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Sudden cardiac arrest in school athletes: understanding the role of pre-participation screening.

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2015-04-13
http://hdl.handle.net/10539/17421

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CHAPTER 1: INTRODUCTION

The concept of sport and competitive participation is an integrated component of society and great emphasis and accolade is given to sporting sensations and spectacular achievements. The young competitor is not exempt and often the pinnacle of sporting and athletic achievement is being won at an ever younger age.

Society and the media consider exercise a benefit for all and encouragement to undertake regular physical activity is endorsed by the medical profession as being the way to a healthy lifestyle. The concept that an athlete, in particular a young athlete, could collapse during participation as a result of a sudden cardiac arrest, strikes to the very heart of society.

Considering the fact that many of these sudden cardiac arrests are due to previously undiagnosed cardiovascular conditions, strikes not only to the heart of society, but impacts significantly on the medical profession.

This research was undertaken to provide insight into the feasibility of identifying these underlying cardiovascular conditions. An understanding of the various causes of sudden cardiac arrest is important and while underlying cardiovascular conditions are not the only causes, they do make up the vast majority and have led to what has been call Pre-Participation Screening Protocols that have been developed to try and identify the athlete at risk.[1]

While these screening protocols have been designed; there is disagreement on the detail that such protocols should include. This research will look at the American Heart Association screening criteria that constitutes a medical history and basic medical examination and compare this to the European Society of Cardiology that add to this, a mandatory resting 12 lead electrocardiogram. The literature review will highlight why there is this disparity in performing a resting 12 lead electrocardiogram

and will also look at whether the basic principles of the screening for these conditions are justifiable on a cost, prevalence and benefit to the individual ratio.

This research will include performing such screening on young athletes and consider the costs and logistics involved in being able to successfully complete the necessary protocols and discuss the feasibility of Pre-Participation Screening Protocols being adopted at high school level.

The time you won your town the race

We chaired you through the market place;

Man and boy stood cheering by,

And home we brought you shoulder high.

To-day the road all runners come,

Shoulder-high we bring you home,

And set you at your threshold down,

Townsman of a stiller town."

By Alfred Edward Housman, 1895

To an Athlete Dying Young

CHAPTER 2: LITERATURE REVIEW

In this chapter a review will be done of the literature with emphasis on Pre-Participation Screening Protocols (PPSP), what is the background and origin of sudden cardiac arrest (SCA) in athletes, some of the identifiable causes and the components that make up the screening protocols including why they differ, in particular, between the United States of America (USA) and Europe and the unresolved debate around the use of the resting 12 lead electrocardiogram (ECG).

2.1 History

Most runners are aware of the legend of how the modern marathon came into being. With Sparta successful in the Battle of Marathon against the Persians, Pheidippides, an Athenian herald was tasked to run the 40km to Athens to announce the Greek victory over Persia. After running across the Plain of Marathon in 430 B.C., Pheidippides delivered his message of victory to the Athenians, uttering the words "*Joy, we win*" and then suddenly collapsed and died. What is left out of the story is that Pheidippides, before his relatively short run of 40km, had already completed 240km in the past two days, when he had been dispatched to fetch reinforcements from Sparta.[1]

In 1896, the Boston Athletic Organization, in preparing for the inaugural marathon, was concerned about the potential health risk that such an event brought to participants. In recognizing this risk, they put out the statement "*Each contestant, in case of accident, is accompanied by a member of the ambulance corps mounted on a bicycle.*" There were a total of 13 runners who took part.[1]

While the physiology and anatomy of the "athletes" heart has been studied since that first Boston Marathon in 1896, it has only been over the last 10 years that sudden cardiac death of a sportsperson has become highly visible in the media.

Despite the history of awareness and in excess of 112 years of medical research on Boston runners, sudden cardiac arrest in athletes still happens.

Why did lifelong athlete and fire-fighter William Caviness[1], die of cardiac arrest just before the finish line of the Chicago Marathon in October 9th, 2011?

Why, in March 2012, did renowned marathon runner, Micah True (the mystical Caballo Blanco) die while running a routine 20km?[2]

Arthur J Siegel[1], writes about the potential benefit of marathon running, the relative cardiac risks and the evidenced based prophylactic measures that are advocated but sudden cardiac arrest in athletes is not unique to marathon runners.

Why did 23 year old Bolton Wanderers midfielder Fabrice Muamba suffer a cardiac arrest during his team's 2012 Footballers Association Cup quarter-final clash against Tottenham Hotspurs?

The sudden death of an athlete during participation in sport is something that is unexpected and tragic.

Young athletes are regarded as healthy individuals, they have a unique attitude to life and skills that are often targeted by talent scouts at an extremely young age in a bid to identify the next sporting sensation. The young athlete may be seen as seemingly invulnerable and capable of extraordinary physical achievement.[3] Pearl S. Buck reminds us:

"The young do not know enough to be prudent, and therefore they attempt the impossible – and achieve it, generation after generation."

2.2 Definitions

2.2.1 Sudden Cardiac Arrest

Sudden cardiac death (SCD) is defined as a non-traumatic, nonviolent, unexpected natural death of cardiac origin occurring within 1 hour of the onset of signs and symptoms in a person without a previously recognised cardiovascular condition that would appear fatal. [4,5]

The American College of Cardiology 36th Bethesda Conference defined SCD as a non-traumatic and unexpected sudden death that may occur from a cardiac arrest, within 6 hours of a previously normal state of health.[6]

2.2.2 Athlete versus Non Athlete

In 2013, active participation in sport is currently considered to be of benefit for the health of an individual.

