Assessment of Cardio-respiratory Fitness: A Study of Male Medical Students and Matched Controls from other Disciplines at Moi University.

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Declaration

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This thesis has been submitted for examination with my knowledge as the University supervisor.

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Dedication

To the women and men who have made a difference in my life: my sweet wife Njeri for tolerating an 'absentee' husband, my daughter Waithera born during my coursework for always waking me up to 'read', my mom Waithera and dad William Magutah for instilling the discipline of hard work in me, and to my brother Maina and his wife Lucy for their 'unreasonable' sacrifice throughout my high school and undergraduate studies.

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Abstract

Cardio-respiratory fitness (CF) is crucial to health among all age groups and high levels are attained following involvement in physical activity (PA). Its assessment involves measurement of physiological markers like heart rate (HR) and maximum oxygen uptake ($\dot{V}O_{2max}$). A $\dot{V}O_{2max}$ below 44 ml/kg/min in young adult males may lead to compromised health. Higher values are indicative of more favourable CF. The current descriptive cross sectional study aimed to compare CF among male university students based on their year of study, past exercise history and assumed knowledge of benefits of CF.

Forty (40) male students aged 18-25 years were randomly selected from the School of Medicine, with matched controls selected from other schools within Moi University. Upon filling a questionnaire on past PA and exercise, and passing a full physical examination, baseline cardio-respiratory functions of HR, blood pressure (BP) and lung function tests were measured. The HR was also assessed during the 20 m shuttle run test (SRT) and, together with BP, further measured at exhaustion and for the first five minutes during abscissa. The $\dot{V}O_{2max}$ was determined using beep test score calculator developed by Ramsbottom et al. (1988). Stata V 9 was used for analysis.

First year students from all programs had significantly higher $\dot{V}O_{2max}$ compared to their fourth year colleagues (44.7±4.8 vs 40.3±5.3 ml/kg/min, $p<0.001$). In addition, they had lower diastolic blood pressure (DBP) at exhaustion from SRT when compared to fourth years (57.3±13.3 vs 64.6±12.7 mmHg, $p=0.01$). Predictors of $\dot{V}O_{2max}$ included year of study, age, weight, baseline respiratory rate and HR, all showing negative correlations. Others included HR after first and second minutes into SRT, and DBP and HR after first and fifth minutes of rest respectively. There were positive correlations between $\dot{V}O_{2max}$

and tidal and inspiratory reserve volumes ($r = 0.37$, $p<0.01$ and $r = 0.45$, $p<0.001$ respectively) as well as the vital capacity ($r = 0.49$, $p<0.001$). Students who exercised, regardless of the regularity, had higher $\dot{V}O_{2max}$ compared to their sedentary colleagues (43.4±5.4 vs 38.6±4.1 ml/kg/min ($p<0.01$). They also had lower HR during 3rd to 6th minute of exertion in SRT, which was further evident after 5th minute of rest. Students who exercised regularly attained higher $\dot{V}O_{2max}$ (45.1±4.7 vs 41.0±5.5 ml/kg/min, $p=0.002$) than the less regular.

Overall, the students had below average fitness irrespective of their course of study. Fourth year students were less physically fit compared to their first year counterparts. Regardless of the frequency, students who exercised had lower HR in 3rd to 6th minute of SRT, and achieved higher $\dot{V}O_{2max}$ portraying that they were fitter than their sedentary counterparts. Likewise, students who exercised regularly had higher $\dot{V}O_{2max}$ compared to their colleagues.

There is need to encourage regular exercise regimes among university students. This is especially so for higher level students. Additionally, further research is needed to show how males compare with female in the same settings.

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List of Abbreviations

BP	Blood Pressure
CDCP	Centre for Disease Control and Prevention
CF	Cardio-respiratory Fitness
DAAD	Deutscher Akademischer Austausch Dienst (German Academic Exchange Service).
DBP	Diastolic Blood Pressure
HR	Heart Rate
IREC	Institutional Research and Ethics Committee
IRV	Inspiratory Reserve Volume
Kg	Kilogram(s)
M.A.S.L	Metres above Sea Level
ml/kg/min	Millilitres per Kilogram body weight per Minute
mmHg	Millimetres of Mercury
PA	Physical Activity
PF	Physical Fitness
RR	Respiratory Rate
SBP	Systolic Blood Pressure
SD	Standard Deviation
SV	Stroke Volume
SEM	Standard Error of the Mean
SRT	Shuttle Run Test
Stata	General-purpose statistical software
TV	Tidal Volume

VC	Vital Capacity
$\dot{V}O_{2max}$	The highest rate of oxygen consumption attainable during maximal or exhaustive exercises (maximal aerobic capacity).

Operational definitions

Regular exercise:	Involvement in at least three one-hour sessions of exercise per week.
Athletic subjects:	Those who report to engage in sports activities regularly (at least three one-hour sessions per week).
Sedentary lifestyle:	Not engaging in any known form of sports or exercise activities.
Physical activity:	Body movement produced by skeletal muscles and resulting in energy expenditure above the basal metabolism.
Physical fitness:	A level of health in which one has muscular endurance and strength, flexibility and cardiovascular endurance upon exertion.
Cardio-respiratory fitness:	Cardio-respiratory systems endurance upon physical exertion that involves skeletal muscles and energy expenditure.
Medical Students:	Subjects enrolled into the university to study Medicine.

Moi University:	The second largest university in terms of students numbers in Kenya, situated in Eldoret town in western part of the country
Heart rate:	The number of heartbeats per unit of time, usually a minute.
Blood pressure:	The measurable pressure exerted by circulating blood upon the walls of blood vessels, usually the arteries.
20 metre shuttle run test:	An indoors fitness assessment test that utilizes incremental nature of workloads (speeds) lasting approximately one minute in each of its 21 levels.

Chapter One

1.1 Introduction

Cardio-respiratory fitness (CF) is crucial to health among all age groups. It is part of the broader Physical fitness (PF) which further entails musculoskeletal endurance and lean body. Broadly, PF has benefits such as maintenance of lipid profile, regulation of blood pressure (BP) and control of cardiovascular ailments, the latter two crucial markers in CF (Miller and Allen, 1989; Ariel et al., 2005; AAPHERD, 1980; Palatini and Julius, 1997; Irazusta et al., 2006). High PF levels and subsequently better CF levels are attained following involvement in physical activity (PA) (Howley and Franks, 1997; ACSM, 1998; Ramsbottom et al., 2010), defined as any bodily movement produced by the contraction of skeletal muscles. This could be organised exercise or any other activities utilising the muscular system and the closely related cardio-respiratory functions pertaining to oxygen supply and utilization. The intensity of this energy expenditure is usually expressed as a percentage of a person's aerobic capacity - percentage of maximal oxygen uptake ($\dot{V}O_{2max}$) (Haskell and Kiernan, 2000; Howley and Franks, 2003).

1.1.1 Youth and PA

With increasing age, there is a decline in PA that occurs throughout adolescence and early adulthood (Caspersen et al., 2000; Sallis et al., 2000). This is a cause for concern because physical inactivity in youth and young adults is associated with increased risk factors for ill health (Getchell et al., 1998; Janz et al., 2002, Powers et al., 2006). According to Centre for Disease Control and Prevention (CDCP) (2003), the United States of America (USA) records portray an increasingly less physically active society, with marked downturns in reported PA during adolescence and young adulthood (USA population reports are more readily available than in other countries). It has been observed that 60% of American adults avoid regular PA, and that nearly half of those aged 12-21 years fail to engage in regular vigorous activity, with the greatest decrease in participation occurring in late adolescence (Arlene et al., 2002). The rates fall from 66% to 29% among the 18-24 year-old age group. The 18-24 year age bracket mainly comprises college students. This group is faced with a challenge of lack of time for PA imposed by the demands of college work. Consequently, this has led to sedentary lifestyles which exemplify a trade-off between time spent on studies and on physical exercises (Caspersen et al., 2000; CDCP, 2003).

