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Dear Editor Prof. Alberto Oliaro,

Thank you to give us the opportunity to improve our manuscript. Quarter-mile walk test sensitive to training-induced fitness changes registered under no. J Sports Med Phys Fitness-9445.

We took on board the comment of the reviewer and have considerably re-written the manuscript. We have done so asking a second native speaker to critically review our work and proofread it. As Mrs. Courtney Lightfoot, BSc, MSc has extensively worked on the manuscript we would like to add her to the list of authors. Additionally, we made some more changes to the author list since Mrs. Chandrie Cox, BSc, MSc would prefer to use her married name Carder. Hope this will not be a problem. Now we have two native speakers, Mrs. Lightfoot from the UK and Mrs. Carder from the USA, having had a close look to the scientific style and English grammar. We hope that the reviewer will be pleased with or effort.

Best regards,

Francesco Sartor, Ph.D.

Senior Scientist

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Quarter-mile walk test sensitive to training-induced fitness changes

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ABSTRACT

BACKGROUND: Cardiorespiratory fitness (CRF) is an important aspect of the overall health of an individual and its monitoring must be promoted in the general population. Thus, the aim of the study was to cross-validate and improve CRF estimation based on quarter-mile Rockport Fitness Walking Test.

METHODS: Thirty participants (31.4 ± 7.99 years) were randomized in either a four-week aerobic training group (10 men and 10 women) or a control group (eight men and two women). CRF was assessed via VO_2max test and estimated via quarter-mile Rockport Fitness and Ebbeling treadmill tests, before and after the training intervention. The original quarter-mile Rockport VO_2 max estimation was found to greatly overestimate CRF by 22 ml

$\cdot$ kg^{-1} $\cdot$ min^{-1}. When its coefficient was updated according to our data, it largely improved (by 6.8 ml $\cdot$ kg^{-1} $\cdot$ min^{-1}). Furthermore, a new-algorithm for predicting VO_2max was designed using multi-linear regression analysis.

RESULTS: The original quarter-mile Rockport Fitness Walking Test was not sensitive to CRF changes. It showed changes in VO_2 max, which were significantly different from the actual observed changes (-1.1 ± 4.08 vs. 1.61 ± 2.84, $p = 0.02$, respectively). Ebbeling treadmill test appeared to systematically overestimate CRF changes. Our new-algorithm showed improved sensitivity for detecting CRF changes and stability.

CONCLUSIONS: The original quarter-mile Rockport Fitness Walking Test equation for predicting VO_2max was neither accurate nor sensitive to changes in CRF, most likely due to cardiovascular drift. Our new-algorithm, based on the same brisk walking test, can provide a more accurate estimate of CRF, which is also sensitive to VO_2max changes, in a broad age range (18 to 50 years).

Key words: Exercise testing; Cardiorespiratory fitness; Walking; VO_2max

Introduction

Cardiorespiratory fitness (CRF) is the ability of the circulatory, respiratory, and muscular systems to supply oxygen to the body during sustained physical activity [1]. CRF has been shown to play a role in protecting against all-cause and cardiovascular disease (CVD) mortality in both men and women [2]. Moderate to high levels of CRF have been suggested to lower the increased risk of mortality associated with obesity [3]. It is clear from previous research that CRF is an important aspect in the overall health of an individual. In previous years, our laboratory has reviewed and developed a number of submaximal CRF assessment protocols [4-6], that could be performed in a variety of settings by a diverse population. As noted by Sartor et al. [6], *"when changes over time in VO_2max need to be monitored, it is important that the submaximal test is precise"*. Nonetheless, a submaximal test that is stable over multiple tests could be insensitive to changes. Therefore, the purpose of this study was to investigate a submaximal test that can not only be performed by a large and diverse population, but is also accurate, precise, and sensitive to exercise-induced CRF changes.