An athlete is defined as, "*a person participating in an organised team or individual sport that requires systematic training and regular competition against others and that places a high premium on athletic excellence and achievement*".[5]

In the European Society of Cardiology (ESC) report on the cardiovascular pre-participation screening of young competitive athletes, the definition is an individual aged 35 years or less and who is regularly engaged in exercise training and participating in official athletic competitions.[7] The Israel Sport Law defines athletes requiring screening as "*individuals who engage in sportive activity at any level of physical endurance.*"

2.3 Pre-Participation Cardiovascular Screening

SCA in young athletes is always a tragic event. While the emotional side may be obvious and perhaps exaggerated by the media, the concept that a young adolescent, participating in sport could collapse and suffer terminal cardiac arrest leaves the parents, friends and community saddened and confused. The obvious solution would be found in the realms of medical science. There must exist an explanation and a plan to prevent such occurrences in the future. The identification of underlying and previously undetected risks through screening programs has been widely and extensively studied and developed.

In 2007 the American Heart Association (AHA) issued a scientific statement regarding recommendations for pre-participation screening for cardiovascular abnormalities in competitive athletes, "*the purpose of pre-participation screening is to provide potential participants with a determination of medical eligibility for*

competitive sports that is based on evaluations intended to identify or raise suspicion of clinically relevant, pre-existing abnormalities."[9]

This is not necessarily as straight forward and when considering the various screening protocols the physician can take heart in Einstein's Constraint: It can scarcely be denied that the supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience. An often quoted version of this constraint says "*Everything should be kept as simple as possible, but no simpler*."[1]

Such screening is based on an understanding that most cases of SCD in the young athlete are related to pre-existing cardiac disease that the individual may not have been aware of.[5] Drezner and colleagues said that in 55% to 80% of cases of SCD the athlete, who has an underlying cardiovascular disease, is completely asymptomatic until the cardiac arrest.[10] The final common pathway of SCD is the development of electrical change in the myocardium with an imbalance which results in a fatal arrhythmia that is ventricular fibrillation in 90% of cases.[11]

The increased sympathetic drive that comes with intense exercise and competition, together with, the linked transient changes in blood volume and electrolytes, increase the risk of these fatal arrhythmia's in athletes.[12]

2.4 Common Aetiologies of Sudden Cardiac Death

There is convincing evidence that the majority of sudden deaths in young athletes (aged < 35 years) is due to a number of primary congenital cardiovascular diseases.[13] The short descriptions below is representative of 5 of these conditions, on the basis of prevalence; and to highlight the complexity of the detection of these conditions in young athletes.

2.4.1 Hypertrophic Cardiomyopathy (HCM)

In the USA the single most common cardiovascular cause of SCD is hypertrophic cardiomyopathy, accounting for around 35% of these deaths.[14,15]

HCM is a primary disease of the cardiac muscle that is most commonly genetically transmitted and is characterised by an hypertrophied left ventricle, and with there being no other obviously identifiable cause of left ventricle hypertrophy. [4]

Ventricular hypertrophy can occur with different patterns, the most common being the interventricular septum which becomes disproportionately thickened.

Microscopically the cellular pattern shows fibrosis and a bizarre pattern that has been called “myocardial disarray”.[16] HCM occurs in about 1:500 of the general population in the USA.[4,15] Young patients with HCM are often completely without symptoms and this group is where most cases of SCD are reported.[17] In a study by Maron a clinical profile of 78 patients who died from HCM before the age of 30 years showed that 55% had never experienced functional limitation.[18] More than 90% of patients who have HCM show ECG abnormalities.[15] The only proviso to this statement is that at a young age these ECG changes may not yet be apparent.[3,19]

2.4.1.1 Athlete’s Heart

Athlete’s heart is regarded as a natural increase in cardiac mass with specific cardiac changes that occur due to a physiological adaption to regular exercise.[3] The first description of an athlete’s heart was by Henschen in 1899 using only a simple examination and percussion to determine cardiac enlargement. Henschen looked at cross country skiers and showed that there was dilatation and hypertrophy of the left and right sides of the heart and that the changes were favourable: “*Skiing causes an enlargement of the heart which can perform more work than a normal heart*.” [19]

The physiological change that happens to the heart as a result of regular exercise is termed cardiac remodelling. This remodelling is not necessarily the same in all

athletes and occurs in around 50% of athletes.[3] The physiological changes that may be expected include:

Increased left and right ventricular chamber size.

Increased left atrium chamber size.

Ventricular wall thickness may be increased.

These changes are usually associated with normal systolic and diastolic function.

This physiological cardiac remodelling may result in an abnormal ECG in about 15% of athletes and represents a false positive in ECG screening for underlying cardiovascular pathology.[20]

In athletes who fall into the so called morphologic “grey zone” it may be difficult to separate mild early changes of hypertrophic cardiomyopathy from the physiologic, exercise–induced, left ventricular hypertrophy (“athlete’s heart”). These athletes may have positive ECG findings but then will require 2 dimensional echocardiography to distinguish clearly if the changes are in fact HCM related.[19,21]

Maron and colleagues have well established some of the features that are evaluated in this “grey zone” that include.[4,21]

- Pattern of left ventricular hypertrophy, the athlete’s heart is more symmetrical.
- Left ventricle internal cavity dimensions in athletes show an enlargement of the end diastolic cavity dimension.
- The left atrium is dilated in HCM but not in the athlete’s heart.
- In HCM there is decreased compliance with abnormal left ventricular diastolic filling which is not seen in the athlete’s heart.
- Female athletes very seldom show left ventricle wall thickness beyond 12mm and if this is seen on echocardiography then it is most likely due to HCM.

