailed information of the test, such as which muscle group will be assessed. FITNESSGRAM®, a test manual currently endorsed by AAPERD, allows the practitioner the option of administering any of the four upper-body strength and endurance tests, without stating their differences.

As fitness test is important for assessing subject’s fitness, hence, a subject should receive the same criterion
classification regardless of what test is administered. If the tests can be used interchangeably, they must be equivalent. Misclassification of a subject may lead to an overestimation of appropriate physical activity or a discouragement in participation. Therefore, this study was designed to determine the interchangeability of the four commonly used upper-body strength and endurance tests.
Chapter 2

REVIEW OF LITERATURE

In most of the physical fitness test batteries, they include upper-body strength and endurance tests, which implied the importance of upper-body strength and endurance in physical fitness (AAHPERD, 1988; Chrysler Fund-Amateur Athletic Union [CE-AAU], 1987; Institute for Aerobics Research [IAR], 1987; PCPFS, 1987).

Upper-body strength and endurance are important for performing daily functions and various physical activities. A fitness test can assess subject’s physical fitness level and help developing a suitable fitness program for the subject. But if the fitness test cannot evaluate or classify the subject’s physical fitness level accurately, it may lead to over or underestimation of the ability of the subject. The present study was to determine the interchangeability of the five commonly used upper-body strength and endurance tests.

The review of literature for the present study focused on the following aspects: (a) validity and reliable of the five upper-body strength and endurance tests, (b) equivalence reliability of the tests, (c) summary of literature review.
Validity and reliable of the five upper-body strength and endurance tests

Pate, Burgess, Woods, Ross, Baumgartner (1993) studied the concurrent and construct validity of three common field tests of upper-body muscular strength and endurance including pull-up, flexed arm hang, push-up, Vermont modified pull-up and New York modified pull-up in children aged 9-10 years. The major findings are that the test performances were significantly associated with measures of weight-relative muscular strength, except push-up test, which was correlated significantly with the criterion measure of absolute strength, \( r(92)=0.32, \ p<0.005 \).

McManis, Baumgartner and Wuest (2000) studied the objectivity and stability reliability of the 90° push-up test for elementary, high school and college-age students. They gave out some recommendations on improving the objectivity and stability reliability of the test, (a) the cadence should not be too slow, (b) elementary students and low-strength college women would be more successful in performing push-ups on their knees, (c) subjects should be required to wear tight, short-sleeved shirt for better judgment on angle of elbows. Baumgartner, Oh, Chung and Hales (2002) also suggested that women and very young individuals should execute push-ups on the hands and knees. Besides the clothing, they pointed out
that hand placement must be specified in the push-up test protocol.

Romain and Mahar (2001) determined the test-retest reliability and equivalence reliability of the push-up and the modified pull-up tests from both norm-referenced and criterion-referenced frameworks. Sixty-two students aged between 10.5 and 12.3 years were administered the push-up and modified pull-up tests. The criterion-referenced test-retest reliability estimates were high for both tests, but the equivalence reliability estimates were considerably lower between them. Also the criterion-referenced equivalence reliability findings were not acceptable.

Clemons, Duncan, Blanchard, Gatch, Hollander and Doucet (2004) determined the relationships between flexed-arm hang and select measures of muscular fitness, which are absolute strength (1RM lat pull down), relative strength (1RM/mass) and muscle endurance (repetitions to failure at 70% of the 1RM). Sixty college-age women were studied and the results showed that flexed arm hang is a test of weight-relative muscular strength and appears unrelated to absolute strength or muscle endurance.
Equivalence reliability of the tests

Pate, Burgess, Woods, Ross, and Baumgartner (1993) found that the performance on the five field tests (pull-up, flexed arm hang, push-up, VMPU and NYMPU tests) were only moderately intercorrelated. The highest interest correlation was between flexed arm hang and VMPU tests, $r(92) = .71, P < .0001$, which are the two tests yielding the lowest percentage of zero scores.

Romain and Hahar (2001) were the pioneers to study the criterion-referenced equivalence reliability estimate between push-up and modified pull-up tests among young children. They found that the classification agreement between push-up and modified pull-up tests was low. Also they pointed out that because the FITNESSGRAM® allowed the physical activity directors to choose among four tests to measure upper-body strength and endurance, the criterion-referenced equivalence reliability of these tests should be examined.