In order for a submaximal test to be able to be performed by a majority of the population, the means by which the test is conducted needs to be commonplace throughout society. Walking is an action that is conducted by the general population every day, making it a widely accessible and performable means by which to be tested submaximally. Walking itself does not require specialist exercise equipment such as a cycle ergometer or step, and the intensity can be easily altered by increasing or decreasing speed. A treadmill can be used, if desired, but walking can easily be performed in numerous locations and settings. Therefore, walking was considered to be the ideal modality for testing the general population. Walking submaximal VO_2max tests have been of interest in the health community for a number of years [6]. A self-paced walking test has previously been developed, but it focuses solely on an elderly population and is not suitable for those with higher functional abilities [7, 8]. Thus, having a submaximal VO_2max test that can serve a wider range of ability and age would be preferable. In an attempt to further improve upon Cooper's field test and make it more adaptable to a wider population, Kline et al. [9] developed a protocol to predict VO_2max based upon a one-mile walk around a track, also known as the Rockport Fitness Walking Test [9]. The Rockport Fitness Walking Test uses variables including weight, age, sex, track walking time, and the heart rate during the fourth quarter of the mile. This method proved to be reliable in both men and women between 30 and 69 years of age. The Rockport Fitness Walking Test was further evaluated and modified to create a test that could be performed in a shorter amount of time [10]. The quarter-mile (approximately 400 meters) Rockport Fitness Walking Test appears to be an ideal option to test a large and diverse population in a way which does not require the use of exercise equipment. It predicts VO_2max through the use of sex, age, weight, end exercise heart rate, and the time taken to complete a quarter of a mile. This prediction equation was originally developed through the testing of male and female college-aged students. However, this test has not yet been validated on a wider spectrum of the population, leaving the question of its versatility unanswered. Moreover, the quarter-mile - walking test was not tested for precision and sensitivity to fitness changes following the introduction of an exercise programme.

The purpose of this study was to validate and develop the equation for the quarter-mile walking test, making it suitable for the general population between the ages of 18 and 50 years and sensitive to training-induced fitness changes.

Materials and methods

Participants

This study was a single-blind randomized controlled design. Men and women between the ages of 18 and 50 were recruited as participants for this study through posters on the premises of the High Tech Campus and then contacted via e-mail. Participants were excluded if they suffered from any chronic disease or cognitive impairments, took medications affecting hormonal and metabolic systems, or were pregnant. Screening for these exclusion factors was done using AHA/ACSM screening tools [11]. Thirty participants were recruited for this study (18 men and 12 women). The a-priori sample size calculation based on George et al. [10] results (r^2 = 0.68; effect size = 2.125, statistical power = 0.8, number of predictors =4, and p value =0.05), indicated that a total of 12 participants would have been sufficient, to create a prediction model. However, due to the added intention to investigate the sensitivity to training-induced changes, it was deemed appropriate to increase the sample size to 20 in the training group and 10 in the control group. Thus, 20 participants (10 men and 10 women) were randomly assigned to the training group through the use of an online randomizer (http://www.randomization.com) and 10 participants were randomly assigned to the control group (8 men and 2 women). Prior to testing, participants were provided with an information sheet detailing the study and were required to provide written informed consent to participate in the study. Submaximal testing and exercise training were conducted at Philips Research Laboratories in Eindhoven, The Netherlands. VO_2max testing was conducted at Máxima Medical Center in Veldhoven, The Netherlands. This study was approved by the Internal Committee of Biomedical Experiments of Philips Research.

Submaximal Testing

Each participant attended the Philips Research laboratory for submaximal testing on two separate occasions. In each testing session, the same protocol was followed. The participant was asked to come dressed in comfortable sporting clothing for exercise and having fasted for the previous two hours from food and caffeine. Upon arrival, the participant was seated and informed of the protocol. The participant's height was measured, and their body weight and composition were assessed using a digital weighing scale that also estimated body fat percentage via bio-electrical impedance (BC-533, Tanita, Amsterdam, The Netherlands). The participant was then given a heart rate chest strap to wear (RS800 CX, Polar Electro, Almere, The Netherlands) in order to monitor heart rate and inter-beat-intervals. The device was started and the participant sat still in an upright position for 10 minutes in order to obtain a resting heart rate (HRR). During this time, the light was switched off to help the participant relax. Following the 10 minutes' rest, the participant began the first submaximal test. For the first submaximal test, the Ebbeling treadmill test was performed [11]. The participant walked on the treadmill (Kettler Marathon TX1, Ense-Parsit, Germany) for four minutes at a speed that raised his heart rate between 50 and 75% of the maximum heart rate. Once this was achieved, the speed was maintained and the incline was increased to 5%. The participant then walked for a further four minutes, or an additional five minutes if the heart rate was not stable in the final two minutes.