There is now also commercial laboratory testing available in HCM, with the potential for obtaining an unequivocal DNA – based diagnosis.

This genetic testing to distinguish the athlete's heart from HCM comes at a cost of US$ 5000 per test.[14]

2.4.2 Congenital Coronary Artery Anomalies (CCAA)

A congenital coronary artery abnormality occurs in up to 1% of the general population. [22] These account for a surprisingly high number of SCD in the young athlete, after HCM (about 20%) and is the most common cause amongst female athletes.[4]

The most common variant is the anomalous origin of the left main coronary artery from the right (anterior) sinus of Valsalva. The pathophysiology of cardiac arrest in athletes with an anomalous coronary artery is due to a sudden ventricular fibrillation that occurs as a result of myocardial ischaemia which happens with aortic dilatation (increased by intensive training) which compresses the anomalous vessel against the pulmonary trunk.[23]

This condition is important to try and diagnose because surgical correction is possible. However, CCAA remains difficult to diagnose, the ECG at rest is usually normal and symptoms of myocardial ischaemia are irregular .[4] The cardiovascular symptoms may be slightly more prevalent than in HCM (in the region of 30%) the gold standard of confirming the diagnosis would be 2 dimensional echocardiography.[24]

2.4.3 Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)

ARVC is the most common cause among young Italian athletes in the Veneto region of Northern Italy.[25] ARVC by definition is a genetic disease of the heart with a primary disorder of the myocardium that involves the right ventricle with only occasional left ventricle involvement and constitutes a progressive and diffuse

myocyte atrophy with fatty infiltration. This results in thinning and dilatation of the right ventricle. The young athlete who has a sudden cardiac arrest with underlying ARVC, is usually on the basis of a fatal ventricular arrhythmia.[4] Various mechanisms have been used to explain this; physical exercise leads to an increase in the right ventricle afterload with subsequent enlargement of the cavity and stretching of the right ventricular myocardium which is then prone to fibrillation.[23]

In the series by Corado, he showed that CCAA and ARVC were the only two cardiovascular conditions associated with sudden death significantly more often in athletes than in non-athletes.[26]

Most patients with ARVC are difficult to diagnose until they develop symptoms. These symptoms are usually syncope on the basis of an intermittent monomorphic ventricular tachycardia. The resting 12 lead ECG in the young athlete with ARVC may show a broad spectrum of abnormalities in 50-90% of people.[4]

2.4.4 Myocarditis:

Myocarditis is most often secondary to a viral infection that increases the risk of cardiovascular collapse and potentially fatal ventricular fibrillation during exercise.[27] The most common, cardiotoxic, virus is Coxsackie B virus.[23]

The myocardium that is inflamed can result in abnormal contractions of the myocardium which then exposes the athlete to a higher risk of a fatal arrhythmia. In most cases the athlete would be asymptomatic but there needs to be a high index of suspicion with symptoms of fatigue, exercise intolerance and palpitations, especially with a preceding recent viral illness.[4]

2.4.5 Congenital Long QT Syndrome (LQTS)

This is an inherited disorder of ventricular repolarization that has an estimated prevalence of 1 in 10 000 in the general population.[28] Young people with LQTS

usually become symptomatic early in life, between the ages of 5 – 15 years. Most would present with either a seizure, palpitations or syncope. The characteristic ECG abnormalities include the prolonged corrected QT interval, T wave alterations and a relative bradycardia.[4]

There is a strong correlation between SCD and exercise with athletes who have LQTS.[17] There are 3 major subtypes with LQTS type 1 being the one predominantly associated with a fatal arrhythmia during exercise; there is a unique recommendation which applies to individuals with LQTS type 1 that they should refrain from competitive swimming because of a strong association between this sport and cardiac events.[29]

2.5 Epidemiology

It is important to first look at the incidence of sudden cardiac death (SCD) that occurs in the general population:

- Atkins et al, in analysing data from 11 urban and rural sites in the United States of America (USA) and Canada found the incidence of sudden cardiac death (SCD) in all children was 3.73/100 000 person years in those between 1 and 11 years of age and 6.37/100 000 person years in those between 12 and 19 years.[30]
- In Denmark, Holst et al, looked at the SCD in the population age group of 12 to 35 years and found an incidence of 3.76/100 000 person years.[31]
- Eckart et al, studied sudden non traumatic deaths among 6.3 million USA military recruits aged between 18 and 35 years old, both male and female. In this population 126 people died due to SCD between 1977 and 2001. Equal to 13/100 000 recruit years.[32]

- Shen et al, in a population age group of 20 to 40 years, in Minnesota, found the incidence of all sudden non traumatic deaths to be 6.2/100 000 person years.[33]
- Papadakis et al, in a population age group of 1 to 34 years, in England and Wales, found the incidence of all sudden deaths reported in a national database to be 1.8/100 000 person years.[34]
- Corrado et al between 1979 and 2004 in the Veneto region in Italy, in a population aged 12 – 35 years showed an incidence of 0.79/100 000 for all sudden deaths of non-athletes reported in a regional registry.[35]

The studies that have been done on the incidence of SCD in the athlete include the following:

- Corrado et al, in a population age group of 12 to 35 years, in the Veneto region in Italy, found an incidence of SCD in competitive athletes reported in a regional registry to be 1.9/100 000 person years.[35]
- Maron et all, in a population age group of 12 to 31 years, in Minnesota, found an incidence of SCD in competitive high school and college athletes to be 0.97/100 000 person years.[36]
- Maron et al, in a population age group of 13 to 19 years, in Minnesota, found an incidence of SCD in high school students competing in athletics to be 0.46/100 000 person years.[37]
- Van Camp et al, in the USA found an incidence of SCD in male basketball players to be 3.6/100 000 person years.[38]
- Holst et al, in a population age group of 12 to 35 years, in Denmark, found the incidence of SCD of competitive athletes to be 1.21/100 000 person years.[31]

