TOPICS IN EXERCISE SCIENCE AND KINESIOLOGY

Process of Science

Is the ACSM and FRIEND Metabolic Equations Valid for Assessing Cardiorespiratory Fitness Among 18-34 Aged Men? : Preliminary Results

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ABSTRACT

Topics in Exercise Science and Kinesiology Volume 2: Issue 1, Article 2, 2021. Metabolic equations, such as ACSM and FRIEND, are used worldwide to indirectly measure the VO_2max in adults, but lack of accuracy seems to occur. 30 men of 18-34 years old performed a maximal incremental test on a treadmill during which direct VO_2max measurements was taken and then have been compared to ACSM and FRIEND metabolic equations. Point of application #1: Better evaluation and exercise prescription among athletic populations. Point of application #2: Act in prevention among sedentary and symptomatic populations. Point of application #3: Improve the assessment of physiological need associated with work tasks, personal protective equipment and the physical preparation of the tactical personnel.

KEY WORDS: Treadmill evaluation, VO_2 estimation, prevention, VO_2max, aerobic capacity, tactical personnel

INTRODUCTION

Metabolic equations are used worldwide to indirectly measure aerobic fitness (VO_2max) in adults. This indirect evaluation method is generally preferred in clinical settings since it is less expensive than direct measurement of VO_2max with a metabolic analyzer, which is more common in the field of sports performance. The American College of Sports Medicine (ACSM) presents the most widely circulated set of guidelines used in clinical settings and their metabolic equations are among the most globally recognized.[1] Overall, the ACSM metabolic equation for measuring VO_2 during a maximal incremental test appears to overestimate the results of clients evaluated among different Quebec university kinesiology clinics by approximately 15%. In the literature, some studies also observed an overestimation of oxygen consumption by the ACSM running metabolic equation.[2,3,4,5] Recently, the Fitness Registry and the Importance of Exercise National Database has developed the FRIEND equation as a solution. However, this study did not evaluate their participants at more than 6 miles/hour (9.66 km/h).[5] Therefore, it may not be well suited for an incremental running test since one is very likely to achieve faster speed while running. We hypothesize that these equations will give significantly different results from those measured. The objective of this study is to compare the results of direct (real) to indirect VO_2max measures using ACSM and FRIEND equations, to assess their estimation reliability in a group of healthy males.

METHODS AND RESULTS

A Combined-Drolet protocol (*combiné Drolet*) was performed in a cohort of 30 healthy men (self-reported), without injuries, running regularly and not taking any drugs that have an impact on heart rate. Participants performed an incremental running test until exhaustion on a treadmill and using a Vyntus CPX metabolic cart[6,7]. The metabolic cart allowed direct measurement of the individual's maximal oxygen consumption during the evaluation. The obtained VO_2max value was then compared to those given by the ACSM and FRIEND equations for which the speed and the slope of the last level completed are used. Statistical analyzes included t-tests and Hedge's tests for size effects. Note that these preliminary results presented are drawn from a more extensive ongoing study.

ACSM formula overestimated the VO_2max systematically for our cohort from 3.1 to 21.0 ml of $O_2/kg*min^{-1}$ (4.6 to 44.9%) and had a mean difference of 13.4 ± 4.5 ml of $O_2/kg*min^{-1}$ (24.9 ± 8.3%) with the measured value. This difference was statistically different (t, (29), $p < 0.001$) and the effect size (Hedge's g) was large (-1.83).

FRIEND formula underestimated the VO_2max on five participants from 0.20 to 6.80 ml of $O_2/kg*min^{-1}$ while overestimated in the twenty-five others from 0.90 to 11.5 ml of $O_2/kg*min^{-1}$ (1.8 to 24.6%) and had a mean difference of 4.1 ± 4.3 ml of $O_2/kg*min^{-1}$ (7.6 ± 7.9%). This difference was also statistically different (t, (29), $p < 0.001$) and the effect size (Hedge's g) was medium (-0.60).

BETTER EVALUATION AND EXERCISE PRESCRIPTION AMONG ATHLETIC POPULATIONS

As the figure below demonstrates, the ACSM formula systematically overestimates the VO_2max for our cohort. Overall, the FRIEND equation shows more accurate results, but still yield significant differences with the measured value. It is interesting to note how important the overestimation can be even at levels closer to the general population. By now, direct measurement remains the gold standard and should be preferred for athletic clienteles and even among more physically active populations. However, these equations will continue to be used due to the lack of accessibility of a metabolic cart during maximal incremental running test despite their lack of validity[3]. Better cardiorespiratory fitness evaluation would improve the intervention quality by a more accurate exercise prescription among different clienteles.

