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BACHELOR THESIS

A Test-Retest Reliability Study of Cooper's Test In Adolescents Aged 16-19 Years

Pontus Sundquist

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Halmstad University

School of Business, Engineering and Science

Thesis supervisor: Eva Strandell

Thesis examiner: Ann Bremander

Abstract

Background: The maximum rate of oxygen consumption ($\dot{V}O_{2max}$) can be measured through numerous tests, either directly or indirectly, where direct methods are considered more accurate, whereas indirect methods are more of an estimation with various degrees of reliability. Cooper's Test is one example of an indirect method considered reliable in estimating $\dot{V}O_{2max}$, with reliability coefficients ranging between 0.897-0.960. Cooper's Test is thus a test that is often used when estimating $\dot{V}O_{2max}$. However, there is a lack of test-retest research done utilising Cooper's Test on a younger population, which is the reasoning behind this study focusing on adolescents. **Aim**: The aim of the study was to study the test-retest reliability of Cooper's Test, in adolescents aged 16-19 years. **Methods**: Twelve healthy adolescents, aged 16-19 years, attending a sports high school participated in a test-retest study (test 1 and test 2) of Cooper's Test. The tests were performed on the short sides of a synthetic grass field, with 66 metres between the two sides, were the participants were instructed to cover as much distance as possible, with high motivation and intensity, for the whole 12 minutes of the Cooper's Test. Each individual participant's data was measured, recorded and later analysed. The total distance covered was then translated into miles and compared to Cooper's original estimated maximal oxygen consumption table for an estimation of each participant's $\dot{V}O_{2max}$ value in $ml*kg^{-1}*min^{-1}$ from test 1 and test 2. The data from the test-retest and its variance was then analysed by a two-way mixed model of intraclass correlation coefficient (ICC) with an absolute agreement type. **Results**: The analysed data from test 1 and test 2 of Cooper's Test showed the results of an ICC (95% CI) of 0.06 (-0.353 to 0.544), indicating a substantial error variance between the two separate Cooper's Tests. **Conclusion**: The data and analysis from this study implied that Cooper's Test was not reliable in the study population, consisting of adolescents. Possible factors influencing the result however were lack of participant motivation and the level of intensity variance during the test-retest of Cooper's Test. Further researchers and amateur and professional users should keep these factors in mind when utilising Cooper's Test to predict $\dot{V}O_{2max}$. More research is needed within this study's age population to draw any definite conclusions on the reliability of Cooper's test on adolescents.

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Background

Cooper's Test

When performing different measurements trying to estimate the maximal oxygen consumption ($\dot{V}O_{2max}$), the reliable consistency of a test's outcome is important to consider, according to Nelson, Silverman and Thomas (2015). A test-retest method determines the stability and consistency of a certain test where the test is given on one day and then repeated a few days later, depending on the strenuousness of the activity (Nelson et al., 2015). One such estimable method that has been tested for its test-retest reliability is Cooper's Test (Bandyopadhyay, 2015; Penry, Wilcox & Yun, 2011). According to Cooper's own study the correlation coefficient was 0.897 (Cooper, 1968), other studies refer to figures where the reliability coefficients were 0.92, 0.93, 0.96 (Aitchison, Amjad, Corbett, Grant & Wilson, 1995; Bandyopadhyay, 2015; Penry et al., 2011), thus indicating that Cooper's Test is reliable in estimating $\dot{V}O_{2max}$ in those particular populations.

Cooper's Test is one of the most popular methods of estimating $\dot{V}O_{2max}$ (Bandyopadhyay, 2015). Besides $\dot{V}O_{2max}$, the test measure cardiovascular fitness and can be used as a relevant method of surveiling any changes in fitness level over time (Cooper, 1968). Other studies have supported Cooper's results through the years, including Penry et al. (2011) and Aitchison et al. (1995). Merely a running track, whistle and a stop watch is needed to complete Cooper's Test, while Bandyopadhyay (2015) adds that the test also requires a measuring tape to measure the distance travelled, further indicating that Cooper's Test is a simple and cheap test to perform.

The initial Cooper's Test was performed on 115 males of US Air Force officers and airmen. All 115 subjects ran for 12 minutes on a measured and flat hard-surface. The subjects performed the test twice. The collected data was then evaluated and compared to the data from a $\dot{V}O_{2max}$ test completed on a treadmill. Of the two tests, the result closest resembling the $\dot{V}O_{2max}$ test was chosen as the comparative data. The $\dot{V}O_{2max}$ test on the treadmill started at a pace of either four or six miles an hour on a grade of 4% or 6%, depending on the subjects' fitness level. The pace was then increased by 0.5 or 1 miles per hour also depending on the fitness level. Cooper's intent was to tire out the subjects after a 3-4 minute run (Cooper, 1968).

Prior to Cooper's Test it was harder to find a reliable method to estimate the $\dot{V}O_{2max}$, while not utilising laboratory equipment. Bruno Balke had extended the previous research, prior to Cooper, correlating the fitness level via oxygen uptake (Cooper, 1968). Cooper then modified the Balke field test and compared estimated $\dot{V}O_{2max}$ levels with direct measurements of $\dot{V}O_{2max}$ levels (Cooper, 1968). Cooper recounted that the correlation between the estimated and the actual $\dot{V}O_{2max}$ levels had a correlation coefficient of 0.897. Thus indicating that Cooper's Test is accurate in its estimation of actual $\dot{V}O_{2max}$ (Cooper, 1968). What is positive about Cooper's Test is that it requires no laboratory equipment, is relatively cheap and time-efficient (Aitchison et al., 1995; Penry et al., 2011), the negative aspect however is that the test can be strenuous and maximal, leading to possible injuries. Cooper's Test also requires high motivation to perform the test at an actual maximum level as it otherwise might influence the results (Aitchison et al., 1995). Aitchison et al. (1995) further explains that lack of motivation might cause differences between direct and indirect testing methods of $\dot{V}O_{2max}$. Cooper (1968) also mentions that motivation should be considered when performing indirect tests for $\dot{V}O_{2max}$ as it might affect the result more than the use of a direct testing method. Penry et al. (2011) adds to the topic, mentioning that participant interaction might increase systematic errors, however adequate motivation levels might reduce the degree of error. Furthermore, Cooper's Test might be less accurate when measurements are performed on a less fit population, a population with a lesser cardiorespiratory fitness level value (Penry et al., 2011).