- Steinvil et al, in Israel, found an incidence in competitive athletes of SCD to be 2.66/100 000 person years.[39]

If the data from Corrado et al is interpreted then the incidence of SCD in young athletes, aged 12 to 35 years is 1.9/100 000 person years compared with an incidence in non athletes of 0.79/100 000 person years. Corrado also showed that while the age range of the study population was 12 to 35 years, up to 40% of the SCD occurred in those younger than 18 years old.[35] It is this data, that has been the driving force behind introducing PPSP in the young athlete.

If the data from Maron in Minnesota and Holst in Denmark is interpreted then the incidence of SCD in athletes is actually lower than in non athletes.[31,36,37] There is no doubt that more intense media coverage is given to the SCD that occurs during competition, this does not mean that potentially as many deaths are occurring in the non athlete with underlying cardiovascular conditions.[38] This means the group of young people to screen for such conditions could potentially include everyone and not just the athlete.

2.6 Pre-Participation Screening Protocols (PPSP)

In 1996 the AHA proposed a series of recommendations that became known as the 12 –element AHA recommendations for pre-participation cardiovascular screening of competitive athletes. These recommendations included 5 questions related to personal history, 3 related to family history and 4 points addressed to the physical examination. A detailed breakdown of these recommendations is attached as appendix 1.[7,9,13,39]

In 2005 the European Society of Cardiology (ESC) recommended that PPSP be implemented for the cardiovascular screening of young competitive athletes in order to detect abnormalities that predisposed to a sport-related cardiac death. This

statement was in support of the AHA consensus statement that PPSP for young competitive athletes is justifiable on ethical, legal and medical grounds.[40]

The difference between the AHA and ESC protocols for pre-participation screening for underlying cardiovascular pathology lies in the inclusion of a routine 12 lead ECG, which the ESC believe has the potential to enhance the sensitivity of the screening process.[40] This is based on the work by Corrado et al who reported a 17 year experience from the Centre for Sports Medicine of Padova, in the Veneto region of Northern Italy. A consecutive series of 33 735 young athletes (<35 years) underwent pre-participation cardiovascular evaluation using history and physical examination and a routine 12 lead ECG. Corrado et al showed that the Italian screening method including using the 12 lead ECG had a 77% greater power for detecting HCM when compared with the AHA protocol of basic history taking and physical examination alone.[40]

The Italian experience of Corrado et al also showed a marked decrease in SCD rates after making ECG part of standard cardiovascular screening.[41] A 12 lead ECG is considered positive if one of the accepted criteria is reported.[40] These criteria are listed in appendix 2.

In 2007 the AHA reiterated its position that a PPSP should include history taking and physical examination and that further testing, including the resting 12 lead ECG remain optional.[9] This was a direct response to the recommendations issued by the European Society of Cardiology and the International Olympic Committee that a resting 12 lead ECG should be included in the PPSP.[5,40]

The reasons why routine ECG is currently not recommended in the USA:

- ECG screening of athletes have a high false positive rate (10-40%).
- ECG false positive rates can cause anxiety, increased costs and unnecessary disqualification from sport.

- Physicians need to work extra to fulfil the screening process if the ECG is added to the standard history and physical examination.
- Physicians may not feel trained enough to interpret the ECG for the screening of cardiovascular conditions.
- Such screening may not be a top health care priority given the relatively low incidence.
- An ECG screening program could cost approximately US$ 2 billion annually for testing in the United States.
- ECG criteria in the young athlete are not yet fully established.[6,9,41,43,44]

Recent guidelines have started being published by the European cardiology societies that propose that some ECG abnormalities found in athletes are benign and should not prompt further investigation. These would include sinus bradycardia, first degree atrioventricular block, early repolarisation and isolated QRS voltage criteria for left ventricular hypertrophy.[45] The interpretation of T waves is also a problem with the inverted T wave in an athlete younger than 16 years not necessarily being predictive of pathology.[45]

There is no doubt that if an ECG could be performed on every athlete that the information generated would certainly go a long way towards identifying those with under lying cardiovascular conditions.

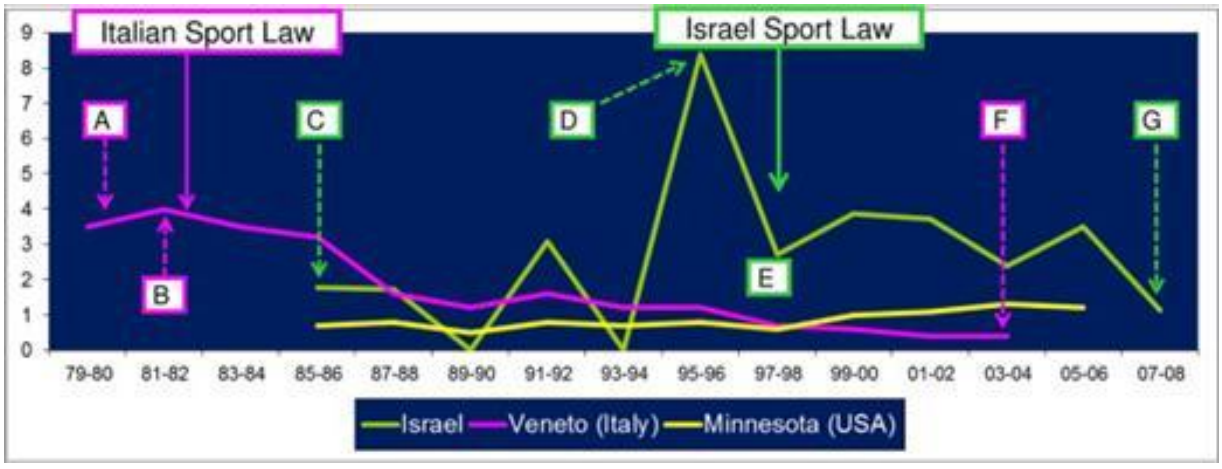
Chang et al, have introduced a new concept best summed up with the following extract from Singularity is Near, 2005 by Ray Kurzweil; "*In the next 40 years, the pace of change is going to be so astonishingly quick that you won't be able to follow it unless you enhance your own intelligence by merging with the intelligent technology we are creating".*[46] In summary Chang is saying that we need to make better use of the powerful computer system and interpretation programs that readily

