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The Reliability of Cooper´s Test in Subjects Between 28-60 Years of Age

Ludwig Johan Anstrén

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Ludwig Anstrén

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Halmstad University
School of Business, Engineering and Science
Thesis supervisor: Hanneke Boon
Thesis Examiner: Charlotte Olsson

Abstract

Background: Maximal oxygen uptake (VO_2max) is a determinant of an individual's ability to handle oxygen during maximal exercise. To measure VO_2max expensive equipment and expertise personnel are required. To make the process of measuring VO_2max easier, several submaximal and maximal tests have been created in which an estimation of VO_2max could be made. Cooper's 12-minute run (12MR) was created in 1968 and was tested on 115 military men with a mean age of 22 years. Since then the 12MR test has been re-tested and validated towards maximal treadmill tests on several occasions. When an age of 30 years is reached, VO_2max starts to decline with 9-10 percent per decade but can be halted by different forms of exercise. With exercise of moderate to high intensity the decline can be halted by almost 50 percent. **Objective:** To investigate the reliability of estimated VO_2max in a test retest scenario of Cooper´s 12MR on a mixed healthy population between the ages of 28-60**. Method:** Nine women and five men, healthy subjects with a mean age of 43 ± 8 participated in the present study. A test retest of Cooper´s 12MR took place with a minimum of seven days between tests. The subjects had to run as many laps as possible on the track during a 12-minute period. Finished laps were then counted and the fraction of the last lap was measured with a measuring wheel and then added to the total distance. To estimate the subjects' VO_2max Cooper´s table was used. **Results**: The single measure Intraclass correlation (ICC) that was found, between the estimated VO_2max made from the initial test to the retest on Cooper´s 12MR, was 0.979. ICC showed a small error variance correlation between the tests and was close to the optimal correlation of 1.0. **Conclusion**: A standardized protocol for performing Cooper´s 12MR showed good repeatability for estimating VO_2max in two separate tests for a mixed population between 28 to 60 years of age.

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Background

Maximal Oxygen uptake

Adenosine triphosphate (ATP) provides energy to the human body's biological processes and the energy is created when the phosphate bond in ATP is broken and becomes Adenosine diphosphate (ADP) and inorganic phosphate (Pi) (Herda, Ryan, Stout & Cramer, 2008). Exercising for longer duration of time requires high levels of oxygen to fuel the long-term energy system, which resynthesize the ATP levels so energy can keep the muscles working (McArdle, Katch, & Katch, 2010). An individual's maximal oxygen uptake (VO_2max) reflects the individual's ability to handle oxygen during exercise (McArdle et al., 2010). During hard exercise the body´s ability to deliver and extract oxygen is vital for sustaining the metabolic demands (Hawkins & Wiswell, 2003).

To accurately measure an individual's VO_2max several factors need to be taken into consideration. Firstly the VO_2max test itself needs to be chosen and there is a specific test that is considered gold standard for this purpose, a graded exercise test where the subjects gets tested until maximal exhaustion (Seneli, Ebersole, O´Conner & Snyder, 2013; McArdle et al., 2010). During the test, the amount of expired air is collected and the components in the air, oxygen and carbon dioxide, will be analyzed (Hopker, Jobson, Gregson, Coleman, & Passfield, 2012). Throughout the years, methods for measuring the amount of oxygen and carbon dioxide during tests in laboratories have changed. Different online breath-to-breath systems such as portable gas analyzers and metabolic carts have been developed to measure individuals' oxygen consumption and therefore also help to draw conclusions about the subjects' VO_2max (Penry et al., 2011; Marsh, 2012). Another method often used is the Douglas bag, which collects the air in a special bag where the air can be analyzed (Cooper, 1968; Grant, Corbett, Amjad, Wilson, & Aitchison, 1995; Bandyopadhyay, 2015; McArdle et al., 2010).

However the online system and Douglas bags have different fundamentals. The online system measures the air in real time, which could lead to measurement errors in volume and concentration when every breath is analyzed, especially at low and high exercise rates (Hopker et al., 2012). The Douglas bag however minimizes the assumptions necessary

compared to the online system, for example, when using Douglas bags, the different temperature and water vapor pressure can be taken into consideration when analyzing the data. Some online systems cannot do that and Douglas bags can therefore be seen as a "gold standard" for measuring expired air (Hopker et al., 2012). VO_2max is reached when a plateau in oxygen consumptions is reached and no more increase occurs even when exercise level is increased (McArdle et al., 2010). However, this kind of test requires sophisticated equipment and instructors with expertise within the area to conduct testing in a safe manner (Marsh, 2012). The limitations and demands of measuring VO_2max infers that it only can be used in exercise physiology laboratories (Seneli et al., 2013). All devices mentioned above are expensive and requires laboratory environment, and there is a need for alternative methods for a simpler estimation of exercise capacity.

