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THE EFFECT OF ALTERNATING STEADY-STATE WALKING TECHNIQUE ON ESTIMATED VO_2MAX VALUES OF THE ROCKPORT FITNESS WALKING TEST IN COLLEGE STUDENTS

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ABSTRACT

THE EFFECT OF ALTERNATING STEADY-STATE WALKING TECHNIQUE ON ESTIMATED VO_2MAX VALUES OF THE ROCKPORT FITNESS WALKING TEST IN COLLEGE STUDENTS. **Allyn Byars, Michael Greenwood, Lori Greenwood, Warren Simpson**. **JEP**online. 2003;6(2):21-25. The purpose of this study was to determine if differences in steady-state walking technique between repeated trials of the Rockport Fitness Walking Test (RW) would affect estimated VO_2max values. Twenty-four male and thirty-seven female college students (n=61), ages 18-39 years, volunteered as subjects. Subjects were randomly assigned to complete two steady-state walking trials of the RW on nonconsecutive days utilizing either normal walking technique or an aerobic walking technique during the pretest and the opposite technique for the posttest. Estimates of VO_2max were calculated using gender and age-appropriate equations and expressed as both absolute (L/min) and relative (mL/kg/min). Data were analyzed using the total group (all subjects) and by gender. Initial results using repeated measures ANOVA indicated no significant differences for either absolute ($p>0.53$ or higher) or relative ($p>0.32$ or higher) estimated VO_2max values for all groups between the two trials. Further analysis included estimated reliability using an intra-class test-retest correlation (2-way ANOVA) for absolute (Total; R=0.99, Male; R=0.97, Female; R=0.92) and relative (Total; R=0.96, Male; R=0.97, Female; R=0.93) values. It was concluded that walking technique and the use of a steady-state walking pace does not adversely influence the reliability of estimating maximal oxygen consumption using the RW.

Key words: Maximal oxygen consumption, Walking technique, Reliability, Rockport fitness walking test

INTRODUCTION

The Rockport Fitness Walking Test (RW) is a maximal paced 1-mile walk test used to evaluate cardiorespiratory fitness through the estimation or prediction of maximal oxygen consumption (VO_2max) in adults (1). Since the original validation study by Kline, et al. (1), the RW has been cross-validated in many samples (2,3,4,5), all of which have supported the accuracy of this field test. However, Dolgener, Hensley, Marsh, and Fejelstul (6) demonstrated that the original RW generalized regression equations over predicted

VO_2max in college men and women and accordingly revised and validated a prediction equation for college age individuals.

Reliability coefficients (test-retest) associated with the original maximally paced RW are reported to be .93 for heart rate and .98 for walking time (1). However, subjects in the Kline et al. validation study completed two to five trials in which the two trials that were within 30 s of elapsed time were used for data analysis, thus, suggesting a learning effect. This learning effect was primarily due to individuals had to learn how to pace themselves at a maximal pace for the 1-mile distance. In another study, the test-retest reliability of two RW trials was found to be 0.97 for relative values of estimated VO_2max (mL/kg/min) using the generalized equation in subjects ages 70-79 (7). Also, in a study of females 65 years and older, investigators reported test-retest reliability coefficients of 0.97 for walking time, 0.92 for heart rate, and 0.95 for absolute (L/min) and 0.97 for relative (mL/kg/min) estimated VO_2max values for the last two of three RW trials indicating a learning effect for the test with much lower values being reported for the combination of all three trials (8). More recently, a study reported reliability coefficients for two trials of the RW performed by high school aged individuals (9). Reliability coefficients (test-retest) were 0.60 for heart rate, 0.67 for walking time, and 0.91 to 0.97 for relative estimated VO_2max values using the Kline, et al. (1) and Dolgener, et al. (6) equations respectively (9).

As a result of these studies, the RW is considered a valid and reliable field test used by many colleges and universities to assess the aerobic performance of students. Consequentially, some students may elect to use different walking techniques (i.e., aerobic or power walking) during test participation which may affect the heart rate and time data used in estimating maximal oxygen consumption from the 1-mile walk test. In addition, previous validity research has indicated that the original maximally paced RW can be performed using a steady-state walk to yield a similar accurate estimation of maximal oxygen consumption from either a 1/4-mile or traditional distance of 1-mile utilizing normal walking technique (10). This is based on the theoretical assumption that regardless of the walking pace, as long as it is consistent, the resulting prediction of VO_2max would not be affected as long as the pace is within the linear proportion of the heart rate and VO_2 relationship. Therefore, the purpose of this study was to determine if differences in steady-state walking technique between repeated trials of the RW would affect estimated VO_2max values.