Population surveys in the USA further indicate that although the prevalence of potential illnesses of physical inactivity such as cardio-respiratory ailments has not been quantified in the population samples, only 33.6% of adolescents and 13.9% of adults are physically fit. The prevalence is 32.9% in adolescent males and progressively declines to 11.8% in adult male between 20 and 49 years old (Mercedes et al., 2005).

1.1.2. Assessment and components of PF

Assessment of PA is important for understanding its relationship with health, and in determining the effectiveness of necessary interventions. Techniques used broadly include behavioural observation, recall questionnaires, interviews, and measurement of physiological markers like heart rate (HR), BP and $\dot{V}O_{2max}$. Methods for these measurements include the use of laboratory based doubly labelled water calorimetry - a direct and excellent method of total energy expenditure and $\dot{V}O_{2max}$ estimation In addition, there are a variety of other less expensive methods such as cycle ergometer, treadmill test and the increasingly popular field methods like the 20 m Shuttle Run Test (SRT) (Speakman, 1997; ACSM, 1998).

The questionnaires show a low reliability and validity and are mainly reserved for application as activity-ranking instruments (Klaas, 2009). The direct determination of $\dot{V}O_{2max}$, on its part is time consuming and requires both expensive equipment and highly trained technicians, and is further impracticable for use with large groups (Jokl, 1958; Shephard, 1969). It utilizes the principle that after loading a dose of water labelled with the stable isotopes of Deuterium (^2H) and ^{18}O, ^2H is eliminated as water, while ^{18}O is eliminated as both water and carbondioxide. The difference between the two elimination rates measures carbondioxide production (Speakman, 1997). Field methods on the other hand are much cheaper than the doubly labelled water method, and are faster to employ compared to both the cycle ergometer and treadmill test because one can handle multiple subjects at a time. Further, field methods are coupled with the use of accelerometers to provide continuous information on body posture and activity allowing objective assessment of subjects' activity and levels of fitness. Accelerometers are electronic motion sensors with a major property of evoking a charge when deformed in a special direction. The magnitude of the resulting voltage is directly related to the extension of the deformation (Genvin et al., 1991). They are mainly worn at the chest level to not only detect the mechanical PA of the body but also the minute-by-minute HR changes.

In the assessment of PF, it is, for several decades now, an established fact that $\dot{V}O_{2max}$ is a critical physiological factor that plays an important role in the determination of physical work capacity and fitness under aerobic conditions (Astrand, 1956; Newton, 1963; Ribisl and Kachadorian, 1969). It is superior to any other single test for evaluating physical work performance and is the most accurate physiological measure of CF (Astrand and

Rodahl 1970; de Vries, 1975). Given the difficulties in the direct estimation of $\dot{V}O_{2max}$, formulae have been developed to indirectly estimate it by subjecting individuals to any of the field non-invasive fitness tests. Thus, it makes it possible to establish the PF level of a person. These tests include determination of $\dot{V}O_{2max}$ using the beep test score calculator developed from the tables published by Ramsbottom et al (1988) which are based on the highest level attained in the SRT protocol. It has an accuracy of within 0.1 ml/kg/min of directly determined $\dot{V}O_{2max}$ values.

1.1.3 Studies on cardio-respiratory fitness

There is a positive correlation between exercise and fitness status among individuals. According to Larsen et al (2003), while elite runners are able to reach very high $\dot{V}O_{2max}$ levels, the adolescent and post adolescent Kenyan males appear to only achieve lower percentages. Training and exercises have been associated with higher $\dot{V}O_{2max}$, which is a marker of CF. A Missouri study on college students at entry established that reported prior exercise habits correlated positively with estimated $\dot{V}O_{2max}$ (Peterson et al., 2003).

It is an accepted criterion that $\dot{V}O_{2max}$ below 44 ml/kg/min in young adult males may lead to compromised health and fitness (http://www.topendsports.com/testing/vo$_2$norms.htm). Persons who have low levels of PA, low $\dot{V}O_{2max}$ and high levels of sedentary behaviour are more likely to have lower cardio-respiratory fitness (Russel et al., 2006). Accordingly, higher $\dot{V}O_{2max}$ is indicative of more favourable CF.

Theories on CF and PA behaviour have argued that influences from settings or neighbourhoods, in addition to those related to the individual and the immediate environment (King et al., 2002) affect the fitness level of a person. In particular, the "social ecological" model posits that individual behaviour patterns are influenced not only by ability and experiences but also by the social and physical environment, which are often shaped by social policies (Sallis and Owen, 1997). Similarly, the "behaviour settings" model supports that within defined physical locations, environmental factors can either facilitate or constrain specific behaviours (Owen et al., 2000). Applied to a learning institution, this suggests that if the 'environmental' support for PA exists, students will be more physically active and possibly be physically fitter. In fact, positive associations have been reported between PA levels of students and their social environment (Gillander and Hammarstrom, 2002). Other studies support that environmental variables are associated with PA (Booth et al., 2001; Craig et al., 2002; Giles-Corti and Donovan, 2002; Humpel et al., 2002; Sallis et al., 2002; and Merom et al., 2003).

In this relation, several predictors of PA and the associated CF have been established. Studies have shown that academic study time is associated with fewer opportunities for PA (Tracie et al., 2006) and this may often be the case where students have much work-load that they opt to forgo physical exercises. Others have however argued that competing demands on time such as hours of homework is unrelated to participation in vigorous PA (Kenneth et al., 1999). Studies on the patterns and the determinants of PA in the quest to reduce sedentary behaviour have indeed positively associated the level of education with activity level. Yet, studying college populations yield a profile of low leisure-time PA and a prevalence of "very poor" aerobic fitness levels (Ainsworth et al., 1992). Older students have also been found to less likely engage in PA (Kenneth et al., 1999), perhaps because of increased academic and social demands.

It has further been found that knowledge of benefits of CF does not necessarily translate to higher exercise levels and fitness (Kiss et al., 2009). In a study on cardio-pulmonary efficiency among Indian medical students and state level athletes following graded exercise on a treadmill, higher $\dot{V}O_{2max}$ was observed in athletes (Das and De, 1991). This is despite the fact that medical students are expected, being aware of the benefits of PF, to have regular exercise and therefore higher $\dot{V}O_{2max}$, indicative of higher CF levels. Among Nepalese medical students, proportions with poor, average, good, very good and excellent fitness were 10.4%, 23.6%, 39.6%, 17.9% and 8.5%, respectively (Pramanik and Pramanik, 2001). This clearly shows that 73.6% of these students did not appear to have been influenced by their medical exposure to elevate their fitness levels.

A study on the level of aerobic capacity in 5th-year medical students of mean age 22.3±0.7 years and average body weight 56.8±11.9 kg in Thailand found that the average $\dot{V}O_{2max}$ of the students was 38.1±8.6 ml/kg/min. Sixty five percent (65%) of these students exercised 0-1 sessions per week and had a $\dot{V}O_{2max}$ of 36.5±8.4 ml/kg/min, 24.3% exercised 2-4 sessions weekly and their $\dot{V}O_{2max}$ was 40.3±9.1 ml/kg/min, and only 10.7% exercised >4 sessions per week or everyday and had a corresponding $\dot{V}O_{2max}$ of 43.2±8.4 ml/kg/min. Further, they were compared to the standard $\dot{V}O_{2max}$ values of the Thai general population and 39.4% categorized in low health fitness group, 40.7% in the health fitness group, and only 19.9% were in the high health fitness group (Tongprasert and Wattanapan, 2007).

In Kenya, while elite runners are able to reach very high $\dot{V}O_{2max}$ levels, the adolescent and post adolescent males *only* achieve lower percentages. However, no national survey has been carried out in the country but it appears that increasing sedentary lifestyles may be a contributing factor (Larsen, 2003).