exist, that may actually make the ECG more common place then history would ever have thought possible, and the interpretation and analysis extremely cost effective.

Steinvil et al, in Israel, has analysed the evidence that mandatory screening actually decreases the risk of SCD after the implementation of such a PPSP, with reference to the Veneto study in Italy, this series was compared to a 2 year period before screening with a subsequent 26 year period post screening.

Steinvil, however, showed one of the limitations of the Corrado study was only going back 2 years when comparing the impact of a 26 year post introduction collection of screening data. Had they gone back further and compared 10 years prior with the 26 years post, they may have found equivocal results.[39]

Steinvil, showed an average yearly incidence of SCD amongst Israeli competitive athletes to be 2.66/100 000 person years.[39] While this incidence is within the accepted range of other studies they found no apparent influence on the incidence of SCD in athletes after introducing a PPSP, including routine ECG testing.[39]



Graph 1

Annual Incidence of Sudden Cardiac Death Expressed per 100,000 Person-Years in the 3 Studies Evaluating the Effects of Screening on the Mortality of Athletes Over Time (Permission was emailed to the author asking for permission to reproduce the graph, no reply has been received to date)

*The Italian study **(pink graph)** concluded that electrocardiography (ECG) screening (started in 1982) significantly reduced the incidence of sudden cardiac death by comparing the sudden death in the 2-year pre-screening period **(A to B)** with the post-screening period **(B to F)**. The Steinvil study is depicted by the **green graph**. Steinvil compared the 12 years before screening **(C to E)** with the 12 years after the onset of mandatory ECG screening **(E to G)**. Had Steinvil limited comparison of the post screening period to the 2-year period preceding the enforcement of screening in Israel (**D to E** vs. **E to G**, as performed in the Italian study), he would have concluded erroneously that screening saved lives of athletes in Israel. The study from Minnesota **(yellow graph)** shows a low mortality rate in a population of athletes not undergoing systematic ECG screening.*[39]

Steinvil concludes that there is significant variation in mortality rates when reviewed over a longer period of time. He also talks about the concept of "*immortality bias*" which is described as a methodology flaw that is often encountered in observational studies. Essentially understood to be that the population of athletes that made it alive to the first screening, represented a selected lower risk population (all athletes who had died of SCA prior to the screening, never made it to screening), it is these lower risk characteristics that can contribute to the observed lower mortality rates in the post screening period.[39]

Shephard has suggested that the one major criticism of the ESC position statement on the inclusion of routine 12 lead ECG testing on athletes as part of PPSP is that ECG screening does not meet long accepted World Health Organization (WHO) criteria for a successful screening program, which include; a moderate prevalence of the condition, an appropriate test sensitivity and specificity and a net benefit to the patient that out-weighs any negative consequences of the screening.[8]

Reported sensitivity of ECG screening in athletes[8]

- Fuller et al: 60 – 70%
- Corrado et al: 89%
- Wheeler et al: 68%
- Pelliccia et al: 51%

Reported false positives of ECG screening in athletes[8]

- Pellicia et al: 37%
- Maron et al: 15%
- Lawless et al: 40%
- Wilson et al: 1.9%

Baggish et al has compared the history and physical examination alone, against performing a history and physical examination together with a resting 12 lead ECG. The study sample was only 510 college athletes in the USA . The history and physical examination lasted 8 minutes and was not done by specialist in either sports medicine or cardiology. The ECG was evaluated using the ESC guidelines. Baggish claimed that after ECG evaluation 11 individuals were identified as high risk for potential underlying cardiovascular pathology against only 5 individuals who were found to be at high risk after history and physical examination alone.[49]

2.7 Cost of PPSP versus the Benefits

It is accepted by most athletes that there is an inherent risk in sports, and many athletes would not necessarily stop participating if they were not guaranteed 100% safety during participation.[8] The incidence of SCD is only 1-2/100 000 person years (for competitors) and potentially only half of these are preventable through a PPSP. There is also, through the advent of automated external defibrillators, many successful outcomes when the need for resuscitation does arise. It is also important that the identification of a potentially lethal underlying cardiovascular condition does

not necessarily improve prognosis as SCA is still very possible even when competitive sports are not undertaken.[8]

Stanford University did a recent study on college athletes. The PPSP that was used included a medical history, basic medical examination and a resting 12 lead ECG. The study found a 10% abnormality in the ECG that prompted further evaluation. When the cost effectiveness was analysed they showed 2.06 life years saved per 1000 athletes at a cost of US$89 per athlete.[47]

There is a suggestion that only college athletes should be screened or that only top level athletes are screened. This is difficult to endorse when there exists evidence from Maron et al that the incidence of SCA in the non-athlete may actually be higher than in the athlete, and there is very poor reporting of these non-athlete SCA. If there is to be a distinction between the degree of competitiveness that warrants PPSP being introduced, the young athlete is being compelled from early in high school to achieve and to exercise to the maximum in order to compete and win. To exclude an athlete on this basis would not seem justifiable.