Ebbeling prediction equation is:

$\dot{V}_{O2max} = 15.1 + 21.8 \cdot \text{Speed [mph]} - 0.327 \cdot \text{HR [bpm]} - 0.263 \cdot \text{Speed [mph]} \cdot \text{Age [years]} + 0.00504 \cdot \text{HR [bpm]} \cdot \text{Age [years]} + 5.98 \cdot \text{Sex [0 = women; 1 = men]}.$

[Eq.1]

At the end of the test, the participant rested until their heart rate was back to resting levels. Resting HR levels were defined as 5% of participants heart rate reserve (heart rate max -heart rate rest). Following this, the participant was taken to the start of the second submaximal test which was the quarter-mile walking test. The test was conducted outdoors on the High Tech Campus premises. The participant was instructed to maintain a brisk walk from the start to the finish of the quarter-mile. The distance was assessed at first by means of G.P.S. system and then subsequently measured using a 60-meter-long measuring tape (Stanley, Born, The Netherlands).

The previously published "old" quarter-mile Rockport Fitness Walking Test prediction equation is:

$\dot{V}_{O2max} = 88.768 + 8.892 \cdot \text{Sex [0 = women; 1 = men]} - 0.0957 \cdot \text{Body Weight [pounds]} - 1.4537 \cdot \text{Walk Time [minutes]} - 0.1194 \cdot \text{HR [bpm]}.$

[Eq.2]

At the end of the quarter-mile walking test, the heart rate monitor was stopped. Both the walk time and the heart rate on cessation of the test were recorded. This submaximal test was conducted at the beginning of the study and at the end of the four-week intervention.

Maximal Testing

Each participant was asked to attend the Sportmax Performance Centre of the Máxima Medical Center for a cycle ergometer (Lode, Excalibur, Groningen, the Netherlands) VO_2max test following the pre and post submaximal tests. The maximal test was conducted at least 24 hours after the submaximal test. The participant came dressed in comfortable sporting clothes having fasted for the previous two hours from food and caffeine, similar to the submaximal sessions. Upon arrival, a member of the research team informed the participant of the protocol for the VO_2max prior to conducting the maximal test. Participants' weight and height were measured. The participant was then seated on the cycle ergometer and set up for the VO_2max. The VO_2max was measured using the Oxycon system (Oxycon Pro Metabolic Cart, Carefusion, California, USA). Calibration of the Oxycon system was executed before each test according to the manufacturer's protocol. The test was conducted by trained cardiac nurses at the Sportmax Performance Centre. The nurses calculated a ramp procedure following ACSM guidelines [12] which enabled the estimated maximum wattage to be reached around 10 minutes. After a two minute warm-up at a light intensity, the test began. The load on the cycle ergometer progressively increased every six seconds according to the protocol selected by the nurse. Encouragement was provided to the participant to help them cycle until complete exhaustion. The test ended once the participant could no longer maintain a pedalling cadence above 60 rpm. After completing a three minute cool down, the participant was allowed to stop. Criteria used in this study to verify maximum oxygen uptake, except for blood lactate which was not measured, are described in Sartor et al. [6].

Training Intervention

Participants in the training group were asked to attend supervised training sessions in a gym 3-4 times per week. During the supervised training sessions, the participant wore a Polar heart rate monitor chest strap. Each of the 20 participants in the training group had an individual training program designed based on their age, sex, and the results from their VO_2max test. The training programs were designed according to the recommended frequency, intensity, time, and type (FITT) framework outlined in Table 7.4 of the American College of Sports Medicine (ACSM) [12] to improve CRF and thus VO_2max performance. During each training session, each participant was given a target heart rate to aim for (i.e., around 50.7 ± 18.9 % of their heart rate reserve for the first two weeks, and 58.0 ± 11.4% for the last two weeks of intervention on a group level). The changes in VO_2max induced by the intervention should allow testing of whether the quarter-mile Rockport Fitness Walking Test [10] was sensitive enough to detect such changes. Figure 1 displays the testing schedule used.