METHODS

In this investigation, sixty-one apparently healthy male (n=24) and female (n=37) college students, ages 18-39 years, volunteered as subjects. Participants were mainly recruited from a university required health-related fitness course in which participation in the RW is a course requirement. The balance of the other participants included volunteer subjects who were enrolled in either a physical education measurement course or a personal health course. In addition, all subjects were administered a health questionnaire in order to screen for individuals who might need medical clearance for participation as well as those taking medications that might influence the heart rate data collected during this study and eliminated from participation. Written informed consent was also obtained from each participant in accordance with the policy statements of the Institutional Review Board of the university in which the study was conducted.

Prior to test participation, students were familiarized with test protocol including a one-day instruction and practice in an aerobic walking technique utilizing an arm swing with the elbows bent at ninety degrees. To prepare for the 1-mile walk test, participants were asked to avoid moderate to high intensity exercise 12 hours before testing, exhaustive exercise at least 48 hours before testing, alcohol and tobacco use, large meals and/or caffeine use at least 3 hours before testing.

The order of the trials was counterbalanced, randomly determined with subjects being administered two steady-state walking trials of the RW on nonconsecutive days utilizing either their normal walking technique (everyday walking style with elbows extended) or the aerobic walking technique during pretest and the other for the

posttest trials. Subjects were instructed by a member of the research team to walk the 1-mile at a self-selected brisk, but less than maximal pace while maintaining a sub-maximal constant pace (steady-state) throughout the entire test. Steady-state pace was determined by monitoring the heart rate of each subject for every lap and assumed if the heart rates for the last two laps were within five beats of each other. As the subjects crossed the finish line for the 1-mile walk, the test administrator immediately recorded both the elapsed time and final exercise heart rate.

Time and heart rate data were collected using electronic heart rate monitors (Polar, Inc., Westburg, NY). All walk testing was performed in a controlled environment with subjects walking a pre-measured perimeter (11 laps), determined with a measurement wheel (Rolatape, Inc.), of two gymnasium floors. Body mass was measured using a standard calibrated physician's scale, with participants wearing lightweight exercise apparel and no shoes.

The statistical analyses were performed using Statistical Package for the Social Sciences (SPSS for Windows Version 9.0) (10). Estimates of maximal oxygen consumption were calculated using gender and age appropriate equations and expressed as both absolute (L/min) and relative (mL/kg/min) VO_2max values. Estimated VO_2max values for subjects <30 years of age were calculated using the Dolgener, et al. (6) equation while values for participants ≥30 years of age were estimated using the Kline, et al. (1) equation. Data were analyzed by comparing the pre-test and post-test estimated VO_2max values of total group (all subjects) and by gender with the initial analysis including a repeated measures ANOVA to determine if there were mean differences between pre-test and post-test data. Reliability analysis consisted of using intra-class test-retest correlations (2-way ANOVA) for both absolute (L/min) and relative (mL/kg/min) VO_2max values with their respected 0.95 confidence intervals being reported. In addition, the Spearman-Brown Prophecy Formula was used to estimate the maximum expected reliability for a single test utilizing the estimated VO_2max values. An alpha level of 0.05 was used for determining significance.

RESULTS

Descriptive data of the participants are presented in Table 1.

Table 1: Descriptive data of the subjects.

Variable	*Total (n = 61)*	*Male (n = 24)*	*Female (n = 37)*
Age (year)	21.28±4.14	20.83±3.09	21.57±4.71
Body mass (kg)	73.18±20.06	88.41±18.49	63.30±14.05
Pre-test walk time (min)	16.16±1.02	15.79±0.88	16.39±1.05
Post-test walk time (min)	15.69±1.75	14.99±1.78	16.15±1.59
Pre-test HRwalk (beats/min)	140.79±21.05	131.67±16.65	146.70±21.68
Post-test HRwalk (beats/min)	146.49±22.39	141.71±23.25	149.59±22.39

HRwalk = heart rate at the end of the 1-mile walk.

Initial results using repeated measures ANOVA indicated that there were no significant differences for either the absolute (p=0.78) or relative (p=0.32) estimated VO_2max values for the total group between the pretest and posttest trials. Repeated measures ANOVA also indicated that there were no significant differences for either the absolute (p=0.53) or relative (p=0.72) estimated VO_2max values for males as well as the absolute (p=0.97) and relative (p=0.36) values for females, thus, demonstrating that the estimated values between the two trials were essentially the same. The estimated VO_2max mean values for the pretest and posttest trials are presented in Table 2.