Several tests without complicated and expensive equipment have been developed for estimation of VO_2max. Some exclude maximal exertion tests such as Åstrand´s submaximal bike test (Åstrand & Ryhming, 1954), Rockport Walking test (Kline et al., 1987), and Non-Exercised-Based VO_2max prediction equations (Malek, Housh, Berger, Coburn & Beck, 2005; Malek, Housh, Berger, Coburn & Beck, 2004). There are also tests, which exclude expensive equipment but include maximal exertion. Cooper´s 12-minute run (12MR) and the multistage 20-yard shuttle run were both created to predict VO_2max without expensive equipment (Cooper, 1968; Legér, Mercier, Gadouryl & Lambert, 1988). The walking/running and bike tests among several others simplified the prediction of VO_2max, and took away the necessity for complicated equipment, which made the tests more accessible and less expensive.

Cooper´s 12-minute run

When creating a new test it is important to both consider validity and reliability. Validity of a measurement means that a test actually measures what it is meant to measure (Thomas et al., 2005). For example, Cooper´s 12MR has been validated through the use of a graded exercise test that gives the actual VO2max (Cooper, 1968). Without reliability however a test cannot be viewed as valid, if it cannot be consistent from one occasion to another occasion (Thomas et al., 2005). After Cooper´s 12MR was developed, several validation studies (Grant et al., 1995; Bandyopadhyay, 2015) have been performed to see how accurate the test actually was to measure VO_2max compared to using treadmill and bicycle test

connected to Douglas bags or online breath-to-breath systems. Also at least one study has tested for both fore validity and reliability (Penry et al., 2011).

Before 1968 a method to estimate VO_2max was Balke's field test. Balke´s protocol involves increasing the grade on a treadmill during constant speed. During the first minute the subject walked at constant speed, 3.3 miles per hour with 0 % grade. After the first minute the grade increases to a 2% grade and thereafter for every minute there is an increase of 1% grade (McArdle et al., 2010). Cooper's purpose was to develop a test to estimate VO_2max with accuracy from a 12MR by modifying the Balke protocol and search for a correlation between a 12-minute run and individuals' VO_2max and with those results create a predictive method of VO_2max using a standardized 12-minute run (Cooper, 1968).

115 military men with a mean age of 22 years performed two or more 12-minutes runs on a flat surface with no less an interval of three days. To validate the method, all 115 men performed a treadmill test connected to either a balanced Tissot gasometer or a Douglas bag (Cooper, 1968). The correlation found between the distance of 12MR and oxygen consumption on treadmill was 0.897, which reflects a highly significant relationship according to Cooper (1968). This correlation coefficient indicated that is possible to estimate VO_2max with a standardized 12MR (Thomas et al., 2005). Cooper also proposed levels of cardiovascular fitness based on distance and if subjects ran more than 1.75 miles they were classified as 'excellent' (see table 1) (Cooper, 1968).

Table 1: "Levels of cardiovascular fitness based on 12-minute performance and VO_2max" (Cooper, 1968 p.203)

Distance (miles)	VO_2max ($ml*kg^{-1}*min^{-1}$)	Fitness level
<1.0	<25.0	Very poor
1.0 to 2.24	25.0-33.7	Poor
1.25 to 1.49	33.8-42.5	Fair
1.50 to 1.74	42.6-51.5	Good
1.75 or more	51.6 or more	Excellent

With respect to reliability, Penry et al. (2011) did a test retest study on Cooper´s 12MR, which showed a reliability coefficient of 0.96 when estimating VO_2max from the initial test to the retest. Moreover, Grant et al. (1995) conducted a comparative study where a correlation between estimated VO_2max on Cooper´s 12MR and a maximal treadmill was

conducted. The correlation that was found was 0.92, which showed that Cooper´s 12MR gave the highest correlation for estimated VO_2max compared to Multistage progressive shuttle run test and a submaximal cycle ergometer test (Grant et al., 1995). Several studies conducted only involved male participants where the participants had a mean age between 22 and 23 years of age (Grant et al., 1995; Cooper, 1968; Bandyopadhyay, 2015). Penry et al. (2011) on the other hand studied both men and women, so the result extended to both sexes, but with a similar age population (mean age of 21,8 years) as the other studies.

Overweight adolescents was another group that Cooper´s test was performed on. Twenty overweight youths took part in a study where Cooper´s 12MR test and cycle ergometry testing procedure were used to test their physical performance (Drinkard, McDuffie, McCann, Uwaifo, Nicholas, & Yanovski, 2001). The results suggested that a 12-minute run/walk could draw conclusions about their physical performance when related to cardiorespiratory fitness and body composition.