INSERT FIGURE 1 HERE

Cross-validation and algorithm improvement

The Eq2 developed by George et al. [10], that will be referred to as “the old-algorithm” for the remainder of this paper, was validated in our study sample. Moreover, new coefficients were calculated based on our data to improve the old-algorithm. This led to a new equation referred to as the “updated-algorithm”. A feed-forward multiple regression model was used to develop a new prediction equation, which we will call here the “new-algorithm”. The main difference between the updated and the new algorithms stands in the predicting parameters used and consequently in the coefficients (see Eq.3 and Eq.4). These computations were performed using Matlab (version R2013b for Windows, The MathWorks Inc., Massachusetts, USA). The parameters chosen for the new-algorithm for the quarter-mile walking test were age, sex, HRR, the peak heart rate reached during the quarter-mile Rockport Fitness Walking Test normalized for the age-predicted maximum heart rate ($(HR_{peak}/HR_{max})*100$), and the walking speed (i.e. distance divided by walking time) of the participant during the test multiplied by the mean heart rate during the final 30 seconds of the test (Speed*30 second HR). Age-predicted maximal HR was derived from (208 – 0.7 · age) Tanaks's regression [13]. The performance of the updated- and the new-algorithms were evaluated using a 10-fold cross-validation technique. This involved removing 10% of the total number of subjects in a ratio of 2 training groups to 1 control group, in both pre and post data, each cycle. The errors calculated by means of this cross-validation technique determined a fairer comparison to the errors found for the equations developed elsewhere (e.g. old-algorithm and Ebbeling test).

Data Analysis

The standard errors of the estimate (SEE) were calculated to assess the accuracy of the various algorithms. A student's t-test was conducted to determine if there were any significant differences between the predictions of the algorithms tested and the observed relative VO_2max.

In order to assess the sensitivity of the updated- and new-algorithm to changes in VO_2max, the change between the pre-test VO_2max data and the post-test VO_2max data were calculated. The change in the observed VO_2max was also calculated. A student's t-test was performed to test if the calculated changes in the observed VO_2max and the predicted VO_2max were significantly different. Data from the control group were used to test the stability of these models.

Results

Participant characteristics are displayed in Table I (mean ± standard deviation). Of our 30 participants, two were not included in the analysis as they did not adhere to the assigned intervention. One of the participants' HR at the end of the quarter-mile Rockport Fitness Walking Test was not available in the pre-test due to technical difficulties.

INSERT TABLE I HERE

Table II shows the variables used for the new-algorithm, the prediction of the quarter-mile Rockport Fitness Walking Test [10], and the prediction of the updated-- and new-algorithms developed in this study. The updated-algorithm produced a correlation coefficient R value of 0.41, (p=0.015). The new-algorithm produced a correlation coefficient R value of 0.65, (p<0.01).

Updated-algorithm:

$$\dot{V}_{O2max} = 101.0287 + 1.9435 \cdot \text{Sex } [0 = \text{women}; 1 = \text{men}] + 0.0043 \cdot \text{Body Weight [pounds]} - 13.5683 \cdot \text{Walk Time [minutes]} - 0.1625 \cdot \text{HR [bpm]}. \quad \text{[Eq.3]}$$

New-algorithm:

$$\dot{V}_{O2max} = 73.8854 + 2.5894 \cdot \text{Sex } [0 = \text{women}; 1 = \text{men}] - 0.1811 \cdot \text{Age [years]} - 0.3037 \cdot \text{HRR [bpm]} + 0.4484 \cdot \frac{\text{HRpeak}}{\text{HRmax}} \cdot 100 + 0.0402 \cdot \text{Speed} \cdot 30\text{s HR } [\frac{miles}{\text{h}} \cdot bpm] \quad \text{[Eq.4]}$$

INSERT TABLE II HERE

When comparing the updated-algorithm, new-algorithm, old-algorithm, and the Ebbeling treadmill-based estimations to the observed VO_2max, it was found that the updated- and new-algorithm did not differ significantly from the VO_2max, but the old quarter-mile Rockport Fitness Walking Testwas significantly greater than the observed VO_2max. For the whole group, Ebbeling estimation was not significantly different from the observed VO_2max in the pre-test , but it was significantly higher than the observed VO_2max in the pre-post deltas (see Table III). The Bland-Altman plots for the updated and the new-algorithms can be seen in Figures 2-3.

INSERT FIGURES 2,3

The differences between the predicted and observed VO_2max values were compared in order to evaluate the sensitivity of the new-algorithm to changes in the VO_2max after a 4-week training intervention. The training-induced a mean increase in the VO_2max of the training group of 1.61 ml· kg^{-1} ·min^{-1}. The increase in VO_2max was significant ($p = 0.02$). The updated-algorithm determined a mean VO_2max increase of 0.27 ml· kg-1 ·min-1, yet this was not significant ($p = 0.65$). The pre-post deltas of the updated and observed did not significantly differ ($p = 0.22$). According to the new-algorithm, the VO_2max increased by 1.67 ml· kg-1 ·min-1. The difference between the estimated pre-test and post-test was significant ($p = 0.05$). When comparing the differences in VO_2max between the observed VO_2max and the new-algorithm predictions, the two values were not significantly different. Table III displays the observed and predicted VO_2max pre-test and post-test values as well as the changes found between the two during pre-test and post-test for the training and control groups separately.