This thesis work is performing a similar test to that of Cooper (1968), however the subjects are younger than that of Cooper's subjects from 1968. In this thesis study, the reliability of Cooper's Test will be tested on adolescents (aged 16-19 years) as there is limited research in this specific age population, since only one scientific article was found utilising adolescents in a similar age spectrum (Das, 2013). Whereas Cooper (1968) had an age range between 17-52 years with an average age of 22.

Other studies on Cooper's Test have used the following age groups respectively: 21.5 ± 3.7 for females, and 22.1 ± 3.5 for males, 22.1 ± 2.4 on males, 22.8 ± 1.7 on males and 18.4 ± 1.54 on females (Penry et al., 2011; Aitchison et al., 1995; Bandyopadhyay, 2015; Das, 2013). As seen, only one peer-reviewed article estimating $\dot{V}O_{2max}$ through the usage of Cooper's Test with younger subjects was found, that of Das (2013) on females. The other studies, as seen above, have a combined average age of approximately 21.5-22.8 years ± their respective standard deviation. The few cases of adolescents, or teenagers, participating in a Cooper's

Test study is the reason why this thesis study is focusing on adolescents between the ages of 16-19 years, on a younger population - To test whether or not the previous reliability testing of Cooper's Test remain as dependable when the age is altered, in this case decreased to 16-19 years.

Additional analysis on Cooper's Test can thus be used to possibly further demonstrate its repeatability. This thesis study aims to do just that, to test the reliability of Cooper's Test on a younger population, possibly leading to more studies and information on, or in other ways providing knowledge within the subject area. When it comes to reliability there is, amongst others, one method of determining systematic variances and error variances between groups through the use of intraclass correlation coefficient (ICC). ICC can thus be used to determine variances when performing a test-retest method on Cooper's Test. There are however other reliability methods to choose from, such as Bland-Altman plots (LOA) and Pearsons *r*. However Pearson *r* has the disadvantage of not assessing systematic errors, while LOA has been criticised with regards to its reliability, according to Weir (2005). ICC therefore seems to be the most appropriate method for this study.

Maximal oxygen consumption ($\dot{V}O_{2max}$)

$\dot{V}O_{2max}$ - History and definition

$\dot{V}O_{2max}$ is closely linked to endurance performance in humans, therefore knowing how to improve or maintain one's $\dot{V}O_{2max}$ level can be of importance (Penry et al., 2011). $\dot{V}O_{2max}$ stands for the maximum rate of oxygen consumption (Aitchison et al., 1995) and can, according to Bandyopadhyay (2015), be defined as the maximum attainable rate of aerobic metabolism during exhausting dynamic work performances within 5-10 minutes. The $\dot{V}O_{2max}$ levels are also related to an individual's capacity for aerobic adenosine triphosphate (ATP) resynthesis, in other words, how well an individual can maintain a physically intense activity for longer than 4-5 minutes (McArdle, Katch & Katch, 2014). $\dot{V}O_{2max}$ is furthermore a measurement of an individual's cardiorespiratory fitness level (Bandyopadhyay, 2015; Penry et al., 2011), although Marchant, Midgley, McNaughton and Polman (2007) criticised $\dot{V}O_{2max}$ as a non-robust measurement of the cardiorespiratory fitness level, where an improved standardisation $\dot{V}O_{2max}$ criteria was desired. However, more research is probably needed to confirm this statement.

Cardiorespiratory fitness (or simply endurance), thus $\dot{V}O_{2max}$, is a fundamental factor for an individual's physical fitness. Other important factors are lactate threshold and work economy. Bach, Berg, Bjerkaas, Helgerud, Helgesen et al. (2007) further explains that $\dot{V}O_{2max}$ is limited by the oxygen supply at maximal levels of exercise, and what determines the delivery of oxygen might be the cardiac output. This might mean that an increased cardiac output will subsequently increase the oxygen supply and delivery, thus also increasing the $\dot{V}O_{2max}$ and the cardiorespiratory and physical fitness level.

$\dot{V}O_{2max}$ can, according to Pentry et al. (1995), be measured in a controlled laboratory setting by collecting expired gas. This method is however relatively costly and time-consuming, and can be difficult to come by. Therefore, an anti pole that is cheap, time-efficient and that requires no laboratory setting is needed, for example Cooper's Test (Aitchison et al., 1995; Penry et al., 2011).

According to Ferretti (2014) the concept of $\dot{V}O_{2max}$ was first observed in 1923, when the linear relationship between oxygen consumption and mechanical power was observed. Or more precisely when the linear relationship reaches a plateau which can not be overcome even when the mechanical power is increased (Ferretti, 2014). This research lead, through the years, to several studies which culminated into several limiting factors and theories on the $\dot{V}O_{2max}$, in other words, factors that limit $\dot{V}O_{2max}$ (Ferretti, 2014). Limiting factors possibly include oxygen flow and resistances, blood circulation and its pressure gradient, oxygen transportation and lungs (if in hypoxia, not in normoxia (normal oxygen levels)) (Ferretti, 2014). Bach et al. (2007) adds that $\dot{V}O_{2max}$ seemingly is limited mostly by the supply of oxygen and the cardiac output.