Maximal oxygen uptake decline when ageing

Decline process

In 2050 the demographics of age are expected to drastically change. The number of individuals over 65 years of age is estimated to change from 7 percent of the world's population to 16 percent or even 19.3 percent (Cohen, 2003; Tanaka & Seals, 2008). According to Tanaka and Seals (2008), the change will also lead to an increase in a group of people they call "exceptionally successful ageing" which could be referred to individuals who seek to maintain or even improve their physical achievements from younger years. Compared to the first Olympic games in 1896, individuals over 45 of today keep exceeding the winning results in those games. As an example, a 46-year-old man has managed to beat the time of the first Olympic winner of 200 meters and a 73-year-old man managed to beat the Olympic winning marathon time with almost 4 minutes (Tanaka & Seals, 2008). Thus, the achievements of physical performance in master athletes have drastically changed and they would have outrun Olympic athletes in their prime a century ago. It has been showed that VO_2max declines with age but also that there can be different level of decline based on

exercise level and sex (Hawkins, MArcell, Jaque, & Wiswell, 2001; Hawkins & Wiswell, 2003; Tanaka & Seals, 2008; Wiswell, et al., 2001).

Declining VO_2max affects people differently depending on their exercise habits but is clearly age-related. It has been shown that for every decade, after 25-30 years of age, a 9-10 percent decline of VO_2max is expected (Hawkins & Wiswell, 2003; Hawkins et al., 2001; Tanaka & Seals 2008). Joyner (1993) mentions similar decline, before the thirties the decline was slight but between 30-50 years of age the decline accelerate to 6-9 percent per decade. VO_2max is dependent on several biological aspects to function well, and when growing older these functions slowly lose their full capacity. Maximal stroke volume, heart rate and arterio-venous oxygen difference are three functions of the cardiovascular system that decrease with age and can be connected to age-related loss in VO_2max (Tanaka & Seals, 2008; Ogawa et al., 1991). Other studies have drawn similar conclusions that the decline of VO_2max and the gradual decrease of the cardiovascular system capacity are related (Hawkins et al., 2001). Also the maintenance of lean body mass and VO_2max are associated in men (Hawkins et al., 2001; Hawkins & Wiswell, 2003). Joyner (1993) connects age-related weight and body fat gain to the decline of VO_2max but only when expressed relative to body weight.

Tanaka and Seals (2008) describe the relationship between endurance performance and VO_2max and from their perspective these two parameters are closely connected in groups of well-trained endurance athletes in a mixed age population. Fitzgerald, Tanaka, Tran and Seals (1997) indicate that the absolute decline in VO_2max in endurance-trained women between 20 to 70 years is higher than for women who have lived a sedentary life. Hawkins et al, (2001) had 228 subjects in different age groups who were compared cross-sectionally and thereafter were re-tested in 8.5 years for a longitudinal comparison. Hawkins et al. (2001) mention similar results as Fitzgerald et al. (1997) but with adults of both sexes, between 40-70 years of age, and those who were endurance trained had a greater or similar absolute decline rate of VO_2max during ageing compared to sedentary adults. One factor that could be the reason for higher absolute decline for athletes is a higher baseline of VO_2max in younger years (Fitzgerald et al., 1997).

Longitudinal studies are viewed to be a more valid option for assessing physiological changes during ageing compared to cross-sectional studies. The reason for this conclusion is that it could be a selection bias in the cross-sectional studies however in longitudinal studies

the mortality rate and dropouts need to be taken into careful consideration. Also, the longitudinal study has the benefit of paired observations of different factors including VO_2max (Hawkins & Wiswell, 2003).

Halting the decline process

Generally the decline of VO_2max starts already in the twenties or thirties especially in sedentary individuals, however individuals can slow down the decline by exercising but once reducing or stopping exercising their decline will proceed (Hawkins & Wiswell, 2003). The process can be slowed down, but the percentage depends on sex, genes and exercise level (Hawkins & Wiswell, 2003). For example, in middle-aged and older women the possibility to reduce the decline of VO_2max seems to be limited to approximately 10 percent, compared to a higher percent for men the same age (Hawkins & Wiswell, 2003).

The reason for women's limited capability of halting the VO_2max decline could be related to the decrease of estrogen levels (Hawkins & Wiswell, 2003). It has been shown that estrogen replacement therapy can halt the VO_2max decline and contribute to maintaining a higher VO_2max (Hawkins et al., 2001). Except for estrogen replacement in women, moderate to high intensity exercise is the best method to halt the decline of VO_2max over time for individuals, regardless of sex (Hawkins & Wiswell, 2003; Wiswell et al., 2001). Joyner (1993) describes an elite athlete whose VO_2max only declined 7 percent from mid-twenties to mid-fifties. The athlete trained five times a week and repeatedly performed 200-meter intervals on a regular basis, which could be an explanation of the limited decline of VO_2max. Also mentioned is the predictor of mortality risk and how it is connected to low cardiorespiratory fitness, which has added to the interest in the age-related decline of VO_2max (Wei et al., 1999).

The ability to halt VO_2max is connected to several factors as mentioned above. It seems that ageing individuals, late thirties and above, who exercise vigorously are able to maintain not only stroke volume and peripheral oxygen extraction but also body composition on the same level as in their twenties to thirties (Joyner, 1993). There could however be other factors that come into play; the speed of aging process varies in different individuals, and this can be partly genetically determined. Mentality and psychological factors can also affect the ability to keep exercising (Joyner, 1993).