It has also been demonstrated by Saltin et al (1995) that it is PA combined with regular training that brings about the high $\dot{V}O_{2max}$. This was clearly observed in studies involving Kenyan runners and their male counterparts leading a sedentary lifestyle. Untrained Kenyan males (14.2±0.2 years) at altitudes approximately 2,000 m.a.s.l have a mean $\dot{V}O_{2max}$ of 47 (44-51) ml/kg/min. Similarly aged males who exercise regularly but not training for competition attain $\dot{V}O_{2max}$ of 62 (58-71) ml/kg/min. On the other hand, Kenyan runners in active training have been shown to have $\dot{V}O_{2max}$ values of up to 68±1.4 ml/kg/min at 2,000 m.a.s.l and 79.9±1.4 ml/kg/min at sea level. A few of them reach levels of up to 85 ml/kg/min.

Further studies (Larsen et al., 2004) have compared untrained Nandi males of mean age 16.6 years from town setting (sedentary lifestyle) and those from rural areas (walk or run to school) in western Kenya at altitude of approximately 2000 m.a.s.l. These have shown that those from town dwelling have a mean $\dot{V}O_{2max}$ of 50 (45-60) ml/kg/min, whereas their village counterparts reach up to 55 (37-63) ml/kg/min ($p<0.01$). Those with higher $\dot{V}O_{2max}$ have been shown to spend significantly higher time in daily physical and sports activities. Similarly, there was a positive correlation between the time spent daily doing sports and $\dot{V}O_{2max}$ when the data from the town and the village males were pooled.

The response to endurance training on physiological characteristics has also been demonstrated to effectively increase $\dot{V}O_{2max}$ and therefore CF. Another study in western Kenya (Nandi district) involving town (sedentary) and village dwellers (circumstantial exercises) aged 16.5 and 16.6 years respectively found that 12 weeks of running exercise training significantly increased $\dot{V}O_{2max}$ in both town (from 50.3 to 55.6 ml/kg/min) and village dwellers, (from 56.0 to 59.1 ml/kg/min). Increase in $\dot{V}O_{2max}$ in both groups shows the benefits of exercise on increasing $\dot{V}O_{2max}$ and levels of fitness (Larsen et al. 2005).

1.1.4 Tools and study aim

The 20 m SRT was designed and validated by Leger and Lambert (1982) to be completed indoors using workloads (speeds) lasting approximately one minute in each of its 21 levels. It is used to estimate an individual's $\dot{V}O_{2max}$ and is an accurate test for CF, one of the all-important 'components of fitness'. It is a progressive test and utilizes a pre-recorded sound signal to dictate running speed from 8.0 km/h in level one to a maximum of 18.5 km/h in level 21, by decreasing the interval between beeps. The incremental nature of the test ensures a gradual increase in work rate. A sequential lap scoring technique is used. Subjects run to exhaustion while maintaining cadence, i.e. reaching the end of the 20 m course in unison with the tape signal. The 20 m course is run on flat surfaces with a continuous multistage protocol. Equipment involved include a pre-recorded audiotape or CD which plays beeps at set intervals, a 20 m measuring tape and recording sheets. Additionally, the facility used should be indoors and have a flat non-slip surface. Preparations for SRT involve arrangement of cones 20 metres from each other, setting up the pre-recorded audio CD and demonstrating to the subjects how the protocol works.

SRT involves continuous running between two lines 20m apart in time to recorded beeps, for which reason the test if also often called 'beep' or 'bleep' test. The test subjects stand behind one of the lines facing the second line, and begin running when instructed by the

CD or tape. The speed at the start is normally 8.5 km/hr, and the subject continues running between the two lines, turning when signalled by the recorded beeps. After about each one minute interval, the sound indicates an increase in speed, usually by 0.5 km/hr, and the beeps will be closer together. If the line is not reached in time for each beep, the subject must run to turn to try catch up the pace within two more beeps. Also, if the line is reached before the beep sounds, the subjects must wait until the beep sounds. The test is stopped if the subject discontinues self, citing exhaustion or if the subject fails to maintain cadence with the beeps twice in a row. Scoring is based on the level of the SRT protocol (Appendix 3) reached, from which the Rambsbottom et al (1988) beep score calculator is employed.

The SRT has been concluded a valid proxy for predicting laboratory $\dot{V}O_{2max}$ and is sufficiently reliable in healthy male adults. It has been demonstrated to give $\dot{V}O_{2max}$ values at a correlation of above $r = 0.95$ ($P<0.001$) when compared to a treadmill test, giving a prediction error of only -0.3 ± 3.3 ml/kg/min with a coefficient of variation of $\pm3.5\%$ (Metsios et al., 2008).

Evidently, the increasingly physical inactivity - sedentary lifestyles - pose a great challenge to health. In addition, there are already known ill effects of being physically unfit. The present study, by use of a 20 m SRT, aimed to assess various CF parameters amongst university students based on their year of study, past exercise history and *assumed* exposure to benefits of being physically fit.

1.2 Statement of the problem

Physical inactivity and sedentary lifestyle are risk factors for cardiovascular disease. While the university students are key to realization of the Kenya's development blue print vision 2030, they bear a heavy workload in their studies and the increasing social demands across the years of study lead them to often forgo important PA and training exercises. Even where they are exposed to the knowledge about the benefits of CF like in medical schools, it is likely that their fitness levels may not be any better. Further, Kenya is currently facing a rapid PA transition which is likely to lead to an increase in preventable chronic non-communicable diseases and hence the need to assess the CF of university students.

1.3 Justification

- It is known that older students (increased academic and social demands) are less likely to engage in PA (Kenneth et al., 1999). However, it is not clear the magnitude of this effect on their levels of CF.
- Studies that have established associations between PA levels of students and their social environment (Booth et al., 2001; Gillander and Hammarstrom, Craig et al., Giles and Donovan, Humpel et al., Sallis et al., (all 2002); and Merom et al., 2003) have not attempted to show its magnitude on various parameters of PF.
- It has previously been observed that with sedentary lifestyles, students have reduced CF (Caspersen et al., 2000; CDCP, 2003). However, this has not been documented in Kenys and it is unclear how it compares with findings elsewhere.
- Although previous studies have compared PF parameters of medical students with data from national level athletes (Das and De, 1991) and the general population (Tongprasert and Wattanapan, 2007), none has compared them to their closest match - fellow students.

- Moi university was selected for the study being a public university with students from all parts of the country hence representation of all regions, and fact that it is strategically located at the heart of the Rift Valley province of Kenya, known to produce most of the professional athletes the country is known for. It was also convenient given that the researcher worked there.

1.4 Null Hypothesis

University students, irrespective of their level of study, past history of physical exercise or study course have similar CF parameters.

1.5 Research questions

1. What changes occur in CF among students between the first and fourth year of study at the university?
2. How does past exercise history affect CF among university students?
3. How do various parameters of CF among medical students compare with those of their non-medical counterparts?

1.6 Objectives

1.6.1 General objective

To compare CF among university students based on year of study, past history of physical exercise and assumed knowledge of benefits of PF.

1.6.2 Specific objectives

1. To estimate the CF status of the study subjects using a 20 m SRT.

2. To correlate cardio-respiratory functions of BP, HR and lung volumes with $\dot{V}O_{2max}$ amongst the study subjects.
3. To characterize CF amongst students based on past history of physical exercise.
4. To establish changes in CF between university students in the first and fourth years of study.

Chapter Two

2.1 Methodology

2.1.1 Study site:

Moi University, Eldoret, Kenya, situated at an altitude of 2000 m.a.s.l.

2.1.2 Study population:

The study population comprised male students from Moi University School of Medicine and matched controls (for age and year of study) drawn from other non-health related schools. Since various cardio-respiratory parameters are clearly different between males and females, the study chose to focus on one of the two genders, opting for the males. Further, medical students are assumed to be more knowledgeable about the benefits of being physically fit given their curriculum scope and therefore a good cohort to study, with controls from non-medical students.

