# Validity and Reliability of Rockport Fitness Walking Test in Malaysian University Students

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## Abstract

Direct measurement of maximal oxygen uptake ($VO_{2max}$) has been well accepted as the most valid test for cardiorespiratory fitness. However, this method requires sophisticated and expensive laboratory equipment as well as trained personnel. It is also time consuming to test each participant individually and the participants themselves have to be physically exerted to obtain a true maximum for the results to be accurate. To overcome these practical problems, the Rockport Fitness Walking Test (RFWT), which is a less strenuous field test, has been used to estimate the $VO_{2max}$. The purpose of the present study was to test the validity and the reliability of the RFWT among the Malaysian students in the Health Campus, Universiti Sains Malaysia. Fifty healthy males ($21.4 \pm 1.6$ year) and 50 healthy females ($21.1 \pm 1.4$ year) recruited from the Health Campus, Universiti Sains Malaysia participated in this study. They performed one treadmill exercise test and two RFWT with the minimal of 4 days interval. The treadmill exercise test was conducted in a laboratory setting to determine the measured $VO_{2max}$ that was used as the criterion value. The estimated $VO_{2max}$ was obtained from the RFWT in an open field testing environment. The generalised equation of the Kline $et$ $al.$ (1987) was used for the calculation of the $VO_{2max}$. The correlation coefficient between the measured and estimated $VO_{2max}$ values was $r = 0.79$ ($p < 0.05$). In terms of reliability, the RFWT has a high test-retest reliability ($r = 0.92$, $p < 0.05$). However, when the results were analysed separately according to gender, the correlation coefficient was 0.72 ($p < 0.05$) for the male participants and 0.31 ($p < 0.05$) for the female participants. The coefficient for the test-retest reliability was 0.91 ($p < 0.05$) and 0.77 ($p < 0.05$) for the male and female participants respectively. These results suggest that the RFWT is a valid and reliable field test for estimation of $VO_{2max}$ among the male students. However, the RFWT tends to over-predict the actual $VO_{2max}$ in the female students of Health Campus. Thus, the use of the RFWT on the female students to estimate their $VO_{2max}$ should be treated with caution.
Key words: maximal oxygen uptake, Rockport fitness walking test, cardiorespiratory fitness, field test

## Introduction

Rockport fitness walking test (RFWT), first developed by Kline et al. (1987), is a field test that estimate maximal oxygen uptake ($VO_{2max}$) from submaximal effort. In comparison to direct $VO_{2max}$ measurement, the RFWT is practical, inexpensive and require minimal equipment and trained staff (Kline et al., 1987). The RWFT has been validated on a broad range of males and females (age 30-69 years) with heterogeneous

fitness level. The test requires the participants to walk briskly but at steady pace for 1-mile during which the heart rate and time to complete the walk will be recorded. Calculation of the $VO_{2max}$ is via the use of generalized or gender-specific prediction equations using sex, age, weight, time to complete 1-mile walk and heart rate at the end of 1-mile walk as predictors. The prediction equations have been showed to exhibit a strong relationship with the measured $VO_{2max}$ (Kline et al., 1987).

RFWT has been shown to be a reliable and valid walking test across a wide range of healthy adult subjects including the elderly (Coleman et al., 1987; Fenstermaker et al., 1992; Zwiren et al., 1991). However, the validity of the RFWT is not equivocal as other researchers have reported an overestimation or underestimation of the $VO_{2max}$ on particular subgroup of population such as among the college students and adult with mental retardation (Dolgener et al., 1994; Kittredge et al., 1994). For instance, Dolgener et al. (1994) revealed that the original RFWT equation over-predicted $VO_{2max}$ values among young college students by as much as 18% in males and 23% in females. However, Chen et al. (2000) found the opposite that the RFWT was a valid test among the young students, with high correlation coefficient between the measured and estimated $VO_{2max}$ values. The study by Chen et al. (2000) actually recruited Malaysian university students studying in the United Kingdom as the participants.   However, test-retest reliability of the RFWT was not reported in that study. As far as we know, there is no other study done on Malaysian university students to confirm the earlier findings. Some researchers pointed out that tests which are valid and reliable for a given population may not be such for another one (Tammik and Jürimäe, 1997). Hence, another study in Malaysia, which has a different weather and environment, is warranted. Therefore, the purpose of this study was to confirm the validity and to establish the reliability of the RFWT among Malaysian students.