Later research speculates that it is not the actual utilization of oxygen that decline with increased weight, instead the increased weight lead to reduced ability to move which lower the sub- and maximal exercise ability (Carrick-Ranson et al., 2013). Therefore the interest of keeping the body composition and avoid gaining weight should be of high priority.

In conclusion, several studies have been done with younger adults and their VO_2max using Cooper´s 12MR and these have shown similar results. Unfortunately, research on maximal aerobic capacity testing on a middle-aged population is largely missing. Not enough studies have been performed on this population to make clear statements on how reliable Cooper´s 12MR actually is. By focusing on measures to halt the decline in VO_2max when ageing, a wider health perspective could be addressed. As mentioned above VO_2max can be connected to be a predictor of mortality risk and is therefore important to consider (Wei et al., 1999). Cooper´s 12MR could be used for tracking individual's progress and follow the changes in VO_2max during a time period, for example ten years. Cooper´s 12MR could be a suitable test for this purpose but first it needs to be reliability tested on a wider population. A test retest scenario of Cooper´s 12MR on a healthy middle-aged population is a first step before advancing any further.

Objective

To investigate the reliability of estimated VO_2max in a test retest scenario of Cooper´s 12-minute run on a mixed healthy population between the ages of 30-55.

Research questions

- Will using the standardized protocol, together with warm-up and a briefing, lead to repeatability of estimated VO_2max in Cooper´s 12 Minute run in this age group?
- Will using the standardized protocol with warm-up and a briefing result in a significantly reliable Cooper's 12MR suitable for further use in this age group?

Method

Subjects

Both men and women were asked to participate and no criteria for fitness level were applied. The criteria for inclusion in the study were that the participants were healthy, had no cardiovascular disease, diabetes, joint or muscle diseases or muscle pains such as ruptures. Their age should have been between 30 to 45 years but due to recruitment challenges during the study the age requirements were widened to 28-60 years (see method discussion for further details).

In this study 5 men and 9 women participated with a mean age of 43 ± 8 ranging from 28 to 60 years. Subjects were recruited from two separate places; from a large company and staff from an elementary school. The recruitment process took place at several occasions. Handouts to a runners club were tried; another attempt was a mass email that was sent out with a brief description of the study asking for volunteers. Individuals spreading the information with word-of-mouth information were also a great help. More detailed information was then dispatched to potential subjects through emails and after showing interest of the study they were asked to participate. Altogether, 16 participants consented to take part in the study but there was a dropout of two, one due to injuries before the first test and one due to influenza before the retest.

Design of test

Cooper´s 12-minute run (12MR). Fourteen participants performed two separate trials of the 12MR. The track was measured to 280 meter with a measuring wheel (Mäthjul, Hard Head, P.R.C (People´s Republic of China)). The ground was flat, made of asphalt and the responsible instructor had constant view of all participants during the entire test. The participants were instructed to run back and forth for 12 minutes on the measured track until the air-horn blew (Signal Horn, Lalizas, Greece). Participants were told not to race with the others in the group and not think about the experience as a race but rather as an individual training exercise for their own development. Instructions for pacing was provided to everyone to make sure they could maintain running during the entire test without having to stop and pause. To help and encourage all participants the instructor tried to give

encouraging word to all runners and let them know when half the time had elapsed. When time ran out the air-horn sounded and the participants were told to stay at that point. With the measuring wheel the remaining distance on the last lap completed was measured. The segment of the last lap was added together with the number of laps finished by each participant to calculate the final distance. To get the estimated VO_2max, the total distance in meters was transformed to miles and using Cooper´s table for predicting VO_2max results were obtained from the table (Cooper, 1968). One subject ran just over two miles, which meant Cooper´s table was insufficient, so Bandyopadhyay (2015) used the following equation to derive Cooper's (1968) result:

$$VO_2\text{max}\ [\text{ml} * \text{kg}^{-1} * \text{min}^{-1}] = 22.351 * (\text{Distance in km}) - 11.288 \quad (1)$$

Test procedure

All participants conducted two separate tests with at least seven days between the occasions. Everyone was given two options when to participate, either before lunch at 11 am or before dinner at 5 pm at the two separate occasions. The subjects were told not to do any excessive training the day before and not eat any large meals within two hours before the test. Before starting the test all participants had a seven-minute warm-up run to the track and when reaching the track five minutes of dynamic stretching was performed to increase performance and decrease the injury risk (Thacker, Gilchrist, Stroup, & Kimsey, 2003). During the stretch final instructions were given and the test started. The groups consisted of two to six participants, with the intention to increase motivation. All trials took place in good weather (sun or cloudy, no rain), temperatures ranging between +3 to +9 degrees Celsius with none or mild wind-strength. All subjects did the second trial on the same time of day as the first with similar weather conditions. To make sure correct distance was measured every time a subject ran passed an administrator the distance was noted. The information was then compared between the administrators to conclude the correctness of all participants distance.