Sherman and Barfield (2006) studied the equivalence reliability among the four upper-body strength and endurance tests (Push-up, pull-up, modified pull-up and flexed arm hang) in FITNESSGRAM®. 383 children in Grades 3 to 6 were tested over a week. The result showed that the equivalence reliability between PSU and MPU was acceptable for boys, but unacceptable for girls. The classifications for boys aged 10 and 11 regarding the push-up and pull-up tests were not
consistent, but they were consistent for girls, except age 11.

Summary of literature review

Upper-body strength and endurance are important for daily functional activities. A valid upper-body strength and endurance can accurately assess and classify subject’s muscular fitness level. This information can help physical educator to develop suitable fitness program for the subject.

The above studies shown that the four field tests are valid for measuring weight related strength rather than absolute strength and endurance. Also, for the equivalence reliability among the tests, there is lack of study on college student.

Definition of Terms

The following terms were defined operationally:

Health-related physical fitness

According to American College of Sport Medicine (2003), health-related physical fitness actually has four components: aerobic fitness, muscular fitness, flexibility and body composition. Muscular fitness is the strength and endurance of individual’s muscles.

Muscular Strength

Docherty (1996) stated that the International System of Units (SI) defined strength as the maximal force or torque developed by a muscle, or muscle group, during one maximal voluntary
action of unlimited duration at a specified velocity of movement.

**Muscular Endurance**

Docherty (1996) defined that muscular endurance is the ability of a muscle, or muscle group, to generate force repeatedly or for an extended period of time.

**Pull up**

According to AAHPED (1988), Pull up was defined as a person using overhand grip, body completely extended, raise until chin clears bar, then lower to full hang as in starting position.

**Flexed arm hang**

AAHPED (1988) defined Flexed arm hang as a person using overhand grip and in a position with chin clearing bar, elbows flexed, chest close to bar and hold this position as long as possible.

**Push up**

Chrysler Fund-Amateur Athletic Union (1987) defined push up as a person in prone position, elbows bent, hands flat on floor, thumbs pointing inward and next to chest, then pushes body up until elbows are straightened, while heels, hips, shoulders, and head remain in the same straight line.

**Modified pull up**

Pate, Ross, Baumgartner (1987) defined it as a person in supine
position, the bar adjusted just out of reach of fully extended arms. That person grasps bar with overhand grip, maintaining arms and legs straight, feet together. Then pull up the body with arms so chin clears the bar.

**Fatigue**

According to Rod et al. (2006), fatigue is defined as the decreased capacity to do work and the reduced efficiency of performance that normally follows a period of activity.

**Research Hypothesis**

According to the above literatures reviewed, it was hypothesized that:

1. There would be no significant correlation between performance of Pull-up test and that of Push-up test.
2. There would be no significant correlation between performance of Pull-up test and that of Modified Pull-up test.
3. There would be no significant correlation between performance of Pull-up test and that of Flexed Arm Hang test.
4. There would be no significant correlation between performance of Push-up test and that of Modified Pull-up test.
5. There would be no significant correlation between performance of Push-up test and that of Flexed Arm Hang test.

6. There would be no significant correlation between performance of Modified Pull-up test and that of Flexed Arm Hang test.
Chapter 3

METHOD

The purpose of the study was to examine the interchangeability of the upper-body strength and endurance tests, including Pull-up test, Push-up test, Modified Pull-up test, and Flexed Arm Hang test by assessing the correlation between the test results among them. This chapter was divided into the following parts: (a) subjects; (b) procedures; (c) method of analysis; and (d) statistical hypothesis.

Subjects

This study was targeted to 19 to 25 years old male, who were qualified to use the fitness room of Hong Kong Baptist University or that of LCSD. Subjects will be selected by convenient sampling. Before the study, subjects was asked to sign on the PAR-Q form and consent form after knowing the purpose, benefits and risks of the study.