$\dot{V}O_{2max}$ - Measurement tests

Aforementioned are descriptions of what $\dot{V}O_{2max}$ actually is defined as and how it was first discovered, but following are few ways in which $\dot{V}O_{2max}$ can be accurately or less accurately measured in several different ways, some methods include the following non-exhaustive listing; Bruce's multistage treadmill test, bicycle ergometre, step test on a bench, Astrand-Rhyming procedure (Epstein, Keren & Magazanik, 1980), multistage shuttle run (Aitchison et al., 1995; Penry et al., 2011), submaximal ergometre test (Aitchison et al., 1995), walking tests (Aitchison et al., 1995). There are also other possible methods of estimating $\dot{V}O_{2max}$, although further research is needed to verify this claim, including self-paced tests (Eston, Evans & Parfitt, 2014; Castle, Mauger, Metcalfe & Taylor, 2013), as well as non exercise models - Where $\dot{V}O_{2max}$ is the dependent variable, and where the independent variable is the body fat in %, Body Mass Index and waist girth (Arenare, Ayers, Jackson & Wier, 2006).

Probably the most important distinction between these tests is that they are either performed in a laboratory (direct method) environment or in a non-laboratory (indirect method, also known as field tests (Cooper, 1968; Penry et al., 2011)) environment, meaning that the indirect tests are estimations of the actual $\dot{V}O_{2max}$, which are measured in a laboratory environment. This field test makes it easier to estimate an individual's $\dot{V}O_{2max}$, since not everyone has access, the expertise needed nor the monetary aid to perform an actual laboratory test (Penry et al., 2011). There are, however, advantages and disadvantages to both approaches. Direct methods of measuring $\dot{V}O_{2max}$ is considered the best method of measuring $\dot{V}O_{2max}$ and thus aerobic fitness, whereas indirect methods, such as Cooper's Test, has other practical advantages. Cooper's Test is inexpensive, simple and requires less expertise to evaluate and execute (Das, 2013). More specifically, in direct methods $\dot{V}O_{2max}$ can be measured by collecting expired gas or by calorimetery (Arenare et al., 2006; Cooper, 1968; Epstein et al., 1980; Penry et al., 2011). The sampled gas concentrations usually consist of oxygen and, or, carbon dioxide (Aitchison et al., 1995; Arenare et al., 2006; Cooper, 1968; Penry et al., 2011).

$\dot{V}O_{2max}$ - Variability & improving $\dot{V}O_{2max}$

Other important factors to consider when measuring, comparing and analysing $\dot{V}O_{2max}$ levels are that $\dot{V}O_{2max}$ levels are varied in the human population when considering age differences, sex, amount of physical activity, genetics and more (Ferretti, 2014). After the discovery of $\dot{V}O_{2max}$ in 1923 several variabilities of $\dot{V}O_{2max}$ within the population was found, these factors might be important to consider in future studies, in sport implementations as well as in age related training or in overall aging. $\dot{V}O_{2max}$ generally decrease with aging, however even at older age endurance and interval training may help slow down the rate at which $\dot{V}O_{2max}$ is decreasing, or even improve it (Ferretti, 2014). There are also several other factors that might affect the $\dot{V}O_{2max}$ or physical fitness of an individual, such as muscle capillarity density, genetic makeup, mitochondrial volume density, muscle oxidative enzyme activity and maximal cardiac output (Ferretti, 2014).

Even the improvement of $\dot{V}O_{2max}$ through training can be the outcome of a variety of training methods, just like $\dot{V}O_{2max}$ is varied within a population (Ferretti, 2014). Since an individual's level of VO_{2max} is related to the maintenance of physical intense activity (McArdle et al.,

2014) and therefore interlocked with the endurance performance (Penry et al., 2011), it might be of interest knowing how to improve $\dot{V}O_{2max}$ through physical training, or what type of physical training to perform. Bach et al. (2007) and Dowling, Gandrakota and Gormley et al., (2008) did two separate but similar studies on what type of training might improve $\dot{V}O_{2max}$. These two studies seem to imply that the best method of improving $\dot{V}O_{2max}$ is through high intensity training at 90-95% of either maximum heart rate (HR_{max}) or oxygen consumption reserve (VO_2R) for best effect, though lower percentages of HR_{max} might improve $\dot{V}O_{2max}$ as well, albeit at a reduced efficiency. A lower level of strenuousness might however be of personal preference for certain individuals, thus 70-90% of HR_{max} is sufficient to improve $\dot{V}O_{2max}$ (Bach et al., 2007; Dowling et al., 2008).

$\dot{V}O_{2max}$ - Physiology

During endurance training or high intensity training (for example long distance running, interval training, or performing a Cooper's Test) the physiological requirements of the human body are increased. The body is in need of energy and oxygen amongst other molecules (McArdle et al., 2014). The energy, both consumed and, generated in this case is ATP (McArdle et al., 2014). As previously mentioned, an individual's $\dot{V}O_{2max}$ levels are related to the capacity for aerobic ATP resynthesis. This means that during aerobic exercise, such as when performing a Cooper's Test, the type I muscle fibres generate ATP molecules, or simply energy (McArdle et al., 2014). ATP is a molecule that is required to perform most of the body's biological work, and can be extracted through several processes from other chemical energy, such as food. In other words chemical energy is stored within the ATP molecule and can be utilised by the type I muscle fibres to execute work (McArdle et al., 2014). ATP is primarily synthesised in cell organelles called mitochondria through different processes, including the electron transport chain and chemiosmosis (oxidative phosphorylation) (Cain, Jackson & Minorsky et al., 2013). As well as the less ATP lucrative processes of glycolysis and the citric acid cycle, yet still of importance for the function of the oxidative phosphorylation (Cain et al., 2013).