The safe approach would simply be to perform PPSP on all children. The AHA estimate this would cost the USA US$2 Billion annually if the PPSP included medical history, basic medical examination and a resting 12 lead ECG.[44]

In the USA cost effectiveness is defined as a Quality Adjusted Life Year (QALY) of US$50 000 or less.[46] In Orange County in the USA with a high school athlete population of 75 000, the QALY of performing an ECG would be US$37 500, an acceptable cost.[46] By comparison the QALY for performing a medical history and basic medical examination in the same setting was calculated at US$84 000. While it may seem logical to remove the medical history and basic medical examination from the PPSP and just do the resting 12 lead ECG, there are a number of conditions that

may be underlying that are not diagnosed on ECG at all, but rather on history and symptoms, conditions the likes of CCAA and myocarditis, discussed previously.

In the Corrado et al series in Italy, the cost of the PPSP, being the medical history and basic medical examination with a resting 12 lead ECG was calculated at 30 Euros per athlete. In this series the percentage of false positives was 7% that required further, unnecessary, evaluation in the form of an echocardiogram, which adds to the cost.[35]

In summary the literature review demonstrates the background to the origin of SCA in athletes and while the aetiologies are well documented as to what underlying cardiovascular conditions can place the athlete at risk, it is the complexity of screening for these conditions that has given rise to different opinions on the gold standard. While the incidence is shown to be low and screening to be expensive, especially when trying to define the “athlete”, when these tragedies do occur, they not only are widely broadcast in the media but place a pressure on the medical profession to deliver a degree of protection and safety.

Especially considering the young are encouraged to participate and compete in sport.

It is after all the healthy lifestyle.

CHAPTER 3: AIMS AND OBJECTIVES

This chapter will outline the aim of this research report and provide a detailed list of the intended objectives.

3.1 Study Aim

The aim of this study was to conduct a pilot Pre-participation screening program that determines the presence of (high) risk individuals for sudden cardiac arrest during sport. This was done by using a medical questionnaire, performing a physical medical examination and undertaking a resting 12 lead ECG in grade 8 learners at a single specifically identified private school in northern Johannesburg, St Stithians Boys College.

3.2 Study Objectives

1. Document the findings of the Pre-Participation Screening Protocol done according to the American Heart Association guidelines that make use of the 12 point questionnaire for the screening of underlying cardiovascular risk factors that may predispose athletes to sudden cardiac arrest.
2. Perform and document the findings of a resting 12 lead ECG done and interpreted according to the European Society of Cardiology criteria for using the resting 12 lead ECG in order to identify an athlete at risk of sudden cardiac arrest.
3. Compare the findings of cardiovascular risk factors as identified by using the American Heart Association protocol with those found by interpreting a resting 12 lead ECG according to the European Society of Cardiology guidelines.
4. Determine the comparative cost of these two particular screening programs.

CHAPTER 4: MATERIALS AND METHODS

This chapter will look comprehensively at the materials and methods used in order for the objectives of the research to be completed.

4.1 Study Design

A prospective, transverse, analytical study.

4.2 Study Site

St Stithians Boys College, High Performance Centre.

4.3 Study Population

The grade 8 learners (equivalent to the first year of high school) at a Johannesburg High School, St Stithians Boys College. The pre-participation screening was done on one afternoon after notice had been given to all learners and parents/legal guardians who signed assent and informed consent respectively.

The Director of Sport for the School was involved in helping plan for the screening in making available a suitable date and time that did not interfere with academic or other school related commitments. This was co-ordinated to take place after school between 13h00 and 15h00.

4.4 Inclusion Criteria:

1. All the male high school grade 8 learners attending St Stithians Boys College , that had given assent, together with informed consent from their respective parents or legal guardian.

A meeting was held with the Director of Sport for St Stithians Boys College and the Headmaster and informed consent was obtained from the Headmaster for the communication envelopes to be distributed to all grade 8 learners.

This process was done by placing in a sealed envelope the letter addressed to the parents/legal guardian explaining the nature of the research and included was the respective informed consent and assent forms. The medical history and family

history component of the AHA Pre-Participation Screening protocol was included for completion by the parent/legal guardian, in the presence, and with the input, of the learner.

Confirmation of ethics approval was also made apparent. There was a second envelope pre-labelled that the informed consent and assent forms were required to be placed inside and detailed instruction that this envelope was to be returned to the Director of Sport.

The communications policy of St Stithians Boys College is such that no specific contact details of parents/legal guardians could be made available to the researcher.

The initial response in the form of completed forms and returned envelopes was exceptionally poor and required repeated announcements and communications with the learners. The Director of Sport did also communicate with parents/legal guardians via on official St Stithians College email requesting participation or at the very least completion of the required documents.

4.5 Exclusion Criteria:

1. Failure to obtain informed consent from the parent or legal guardian.
2. Failure to obtain assent from the learner.
3. Any learner who was not present on the day the Pre-Participation Screening was done.
4. Any learner where the medical questionnaire was incomplete.

4.6 Data Collection

The AHA 12 element medical history and examination was used as the representative PPSP done in the USA.