Procedures

In this study, subjects were invited to perform the five upper-strength and endurance tests in a specific sequence, which is pull-up, push-up, modified pull-up, and flexed arm hang. All tests will be conducted in the fitness room of Hong Kong Baptist University or the fitness room of LCSD.

The subjects were strongly advised to wear sporty clothing and not to have a heavy meal 2 hours before the tests. The
subjects were invited to do warm up exercises, which included 5 minutes cycling and then 5 minutes related stretching exercises. After the warm up exercises, subjects would be invited to perform the tests.

The description of the pull-ups, push-ups, modified pull-ups and flexed arm hang tests were described by the FITNESSGRAM® (2007):

**Pull-ups**

The subject should start will hanging position on the bar with an overhand grasp. The subject uses the arms to pull the body up until the chin is above the bar and then lowers the body again into the full hanging position. The exercise is repeated as many times as possible. There is no time limit.

**Push-ups**

The subject should begin with a prone position with hand place under or slightly wider than the shoulder, fingers stretched out, legs straight and slightly apart, and toes tucked under. Then pushes up of the mat with the arms until arms are straight, keeping the kegs and back straight. The subject then lowers the body using the arms until the elbows bend at a 90° angle and the upper arms are parallel to floor. This movement is repeated as many times as possible.

**Modified pull-ups**

The student grasps the bar with an overhand grip. The pull
up begins in this “down” position with arms and legs straight, buttocks off the floor, and only heels touching the floor. The student then pulls up until the chin is above the bar. The subject then lowers the body to the down position. Movement continues in a rhythmic manner.

**Flexed Arm Hang**

The subject grasps the bar with an overhand grip. With the assistance of one or more spotters, the student raises the body off the floor to a position in which the chin is above the bar, elbows are flexed, and the chest is close to the bar. The position is held as long as possible.

There will be three minutes rest between each test.

**Delimitations**

The following delimitations were included in this study:

1. The subjects of the study were delimited to the males who were qualified to use the fitness room of Hong Kong Baptist University or that of LCSD and aged between 19 to 25 years old.

2. All the tests were carried at the fitness room of Hong Kong Baptist University or the fitness room of LCSD.
Data Analysis

Statistical hypothesis

The following null hypothesis was examined:

1. There would be significant correlation between performance of Pull-up test and that of Push-up test.
2. There would be significant correlation between performance of Pull-up test and that of Modified Pull-up test.
3. There would be significant correlation between performance of Pull-up test and that of Flexed Arm Hang test.
4. There would be significant correlation between performance of Push-up test and that of Modified Pull-up test.
5. There would be significant correlation between performance of Push-up test and that of Flexed Arm Hang test.
6. There would be significant correlation between performance of Modified Pull-up test and that of Flexed Arm Hang test.

Statistical Analysis

Data were reported as mean and standard deviation. Minimum and maximum values of variables were analyzed by the Statistical Package for Social Science (SPSS). Pearson
Production Moment Coefficient of Correlation (r) was used to examine the correlation between the test result. An alpha level of $p<0.05$ indicated statistical significance.

**Limitations**

The following limitations were included in this study:

1. The subjects are restricted to the students who can use the fitness room of Hong Kong Baptist University or LCSD.
2. The motivation of the subjects in performing the tests, as all the tests are with no time limit, was uncontrollable. It might affect the results of the study.
3. The performance of the subjects might be affected because of their physical lifestyle and the physical activity level.
4. The performance of the subjects might be affected due to their different physical characteristics.
5. Study findings are applicable only to the subjects included in this study.
Chapter 4

Result

20 males aged between 21 and 25 were invited to participate in this study. The purpose of the study was to examine the interchangeability of the upper-body strength and endurance tests, including Pull-up test, Modified Pull-up test, Flexed Arm Hang test and Push-up test by assessing the correlation between the test results among them. All subjects engaged in pull-up, push-up, modified pull-up and flexed arm hang.