Oxygen plays an important role in the synthesis of ATP (Cain et al., 2013). Oxygen is an electron acceptor, making the molecule electronegative, this property is important in the oxidative phosphorylation process when creating a difference in the concentration between two mitochondrial membranes - Where protons in the mitochondrial intermembrane space are driven back into the mitochondrial matrix via the ATP synthase protein complex, which phosphorylate adenosine diphosphate (ADP) into ATP (Cain et al., 2013). Essentially just adding an inorganic phosphate to the ADP molecule which creates ATP (Cain et al., 2013). Thus, increased physical activity equals increased oxygen consumption. The oxygen reaches the cells from the ambient air through the respiratory system, reaching the lungs and subsequently the blood and different cell tissues (Ferretti, 2014).

As a concluding remark on the physiology, the variability of $\dot{V}O_{2max}$ and endurance training as a whole, Cooper's Test should, in light of all the studies mentioned in this thesis, perhaps be tested for its variability amongst different groups of ages, training level, sex and furthermore just for its actual reliability as a $\dot{V}O_{2max}$ estimable test.

Aim

The aim of the thesis work was to study the test-retest reliability of Cooper's Test, in adolescents aged 16-19 years.

Research questions

Can Cooper's Test be utilised on adolescents aged 16-19 years, with a reliable outcome?

Methods

Subjects

The subjects were contacted due to their enrolment in a local sports high school. Upon acceptance to visit the sports high school oral information was given out along with relevant documents. Age was the only inclusion criteria used in the study, accepting adolescents between the ages of 13-19. No sex criterion was applied. All test subjects whom participated in the study also had to pass the exclusion criteria of not having any illnesses, diseases or injuries that might have influenced the tests or harmed the subjects. All in all 28 subjects signed the informed consent and the subject questionnaire. 16 subjects attended the first Cooper's Test occasion (test 1), whereas 20 subjects attended the retest of Cooper's Test (test 2). In total 16 individuals dropped out of the study. In the end 12 subjects, aged 16-19 years with a mean (SD) age of 17 ± 1 years, performed both test 1 and test 2, these 12 are the subjects included in the results analysis and the thesis study.

Study design & procedure

12 subjects performed two Cooper's Test runs of 12 minutes activity with a rest period of one week in between the separate runs. The 12 minute tests were executed across the short sides of a synthetic grass field. The participants were instructed to start at the side line, running straight across to the opposite side line and back, this was considered a full lap, which was marked by the test leader. The short sides of the synthetic grass field was 66 metres across, this means that one lap was 132 metres back and forth. The measurement was done using a measuring tape and the time keeping was performed on a mobile phone (iPhone 6s Plus, Apple Inc., California, USA). After each Cooper's Test the temperature, wind force, humidity and atmosphere was detailed. After the execution of test 1 the atmosphere was cloudy, with a temperature of 1°C, 93% air humidity and 11 km/h of wind force. On the day of test 2, the atmosphere was similar to that of test 1, with cloudy weather, still a temperature of 1°C with 90% air humidity and 12 km/h of wind force.

Before the actual test begun the test leader went through the procedure, informing everyone not to compete with each other, but to run their own race and that everyone were to stand still at the 12 minute mark, in order for the test leader to mark their position and direction in order to later measure their total distance travelled. Eight minutes of warming up was scheduled before the test-retest runs, see appendix 3 for the specific warm-up exercises. During the actual test the test leader was calling out every fourth minute, letting every participant know how much time they had run and how much time was left to the 12 minute mark, an additional call out was made at the 11 minute mark to push the participants the very last minute of the Cooper's Test. The individual measurement was done in such a way that depending on what side line the subject was closest to the distance was either added to the 66 metres side line measurement or subtracted to the 132 metre side line. For example, if a participant had run 19 laps with one metre left to finish the 20th lap 132 metres was multiplied with 20 laps and then subtracted with one metre. If on the other hand a participant had run 19 laps and had just reached the second side line the measurement would have been 19 laps multiplied by 132 metres added a half lap of 66 metres. Same procedure was performed if the participant had run 5 metres from the second line, simply 5 metres would have been added to the 66 metres. All the individual data of the total distance travelled in metres was then converted into miles in order to utilise Cooper's table (Cooper, 1968) of predicting $\dot{V}O_{2max}$, the closest table distance was chosen. One metre was converted to 0.000621371192 miles and then multiplied with the total distance run.

Ethical and social considerations

Ethical considerations include considerations of plagiarism, misrepresentation, fraud, inaccurate interpretation of data and more (Nelson et al., 2015). Nelson et al. (2015) explains that pressure might tempt an author to act unethically, mentioning four factors that can augment the pressure, including behaving unethically due to the need or desire to be granted funding for research, to publish scholarly findings, to complete a graduate degree or the desire to obtain some sort of reward. In this thesis work no external funding was involved for the student, leading to less pressure and thus less chance that the author will act unethically (Nelson et al., 2015). Other factors of importance to consider are the welfare of the society and the subjects involved. Any decision-making should be true and genuine, thereby avoiding fraud and misrepresentation (Nelson et al., 2015). In the project plan and thesis work the author of the work signifies that no intentional or knowingly unethical behaviour was acted upon, including: Plagiarism, fabrication, falsification, nonpublication of data, faulty data-gathering procedures, poor data storage, retention, misleading authorship or unacceptable publication practises, as are mentioned by Nelson et al. (2015).

All participating subjects were volunteers and all had read and signed the informed consent, subject questionnaire and written subject information (one copy and one original), containing all relevant information including the test requirements (such as whether the subjects can maintain high degree of motivation and intensity throughout the 12 minute run, and whether they had any previous experience with Cooper's Test), potential risks, ethical and social considerations, possible benefits, handling of personal information and more (see appendices 1 and 2). The original documents were kept safe, as to keep it confidential, the documents were approved by Halmstad University. Under aged pupils (aged 17 years or younger) were informed to sign the documents with their guardian, but it was not mandatory to do so, since children aged 15 years or above can sign the documents themselves as long as they understand the implications of the study (Forskning som involverar barn, 2016). Furthermore, the subjects were given information about certain conceivable risks, such as strains, ruptures and accidents. The subjects were free to withdraw from the study at any time, without any questions asked about the reason for withdrawal, and each individual participant's name was, during data analysis, exchanged to a number through 1-12 to conform to the subject confidentiality of the study. The data was furthermore kept in, and worked on in, a USB given by the responsible authority (Halmstad University) of the thesis work. The responsible authority has the uttermost responsibility for the research, according to Vetenskapsrådet ("Forskning på människor", 2015).