The addition of the resting 12 lead ECG was interpreted against the criteria as set out by the ESC.

Both the AHA table and ESC criteria are listed below:

Table 1: Adapted Medical History Questionnaire from the 12 Element AHA Recommendations for Pre-participation Cardiovascular Screening of Competitive Athletes.[35]

Personal history	Yes or No
1. Do you experience chest pain or discomfort, when exercising.	
2. Have you ever collapsed, fainted or felt like fainting during exercise.	
3. Do you get short of breath or tired, during exercise, that appears out of keeping with the amount of exertion.	
4. Are you aware whether or not you have a heart murmur.	
5. Do you have high blood pressure.	

Family History	Yes or No
1. Has any relative under the age of 50 years died from a heart problem.	
2. Are you aware of any close relative, under the age of 50 years that has a heart disability.	
3. Do you have any specific knowledge of known heart conditions in family members, eg Hypertrophic cardiomyopathy, Marfan syndrome, Long QT syndrome.	

Physical Examination	Findings
1. Heart murmur (auscultation should be performed in supine and standing positions or with valsalva manoeuvre, specifically to identify murmurs of dynamic left ventricular outflow tract obstruction.	
2. Femoral pulses to exclude aortic coarctation.	
3. Physical stigmata of Marfan syndrome.	
4. Brachial artery blood pressure (sitting position) preferably taken in both arms.	

Table 2: Criteria for a positive 12 lead ECG, as set out by the ESC[35,40]

P wave	Yes or No
• Left atrial enlargement: negative portion of the P wave in lead V1 ≥0.1mV in depth and ≥0.04s in duration;	
• Right atrial enlargement: peaked P wave in leads II and III or V1 ≥0.25mV in amplitude.	

QRS complex	Yes or No
• Frontal plane axis deviation: right ≥ +120 or left -30 to -90;	

• Increased voltage: amplitude of R or S wave in standard lead ≥2mV, S wave in lead V1 or V2 ≥ 3mV, or R wave in lead V5 or V6 ≥ 3mv;	
• Abnormal Q waves ≥0.04s in duration or ≥25% of the height of the ensuing R wave or QS pattern in two or more leads;	
• Right or left bundle branch block with QRS duration ≥0.12s;	
• R or R' wave in lead V1 ≥0.5mV in amplitude and R/S ratio ≥1.	

ST – segment, T waves and QT interval	**Yes or No**
• ST segment depression or T wave flattening or inversion in two or more leads;	
• Prolongation of heart rate corrected QT interval >0.44s in males and >0.46s in females.	

Rhythm and conduction abnormalities	**Yes or No**
• Premature ventricular beats or more severe ventricular arrhythmias;	
• Supraventricular tachycardias, atrial flutter or atrial fibrillation;	
• Short PR interval (<0.12s) with or without 'delta' wave;	
• Sinus bradycardia with resting heart rate ≤40 beats/min;	
• First (PR≥0.21s), second or third degree atrioventricular block.	

4.7 Ethics Clearance

Ethics Clearance was obtained from the Human Research Ethics Committee (Medical), University of the Witwatersrand. Reference number: M111131. Certificate attached as appendix 3.

- A meeting was organised with the Headmaster and the Director of Sport for St Stithians Boys College and a brief synopsis of the intended research and parameters presented. An information leaflet accompanied the request, attached as appendix 4.

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- Informed consent to undertake the research study at the St Stithians Boys College on grade 8 learners was given by the Headmaster of the Boys College.
- Informed consent was provided by parent or legal guardian of the learner.
- An information leaflet accompanied the request to the parent or legal guardian, attached as appendix 5. These forms were placed inside a sealed envelope that had been labelled with the learners name and surname. Inside this envelope was a further empty envelope that had been pre-labelled for the researcher. The envelopes were handed to all grade 8 learners at the Boys College. The completed forms were to be placed in the second envelope, sealed and returned by hand to the Director of Sport. Allowance was made for all consent forms to be emailed and faxed to the researcher.
- Assent was provided by the learner.
- An information leaflet accompanied the request to the learner, appendix 6. These documents were placed in the same envelope that was distributed containing the parents/legal guardians informed consent form and information leaflet. The student assent forms were placed in the same second envelope that was pre-marked for the attention of the researcher and returned by hand to the Director of Sport. Allowance was made for all of these forms to be emailed and faxed to the researcher.
- The medical history questionnaire was required to be completed at home and could be completed by the parent/legal guardian in the presence of the learner. The detail required in the medical history is such that the learner would have to provide the information to the parent/legal guardian.
- The family history was required to be completed by the parent/legal guardian.

- The medical and family history form was assigned a numerical number that identified the learner. This form is attached as appendix 7.
- The informed consent form for the Headmaster is attached as appendix 8.
- The informed consent form for the parent/legal guardian is attached as appendix 9.
- The assent form for the learner is attached as appendix 10.
- Learners who had a positive finding on the AHA and or the ESC guidelines were advised of this finding, counselled and cardiology referral was suggested and where needed facilitated.

The venue for the PPS was on the St Stithians Boys College premises at the “High Performance Centre”. The PPS took place after school during the normal academic term. The Director of Sport for the Boys College was present throughout the PPS. The researcher was present and 5 registered nurses accompanied the researcher. These registered nurses were from the Netcare Milaprk Hospital Group, Cardiology Unit. The registered nurses were responsible for their own transport to and from St Stithians Boys College.