The physical characteristics of the subjects were shown in the table 1:

Table 1

Physical characteristics of the subjects (N=20)

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Mean</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>21-25</td>
<td>22.8</td>
<td>1.28</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.58-1.82</td>
<td>1.73</td>
<td>0.65</td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td>130-184</td>
<td>150.70</td>
<td>12.44</td>
</tr>
</tbody>
</table>

The descriptive statistics of the subjects’ performance in the Pull-up Test (test 1), Push-up Test (test 2), Modified Pull-up Test (test 3) and Flexed Arm Hang Test (test 4) were shown in table 2:

Table 2

Descriptive statistics of the subjects’ performance in the
test 1, test 2, test 3 and test 4 (N=20)

<table>
<thead>
<tr>
<th>Test</th>
<th>Range</th>
<th>Mean</th>
<th>±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1(rep)</td>
<td>0-16</td>
<td>8.60</td>
<td>5.01</td>
</tr>
<tr>
<td>Test 2(rep)</td>
<td>8-56</td>
<td>37.60</td>
<td>11.80</td>
</tr>
<tr>
<td>Test 3(rep)</td>
<td>1-28</td>
<td>16.55</td>
<td>6.73</td>
</tr>
<tr>
<td>Test 4(s)</td>
<td>0-43</td>
<td>21.05</td>
<td>10.88</td>
</tr>
</tbody>
</table>

Test 1: Pull-up Test
Test 2: Push-up Test
Test 3: Modified Pull-up Test
Test 4: Flexed Arm Hang Test

The Pearson correlation between the subjects’ performance in the four tests was computed. The Pearson correlation coefficient and the coefficient of determination were shown as the following Table:

Table 3

The Pearson correlation between the subjects’ performance in the Pull-up Test (test 1), Push-up Test (test 2), Modified Pull-up Test (test 3) and Flexed Arm Hang Test (test 4)(N=20)

<table>
<thead>
<tr>
<th></th>
<th>r</th>
<th>r²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation between Test 1 and Test 2</td>
<td>0.48**</td>
<td>0.23</td>
<td>0.03</td>
</tr>
<tr>
<td>Correlation between Test 4 and Test 3</td>
<td>0.87**</td>
<td>0.76</td>
<td>0.00</td>
</tr>
</tbody>
</table>
| Test Combination          | Correlation | p-value | Alpha  
|---------------------------|-------------|---------|-------
| Test 1 and Test 3         | 0.74**      | 0.05    | 0.00  
| Test 1 and Test 4         | 0.69**      | 0.05    | 0.00  
| Test 2 and Test 3         | 0.33        | 0.11    | 0.16  
| Test 2 and Test 4         | 0.70**      | 0.05    | 0.00  

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

Using the Pearson product-moment correlation coefficient, the finding showed that the correlation between the Pull-up test and Push-up test; Pull-up test and Modified Pull-up test; Pull-up test and Flexed Arm Hang test; Push-up test and Modified Pull-up test; Modified Pull-up test and Flexed Arm Hang test were significant. Only the correlation between Push-up test and Flexed Arm Hang test was not significant.

The following figures show the relationship between the subject’s performance of Pull-up test, Push-up test, Modified Pull-up test and Flexed Arm Hang test:
Figure 1

Scatter plotted graph showing the relationship between the subjects’ performance of the Pull-up test (test 1) and that of Push-up test (test 2).
Figure 2

Scatter plotted graph showing the relationship between the subjects’ performance of the Pull-up test (test 1) and that of Modified Pull-up test (test 3)
Figure 3
Scatter plotted graph showing the relationship between the subjects’ performance of the Pull-up test (test 1) and that of Flexed Arm Hang test (test 4)
Figure 4

Scatter plotted graph showing the relationship between the subjects’ performance of the Push-up test (test 2) and that of Modified Pull-up test (test 3)
Figure 5

Scatter plotted graph showing the relationship between the subjects’ performance of the Push-up test (test 2) and that of Flexed Arm Hang test (test 4)
Figure 6
Scatter plotted graph showing the relationship between the subjects’ performance of the Modified Pull-up test (test 3) and that of Flexed Arm Hang test (test 4)

As the correlation between Push-up test and Flexed Arm Hang test was not significant, the null Hypothesis “There would be significant correlation between performance of Push-up test and Flexed Arm Hang test.” was rejected. For other
combinations, as the correlation between them were significant, so the following null hypotheses were accepted:
1. There would be significant correlation between performance of Pull-up test and Push-up test.
2. There would be significant correlation between performance of Pull-up test and Modified Pull-up test.
3. There would be significant correlation between performance of Pull-up test and Flexed Arm Hang test.
4. There would be significant correlation between performance of Push-up test and Modified Pull-up test.
5. There would be significant correlation between performance of Modified Pull-up test and Flexed Arm Hang test.