The findings in the study could contribute to the society in adding further knowledge to the reliability of Cooper's Test in a younger population. Which is especially interesting considering the few amount of test-retest studies on Cooper's Test where teenagers have participated, as most studies focus on the approximate ages between post-teenage and pre-pension and not strictly on the teenage years (Aitchison et al., 1995; Bandyyopadhyay, 2014; Cooper, 1968). In other words, the study could indicate whether or not Cooper's Test could reliably be repeated with the same outcome. And if it can not be repeated with the same outcome, discussions could be made on what possible factors are inhibiting the reliability. This discussion could possibly be of use for coaches, trainers, instructors, sports teachers, future research and the commonality.

Statistical analysis

The program SPSS (IBM SPSS version 20, Chicago, IL, USA) was used as the statistical analysing software. The reliability control of Cooper's Test was done through the test-retest method (Nelson et al., 2015). The method for calculating the stability (coefficient of reliability) was done using ICC (95% CI), two-way mixed model (fixed rater) and absolute agreement. ICC is a reliability coefficient (R), in accordance with Nelson et al. (2015) and determines whether there are systematic and error variances in the different test trials (Nelson et al., 2015). The closer the ICC is to 1.0 the higher the reliability, the closer to 0.0 the lower the reliability (Weir, 2005). A two-way mixed model and single measures was used because each subject was rated by the same (fixed *k*) judge and the subjects themselves have been randomly chosen, which is in accordance with Fleiss and Shrout (1979). A consensus on what is considered a good level of ICC does not currently exist, according to Weir (2005). Koch and Landis (1977) however mentions benchmarks that could be used regarding the strength of the agreement, where an ICC below 0.00 was considered poor, 0.00-0.20 was considered as a slight agreement, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial and lastly, 0.81-1.00 as almost perfect.

Results

12 adolescents aged 16-19, with a mean age of 17 ± 1 years, participated in both test 1 and test 2 of Cooper's 12 minute test. Eight out of twelve subjects considered themselves being able to maintain a high degree of motivation and intensity during a 12 minute run (four out of twelve did not give an answer in the questionnaire) and seven out of twelve subjects had prior experience in performing Cooper's Test, whereas five out of twelve had no prior experience. Furthermore, the subjects have a mean (SD) of 11 ± 2.5 years in training experience, as well as performing 5.5 ± 2 training sessions per week. The mean weight of the subjects was 65 ± 10 kg and the mean height was 179 ± 7 cm, as can be seen in table 1. Table 1 also presents the result data from the Cooper's Test, test 1 and test 2. The mean and standard deviation of the total distance travelled was 1.614 ± 0.18 miles on test 1, whereas the mean and standard deviation on test 2 was 1.448 ± 0.24 miles with an ICC (95% CI) of 0.06 (-0.353 - 0.544) indicating a low reliability. The $\dot{V}O_{2max}$ was calculated to a mean and standard deviation of 46.8 ± 6.5 $ml*kg^{-1}*min^{-1}$ during test 1 and was calculated to 40.6 ± 8.7 $ml*kg^{-1}*min^{-1}$ during test 2, with an ICC (95% CI) of 0.06 (-0.353 - 0.544) indicating a low reliability. Figure 1 presents the individual estimated $\dot{V}O_{2max}$ during test 1 and test 2.

Table 1. Participant description of age, weight and height, n = 12. As well as Cooper's Test result in total distance covered in metres, miles and $\dot{V}O_{2max}$ from both test 1 and test 2 of Cooper's Test.

Description	Mean	Standard deviation
Age (years)	17	1
Weight (kg)	65	10
Height (cm)	179	7
Distance: Test 1 (m)	2598	282
Distance: Test 2 (m)	2330	387
Distance: Test 1 (miles)	1.614	0.18
Distance: Test 2 (miles)	1.448	0.24
$\dot{V}O_{2max}$: Test 1 ($ml*kg^{-1}*min^{-1}$)	46.8	6.5
$\dot{V}O_{2max}$: Test 2 ($ml*kg^{-1}*min^{-1}$)	40.6	8.7