Further analysis included estimated reliability using an intra-class test-retest correlation (2-way ANOVA) for both absolute (R=0.99) and relative (R=0.96) estimated VO_2max values for the total group. Reliability was also estimated for males and females to determine if gender was a factor that affected the reliability coefficient. For

males, the reliability for estimated VO_2max values in absolute (R=0.97) and relative (R=0.97) terms was similar to the total group while the reliability in absolute (R=0.92) and relative (R=0.93) terms for females was slightly lower.

In addition, the Spearman Brown Prophecy Formula was used to estimate the maximum expected reliability for a single test administration for both absolute ($R_{1,1}$=0.98) and relative ($R_{1,1}$ =0.93) values of the total group. Single test administration coefficients were also estimated for male absolute ($R_{1,1}$=0.93) and relative ($R_{1,1}$=0.94) values as well as for female absolute ($R_{1,1}$=0.85) and relative ($R_{1,1}$=0.88) estimated VO_2max values. The 0.95 confidence intervals for the reliability estimates of both single and double administrations of this test are presented in Table 3.

Table 2: Repeated Measures ANOVA for Estimated VO_2max Values for the RW.

Group	*Pre-Test*	*Post-Test*	*F*	*p*
Total (n=61)				
L/min	2.68±0.75	2.69±0.77	0.078	0.781
mL/kg/min	36.89±5.56	37.16±5.72	0.992	0.323
Male (n=24)				
L/min	3.52±0.34	3.53±0.36	0.414	0.526
mL/kg/min	40.66±4.98	40.78±4.86	0.128	0.714
Female (n=37)				
L/min	2.14±0.33	2.14±0.35	0.001	0.972
mL/kg/min	34.45±4.48	34.82±5.01	0.874	0.356

Table 3: Intra-class Reliability Coefficients and 95% Confidence Intervals for the RW.

Group	*R*	*C.I.*	*R*	*C.I.*
Total (n=61)	L/min		mL/kg/min	
One Administration	0.98	0.96-0.99	0.93	0.89-0.96
Two Administrations	0.99	0.98-0.99	0.96	0.94-0.98
Male (n=24)				
One Administration	0.93	0.85-0.97	0.94	0.87-0.98
Two Administrations	0.97	0.92-0.99	0.97	0.93-0.99
Female (n=37)				
One Administration	0.85	0.73-0.92	0.88	0.77-0.93
Two Administrations	0.92	0.84-0.96	0.93	0.87-0.97

R = intra-class correlation coefficient (all coefficients were significant at $p \leq 0.001$

DISCUSSION

The results of this study on differences in estimated VO_2max values of the RW using alternating steady-state walking techniques support the work of previous findings (1,7,8,9). The intra-class test-retest reliability coefficients demonstrated in this study, for the total group as well as those for males and females expressed in both absolute and relative terms, were very similar to those previously reported. In addition, the investigators failed to find any practical differences in the estimated VO_2max values of the RW as the result of using the two different walking techniques implemented in this study. The lack of differences could be due to no practical differences in economy or efficiency of movement between the two techniques, or perhaps the subjects' inability to develop efficiency in the short amount of instructional time provided for learning the aerobic walking technique. Also, there was no comparison between a maximal pace as originally prescribed for the RW and the steady-state pace performed by the participants in this study. In addition, since actual VO_2max was not measured as part of this study, the validity of using an aerobic walking technique may be in question as a consequence of no existing validation studies for this particular walking technique. However, beyond these limitations, these results are the first to be reported from a steady-state version of the RW.

As previously cited, the RW has just recently been investigated for accuracy as a steady-state field test for estimating VO_2max from a 1/4-mile walk as well as the traditional distance of 1-mile (10). However, as previously noted the subjects participating in this study utilized only the normal walking technique and did not include the aerobic walking technique as part of their validity investigation. Additionally, it would seem reasonable to accept these results based on the theoretical linear relationship between heart rate and VO_2 in predicting maximal oxygen consumption. Also, there would appear to be no learning effect for the RW as the result of eliminating the maximal pace of the original RW. As previously noted, earlier findings (1,8) seem to indicate that acceptable test-retest reliability of the RW was a function of practice and learning how to pace oneself at a maximal pace throughout the entire 1-mile walk. It would also seem logical to assume that a

shorter version of the RW could be developed to elicit an acceptable steady-state for predicting VO_2max when compared to other similar field tests.

CONCLUSION

As a result of these findings it was concluded that walking technique and the use of a steady-state walking pace does not adversely influence the reliability of estimating maximal oxygen consumption using the Rockport Fitness Walking Test. However, future additional validity investigations into the development of a shorter steady-state walking test may be warranted for both normal and aerobic walking technique.

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