Discussion

The purpose of the study was to examine the interchangeability of the upper-body strength and endurance tests, including Pull-up test, Modified Pull-up test, Flexed Arm Hang test and Push-up test by assessing the correlation between the test results among them. All subjects engaged in pull-up, push-up, modified pull-up and flexed arm hang tests. In the following discussions, four parts would be divided: (1) Relationship between Pull-up test, Modified Pull-up test and Flexed Arm Hang test, (2) Relationship between Push-up test, Pull-up test and Modified Pull-up test, (3) Relationship
between Push-up test and Flexed Arm Hang test, and (4) Review of setting of all the tests.

**Relationship between Pull-up test, Modified Pull-up test and Flexed Arm Hang test**

Pull-up test and Modified Pull-up test are commonly used to assess upper body strength and endurance in different organizations. For instance, Pull-up test and Modified Pull-up test were involved in the physical fitness test of Hong Kong Police Force as a prerequisite of recruitment for male and female respectively.

According to the present study, it was found that there were significant correlation between the performance of Pull-up test and Modified Pull-up test \((r=0.87; \ p<0.05)\); Pull-up test and Flexed Arm Hang test \((r=0.74; \ p<0.05)\); Modified Pull-up test and Flexed Arm Hang test \((r=0.70; \ p<0.05)\). In other words, for the performance of Pull-up test and Modified Pull-up test, 76% of the variance was shared. For Pull-up test and Flexed Arm Hang test, 55% of variance was shared. And for Modified Pull-up test and Flexed Arm Hang test, 49% of variance was shared. The high-shared percentage was due to the similar muscle group recruited in the tests. The muscle group include biceps brachii, brachioradialis, latissimus dorsi, posterior deltoïd, rhomboid, teres major
and trapezius. The variances that were not shared may be attributed to the difference between the settings of both tests and subjects’ motivation to perform the tests. Also, as the motions of different tests were different, the contribution of different muscle may also be difference, even the recruited muscle group was similar. This may lead to lower percentage of variance shared.

**Relationship between Push-up test, Pull-up test and Modified Pull-up test**

In the present study, it was found that there were significant correlations between Push-up test and Pull-up test ($r=0.48$, $p<0.05$); Push-up test and Modified Pull-up test ($r=0.69$, $p<0.05$). So the subject’s performance of Push-up test and Pull-up test shared 23% variance and for the performance of Push-up test and Modified Pull-up test, 48% of variance was shared. In other words, 77% of variance between the performance of Push-up test and that of Pull-up test were not shared, and 52% of variance between performance of Push-up test and Modified Pull-up test were not shared. The large percentage variances, which were not shared, may mainly due to the different muscle groups recruited in the tests. For Push-up, it will recruit deltoideus, coracobrachialis pectoralis major, pectoralis minor and triceps brachii. For
Pull-up and Modified Pull-up, the muscle group include biceps brachii, brachioradialis, latissimus dorsi, posterior deltoid, rhomboid, teres major and trapezius. For those shared variance, they may be due to the research setting. As the tests took place in the fitness room of Hong Kong Baptist University and LCSD, so the subject were restricted in those who were qualified to use the fitness, which means that they may have certain upper body strength and endurance training.

**Relationship between Push-up test and Flexed Arm Hang test**

There were no significant correlation between the subject’s performance of Push-up test and that of Flexed Arm Hang test shown in this study (r=0.33, p>0.05). The variance shared between two tests was only 11%. The low percentage of variance shared may due to the difference in muscle group recruited and the motivation of doing the test. For Flexed Arm Hang test, it requires high motivation to perform the test, because the isometric contraction will lead to muscle soreness, and the ability of pain tolerance and motivation will affect the test result.
**Review of setting of all the tests**

As one of the correlations between tests was not significant, which implied that four tests couldn’t be used interchangeably.