2.1.3 Study design:

This was a descriptive cross-sectional study. It gives a *snapshot* on CF amongst Moi university students between January and April 2010 when data was collected.

2.1.4 Sampling procedure:

Subjects were randomly sampled from first and fourth years of study. This was advised by fact that most undergraduate studies are completed after the fourth year level, giving a good criterion for çomparison based on year of study. Using class registers, registration numbers were subjected to a random selection by an independent ballot for each first twenty students per class and school. All consented and met the inclusion criteria.

Inclusion criteria: Healthy adults aged 18-25 years and a normal physical examination. This is the expected normal age bracket for students in undergraduate studies in Kenya.

Exclusion criteria: Subjects with cardio-respiratory or any physical injuries, a smoking history, or who drunk ≥35 units of alcohol per week (8g/10ml of alcohol equivalent to one unit). Five hundred (500) ml Kenyan Tusker beer brand has 2.8 units of alcohol; an equivalent volume of Busaa has 21.25 (Papas et al., 2008).

2.1.5 Sample size:

Eighty (80) male students were recruited. Data on the proportions of students and/or general population on CF in the country that could be employed to determine the sample size were unavailable. In addition, assuming that 50% participated in PA/exercise and had favourable CF could have yielded an unrealistically high sample size for the kind of study (using Fischer's method of sample size determination). Further, since several related studies have used samples of 30 or less (Paliczka et al., 1987; Das and De, 1991; Larsen et al., 2004; Cooper et al., 2005 and Larsen et al., 2005) with good results, 80, being a more realistic and achievable sample size was settled at.

2.1.6 Data collection:

A questionnaire on reported PA and physical exercise patterns was administered (Appendix 1). Participants were asked to wear appropriately for the exercise protocol, by putting on sports shorts, t-shirts and shoes. They were thereafter subjected to a full physical examination to exclude any underlying medical conditions and physical disabilities. Height and weight measures (using a heightometer and a mechanical scale (CAMRY Mechanical scale, BR9012, Shanghai, China), respectively were then recorded after having subjects remove their shoes and any heavy clothing, and before subjects could start the running protocol. Height was taken in centimetres whereas units used for weight were kilogram. Both were entered into the questionnaire. Further, before starting the 20 m SRT protocol, baseline BP measurements of all subjects were taken using a Mercury Sphygmomanometer (EKRA Erkameter 3000, Germany). Respiratory rate (RR) and various lung functions were also measured using a spirometer (Spirosift SP-5000, Fukuda Denshi, Japan). These included the tidal volume, inspiratory volume and vital capacity, Additionally, the HR was also determined at the baseline and continuously during the test using an ActiTrainer™ accelerometer (Actigraph, Pensacola, FL, USA), which were tied at the chest level to accurately detect any deviations courtesy of voltages generated at the heart level and depicted as the HR. This type of accelerometer, unlike the previous makes is able to record HR on a continuous basis. This data was later downloaded into the computer as continuous data. Upon withdrawal from the run test, the $\dot{V}O_{2max}$ was determined using the beep test score calculator and based on the level reached in the protocol. During the recovery phase, HR and BP measurements were further taken at intervals of one minute for five minutes.

The beep test score calculator was developed by Ramsbottom et al (1988). It has an accuracy of within 0.1 ml/kg/min of the published $\dot{V}O_{2max}$ values, and is used following a 20 m SRT protocol (Appendix 3). The 20 m SRT is designed to be completed indoors, away from external noise disruptions of the field since it employs sound signals. Further, the floor is more even indoors. It utilizes incremental workloads (speed) lasting approximately one minute in each of its 21 levels. It also utilizes pre-recorded sound signal to dictate running speeds from 8.0 km/h in level one to a maximum of 18.5 km/h in level 21, by decreasing interval between beeps. The incremental nature of the test ensures gradual increase in work rate. Subjects run to exhaustion while maintaining cadence. The run test is terminated either at the point participants fail to cope with beeps twice in a row, signifying exhaustion, or when they subjectively withdraw citing exhaustion.

2.1.7 *Data management and analysis:*

Stata version 9 was used for analysis. Measures of association (Pearson correlation coefficient) were performed to establish associations between students' cardio-respiratory functions and their respective CF. A t-test was performed for equality of $\dot{V}O_{2max}$ and for measures of HR and BP during recovery period in each two groups, enabling comparison of levels of CF. Data were presented as means. Standard error of the mean (SEM) and standard deviation (SD) were considered where appropriate. A $p<0.05$ was considered significant.

2.1.8 Ethical considerations:

The purpose of the study was explained to the participants before seeking their signed consent. They were informed of their right to withdraw at any stage of the study if they needed to. Personal information and data collected were kept in confidence and only used for the study purposes. A first aid kit and a qualified first aider remained available throughout the data collection process. Further, approval to carry the study was obtained from Moi University IREC before initiation of the study.

Chapter Three

3.1 Results

3.1.1 Bio-demographic characteristics

All students in first year from different schools had similar bio-demographic data. A similar pattern was observed in the fourth year of study except for baseline HR which was higher amongst medical students (76.2±8.1 vs 72.0±4.1 bpm, p = 0.02). Age, height, weight, BP and lung function tests showed no differences within the same year of study. Table 1 summarizes the mean bio-demographic data of the study subjects.

Table 1 Bio-demographic data of subjects (Mean ± S.D)

Variable	*First year*		*Fourth year*	
	Medical	*Other schools*	*Medical school*	*Other*
Age (years)	19.7 ±0.9	19.9±1.1	23.0±0.5	23.1±0.7
Height (cm)	180.3±6.9	177.0±5.8	175.2±8.3	176.1±6.8
Weight (kg)	65.8±7.2	64.2±6.9	63.4±7.7	66.6±7.2
Baseline HR (bpm)	72.4±2.7	71.0±3.4	76.2±8.1*	72.0±4.1
Baseline SBP (mmhg)	111.6±8.8	113.8±7.3	114.4±5.9	114.2±8.4
Baseline DBP (mmhg)	72.2±6.2	71.6±7.2	74.1±6.0	72.3±7.7
Baseline RR (bpm)	15.0±1.0	15.2±0.9	15.6±1.2	15.3±0.7
TV (litres)	0.5±0.1	0.5±0.01	0.5±0.1	0.5±0.02
IRV (litres)	3.1±0.1	3.1±0.1	3.1±0.2	3.1±0.1
VC (litres)	4.8±0.2	4.8±0.2	4.7±0.3	4.7±0.1

DBP, diastolic blood pressure (BP); HR, heart rate; IRV, inspiratory reserve volume; RR, respiratory rate; SBP, systolic BP; TV, tidal volume; VC, vital capacity.
*p<0.05.