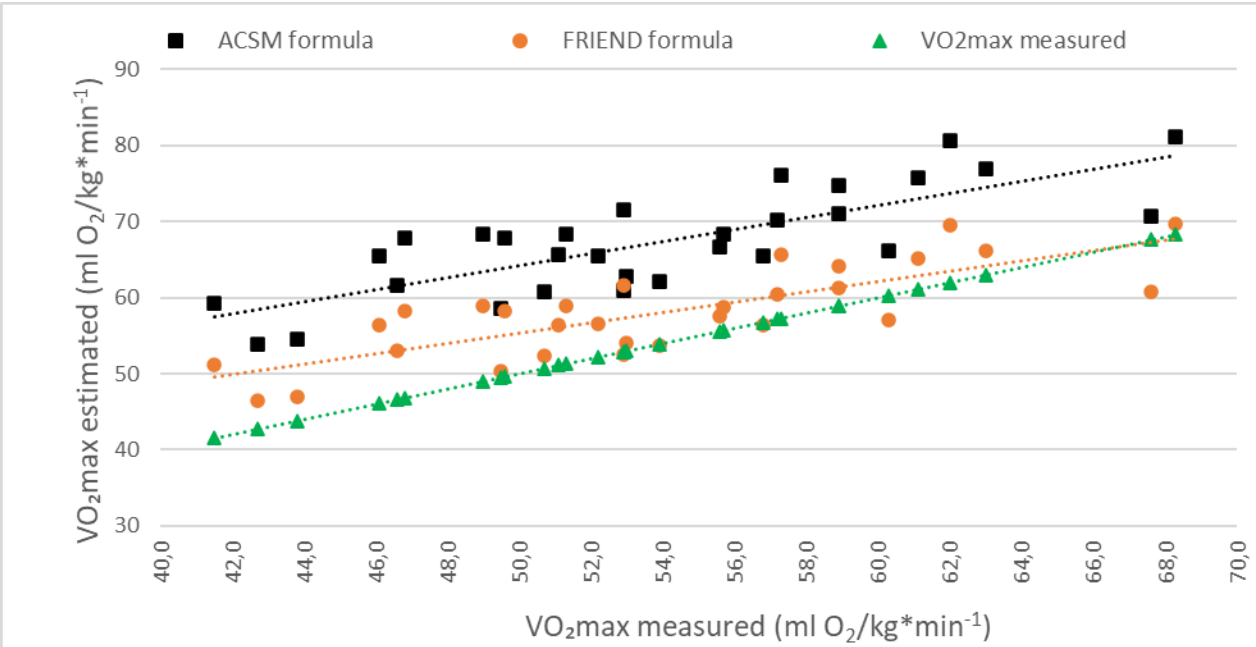

Figure 1. Estimated value of VO_2max (ml of O_2/kg*min^{-1}) using the ACSM and FRIEND equations in comparison with the measured value.

ACT IN PREVENTION AMONG SEDENTARY AND SYMPTOMATIC POPULATIONS

Table 1. Prevalence of insufficient physical activity among adults aged 18+ years (age-standardized estimate) (%). Data taken from the World Health Organization website : https://apps.who.int/gho/data/view.main.2482?lang=en

			Both sexes	Male	Female
Global	2016	18+ years	27.5 [25.0-32.2]	23.4 [21.1-30.7]	31.7 [28.6-39.0]
Africa	2016	18+ years	22.1 [19.9-24.0]	18.4 [15.8-20.9]	25.6 [22.8-28.2]
Americas	2016	18+ years	39.3 [37.4-40.9]	33.1 [30.8-34.0]	45.2 [42.9-48.6]
South-East Asia	2016	18+ years	30.5 [21.6-46.8]	22.9 [15.1-49.8]	38.3 [27.0-64.0]
Europe	2016	18+ years	29.4 [27.9-32.1]	26.2 [23.9-29.5]	32.4 [30.5-37.0]
Eastern Mediterranean	2016	18+ years	34.9 [32.1-39.2]	26.9 [25.4-30.6]	43.5 [41.4-46.6]
Western Pacific	2016	18+ years	18.6 [16.5-23.5]	18.8 [16.3-25.1]	18.5 [15.5-27.3]

It is known that higher cardiorespiratory fitness reduces the risks of premature mortality and the incidence of cardiovascular and respiratory disease or even colorectal cancer[8]. In fact, a meta-analysis showed that an increase in VO_2max of 3.5 ml of O_2/kg*min^{-1} lower the risk of all-cause mortality of 13% and the risk of coronary heart disease and cardiovascular disease of 15% among general population[9]. Moreover, it has been identified that an increased VO_2max reduces the risk to suffer from hypertension, a major risk factor for heart disease and stroke. A recent report found that at least one third of adults in the United States suffer from hypertension[10]. Since VO_2max is considered a valid measure of cardiorespiratory fitness, it seems vital to improve indirect formulas as it could become an important prevention tool for symptomatic patients in rehabilitation as well as for sedentary, or overweight/obese individuals. Indeed, overestimation in VO_2max leads to inadequate exercise prescription and goals which increases the risk of drop outs. Accurately predicting energy expenditure and oxygen consumption may be pertinent to this population in order to prevent negative health events. It seems important to do so, given the worldwide increasing sedentary behaviors.

IMPROVE THE ASSESSMENT OF PHYSIOLOGICAL DEMAND ASSOCIATED WITH WORK TASKS, PERSONAL PROTECTIVE EQUIPMENT AND THE PHYSICAL PREPARATION OF THE TACTICAL PERSONNEL

Finally, better estimation of VO_2 could provide a better understanding of the physical conditions that tactical personnel need to complete their tasks while preserving their own health and safety. Indeed, they may be required to perform dynamic movements and/or strenuous exercise such as running or lunging while dealing with insecurity or violence. The level of energy deployed can make a difference on the performance achieved[11]. Also, some of those jobs require the use of personal protective equipment (PPE) to prevent injuries, but the performance would decrease on average by 1% for each kg of load added[12]. Moreover, the addition of a body armor while completing exercise increased the metabolic demand which could altered cognitive functioning. This suggests that exercise and body armor may influence one's ability to take tactical decisions[13]. Thus, it seems essential that the physical preparation of these workers be adequate in order to complete their tasks without posing too great of a risk to their health and safety. More precise results regarding VO_2 and VO_2max will entail better evaluations of jobs requirements and the impacts of PPE allowing proper preparation.

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EQUIPMENT UTILIZED

Vyntus CPX metabolic cart (Jaeger-CareFusion, Höchberg, Germany)

Treadmill (Cybex, USA)

Heart rate monitor with chest-strap (RS800, Polar, USA)

Balance scale (Seca, France)

Sphygmomanometer (Physio Logic, AMGMedical, Canada)