INSERT TABLE III HERE

Discussion

This study provides a new-algorithm which is able to both accurately and precisely predict VO_2max of a general population simply through walking quarter-mile at a brisk pace. This is a reliable submaximal method that generally takes under five minutes and does not require expensive equipment, only a validated heart rate monitor with stop-watch function and a measuring instrument (e.g. tape measure) are required. The results from this study show that the equation developed by George et al. [10] based on the quarter-mile Rockport Fitness Walking

Test overestimates VO_2max values when applied to a population other than college-aged individuals. Although the original Rockport one-mile walking test has been cross-validated and shown to be accurate on a wide range of individuals [14-16], the quarter-mile Rockport Fitness Walking Test, to our knowledge, has not been cross-validated.

The new-algorithm developed in this study had a 10-fold cross-validation SEE of 5.6 ml· kg^{-1} ·min^{-1} (around 14%). This was found to be more accurate than the existing old-algorithm and the Ebbeling prediction equation, which were found to have SEEs of 21.9 ml· kg^{-1} ·min^{-1} (about 58%) and 9.95 ml· kg^{-1} ·min^{-1} (26%), respectively. The updated-algorithm based on George et al. 's equation [10], but with adjusted coefficients to the data of this study showed a drastic improvement in accuracy (down to 18% relative error).

The old-algorithm based on the quarter-mile Rockport Fitness Walking Test was designed to be valid for typical college-aged individuals (age range, 18-29 years)[10]. The participants in this study ranged in age from 19 years to 46 years. The greater diversity in our sample compared to the sample used to develop the quarter-mile Rockport Fitness Walking Test [10] may provide an explanation for the inaccuracy observed when using the old-algorithm in our participants. It should be noted that both the quarter-mile Rockport and Ebbeling models were trained (in machine learning terms) on different datasets, whereas our updated-algorithm and new-algorithm were trained on the current dataset. This could potentially explain the overall better performance of our updated and new models. However, in order to demonstrate a greater understanding of the validity of our updated- and new-algorithms we considered 10-fold cross-validation errors and not algorithm-training errors. Nevertheless, the most plausible explanation of George et al.'s [10] old-algorithm overestimation is cardiovascular drift [17]. George et al.'s data were collected after participants had already walked three-quarters of a mile, but the data used to develop George et al.'s [10] algorithm was collected during the final quarter-mile. In order to have heart rate data that would accurately predict a person's reaction to briskly walking a quarter-mile, the data should have been extrapolated from the first quarter of a mile. The findings of this study suggest that heart rate is an important variable in predicting VO_2max due to the direct relationship of VO_2 and workload [18]. However, heart rate on its own does carry some prediction errors [19], suggesting that there is possibly a need for other parameters in predicting VO_2max. Moreover, body composition is not strongly associated with VO_2max as age increases; since in the elderly, it is less related with lean body mass [20], which could be another explanation as to why the old-algorithm largely overpredicted VO_2max scores in this study. Yet, the original one-mile Rockport is accurate and relies on the same parameters as the quarter-mile Rockport Fitness Walking Test [9, 10]. This seems to support the idea that the main factor that determined the high over-estimation of the old algorithm was cardiovascular drift.

As for the Ebbeling test [11], it has shown to be accurate and sensitive to VO_2peak changes [21, 22], and it has been used previously to track VO_2max changes [23]. Our study found the Ebbeling to be accurate in predicting VO_2max scores during the pre-intervention but overall inaccurate in predicting VO_2max scores in the post-intervention, indicating a lack of precision and sensitivity.

A precise and sensitive test would be valuable to track changes in the VO_2max should an individual have the desire to increase their fitness through increasing aerobic capacity using an exercise programme. However, it is not always appropriate to maximally exercise an individual, especially those who are particularly unfit or unable to fully exert themselves; thus, a submaximal test that is precise and sensitive is required. This new-algorithm developed could fill that requirement.

A possible limitation of this study and test is the replication of the test, as we were able to use a straight quarter-mile path with no obstructions. This may not always be feasible for testing which may pose a difficulty for others who may want to use this test but cannot find the space to do so. Yet, if the space is available a straight quarter-mile is more standardisable.