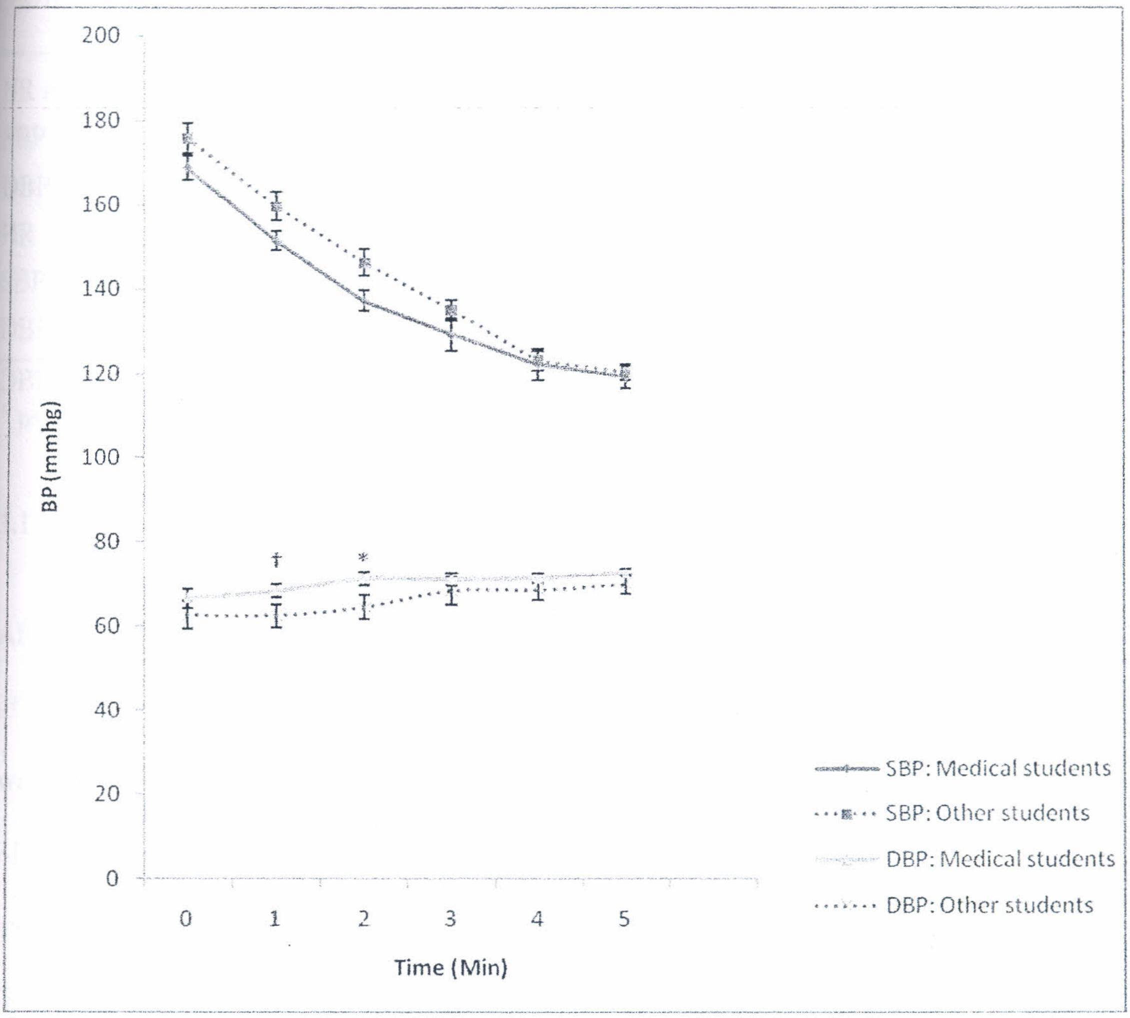

Figure 1 Comparison of BP during abscissa period for students from different disciplines of study. Error bars represent SEM.
†p = 0.03, *p = 0.02.

When the cardiovascular variables of HR, SBP and DBP were compared between students categorised in first and fourth years in pooled data, only DBP at exhaustion showed a significant difference in the mean values as shown in Table 2.

Table 2 Comparison of cardiovascular measures in different years of study (Mean ± S.D).

Variable	*First year*	*Fourth year*	P value
HR at exhaustion (bpm)	188.6± 9.0	189.5± 9.4	0.69
SBP at exhaustion (mmhg)	168.5± 16.4	172.4± 14.6	0.26
DBP at exhaustion (mmhg)	57.3± 13.3	64.6± 12.7*	0.01
HR after 5 minutes (bpm)	106.5± 87.8	109.7± 10.1	0.12
SBP after 5 minutes (mmhg)	115.7± 11.3	119.9± 9.9	0.08
DBP after 5 minutes (mmhg)	70.1± 6.4	71.4± 8.0	0.44

DBP, diastolic blood pressure; HR, heart rate; SBP, systolic blood pressure.
* $p<0.05$, year 1 versus year 4.

3.1.3 Correlates of $\dot{V}O_{2max}$

After subjecting participants to the 20 m SRT, predictors of CF were analysed predictors of CF. They included various bio-demographic factors namely year of study, age and weight, and baseline cardio-respiratory measurements during and immediately after the SRT (Table 3).

Table 3 Correlations of various variables and $\dot{V}O_{2max}$ (n=80).

Variable	Pearson's	P value
Year of study	-0.40	<0.01
Age (years)	-0.41	<0.01
Weight (kgs)	-0.23	0.04
Baseline RR(bpm)	-0.49	<0.001
TV (litres)	0.37	<0.01
IRV (litres)	0.45	<0.001
VC (litres)	0.49	<0.001
Baseline HR (bpm)	-0.25	0.02
HR after 1 min run (bpm)	-0.31	<0.01
HR after 2 min run (bpm)	-0.30	0.01
HR after 5 min rest (bpm)	-0.48	<0.001
DBP at exhaustion (mmhg)	-0.27	0.01
DBP after 1 min rest (bpm)	-0.25	0.03

HR, heart rate; DBP, diastolic blood pressure. TV, tidal volume; IRV, inspiratory reserve volume; VC, vital capacity.

3.1.4 Characterization of CF markers based on exercise history

Mean $\dot{V}O_{2max}$ of students who reported to have exercised at least once in the past three weeks (n=66) differed from that of those who had not exercised at all (n=14). The physically active group achieved higher $\dot{V}O_{2max}$ compared to their colleagues who did not exercise (43.4±5.4 (SEM 0.67) vs 38.6±4.1 (SEM 1.09) ml/kg/min, $p<0.01$). When the data were disaggregated into the year of study, first years who reported to physically exercise over the past three weeks (n=36) posted a $\dot{V}O_{2max}$ of 45.2±4.8 against 40.9±3.7 ml/kg/min ($p=0.04$) for those who had not (n=4). A similar pattern was observed amongst the fourth years, where physically active students (n=30) had higher $\dot{V}O_{2max}$ compared to colleagues (n=10) who did not exercise (41.2±5.5 vs 37.8±4.1 ml/kg/min, $p=0.04$).

Further, 55.6% (20) first and 60% (18) of the fourth year students reported regular physical exercise (at least three one-hour sessions per week) while 44.4% (16) of the first and 40% (12) of fourth year students had had less regular patterns. The first years who were physically active had higher $\dot{V}O_{2max}$ levels compared to their irregularly exercise colleagues (47.0±4.5 vs 42.9±4.2 ml/kg/min, $p=0.01$). A similar pattern was noted amongst the fourth years with $\dot{V}O_{2max}$ values of 43.0±4.16 against 38.5±6.3 ml/kg/min ($p=0.02$) in favour of those who exercised regularly. Pooling the data maintained the same pattern of higher $\dot{V}O_{2max}$ for those who exercised regularly (45.1±4.7 vs 41.0±5.5 ml/kg/min, $p=0.002$). This is illustrated in Figure 2.