## Methodology

### Subjects

Hundred (50 males and 50 females) healthy Malaysian university students, aged between 19 and 25 years from the Health Campus of the Universiti Sains Malaysia, were included in the study. The participants were selected after they responded to flyers distributed in the campus. The participants were excluded if they had any of the following criteria: i) a history of cardiovascular disease; ii) resting systolic blood pressure >200 mm Hg; iii) resting diastolic blood pressure >115 mm Hg. The qualified participants were asked to read and sign an informed consent form. This study was approved by the Research and Human Ethics Committee of the Universiti Sains Malaysia.

### Exercise Protocol

Each selected participant was asked to complete three exercise tests: one treadmill exercise test and two Rockport Fitness Walking Tests (RFWT).   The sequences of the tests, whether one would perform the treadmill test first or the RFWT first were decided by card flipping.  Each test was conducted on a separate day with at least 4 days rest in between the tests to eliminate possible fatigue effects (O'Gorman, 2000).

Participants were instructed to get sufficient sleep (at least 6-8 hours) and avoid large food, caffeine, tobacco products, or alcohol for 3-hour prior to testing (ACSM, 2006).

Besides, participants were asked to avoid strenuous exercise 24 hours prior to the testing. Prior to the first test, body weights (to nearest 0.1 kg) and height (to the nearest 0.25 cm) were measured.

### Treadmill Exercise Test

True maximal oxygen uptake ($VO_{2max}$) was assessed by running on an electromechanical treadmill (Quinton, USA).    The treadmill was programmed according to the Bruce protocol. Following familiarization period to the treadmill, the participants were asked to run to exhaustion, that is until they could no longer continue running despite verbal encouragement. Breath gas samples were collected via facemask and analysed with the use of automatic respiratory gas analyser ($V_{max}$ Spectra Analyser, USA). $VO_{2max}$ values were computed every 20 seconds by an online computer system (Dell). The test was supervised by a physician throughout the procedure to ensure safety of the participants.

The criterion for $VO_{2max}$ is a plateau in oxygen uptake with an increase of workload. If this is not present, the secondary criteria would be used which are: i) heart rate at exhaustion should be within 10 beats.min$^{-1}$ of age-predicted maximum heart rate; ii) respiratory quotient (RQ) should be greater than 1.15.    Oxygen consumption was considered maximal if two of these criteria were met (ACSM, 2006).

### Rockport Fitness Walking Test

RFWT was conducted using the protocol of Kline et al. (1987) in an open field course of 220 yards marked with skittles. In order to determine the test-retest reliability of the RFWT, each participant was requested to perform the test twice, separated by al least 4 days interval.  After a brief warm up, the participants were asked to walk as brisk as possible for 1-mile with their heart rate monitored. They were also reminded to maintain the speed throughout the test, but without running or jogging. As the participants crossed the finish line, the time to finish the walk and heart rates were immediately recorded.

The estimated $VO_{2max}$ of the subjects were calculated by using the generalised prediction equation of Kline et al. (1987).

$VO_{2max}$ [ml.kg$^{-1}$.min$^{-1}$] = 132.853 - 0.0769(BW) − 0.3877(Age) + 6.315(Sex) − 3.2649(T) − 0.1565(HR)
*where BW = body weight in pounds; Age measured to the last year; Sex = 0 (female) and 1 (male); T = walk time measured to the nearest hundredth of a minute and HR = heart rate (beats.min$^{-1}$) measures immediately at the end of the walking test.*

### Statistical Analysis

All statistical analyses were performed using Statistical Package of the Social Sciences (SPSS) for Windows (*version 12.0*). Data are displayed as mean ± SD, and the level of significance was set at *P* less than .05. Descriptive statistics were calculated for each of the following variables: age, body height, body mass, body mass index (BMI), percentage of body fat, resting heart rate, resting blood pressure, and the measured and estimated $V\dot{O}_{2max}$. To see the consistency of the RFWT, paired t-test was used to compare the means of the estimated $VO_{2max}$ for trial 1 and trial 2 of the RFWT. Pearson product-moment correlation coefficients were used to determine the validity and the test-retest reliability of the RFWT.

# Results

### Participants Characteristics

A total of 100 subjects (50 males and 50 females) with the mean age of $21.2 \pm 1.5$ years participated in this study. Demographic data and physiological characteristics of the participants are summarized in Table 1.