Ethical considerations

Ethical considerations were of great importance when the recruitment process was in progress. All participants were well informed about the procedure and the reason of the study; all details could also be read in the informed consent. When work was done with this group extra precautions were considered to avoid injuries and risking participants health situation. Everyone was given a full explanation of the procedure and informed about discomforts and risks, the aims and benefits of the test were explained and it was clarified that withdrawing from the project at any given time was acceptable under any circumstances (Thomas, Nelson, & Silverman, 2005). Also the participants had to confirm that they believed in their own capacity to be able to run for 12 minutes without pausing. Physical characteristics for all participants are displayed in the results section**.** Both participants and instructor then signed a written informed consent form that was saved in a safe location. The written form and the procedure of the test were all approved by Halmstad University.

Social considerations

By evaluating a different age population compared to earlier studies, more data on Cooper´s 12-minute run reliability will be accessed. Evaluating this age population gives a wider perspective of how middle-aged individuals perform during maximal effort. A deeper knowledge in the area can simplify the process for middle-aged individuals to determine their own VO_2max. Simplifying this process could help individuals not only to determine VO_2max but also increase their understanding for their own bodies and its physical capacity. When a higher age is reached, around 75 years of age, almost half of the VO_2max capacity has been lost. VO_2max is an important factor in everyday life but when it has declined too much, common activities can be hard to perform (Hawkins & Wiswell, 2003). So by understanding the VO_2max capacity and how it affects individuals during aging it can help to break the decline and improve overall living standards and with that, have a positive impact on health in general as well as health economics.

Statistical analysis

The collected data were inserted into Microsoft Excel (2011) and the results were done here into graphs and figures. All statistical analysis was performed in SPSS (IBM SPSS version 20, Chicago, IL, USA). To determine if the data were normally distributed or not, Shapiro-Wilks investigation method was used. Shapiro-Wilks test had the ability to test for normality in groups smaller than 20 and was therefore chosen for the present study (Shapiro & Wilks, 1965). The mean was used to present the data because the group was normal distributed according to Shapiro-Wilks and the mean provides a more accurate description of the data (Vincent & Weir, 2011).

To estimate the reliability of the test scores, an intraclass correlation (ICC) was considered the optimal procedure. ICC functions as an estimator of systematic and error variance between tests and was therefore well suited for handling data for the present study (Thomas et al., 2005). A two-way-mixed model together with the single measure opinion was used to estimate ICC and the confidence interval was set to 95%. ICC has a result span of 0.0 to 1.0; the closer to 1.0 it is the greater correlations and lower error variance (Vincent & Weir, 2011). When the value of ICC reaches higher than 0.8 the measurement errors is kept to a minimum and the results can be viewed as good (Weir, 2005).

Results

In total 14 participants took part in the study, 5 men and 9 women. Table 2 show the mean age 43 ± 8 (28-60 years), height 172 ± 10 centimeters (160-189 cm) and weight 68 ± 12 kilograms (54-92 kg). Table 3 shows how frequently the participants exercised.

Table 2: Descriptive characteristics for the measured subjects.

	N	Minimum	Maximum	Mean	Std. Deviation
Age (years)	14	28	60	43	8
Height (cm)	14	160	189	172	10
Weight (kg)	14	54	92	68	12

Table 3: Description of exercise level, in hours per week.

Exercise level, hours a week	1-2 hours	3-4 hours	4 hours or more
N	6	5	3

The mean distance the subjects ran during the first test was 2503 meters, which gave an estimated VO_2max mean value of 44.6 ml*kg^{-1}*min^{-1} as seen in table 4. The retest session gave a mean distance of 2533 meters and an estimated VO_2max mean value of 45.3 ml*kg^{-1}*min^{-1}. Estimated VO_2max from the first test had a statistically significant positive relationship with estimated VO_2max from the second test. Single measure ICC between the estimated VO_2max made from the initial test to the retest on Cooper´s 12MR, was 0.979 and the 95% CI was between 0.935 and 0.993 which can be seen in table 4.

Table 4: results of Cooper´s 12-minute run, test and retest performance. Results are presented in maximal oxygen uptake (ml*kg^{-1}*min^{-1}) and in distance (m). The ICC and 95% CI from the test retest scenario is presented.

	N	Min.	Max.	Mean	Std. Deviation	ICC	95% CI
VO_2max test (ml*kg^{-1}*min^{-1})	14	34.6	61.4	44.6	8.4	0.979	0.935-0.993
VO_2max retest (ml*kg^{-1}*min^{-1})	14	30.2	63.1	45.3	9.3		
Distance test (m)	14	2029.0	3254.0	2503.6	381.1		
Distance retest (m)	14	1856.0	3328.0	2533.6	416.7		

Results from test and retest are presented in estimated VO_2max and can be seen in figure 1.