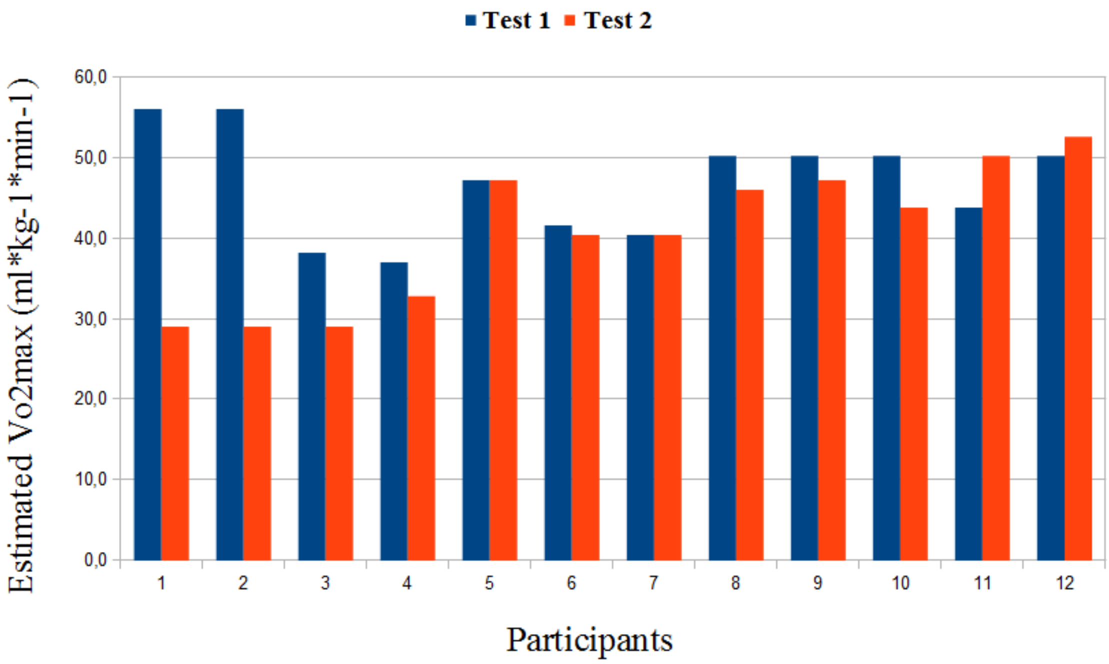

Figure 1. Individual estimated $\dot{V}O_{2max}$ value from test 1 and test 2. Blue bars represent individual $\dot{V}O_{2max}$ from test 1, orange bars represent individual $\dot{V}O_{2max}$ from test 2.

Discussion

The thesis work aimed to study the test-retest reliability of Cooper's Test, in adolescents aged 16-19 years. The results demonstrated that the test-retest reliability coefficient was low, at an ICC (95% CI) of 0.06 (-0.353 - 0.544).

Results discussion

According to this thesis study the results indicated a low repeatability of Cooper's Test. There were large individual performance differences between the subjects from test 1 to test 2, a substantial gap of $\dot{V}O_{2max}$ can especially be seen between participant 1 and 2. And only four out of twelve participants increased their distance run from test 1 to test 2, which is an indicator of the individual $\dot{V}O_{2max}$ variance. This indicates that the subjects for some reason did not cover as much distance, on average, during test 2 as during test 1. These results do not correspond with the findings from similar studies where the reliability of Cooper's Test was considerable higher, in fact, with a reliability coefficient between 0.897-0.960 in contrast to the ICC of 0.06 found in thesis work (Aitchison et al., 1995; Bandyopadhyay, 2015; Cooper, 1968; Penry et al., 2011). No studies, in the author's knowledge, mention the possible reliability influence adolescents might have on test-retesting of Cooper's Test compared to an older population. Since Cooper's original study (Cooper, 1968) was performed on males aged 17-52 years and consequent studies have, according to Aitchison et al. (1995); Bandyopadhyay (2015) and Penry et al. (2011), focused on a similar age range, it is likely that the Cooper's Test might be more reliable in estimating $\dot{V}O_{2max}$ in a generally older population than that of this thesis study. Furthermore the lack of test-retest studies performed on adolescents adds to the existing contingency of Cooper's Test reliability in estimating $\dot{V}O_{2max}$. According to the results in this thesis study, the usefulness of Cooper's Test performed by adolescents can be questioned if not performed at near maximal or maximal intensities, which requires a high degree of motivation. Future research could continue the test-retesting of Cooper's Test in adolescents, perhaps focusing on motivation, practical methods and willingness to run at near maximal or maximal intensities and how these factors might influence the reliability of the test, as there is limited research within this particular area in the current state.

Methods discussion

The short sides of a synthetic grass field, with a distance of 66 metres between, was used in this thesis work as the running course. This short distance might have an effect on the result outcome since this forces the participants to change direction every 66 metres instead of running in a straight line, or an ovoid shape, for 12 minutes. This means that for every lap (one lap is 132 metres) run the participants had to perform two turns, which is an average turn rate of 39 times per participant during test 1 and 35 times during test 2. These quick turns wastes energy and time that could otherwise have been preserved in order to achieve a greater distance run during both tests and thus resulting in a greater estimated $\dot{V}O_{2max}$ value.

Bandyopadhyay (2015) mentions the practical use of a running track, however the inconvenience and the pricing of a nearby running track was deemed too high as to be used in the thesis work. A 200 metre distance of asphalt was also considered but it was hard to find an unoccupied segment of 200 metre asphalt and thus the convenient and free synthetic grass field was the eventual decision. Also, since the Cooper's Tests were performed outside, potential differences in climate had to be considered. An optimal testing procedure might have been indoors, thus being unaffected by differences in wind force, humidity, temperature and other factors. Furthermore, a method of documentation utilising a filmed recording of the two sessions could have been used, which could have functioned as a more reliable scoring procedure. No appropriate indoor hall was used however due to similar reasons of not utilising a running track, convenience and pricing. During the actual tests there were however no significant differences in climate, with +1 °C and cloudy weather on both occasions and the difference in wind force and air humidity was small at 11km/h and 12km/h, 93% and 90% from test 1 and test 2 respectively. As a whole these decisions, of running outside on a synthetic grass field and having to turn every 66 metres, certainly had a less relative impact on the results when considering the likely subject errors of lack of motivation and intensity during test 2.

Measurement errors

When executing a test that depends on reliability and repeatability the measurements and the material used should be accepted as reliable, for example a measuring tape was used in this thesis work to measure distance travelled in centimetres, this is considered as an accepted method of measuring height or length and consequently distance (Nelson et al., 2015). In general there are four factors to consider regarding sources of measurement errors, these include the subjects, the testing procedure, the scoring from the testing and the instrumentation used (Nelson et al., 2015). In order to find any reliability deviations, these four different factors will be discussed in accordance with Nelson et al. (2015).