Table 1. Participants Characteristics

| Characteristics | | Males (n = 50) | Females (n = 50) | Combined (n =100) |
|---|---|---|---|---|
| Age (year) | | $21.4 \pm 1.6$ | $21.1 \pm 1.4$ | $21.2 \pm 1.5$ |
| Height (cm) | | $171.6 \pm 5.8$ | $158.5 \pm 5.5$ | $165.0 \pm 5.6$ |
| Weight (kg) | | $68.5 \pm 14.2$ | $50.8 \pm 7.5$ | $59.6 \pm 10.8$ |
| BMI $(kg.m^{-2})$ | | $23.1 \pm 4.4$ | $19.9 \pm 2.5$ | $21.5 \pm 3.4$ |
| Percentage of body fat (%) | | $19.8 \pm 6.9$ | $24.1 \pm 5.0$ | $21.9 \pm 5.9$ |
| Resting heart rate $(beats.min^{-1})$ | | $76.0 \pm 13.0$ | $80.5 \pm 12.1$ | $78.2 \pm 12.5$ |
| Resting blood | Systolic | $124.1 \pm 13.0$ | $106.0 \pm 8.8$ | $115 \pm 10.9$ |
| pressure (mmHg) | Diastolic | $70.7 \pm 8.8$ | $65.0 \pm 7.4$ | $67.8 \pm 8.1$ |

Abbreviations: BMI, body mass index;
NOTE. Values are expressed as mean value ± SD

### Test- Retest Reliability of RFWT

Analysis using t-test of the combined data revealed that there was no significant difference between the two RFWT walking ($45.4 \pm 6.4$ versus $45.6 \pm 6.5$ $ml.kg^{-1}.min^{-1}$; $P > 0.05$).   Analysis using Pearson product-moment correlation showed that the RFWT has a high test-retest reliability ($r = 0.92$, $p < 0.05$). However, when the results were analysed separately ,according to gender, the correlation coefficient for the test-retest reliability was 0.91 ($p < 0.05$) and 0.77 ($p < 0.05$) for the male and female participants respectively (Table 2).

Table 2: Test-Retest Reliability of the Rockport Fitness Walking Test

|  | Estimated $VO_2$max ($ml.kg^{-1}.min^{-1}$) | | Paired t-test | Person product moment |
|---|---|---|---|---|
|  | Trial 1 | Trial 2 | p-value[*] | r[+] |
| Males | 49.5 ± 5.4 | 50.0 ± 5.2 | 0.111 | 0.906, p<0.05 |
| Females | 41.2 ± 4.3 | 41.1 ± 4.2 | 0.669 | 0.767, p<0.05 |
| Combined | 45.4 ± 6.4 | 45.6 ± 6.5 | 0.508 | 0.917, p<0.05 |

Data were presented as Mean ± S.D.

[*] paired t-test applied and t-statistic p-value significant if < 0.05

[+] Pearson product-moment correlation (p < 0.05)

## Validity of RFWT

The correlation coefficient between the $VO_{2max}$ measured from treadmill test and those estimated from RFWT was r = 0.79 (p < 0.05). However, when the results were analyzed separately according to gender, the correlation coefficient was 0.72 (p < 0.05) for the male participants and 0.31 (p < 0.05) for the female participants. The RFWT was shown to over-predict the actual $VO_{2max}$ among the female students (Table 3, Figure 1 and 2).

Table 3: Validation analysis of the Rockport Fitness Walking Test

|  | Males | Females | Combined |
|---|---|---|---|
| Measured $VO_2$max ($ml.kg^{-1}.min^{-1}$) | 45.8 ± 8.2 | 32.9 ± 4.1 | 39.3 ± 6.1 |
| Estimated $VO_2$max (Trial 1 + Trial 2) ($ml.kg^{-1}.min^{-1}$) | 49.8 ± 5.2 | 41.2 ± 4.0 | 45.5 ± 4.6 |
| Correlation coefficient (r) | 0.72 | 0.31 | 0.79 |
| SEE | 5.69 | 3.91 | 5.60 |