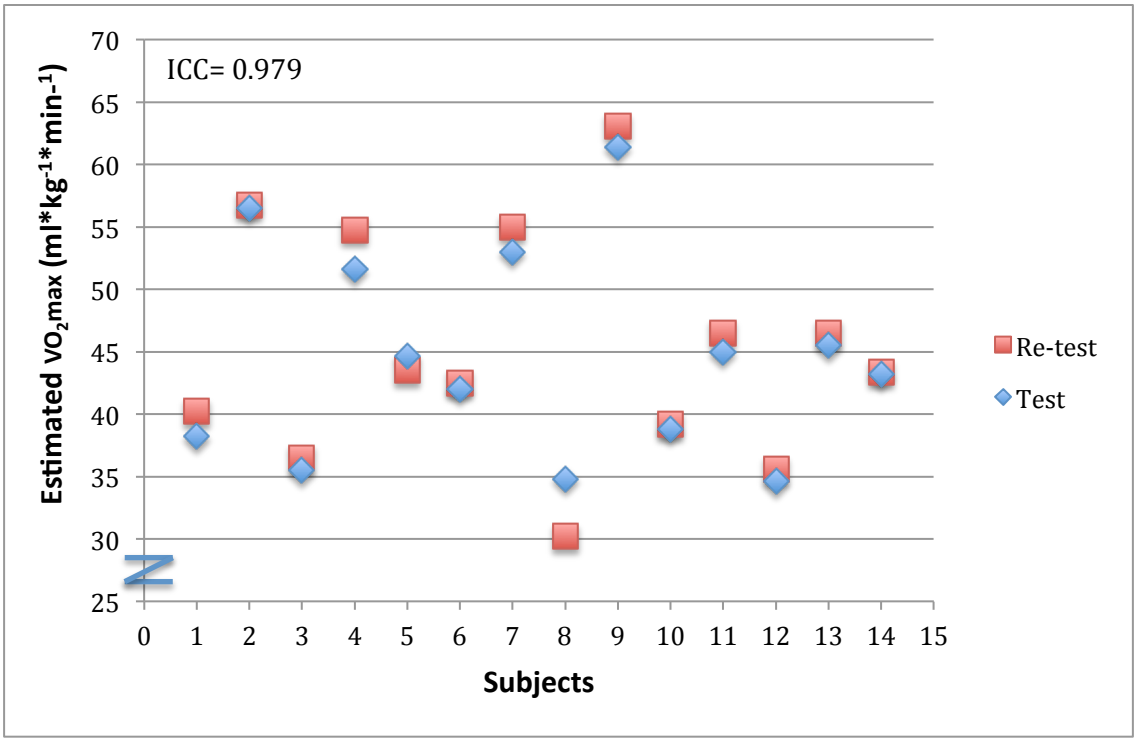

Figure 1: Results of estimated VO_2max from Cooper´s 12-Minute run, test and retest. Results are presented in maximal oxygen uptake (ml*kg^{-1}*min^{-1}).

Discussion

The objectives of the current study were to determine the reliability of estimated VO_2max with Cooper´s 12MR in a healthy middle-aged population on a test retest scenario. The current study's results showed low error variance and an ICC of 0.979, which is very close to the optimal ICC value of 1.0 (Vincent & Weir, 2011). In other words, the distances traveled in the initial test compared to the retest were very similar, which then gave very similar estimated VO_2max for the participants. It also shows that the majority of the subjects increased their distance on the retest slightly which is reasonable because no practice run was applied and a learning phase was to be expected. Cooper´s 12MR has yet to be validated on this mix middle-aged group but the current study's results show good reliability correlation for estimation of VO_2max and could therefore be of use for further studies in the area.

Result Discussion

Cooper´s 12MR has been tested both for reliability and how well it validates to actual VO_2max but the studies have mostly had similar populations, i.e. men in their early twenties (Grant et al., 1995; Cooper, 1968; Bandyopadhyay, 2015). Grant et al (1995) tested 22 men and Bandyopadhyay (2015) 88 men, both with men in their twenties, on Cooper's 12MR and direct measurement of VO_2max for validity while Penry et al. (2011) tested 33 women and 28 men in their early and late twenties for reliability on a test retest scenario for Cooper´s 12MR. Drinkard et al. (2001) tested in total 20 overweight children and concluded that the 12MR test was a reliable test to measure VO2 uptake and physical performance. Lastly, Cooper´s (1968) original study validated the test in 115 men where the majority of the subjects were in their twenties. The present study had similar result as Penry et al. (2011), where their reliability coefficient was 0.96 for estimating VO_2max from Cooper´s 12MR test retest scenario by using a G-theory analysis. ICC for the present study was 0.979, which can be seen as similar to the results by Penry et al. The reliability coefficient for estimating VO_2max during repeated testing of Cooper´s 12MR was that of 0.96 and is considered as excellent according to Penry et al. (2011) However the present study showed a good ICC value of 0.979 which is close to the optimal ICC value of 1.0 (Weir, 2005).

The main difference in the present study compared to earlier studies was the age range of the subjects. The mean age in the present study was more than 20 years higher compared to the mean age in the study of Penry et al. (2011). The participants should be healthy and all levels of exercise were accepted to join so age was the main thing that separated the studies but that did not seem to have an effect on the reliability coefficient for the present study.