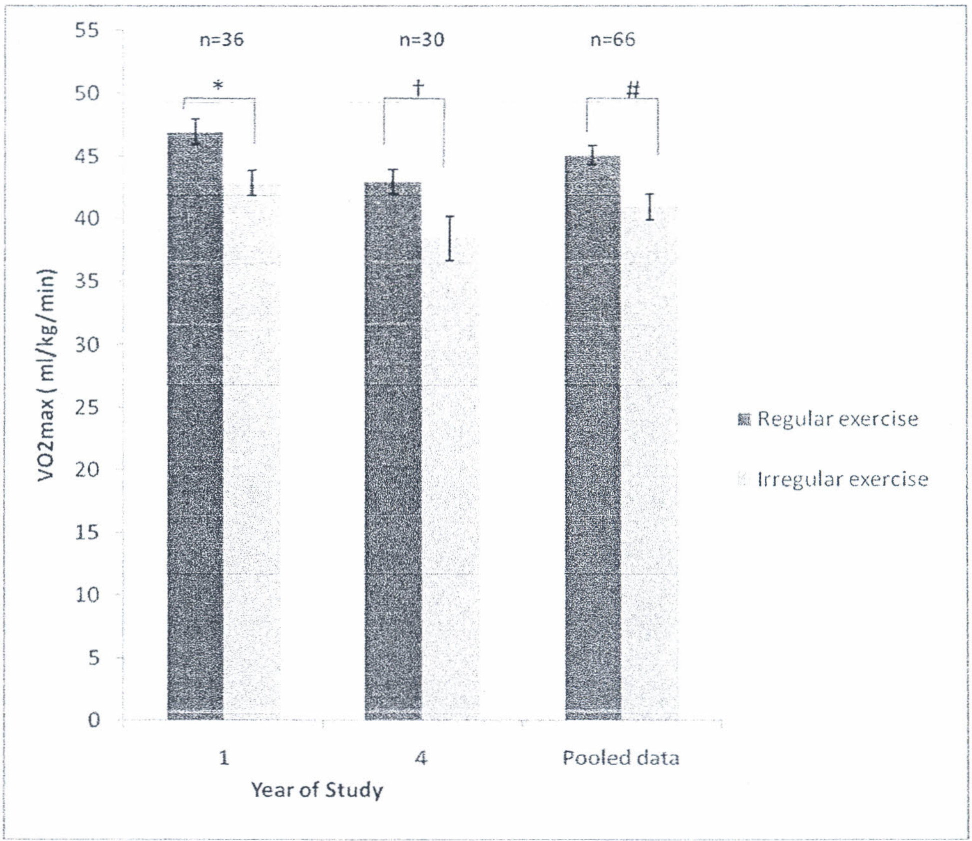

Figure 2 $\dot{V}O_{2max}$ levels attained by subjects based on reported frequency of exercise. Error bars represent SEM.
*p=0.01, †p=0.02, #p=0.002

The baseline RR was significantly lower among students with regular compared to those with irregular exercise (15.0±0.9 vs 15.6±1.1 b/m, p = 0.01). There was no cardiovascular variable either at the baseline, during the test or the subsequent rest period that was statistically different between the two groups. However, as shown in Figure 3, comparing students on the basis of whether or not they were involved in at least one session of exercise in the past three weeks showed significantly lower HR during the 3rd to 6th minute of the shuttle run for those reporting involvement in exercise, regardless of the regularity. They also had their HR significantly lower after the 5th minute of rest compared to their colleagues who did not exercise (106.9±9.0 vs 113.6±7.4 bpm, p = 0.01). No other variable showed significant difference in these students.

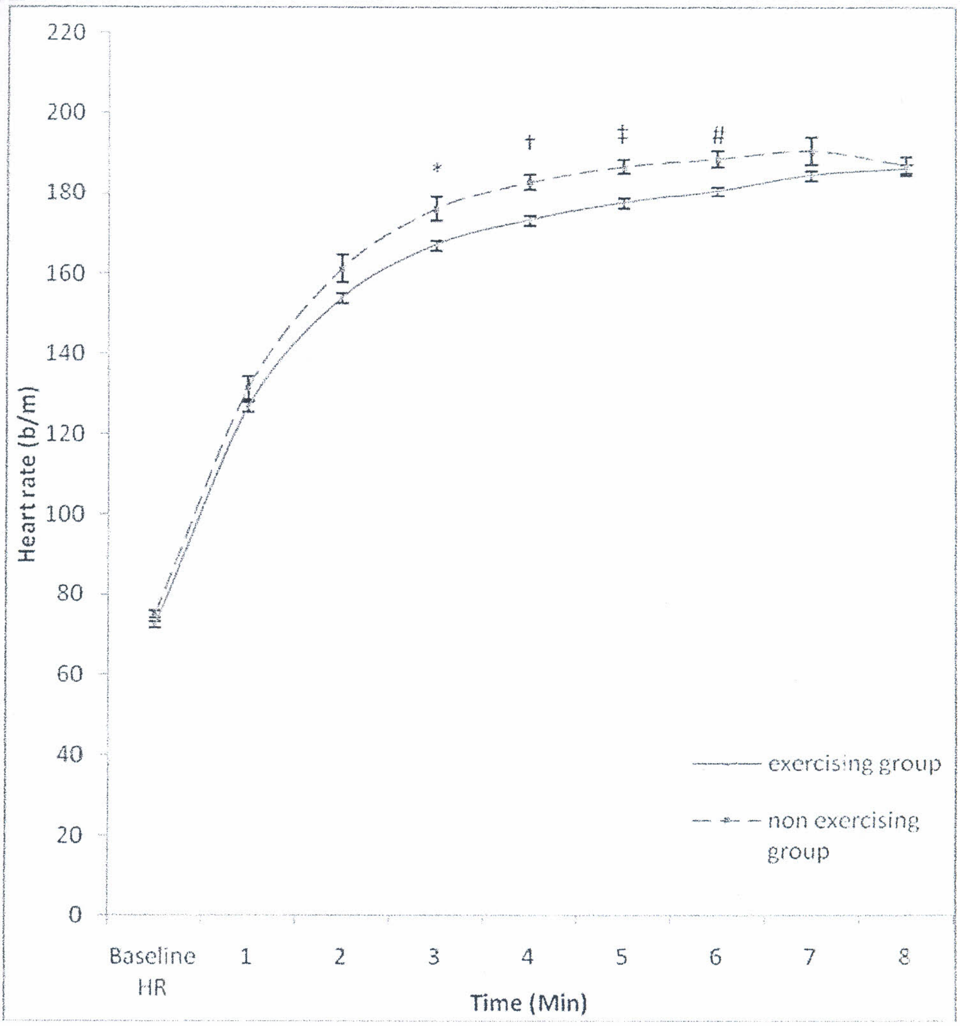

Figure 3 Comparison of HR during SRT based on reported exercise activities in the last three weeks. Error bars represent SEM.
*p=0.02, †p<0.01, ‡p=0.01, #p=0.02

Chapter Four

4.1 Discussion

Assessment of PA is important for understanding its relationship with health. A clear correlation between PA and fitness status exists among individuals. With similar bio-demographic characteristics but different levels of exposure and participation in PA, subjects would be expected to portray different fitness levels. In the present study, there was homogeneity in the baseline bio-demographic data for all students in the same year of study irrespective of their courses and schools. The only significant difference was in the baseline HR amongst fourth year students, where those from the School of Medicine had higher values. This homogeneity enhanced comparison after the run test.

4.1.1 Study findings and mechanisms.

Students in the fourth year of study had significantly lower $\dot{V}O_{2max}$ compared to their first year colleagues, regardless of the school they were drawn from. The $\dot{V}O_{2max}$ for first years in the pooled data was significantly higher than that of the fourth years, which suggests a decline in PF levels amongst the latter group. Their mean $\dot{V}O_{2max}$ was lower-than-average of 44 ml/kg/min for their age (http://www.topendsports.com/testing/vo2norms.htm), which may lead to compromised fitness. Further, the DBP for the fourth years at exhaustion was significantly higher than that of the first year students. These show lower CF among the fourth year students. Previous studies (Caspersen et al., 2000; CDCP, 2003) suggested that increasing college-work demands across the years of study may be contributing to the lower fitness levels among students in higher years of study due to fewer opportunities for PA (Tracie et al., 2006).

It has previously been shown (Kenneth et al., 1999; Caspersen et al., 2000; Sallis et al., 2000) that older students are less likely to engage in PA, perhaps because of an increase in academic and social demands. This is a likely reason for not only the lower $\dot{V}O_{2max}$ when compared to their first year counterparts, but also their below average $\dot{V}O_{2max}$ levels for their age, and the corresponding higher DBP at exhaustion. It is known that PA helps to maintain normal lipid profile and regulate BP through its effect on blood vessel elasticity (Palatini and Julius, 1997; Ariel et al., 2005; Irazusta et al., 2006). Therefore, the less active older subjects are likely to have higher lipid deposition in their blood vessels, thus reducing vessel elasticity. This is a likely contributor to the higher DBP at exhaustion when metabolic demand in the tissues is maximal.