SEE , standard error of estimate = $SD \sqrt{1 - (r^2)}$, where SD = standard deviation of the measured $VO_2$max and r is the correlation coefficient between estimated and measured $VO_2$max
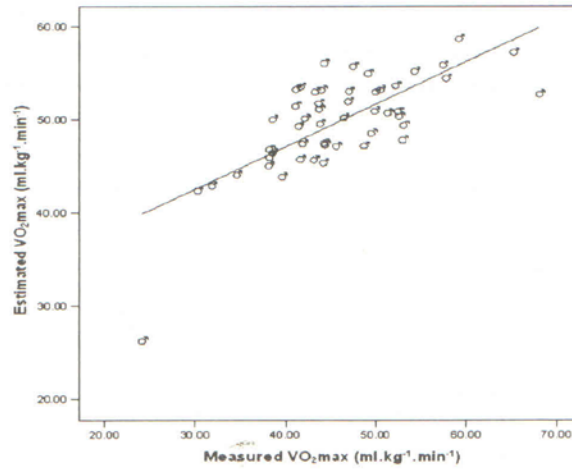
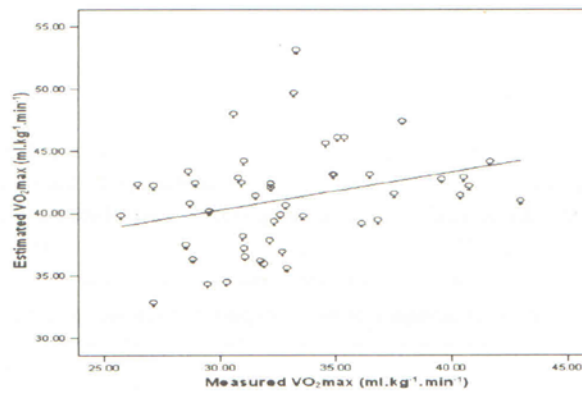Figure 1 Scattergram for the estimated and measured VO$_2$max for the male participants.



Figure 2 Scattergram for the estimated and measured VO$_2$max the female participants

## Discussion

Analysis of the combined data suggests that the RFWT is a valid test among young Malaysian students, as a moderately strong significant correlation (r = 0.79) was established between estimated VO$_{2max}$ and the measured VO$_{2max}$. The present study also found that the RFWT is a reliable test among the tested population. The study found no significant difference between the two RFWT performed at two separate days and their correlation coefficient is high (r = 0.92).

The validity of RFWT as revealed in the present study is consistent to the findings by Coleman et al. (1987) and Chen et al. (2000), both of which used young subjects below the age of 30 as participants. The correlation coefficient obtained in the present study is similar to the value obtained in the study by Coleman et al. (1987) (r = 0.79), but much lower compared to the value obtained by Chen et al. (2000) (r = 0.92). In contrast,

Dolegner et al. (1994) concluded that the original RFWT was invalid to be used in the young subjects. The study found only a moderate correlation (r = 0.69) between the measured and estimated $VO_{2max}$ obtained from the young college students aged from 16 23 years of age. Dolegner et al. (1994) hypothesised that the discrepancy of between the results could be due to the differences in the fitness levels of the participants which have an important effect on the prediction of the $VO_{2max}$. Those participants whose fall into the low to middle fitness categories, their estimated $VO_{2max}$ tend to overestimate the true value and vice- versa with those in high fitness category. In response to this finding, Dolegner et al. (1994) developed a new predictive equation for $VO_{2max}$, using the same predictive variable as in the original equation by Kline et al. (1987), except the variable age was excluded from the final equation.

The present study revealed that the original generalised equation by Kline et al. (1987) yielded much lower correlation coefficient for females than for the males (r = 0.31 and r = 0.72 respectively). The equation overpredicted the estimate of $VO_{2max}$ by as much as 25.2% in females, compared to 8.7% in males. This pattern is similar to earlier findings by Dolgener et al. (1994), George et al. (1998) and Chen et al. (2000), all of which found lower correlation coefficient for female participants when compared to the male counterparts.   For example, Chen et al. (2000) which use the same prediction equation as the present study to obtain the estimated $VO_{2max}$ found that the correlation coefficient for the female is far lower ( r = 0.67) than that of the males (r = male 0.81).   Thus, all evidence indicated that females tend to exhibit a lower predictive accuracy than the males when estimating the $VO_{2max}$ using the generalised prediction equation of Kline et al. (1987). Therefore based on these findings, the use of generalised prediction equation of Kline et al. (1987) to estimate the $VO_{2max}$ on the female college and university students should be treated with caution.

In conclusion, the results of the present study suggest that the RFWT is a valid and reliable field test for estimation of $VO_{2max}$ among the male students. However, the test tends to over-predict the actual $VO_{2max}$ among the female students.

## Acknowledgements

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