Penry et al. (2001) and Grant et al. (1995) mention the importance of motivation for performing maximal testing and it can be applicable to the present study as well. There was a possibility that the majority of the subjects were more motivated to improve the performance during the retest since they had a better result at the retest. The two individuals on the other hand who did not improve their results expressed a view that they were less motivated at the second test and their results were also in the opposite direction.

Four individuals, all above the age of 40 and even one over 50 years of age, reached the level 'excellence' according to Cooper's proposed levels of cardiovascular fitness which was

further than 1.75 miles during 12 minutes (see table 1). To perform such a good endurance level at an age of late forties and early fifties when VO_2max normally should start to decline more rapidly (Joyner, 1993) shows that it is possible to maintain high VO_2max during ageing (Hawkins & Wiswell, 2003; Wiswell et al., 2001). When individuals reach their early thirties and above, the decline in VO_2max begins with approximately 6-10 percent a decade (Tanaka and Seals 2008; Joyner 1993). Endurance athletes can halt the decline with almost 50 percent more than individuals with an sedentary lifestyle mostly with the help of moderate to high exercise (Hawkins & Wiswell, 2003; Wiswell et al., 2001).

Cooper´s 12MR has been tested both on younger adults (Penry et al., 2011; Grant et al., 1995; Cooper, 1968; Bandyopadhyay, 2015) where a correlation between Cooper´s 12MR and direct measurement of VO_2max showed high significance. Another study was conducted on overweight children and by using Cooper´s 12MR showed that physical performance could be connected to body composition and cardiorespiratory fitness (Drinkard et al., 2011). This study tested a slightly older age group, which, to the author's knowledge, had not been tested previously. It is important to develop age-general methods for evaluating VO_2max, because the proportion of elderly people in society is likely to increase in the future (Cohen, 2003). The validity was not tested in the present study but instead a good ICC value above 0.8 was found (Weir, 2005). The ICC value of 0.8 for estimation of VO_2max in a test retest scenario showed a good correlation and showed that the test is reliable for estimating VO_2max in a mixed population (Weir, 2005). Preferably, the test should also be validated in a yet older population, which would make it even more useful.

Method discussion

When performing Cooper´s 12MR a 400-meter running track would be the optimal place. The test leader would thus have full view of all participating subject during the test and be able to make him/herself heard during the entire test. However no suitable 400-meter running track was available for use in this study. Paying for every subject to run twice on a track was too expensive and also logistically complicated so other options had to be considered. Instead a flat asphalt surface was found and used. Due to the shape of the track a turn at each end was necessary. This meant that the participating runners had to slow down at the end to be able to turn around. Because of the track shape a slight

underestimation of VO_2max was likely to be expected. Losing and have to gain new speed take both time and energy, which could lead to a shorter final distance than on a 400-meter running track where no turning would be necessary. However, since the test took place at exactly the same place both times the circumstances and potential errors were the same.

All trials were performed outside which means weather could be an error for performance. Wind, temperature and downfall were all relevant errors that had to be considered. During the separate trials weather conditions were however similar. Small changes in temperature and wind appeared and could potentially have had a minor impact in the results.

Several complications occurred when trying to recruit subjects for the tests. Especially recruiting subjects in the correct age population was difficult. The initial goal was to only have subjects between 30-45 years because of potential health risk and lack of knowledge. Unfortunately not enough subjects in the correct age volunteered which created difficulties. Subjects above 45 years found interest in the study and volunteered and they guaranteed their wellbeing; therefore the test leader accepted their interest and let them participate in the study. One subject was below 30 and the reason was communication difficulties and the subject´s correct age was not affirmed until the test moment. Because of the recruitment challenges the subjects who volunteered were all healthy with time to participate and motivated to perform the tests. The results from the initial test to the retest were very similar and gave a nearly perfect reliability coefficient as mentioned above.

There were four “outliers” in age, one younger as well as three older participants outside of the intended age range of 30-45. For these individuals, test retest results were very similar to the rest of the group and their values for estimated VO2max were reasonable and not out of line. Therefore, their data was included in the overall results and did not significantly change the ICC.

Time was also a factor in the decision, insufficient time to perform the tests had a great impact on the decisions. Because of the resting period in-between test not enough time remained to search for new subjects and therefore all subjects who performed the test retest were included in the results.

The optimal research would be to do validity and reliability analysis of Cooper´s 12MR on a middle-aged population and see how well the standardized 12MR estimates VO_2max and how it correlates to breath-to-breath analysis of VO_2max. Unfortunately there were

limitations such as: lack of time and resources but also a potential risk of testing individuals older than 55. Ageing increases the risk for cardiovascular diseases which could make it difficult to perform safe tests with the current level of information on health of the individuals which was only based on their own reporting. An attempt to start the research with a middle-aged population is not halted by these limitations.

Individuals between 30-60 years have yet to be properly tested both for validity and reliability for Cooper´s 12MR. Younger adults have been tested for both validity and reliability on multiple occasions but when reaching 30 years or older a correlation between Cooper´s 12MR estimation of VO_2max and the actual measured VO2max value need to be investigated. Generally, for any test to be used in research it would be optimal to properly validate and test the reliability in a wider population e.g. across different ages, exercise levels, sex to determine if the test is appropriate to use for these populations as well.