Conclusion

The new-algorithm based on a quarter-mile walking test developed in this studyis believed to be an accurate method for estimating VO_2max among an average population between 18 and 50 years of age and demonstrated sensitivity to changes following a four-week exercise intervention. These features of the new-algorithm make it a potentially useful model in predicting VO_2max and monitoring changes in CRF over time. Future research could further develop and test the new-algorithm on other population samples, such as patient groups.

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NOTES

Conflicts of interest.—

Alberto G. Bonomi and Francesco Sartor work for Philips Electronics B.V.. Chandrie Cook and Gabriele B. Papini were conducting an internship at Philips Research when the study was conducted. All other authors have no conflict of interest.

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Authors' contributions.—

Gabriele B Papini has processed, analyzed the data and created the prediction models, and co-drafted the manuscript. Chandrie Cook has collected the data, analyzed the data, and drafted the first version of the manuscript. Hans-Peter Kubis has co-designed the study, critically evaluated the results and revised the manuscript. Alberto G. Bonomi has co-designed the study, critically evaluated the results and revised the manuscript. Courtney J. Lightfoot has critically revised and proofread the manuscript. Francesco Sartor was the principal investigator, and has organized the study, collected data, analyzed data, critically evaluated the results, co-drafted the manuscript.

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Table I.— Descriptive characteristics and data from the quarter-mile walk test of all participants

Characteristics	Values	Ranges
Weight (kg)	64.8 ± 12.1	56 – 100
Height (m)	1.76 ± 0.07	1.63 – 1.87
BMI (kg · m^{-2})	25.0 ± 3.38	19.3 – 34.0
Fat Mass (%)	24.5 ± 7.74	10.4 – 42
Age (years)	31.1 ± 8.09	19-46
HRR (beats · min^{-1})	70.4 ± 8.21	53.7 – 85.8
Walk Time (minutes)	3.46 ± 0.35	2.93 – 4.32
Mean HR (beats · min^{-1})	123 ± 11.0	103 – 154
VO_{2max} (ml· kg^{-1} ·min^{-1})	38.3 ± 7.21	26.6 – 51.1

Means ± standard deviation

Table II.— Means, Standard deviations for the variables used in the new algorithm and for the observed VO_2max,; with the addition of Standard Errors of the Estimate, the old, the updated, the new, and the Ebbeling algorithms for the whole group (n = 30)

Characteristics	Mean ± SD	SEE (ml/min/kg)
Age (years)	31.4 ± 7.99	-------
HR_{rest} (beats · min-1)	71.4 ± 9.44	-------
$(HR_{peak}/HR_{max}) \cdot 100$	72.9 ± 8.17	------
Speed · 30 s HR (miles · h^{-1} · beats · min-1)	561.8 ± 83.54	------
VO_{2max} (ml· kg-1 ·min-1)	37.9 ± 7.41	------
Old Algorithm for the 400 meter Walk Test (ml· kg-1 ·min-1)	58.3 ± 4.96*	21.90
Updated Algorithm for the 400 meter Walk Test (ml· kg-1 ·min-1)	37.9± 4.42[&]	6.8[&]
New Algorithm for the 400 meter Walk Test (ml· kg-1 ·min-1)	38.0 ± 5.87[&]	5.6[&]
Ebbeling (ml· kg-1 ·min-1)	40.2 ± 10.25*	9.95

*The old quarter-mile Rockport Fitness Walking Test algorithm and the Ebbeling algorithm were significantly higher than the observed VO_{2max} ($p < 0.05$)
[&]10-fold cross-validation errors

Table III.— Pre-test and post-test values of the observed VO_2max, the Old-Algorithm, the Updated-Algorithm, and the New-Algorithm for the quarter-mile (400 meters) Walk Test predicted VO_2max, and the Ebbeling predicted VO_2max in both training and control groups. Changes in VO_2max between the pre-test and post-test

	Training			**Control**		
	Pretest	**Posttest**	**ΔPosttest-Pretest**	**Pretest**	**Posttest**	**ΔPosttest-Pretest**
Observed VO_{2max}	37.8 ± 7.25	39.4 ± 6.98	1.61 ± 2.84	34.8 ± 7.43	35.8 ± 7.47	0.92 ± 1.63