Students undertaking Medicine in their fourth year of study may be assumed to be more knowledgeable about the importance of PF due to the scope of the medical school curriculum. They, however, achieved a below average $\dot{V}O_{2max}$ during exercise. Tongprasert and Wattanapan (2007) previously demonstrated a similar below average fitness level amongst 5th year medical students in Thailand. For most healthy young men, there is enhanced early DBP decay during and immediately following exercise which allows stroke volume (SV) to increase despite an increase in diastolic viscoelastic resistance and chamber stiffness (Nonogi et al., 1988). The higher DBP in the first two minutes of the abscissa among the medical students thus implied poorer fitness when compared to subjects undertaking other disciplines of study. It seems reasonable to suggest that (assumed) knowledge on the benefits of being physically fit may not necessarily lead to the quest for PF. It should be noted, however, that the present study did not test attitudes to PA.

Various variables correlated with the CF levels of students. The year of study, age and body weight correlated negatively with $\dot{V}O_{2max}$. This may, to some extent, be attributed to the fact that increasing age, ia associated witha notable decline in PA (Caspersen et al., 2000; Sallis et al., 2000). Physical activity and regular exercise are necessary for improved fitness status primarily by enhancing maximal oxygen uptake among individuals (Larsen, 2003).

Respiratory variables also showed correlations with the PF of the study participants. Tidal volume, inspiratory reserve volume and vital capacity correlated positively with $\dot{V}O_{2max}$. Accordingly, students with higher lung volumes and more capacities were more likely to be physically fitter compared to their colleagues with lower lung functions. Previous studies have shown that lung function parameters have a positive relationship with regular exercise, and that regular exercise increases pulmonary capacity (Wasserman et al., 1995; Twisk et al., 1998). Results in the present study further indicated that baseline RR had a negative correlation with $\dot{V}O_{2max}$, such that subjects with higher baseline RR were less fitter compared to their colleagues with lower values. It may be possible that the higher RR may compromise $\dot{V}O_{2max}$ by reducing arterial oxygen partial pressure due to the shorter gaseous exchange time at the respiratory membrane. Even though a large safety factor exists (time red blood cells remain in alveolar capillaries), the alveolar oxygen tension is reduced by increased RR so that only a smaller amount of oxygen is available to diffuse and be bound to haemoglobin.

Liang et al (1993) identified resting BP as the sole significant cardiovascular predictor for $\dot{V}O_{2max}$. The present study, however, suggests additional predictors. There was significant negative correlation between $\dot{V}O_{2max}$ and the HR after the first two minutes of the SRT protocol; students with higher rates were more likely to be less physically fit. This shows that students whose HRs are higher immediately following exertion achieve less $\dot{V}O_{2max}$ compared to their colleagues with lower rates and are therefore less fitter. The same trend, higher HR for students with lower $\dot{V}O_{2max}$ was observed after five minutes of rest from the SRT, such that the drop in HR was slower for the less physically fit. Additionally, a correlation was demonstrated between $\dot{V}O_{2max}$ and DBP immediately following the test. The DBP at exhaustion and after the first minute of rest showed a negative correlation to $\dot{V}O_{2max}$. The present results however did not demonstrate a significant correlation between SBP and $\dot{V}O_{2max}$. Thus, students whose DBP was lower were considered physically fitter. This is in agreement with Nonogi et al (1988) who demonstrated that the DBP decay during and immediately following exercise allows SV to increase. An increase in SV is necessary for exertion endurance in fitness. Froelicher and Myers (2006) have previously shown that BP responses to dynamic exercise in normal subjects include either a decrease (mainly) or no change in DBP, a progressive increase in SBP and a widening of the pulse pressure.

Mean $\dot{V}O_{2max}$ for students who reported to have exercised at least once in the past three weeks was significantly higher than values from their colleagues. Reported prior physical exercise was related to $\dot{V}O_{2max}$ amongst the students. This remained true even when data were disaggregated into years of study. Separately, the first and fourth year students who reported to have exercised over the past three weeks had higher $\dot{V}O_{2max}$ compared to their colleagues who had not. Previous studies at similar altitudes of 2000 m.a,s,l (Larsen, 2003; Peterson et al., 2003) demonstrated a similar pattern of lower $\dot{V}O_{2max}$ among the more sedentary individuals. These present findings underscore the value of PA even at suboptimal level.

When data based on regularity of exercise, students who exercised regularly (at least three one-hour sessions per week) had higher $\dot{V}O_{2max}$ compared to their colleagues who did not. The $\dot{V}O_{2max}$ amongst first year students who exercised regularly was even higher when compared to those who exercised less regularly. Higher levels of fitness than in the pooled data in both categories could be attributed to their relatively younger age since the fourth year subjects attained lower values than those of the pooled data. Fourth year subjects who engaged in regular physical exercise had significantly higher $\dot{V}O_{2max}$ than their less colleagues who exercised less regularly, maintaining the trend observed amongst the first year students. This shows that irrespective of the age and year of study and its associated workload, the more subjects engage in regular exercise the more they are likely to raise their $\dot{V}O_{2max}$. Similarly, Larsen et al (2004) showed that subjects who attain higher $\dot{V}O_{2max}$ at similar altitude as the present study spend significantly higher mean time daily in physical and sports activities.

Students with reported involvement in exercise activities had significantly lower HRs from the 3rd to 6th minute of the SRT. It was only after three minutes in the shuttle run that a difference in HR was demonstrable basing on whether or not students exercised. This increase is in the quest to increase cardiac output which is a derivative of HR and SV, both of which increase differently in subjects depending on their exercise regimes. It has previously been shown, for instance, (McArdle et al., 2000; Wilmore and Costil, 2005) that subjects who exercise have less stiff blood vessels due to less fat deposits which, with increased skeletal muscle tone and sympathetic stimulation during exercise, increase venous return by reducing peripheral resistance and thereby increasing SV. Accordingly, subjects who do not exercise, on the other hand are more likely to increase their cardiac output upon endurance exertion mainly by significantly raising their HR as opposed to a higher rise in SV. It seems logical to suggest that it takes about three minutes to demonstrate the difference in how the body adjusts to meet rising metabolic needs while studying subjects based on whether or not they participate in PA.

It appears that after the 3rd minute of exercise, the difference in adjustment of the various body systems to meet the increasingly rising metabolic needs becomes more elaborate depending on the exercise regime. This is in order to increase the cardiac output to cater for the increasing demands during exertion. Nonogi et al (1988) similarly demonstrated that the body adjusts the various factors that increase cardiac output during exercise, which is necessary for exertion endurance in fitness. By the 4th minute into the SRT, the body systems for students who do not exercise appear to be such stressed that the HR must more significantly rise above that for their colleagues who undertake physical exercise. This difference remains clear but diminishes progressively after the 5th minute.

Given that there was no significant difference in the mean baseline HR before the test, it is evident that students who do not exercise have a higher increase in HR after the 3rd minute following physical exertion compared to their colleagues who do. It seems reasonable to suggest that the first 3-6 minutes are crucial in the adjustment of HR as a determinant of cardiac output among sedentary subjects compared to their colleagues who exercise. The higher increase in HR may contribute to the fact that they are only able to achieve lower $\dot{V}O_{2max}$. Subsequently, they are at a greater risk of compromised CF on exertion as opposed to their colleagues who exercise, who increase their cardiac output mainly by increasing SV.