Subject errors are believed to be the main culprit in the individual subject variance, mainly due to lack of motivation and possibly due to mental interference between the subjects, for example competition, although no such behaviour was noticed by the test leader. Competition between subjects and its potential negative implications was furthermore discussed orally prior to the test runs. The lack of motivation was believed to exist because of the drastic decrease in performance on test 2, but also because it later got revealed that the participants were to engage in a football game later that evening and thus probably wanted to save some physical and mental energy for the game, most likely resulting in a lack of motivation in performing as good as they had performed the previous week, also performing the exact same demanding test once again could have influenced the participants mentality and thus their motivation. This lack of motivation and this difference in distance run then resulted in a skewed data set which was found lower than the result data and distance covered than the participants could have performed in usual cases, making it hard to draw any accurate conclusions from the research questions other than that the low reliability level of 0.06 was likely due to subject measurement errors within the study.

No studies, in the author's knowledge, test-retesting Cooper's Test discuss the direct influence of motivation from their subjects and how it was dealt with or how it might have influenced the $\dot{V}O_{2max}$ estimation, instead the studies merely explain the importance of a high degree of motivation to achieve maximal effort for the reliability of the result (Aitchison et al., 1995; Penry et al., 2011). This is why the thesis study included the subject information and informed consent where it was stated that the ability to perform the tests with high intensity and motivation was important.

Errors in scoring were likely very low as it was a simple procedure of taking note every time a participant crossed the starting line and then measuring their individual total distance travelled, however there is always the possibility of a random error caused by the test leader, for example mix ups or unknown mistakes. Instrumental errors were also perceived as being low as it too was a simple procedure of measuring the distance (with simple instruments) run by the participants, however depending on how tightly or loosely the test leader pulled on the measuring tape slightly differences in the outcome was possible to occur. The test leader did test out this prior to the real testing occurred, additionally it was only one test leader measuring the distance, providing a more stable and reliable outcome than if several test leaders were measuring, all pulling on the measuring tape with different strengths and techniques.

Future research

Future work might consider retrying this particular thesis work's method in adolescents with these mentioned improvements; performing the tests inside on a long track, or a 400 metre ovoid running track as to diminish rate of turning and potential climate impacts as well as actually performing an actual direct method of measuring $\dot{V}O_{2max}$ in a laboratory setting, which according to Das (2013) is more accurate since it directly measures $\dot{V}O_{2max}$ instead of estimating it as Cooper's Test does (Cooper, 1968). But most importantly making sure that the participants truly understand the importance of maintaining a high motivation and intensity throughout both Cooper's Tests and that the test leader has a method of aiding in keeping the motivation levels high, since it otherwise most likely will influence the reliability and thus the results of the study. In addition to further explanation of the importance of maintained motivation and intensity and to discourage interaction between subjects, an RPE scale might be used to assess perceived rate of exertion during the actual test runs to make sure that the test subjects are running with a near-maximum or maximum effort. Furthermore it would be interesting to see Cooper's Test tested on different ages such as elders (seniors) and juveniles (pre teen) as the research in this particular field is, in the author of this study's knowledge, limited.

Conclusion

The data and analysis from this study implied that the repeatability of Cooper's Test was not reliable in these specific adolescents aged 16-19 years. Possible factors influencing the result however were lack of participant motivation affecting the intensity levels from test 2. Further researchers and amateur and professional users should keep these factors in mind when utilising Cooper's Test to predict $\dot{V}O_{2max}$. More research is however needed within this age population to draw any definite conclusions on the general reliability of Cooper's Test.

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Appendices

Appendix 1 - Subject information & informed consent

Informerat Samtycke

Bakgrund

Hej. Jag heter Pontus Sundquist, och studerar på Högskolan i Halmstad. Jag går det tredje och sista året på programmet 'Biomedicin - inriktning fysisk träning'. Jag har en förfrågan till dig om du är intresserad av att delta i en studie, som ingår i mitt examensarbete.

Det är en studie där jag kommer att prova hur bra ett visst sorts träningstest (Cooper's Test) relaterar till din maximala syreupptagningsförmåga. Jag vill alltså se om Cooper's Test kan förutspå din kropps maximala syreupptagningsförmåga, det vill säga, hur mycket syre du maximalt tar upp i kroppen. Det finns studier som redan menar att det faktiskt fungerar att förutspå syreupptagningsförmågan, det jag ska göra är att egentligen dubbelkolla att det faktiskt stämmer. Vad som är så intressant med detta är att om testet "fungerar" så behöver man inte använda dyr laborationsutrustning, utan kan istället göra detta test istället.

Förfrågan om deltagande

Du har förfrågats i och med att du studerar på Aspero och genom att du är i gymnasieåldern. Det vill säga, jag vill se om Cooper's Test är pålitligt även för ungdomar i din ålder. För att du ska kunna delta i studien finns dock vissa krav som ska uppfyllas, dessa är att du inte har några skador eller sjukdomar såsom diabetes, muskelskador, rupturer, eller andra kardiovaskulära och muskel- och skelettsjukdomar. Du ska med andra ord vara frisk, skadefri och inte ha andra åkommor som kan påverka studiens resultat för att kunna delta i studien. Dessutom behöver jag din målsmans underskrift om du är under 18 år, det vill säga, din målsman ska skriva under och godkänna att du är med och deltar i studien. Mer information om detta kommer längre ned.

Hur går testtillfällena till?