Old-Algorithm for the 400 meter Walk Test VO_{2max}	58.5 ± 4.46†	57.5 ± 4.58	-1.1 ± 4.08†	59.6 ± 6.85	58.1 ± 4.75	-1.4 ± 4.30
p-value	0.00*	0.00*	0.02*	0.00*	0.00*	0.09
Updated-Algorithm for the 400 meter Walk Test VO_{2max}	37.97±3.48	38.02±3.94	0.27±2.49	38.38±4.43	37.05±6.96	-1.33±3.30
p-value	0.92	0.38	0.22	0.33	0.93	0.06#
New-Algorithm for the 400 meter Walk Test VO_{2max}	37.32 ± 5.70	39.0 ± 5.47	1.67 ± 3.43	37.39 ± 7.37	38.04 ± 5.95	0.65 ± 3.08
p-value	0.73	0.78	0.86	0.52	0.68	0.61
Ebbeling VO_{2max}	38.0 ± 9.94	43.5 ± 8.42	5.48 ± 7.35	36.9 ± 12.4	41.9 ± 11.00	5.0± 3.74
p-value	0.96	0.12	0.04*	0.87	0.30	0.01*

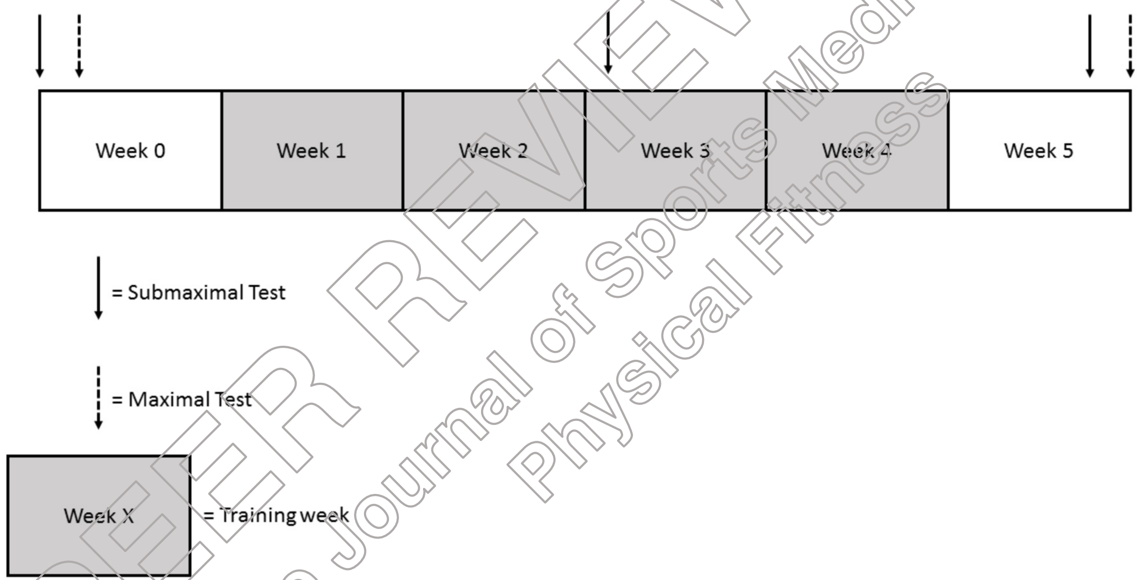
All VO_{2max} values are expressed in $ml \cdot kg^{-1} \cdot min^{-1}$. Means ± standard deviation
* significant differences found between the predicted VO_{2max} and the observed VO_{2max} values
Training group n = 18, control group = 10; † training group n = 17, control group = 10