For the consideration of muscle group recruited, at least two tests including Push-up test should be held to assess upper body muscular strength and endurance. Because Push-up test involved deltoideus, coracobrachialis pectoralis major, pectoralis minor and triceps brachii. For Pull-up, Modified Pull-up, and Flexed Arm Hang, they involved biceps brachii, brachioradialis, latissimus dorsi, posterior deltoid, rhomboid, teres major and trapezius. So most of the major muscle on upper body would be assessed.
Chapter 5

SUMMARY AND CONCLUSION

Summary of Results

The present study was designed to examine the interchangeability of the upper-body strength and endurance tests, including Pull-up, Modified Pull-up, Flexed Arm Hang and Push-up by assessing the correlation between the test results among them.

20 male subjects participated in this study. They performed pull-up, push-up, modified pull-up, and flexed arm hang in the fitness room of Hong Kong Baptist University or fitness room of LCSD. The repetitions of Pull-up test, Push-up test, Modified Pull-up test, and the time duration of Flexed Arm Hang test were recorded, and the test results data were analyzed by using Statistical Package of Social Science (SPSS). Pearson Product Moment Coefficient of Correlation (r) was used, and 0.05 level of significance was set.

The results of this study were summarized as follows:

1. There was significant correlation between performance of Pull-up test and Push-up test (r=0.48, p<0.05). The common variance of the two tests was 23% (coefficient of determination = 0.23).

2. There was significant correlation between performance of Pull-up test and Modified Pull-up test (r=0.87; p<0.05).
The common variance of the two tests was 76% (coefficient of determination = 0.76).

3. There was significant correlation between performance of Pull-up test and Flexed Arm Hang test \((r = 0.74; \ p < 0.05)\). The common variance of the two tests was 74% (coefficient of determination = 0.74).

4. There was significant correlation between performance of Push-up test and Modified Pull-up test \((r = 0.69, \ p < 0.05)\). The common variance of the two tests was 48% (coefficient of determination = 0.48).

5. There was significant correlation between performance of Modified Pull-up test and Flexed Arm Hang test \((r = 0.70; \ p < 0.05)\). The common variance of the two tests was 49% (coefficient of determination = 0.49).

6. There was no significant correlation between performance of Push-up test and Flexed Arm Hang test. \((r = 0.33, \ p > 0.05)\) The common variance of the two tests was 11% (coefficient of determination = 0.11).

**Conclusion**

From the findings, it was found that the subject’s performance of Push-up test and that of Flexed Arm Hang test had no significant correlation, so it was concluded that the four upper body muscular strength and endurance test couldn’t be used interchangeably.
Recommendation of Further Study

1. The age group, the sex group should be extended, since there might have differences in upper body muscular strength and endurance.

2. Body weight of the subjects should be considered as well, as all the tests are weight bearing, so body weight will significantly affect the difficulty of the tests.
Reference


Institute for Aerobics Research. (1987). FITNESSGRAM user’s manual Dallas, TX: Author


Education, Recreation and Dance, 58(9), 71-73.


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CONSENT FORM

The information in this consent form is provided so that you can decide whether you wish to participate in this study. It is important that you understand that your participation is completely voluntary. This means that even if you agree to participate you are free to withdraw from the experiment at anytime, to decline to participate in any portion of the study, without penalty.

This experiment poses no known risks to your health and your name will not be associated with the findings. You may feel tired and sweat during the experiment.

Your participation will take approximately 20 minutes. Also, upon completion of your participation in this study you will be provided with a brief explanation of the question this study addresses. If you have any questions not addressed by this consent form, please do not hesitate to ask. You will receive a copy of this form, which you should keep for your records.

Thank you for your time.

___________________________
Researcher’s Signature

CONSENT STATEMENT:

I have read the above comments and agree to participate in this experiment. I understand that if I have any questions or concerns regarding this project I can contact the investigator.

___________________________  ____________
(participant’s signature)                (date)
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.

YES to one or more questions
Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.
• You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
• Find out which community programs are safe and helpful for you.

NO to all questions
If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:
• start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
• take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

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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Supported by: Health Canada Santé Canada

Informed 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 in doubt after completing this questionnaire, consult your doctor prior to physical activity.