Conclusion

A standardized protocol for performing Cooper´s 12MR showed good repeatability for estimating VO_2max from two separate tests for a mixed population between 28-60 years of age. The results show that the mentioned population's results are comparable in a test retest scenario. Further research could be done on the middle-aged population and see how well their results correlates to actual VO_2max by validating the test against maximal treadmill test with breath-to-breath analysis.

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Appendix

Appendix 1- Informed Consent

Informed Consent

Namn på deltagande_____

- Titel på studie: Testa reliabiliteten på Coopers 12-minuter löpningstest på en medelålders population.
- Undersökarens namn och information: Ludwig Anstrén, Student vid Halmstads Högskola
- Syfte med studien: Huvudsyftet med den här studien är att testa reliabiliteten på Coopers 12-minuter löpningstest hos en medelålders population.
- Studiens tillvägagångssätt: Testen kommer att ta plats vid två separata tillfällen med en veckas mellanrum. Testen är utformat så att du kommer att springa på en utmätt sträcka (arena eller annat) och på 12 minuter springa så långt som möjligt. Det är den distansen som avklaras och mäts för resultatet.
- Möjliga risker: Cooper testet är ett hög intensivt löpningstest. Springa på en hög intensitet är inte lätt och kommer kräva både vilja och motivation för att genomföra, dock är detta ett måste för att resultaten verkligen ska vara trogna din prestation. Träning på en hög intensitet kan leda till negative biverkningar dagarna som följer. Bland annat kan musklerna värka (träningsvärk) och känslan av allmän trötthet kan uppstå. Det finns också risker för andra skador. Därför kan du inte delta ifall du har några hälsoproblem så som: diabetes, hjärt- och kärlsjukdomar och led- eller muskelsjukdomar. Ifall känslan av obehag infinner sig innan, under eller efter testet prata med testledaren omedelbart.
- Fördelar: Med deltagande i studien hjälper du mig att skaffa information en bredare kunskap och förståelse kring Cooper testet och dess reliabilitet. Personligen kommer du att få estimering av din maximala syreupptagningsförmåga (Vo2max) enligt Coopers standard och tidigare resultat. Information kan användas som en mätbar enhet för din aeroba kapacitet och fitness.

- Övrig information: Ditt deltagande är fullständigt frivilligt vilket betyder ifall du känner dig obekväm eller inte längre intresserad är du fri att dra dig ur precis när det passar dig utan att ge en anledning. All information som samlas ihop av testledaren är strikt under sekretess. Enbart testledaren, övervakande handledare och examinator av arbetet på Halmstad Högskola kommer att få ta del av informationen. Informationen som kommer att användas från testet är ålder, vikt, längd, kön och Vo2max estimerad från Coopers ekvation.
- "Jag har last och förstått informationen som star ovan. Jag är medveten om riskerna, fördelarna och naturen av det här testet. Jag är också fullt medveten om att jag vid vilket tidpunkt som helst kan ta tillbaka min "consent" och utgå från testet utan att ge någon anledning".
- Jag, som undersökare bekräftar att jag har gjort allting jag kan för att informera deltagande individer om riskerna, fördelarna, testets natur och tillvägagångssätt som dom kommer att delta i. Jag har även gjort allt jag kan för att svara på frågor och sett att signatur har placerats nedan och gett deltagande en kopia av informationen med signatur.

Deltagandes signatur _____ Datum_____

Undersökandes signatur _____ Datum_____

Appendix 2- Questioner for health

Allmän information och hälsofrågor:

Frågorna som ställs är enbart för er egna skull och säkerhet. Eftersom Coopers test är maximalt fysiskt test är frånvaron av visa sjukdomar och hälsoproblem nödvändiga för att fastställa säkerheten för er som deltar.

Deltagarens Namn_____
Deltagarens Ålder_____
Deltagarens Vikt_____
Deltagarens Längd_____

Tidigare tränings erfarenhet_____
_____

Deltagarens Kön Kvinna Man

- Har du någon form av diabetes? Ja Nej
- Har du någon form av hjärt- och kärlsjukdomar? Ja Nej
- Har du någon form av led- eller muskelsjukdom? Ja Nej
- Har du högt blodtryck eller ombetts av läkare att inte delta i ansträngande aktiviteter? Ja Nej
- Någon annan skada som irriteras, exempelvis knä problem som kan förvärras av maximal löpning? Ja Nej
- Finns det något annat som testledaren bör veta kring din hälsa innan testet? Ja nej

- Ifall ja vad: _____

Signatur deltagande _____

- Göra om testet om några år och testa hur det se rut då
- Jämföra olika grupper och deras nivåer I träning osv

Thanks for this time

PO Box 823, SE-301 18 Halmstad
Phone: +35 46 16 71 00
E-mail: registrator@hh.se
www.hh.se