Vad är då detta för test? Jo, det är väldigt enkelt. Det du ska göra är att vid två tillfällen, som tar ungefär 45 minuter, springa med hög intensitet i 12 minuter. Testet kommer ske nära Halmstad Högskola, så du behöver kunna och vara villig att ta dig dit på egen hand. Banan är 200 meter lång, markerat med två koner. Syftet är att jag ska mäta hur långt du hinner springa på dessa 12 minuter, ett så kallat Cooper's Test, för att sedan själv göra beräkningar på din eventuella maximala syreupptagningsförmåga med hjälp av en analytisk programvara som kallas för SPSS. Innan testet börjar kommer vi ha en gemensam uppvärmning på cirka tio minuter. Därefter startar testet. Viktigt är att du som tidigare nämnt, är frisk och skadefri, så att du kan med hög intensitet och motiverat genomföra testet - Det vill säga att du klarar av att springa 12 minuter i sträck efter din bästa förmåga. Efter första testtillfället kommer du att få vila en vecka innan vi kör exakt samma test igen. Slutligen är det alltså viktigt att du har möjligheten att slutföra den 12 minuter långa löpningen, dock såklart i din egen takt och så snabbt du själv klarar av.

Finns det risker med testtillfällena?

Det finns inga större risker för dig att göra testet om du är fullt frisk och är med i den gemensamma uppvärmningen. Däremot finns alltid de risker som vanligtvis förekommer vid gång och löpning, d.v.s. eventuella fallrisker eller muskelsträckningar med mera. Dock kan eventuell muskelsmärta uppstå beroende på hur van du är att springa i 12 minuter med intensiv aktivitet.

Fördelar med att vara med i studien?

Förutom ett inslag av fysisk aktivitet, så kan en fördel med studien vara att se om just Cooper's Test kan förutspå din maximala syreupptagningsförmåga, och se om testet generellt kan nyttjas på flera olika personer. I så fall är det ett test som du vet om att du kan använda på dig själv för att förutspå din maximala syreupptagningsförmåga i framtiden.

Hantering av data och sekretess

All personlig information som handlar om dig kommer att behandlas ur ett etiskt perspektiv, exempelvis kommer all information om dig att förvaras i ett USB-minne som ägs av Högskolan i Halmstad och som även efter studien kommer att förvaras på Högskolan. Specifika uppgifter kommer inte kunna härledas till dig som individ då den inte offentliggörs. Inga namn kommer att nämnas i studien, utan resultaten kommer endast presenteras i grupp, till exempel att 15 personer deltog i studien. Huvudman för studien är Högskolan i Halmstad och står således som ansvarig för studien.

Information om studiens resultat

Du har möjlighet att ta del av resultatet i studien efter att det sammanställts och publicerats, eller att inte ta del av resultatet om så önskas. För att ta del av informationen vänligen kontakta mig (se kontaktinformation längre ned).

Frivillighet

Deltagande i denna studie är helt frivilligt och i kan när som helst under studien avbryta ditt samarbete, utan förklaring. Du får då även be oss radera all data insamlat på dig. Om du vill avbryta ditt medverkande i studien så vill jag att du kontaktar mig.

Ansvariga

<u>Ansvariga för studien är:</u>

Pontus Sundquist

Biomedicin - inriktning fysisk träning

Högskolan i Halmstad

Tel: 072 - 520 46 26

Mail: ponsun13@student.hh.se

Handledare:

Eva Strandell

Högskolan i Halmstad

Eva.Strandell@hh.se

Huvudman:

Högskolan i Halmstad

Samtyckesformulär

Nedan ger du ditt samtycke till att delta i den ovan beskrivna studien, där du ombeds att springa med hög intensitet i 12 minuter. Läs igenom informationen noggrant och ge därefter ditt medgivande genom att signera ditt namn längst ned på denna sida. Detta samtyckte finns i två exemplar, ett som du behåller själv och ett som Högskolan i Halmstad behåller efter studiens gång.

Jag medgiver att jag:

- Har tagit del av informationen kring studien och förstår vad den innebär.
- Har fått ställa de frågor jag önskar och vet vem som är ansvarig huvudman om jag har fler frågor (Högskolan i Halmstad).
- Deltar frivilligt i studien och förstår varför jag har blivit tillfrågad.
- Vet att jag när som helst kan avbryta mitt deltagande i studien utan att ange orsak.

Jag intygar härmed att jag har läst det informerade samtycket och tagit del av informationen kring studien. Jag förstår vad deltagande i studien innebär och ställer upp frivilligt.

Datum____

Namnteckning______________________________Namnförtydligande_____________________

Datum____

Målsman:

Namnteckning______________________________Namnförtydligande_____________________

Testledare:

Datum____

Namnteckning______________________________Namnförtydligande_____________________

Appendix 2 - Subject questionnaire

Hälsoformulär

Frågeformulär - Generell hälsa och aktivitet

Nedan finner du frågor som är kopplade till samtyckesformuläret samt din generella hälsa och fysiska aktivitet som är viktiga för mig att veta om innan vi testar dig. Skriv svar på raden, eller ringa in där frågan kräver det. Både din målsman och din egen namnteckning och namnförtydligande ska skrivas under nedan:

Datum____

Namnteckning______________________ ______________________

Namnförtydligande______________________ ______________________

Ålder____

Vikt____

Längd____

Kön: Man Kvinna Annat

Anser du dig klara av att springa 12 minuter med hög motivation och hög intensitet? Ja Nej

Antal år som du tränat____

Träningspass i veckan____

Har du tidigare erfarenhet av Cooper's Test? Ja Nej

Övriga
kommentarer____
____
____
____

Testledare: Pontus Sundquist

Utgivare av formuläret: Pontus Sundquist

Kontaktinformation:

Tel: 072 - 520 46 26

Mail: ponsun13@student.hh.se

Appendix 3 - Method warm-up

Warm-up exercise	**Time (min) - Total: 8 minutes**
1. Slow jogging (slightly faster than individual walking speed)	2
2. Side stepping	2
3. Slow high knee jogging	1
4. Jogging (at normal individual pace)	1
5. Stand still full range of motion movement in hip and knee joint	2

The author of the bachelor's thesis was born in 1994 and has an interest in exercise and nutrition, specifically related to strength training and hypertrophy training.

HALMSTAD UNIVERSITY

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