4.1.2 Applications

In order to improve CF among university students, several applications may be derived from these findings. There is need to encourage not just physical exercise but the frequency of the same – to ensure regular exercise regimes among university students. Further, because the less active older students have higher DBP immediately following exertion, which would, according to Nonogi et al (1988) reduce SV necessary for exertion endurance in CF, higher level students should be encouraged to participate in PA.

4.1.3 Suggestions for further research

Further research needs to be done to see how males compare with females in this same context and setting with the quest to identify their predisposition to the ill-effects of being less physically fit. Studies comparing medical students to the state level athletes and to the general population are also recommended since they would give a clearer picture of the current state of health related physical fitness in the country, and form a better basis for recommendation of public health interventions.

4.1.4 Study limitations

The method used to estimate $\dot{V}O_{2max}$ (SRT), although valid and reliable (Leger and Lambert, 1982; Ramsbottom et al., 1988; Metsios et al., 2008) may have greater variability compared to the more direct measure – the doubly labelled water method (Speakman, 1997). Another limitation that could not be addressed using SRT was the inability to separate performance defined by motivation of participating in the field test from that of actual fitness, so that some students may actually have achieved $\dot{V}O_{2max}$

values not commensurate with their fitness levels. Further, data collection from a single geographical region and a relatively small sample limits wide extrapolation of the findings, which limitation is further compounded by the study having been done at a high altitude of 2000 m.a.s.l, that is otherwise known to lead to altitude-induced erythropoiesis which could improve aerobic performance independently of exercise regimes. This study could also not address the issue of the effects of the different types of exercise performed by the subjects, ranging from casual walks to performance of vigorous activities. A last limitation perceived in the current study was fact some subjects were unwilling to strictly follow the dressing code best suited for the SRT protocol, which may have affected their level of endurance.

4.2 Conclusions:

Significant predictors of CF demonstrated by subjects from the present study included the year of study, HR in the first two minutes of physical exercise and after the fifth minute during the abscissa, and DBP both at exhaustion and after the first minute of rest. Generally, the students studied had below average fitness levels for their age ($\dot{V}O_{2max}$ <44ml/kg/min). Irrespective of the course they were undertaking, fourth year students achieved lower $\dot{V}O_{2max}$ and were less physically fit compared to their first year counterparts. Overally, medical students have a poorer CF level compared to students undertaking other disciplines of study.

Students who exercised regularly had higher fitness levels compared to their colleagues in the same year of study with irregular exercise regimes. Regardless of the frequency, physically active students attained significantly lower increase in HR during the SRT.

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Appendices

Appendix 1. Informed Consent Form

STUDY TITLE:

Assessment of Cardio-respiratory Fitness: A Study of Male Medical Students and Matched Controls from other Disciplines at Moi University.

INVESTIGATOR: Karani Magutah. (MSc Student)

Dept of Medical Physiology,

BOX 30197 00100 Nrb

Purpose and background:

The study is primarily aimed at assessing the level of CF for various groups of Male Students in the University.

Procedure:

If you consent to, you will be interviewed, your lung function tests done and your CF assessed with a sole aim of eliciting the information/data to meet the purpose of study.

Benefits:

There will be no direct benefit from participating in the study. However the findings and recommendations of the study will be documented.

Risk:

There is no known /anticipated direct risk to the participants in the study. However, maximal exertion may cause syncope or other forms of discomfort but a qualified first aider will be available during your test.

Confidentiality:

All information and measurements will be considered confidential, and consent forms used locked to prevent loss of confidentiality to participants.

Right to refuse or withdraw:

Your participation in the study is entirely voluntary and you are free to refuse to take part or withdraw at any time.

If you consent, please indicate so by signing this form:

For participant

I agree to participate in this study: .... DATE:..............................

Appendix 2. Participants' Record Form/Questionnaire

Name/Number____________________________

YOB……………

Year of study……………….

Course………………..

Physical ailment/injury (if any) ....

Height: ………………cm

Weight: ……….. kg

BMI: ………….. kg/m^2

Baseline BP: ………..over …………..mmHg

Baseline Pulse rate: ………….B/M

Baseline RR: …………..B/M

Lung functions:

IRV……………

TV……………..

ERV……………..

Inspiratory capacity (IRV+TV): ……………L

Vital capacity (IRV+TV+ERV):……………L

1. During the past 3 weeks, did you participate in any physical activities or exercises such as running, soccer, gardening, or walking?

    1 Yes

    2 No

    9 No response

2. If yes, how often do you perform this/these activities?

    1 More than three sessions per week (Regularly)

    2 Less than three sessions per week

Appendix 3. Beep Test Recording Sheet

Date: ________________ Time: _____________ Weather Conditions:

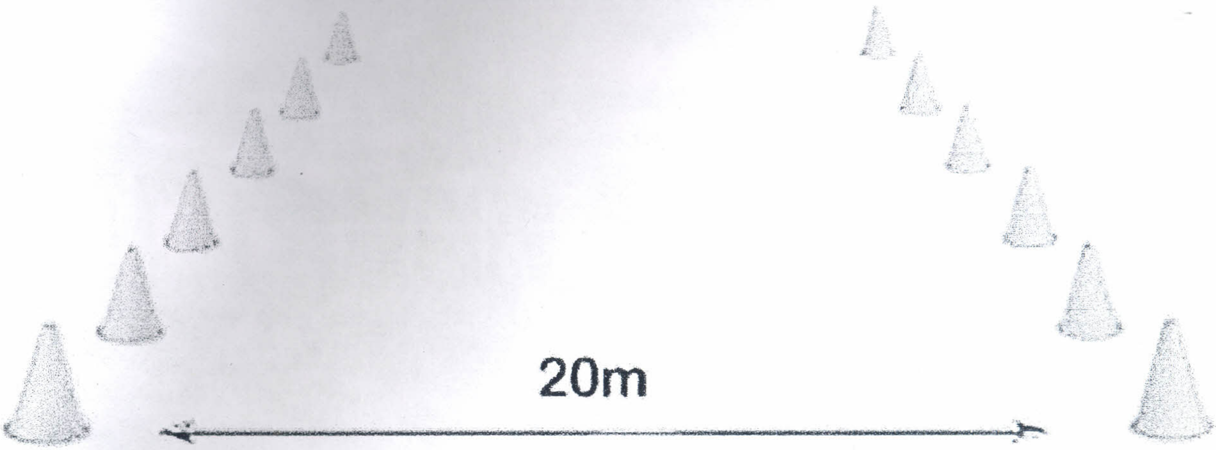
Level 1 1 2 3 4 5 6 7
Level 2 1 2 3 4 5 6 7 8
Level 3 1 2 3 4 5 6 7 8
Level 4 1 2 3 4 5 6 7 8 9
Level 5 1 2 3 4 5 6 7 8 9
Level 6 1 2 3 4 5 6 7 8 9 10
Level 7 1 2 3 4 5 6 7 8 9 10
Level 8 1 2 3 4 5 6 7 8 9 10 11
Level 9 1 2 3 4 5 6 7 8 9 10 11
Level 10 1 2 3 4 5 6 7 8 9 10 11
Level 11 1 2 3 4 5 6 7 8 9 10 11 12
Level 12 1 2 3 4 5 6 7 8 9 10 11 12
Level 13 1 2 3 4 5 6 7 8 9 10 11 12 13
Level 14 1 2 3 4 5 6 7 8 9 10 11 12 13
Level 15 1 2 3 4 5 6 7 8 9 10 11 12 13
Level 16 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Level 17 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Level 18 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Level 19 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Level 20 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Level 21 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

* circle the level reached for each participant, and write their name next to that line.

Recordings during the Abscissa (Rest Period)

Time (minutes after exercise exhaustion)	BP	PR
At exhaustion		
60 s		
120 s		
180 s		
240 s		
300 s		

Appendix 4: Images from the Shuttle Run Protocol.



Shuttle run test arrangement (cones)

Baseline measurements (current study) being taken before the SRT.

Appendix 5: Images of subjects during the Shuttle Run Protocol.