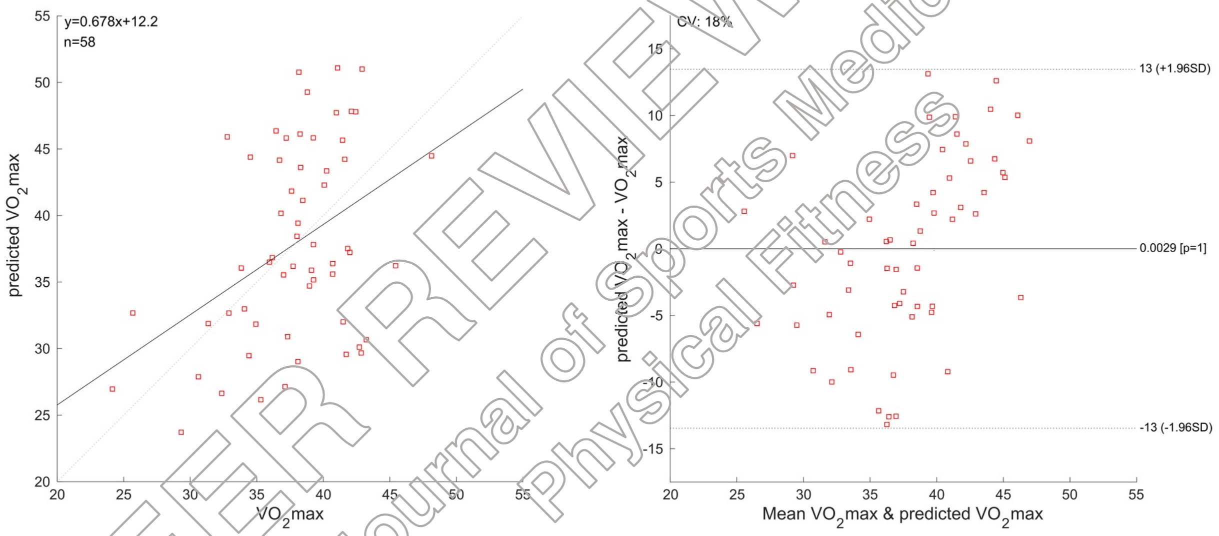
TITLES OF FIGURES

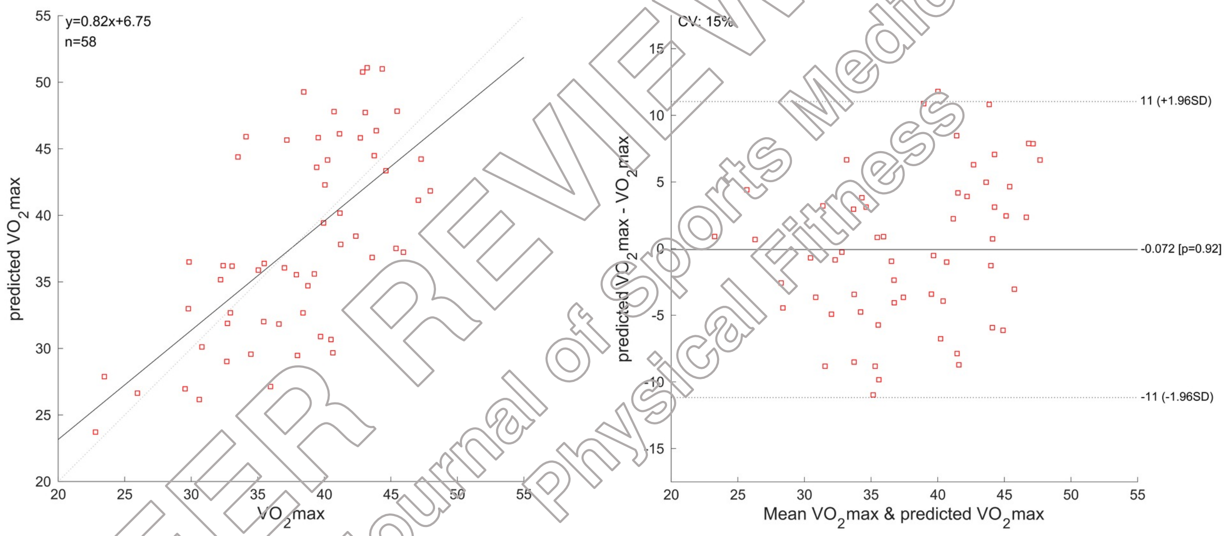
Figure 1.— Displays the testing schedule used during the study. Participants came in week 0 for the pretests. Weeks 1-4 included the intervention for those in the training group. During week 3 the mid submaximal test was performed on both groups. During week 5 the posttests were performed.

Figure 2.— Scatter plot and Bland-Altman plot of the updated-algorithm based on quarter-mile Rockport Fitness Walking Test as developed by George et al. (see text for reference).

Figure 3.— Scatter plot and Bland-Altman plot of the new-algorithm based new features extracted from the quarter-mile Rockport Fitness Walking Test (see text for more details).


Week 0
Week 1
Week 2
Week 3
Week 4
Week 5
= Submaximal Test
= Maximal Test
Week X
= Training week


y=0.678x+12.2
n=58
predicted VO2max
VO2max
CV: 18%
13 (+1.96SD)
0.0029 [p=1]
-13 (-1.96SD)
predicted VO2max - VO2max
Mean VO2max & predicted VO2max



y=0.82x+6.75
n=58
predicted VO2max
VO2max
CV: 15%
11 (+1.96SD)
-0.072 [p=0.92]
-11 (-1.96SD)
predicted VO2max - VO2max
Mean VO2max & predicted VO2max