4.8 Measuring Instrument

Equipment that was used included two ECG machines, provided by Welch Allyn; an automated blood pressure monitor capable of measuring blood pressure, heart rate and oxygen saturation. This machine was manufactured by Phillips and made available for the day from Chris Hani Baragwanath Academic Hospital with the permission of the Senior Clinical Executive, Dr Nkele Lesia. An electronic scale that requires the learner to stand on was supplied by the researcher and manufactured by Phillips, with weight measurement in kilograms. A measuring tape with intervals marked in centimetres was used for obtaining height measurements.

The venue was divided into 4 specific areas. The learners were required to remove their shirts and shoes for the duration of the PPS and were advised that should they at any stage have a question or a concern that they were to bring this to the attention of the researcher.

- The first area was for the performance and documentation of the weight, blood pressure, heart rate and height. These measurements were undertaken by the same registered nurse and recorded on the sheet of paper that correlated with the numerical number assigned to the learner. The weight was taken with the learner standing upright with the measuring scale on a level hard surface and measured in kilograms. The measurement was taken with the learner wearing school pants and belt with shoes and shirts removed. The learners were asked to ensure their pockets were empty. The blood pressure was measured on the left arm in the brachial area and done with the student sitting on the bed and then in a standing position. The height was measured against the wall with shoes removed and measured in centimetres.
- The second and third areas were used for the performance of the resting 12 lead ECG. The Welch Allyn machines were checked by the researcher and set at a standard speed on 10mm/mV. A routine 12 lead ECG was done on all learners in the supine position. The date of the ECG was entered on the paper and the ECG was assigned the numerical number that correlated with the identity of the learner. The two areas for the performance of the ECG's were staffed by two of the registered nurses.
- The fourth area was for the final component of the AHA 12 point PPS and included the basic physical examination. This was done by the researcher. Coarctation of the aorta was excluded by palpation of the radial pulse and

simultaneously the femoral pulse, both on the left side and any significant delay documented. Cardiac murmurs were auscultated for in the supine and standing position. Marfans stigmata were checked and included looking for musculoskeletal signs and ocular signs. This examination had a registered nurse present with the researcher and was done in an area where privacy of the learner was ensured. The learner was required to loosen their belt but not remove their pants for femoral artery palpation. Shirts were removed for the duration of the PPS. The results of this examination were recorded and dated on the paper with the learner again identified by the pre-arranged numerical number.

A final set of demographic data was asked by a registered nurse and included the learners age, ethnicity, co-morbidity, type of sport they participate in and whether or not the learner was currently ill. This data was then recorded in a table, together with the height and weight measurements of the learner.

Table 3: Additional demographic data

Demographics	**Findings**
1. Age	
2. Ethnicity	
3. Height	
4. Weight	
5. Co-morbidity	
6. Participating in sport	
7. Currently ill	

4.9 Data Analysis

The captured data has been recorded using Excel spread sheets.

2D column charts were used to compare values across categories.

2D line graphs were used to display trends for ordered categories of the demographic data.

CHAPTER 5: RESULTS

This chapter will review the results of the research in keeping with the objectives.

On Wednesday the 2nd October 2012 at 13h00 the PPSP was done at St Stithians Boys College at the High performance centre. A total of 49 Grade 8 male learners underwent pre-participation screening. This number of learners was from a total Grade 8 class of 164 male learners. Informed consent and Assent forms were obtained from 49 learners and parents/legal guardians alike. 1 parent returned the form without giving consent on religious grounds. A total of 114 forms were not returned. 2 parents did comment at a later stage that they had been unaware of the proposed research taking place.

Category 1: Cardiovascular history and questionnaire together with basic physical examination:

The medical history and family history was completed at home by the parent/legal guardian in the presence of the learner. The tables below are the documented findings for the medical history, family history and basic medical examination and together they make up the completed 12 element AHA screening protocol for underlying cardiovascular risk.

Table 4: Cardiovascular History of Learners

Learner	Do you experience chest pain or discomfort, when exercising.	Have you ever collapsed, fainted or felt like fainting during exercise.	Do you get short of breath or tired, during exercise, that appears out of keeping with the amount of exertion.	Are you aware whether or not you have a heart murmur.	Do you have high blood pressure.
1	No	No	No	No	No
2	No	No	Sometimes	No	No
3	No	No	Sometimes	No	No
4	No	No	No	No	No
5	Sometimes	No	No	No	No
6	Yes on the Right	No	No	No	No
7	No	Yes	No	No	No
8	No	No	No	No	No
9	No	No	No	No	No
10	Sometimes	No	Sometimes	No	No
11	No	Sometimes	No	No	No
12	No	Palpitations	Shortness of breath	No	No
13	No	No	No	No	No
14	Yes	No	No	No	No
15	No	No	No	No	No
16	No	No	No	No	No
17	No	No	Sometimes	No	No
18	No	No	Sometimes	No	No
19	No	No	Sometimes	No	No
20	No	No	No	No	No

21	No	No	No	No	No
22	No	No	Sometimes	No	No
23	Yes	No	No	No	No
24	No	No	No	No	No
25	No	No	No	No	No
26	No	No	No	No	No
27	No	No	No	No	No
28	No	No	SOB	No	No
29	No	No	No	No	No
30	No	No	No	No	No
31	No	When younger	No	No	No
32	No	No	Sometimes	No	No
33	No	No	Sometimes	No	No
34	No	No	No	No	No
35	No	No	Sometimes	No	No
36	No	No	Sometimes	No	No
37	No	No	Sometimes	No	No
38	No	No	No	No	No
39	No	No	No	No	No
40	No	No	Sometimes	No	No
41	No	No	Sometimes	No	No
42	Yes	No	Sometimes	No	No
43	No	No	No	No	No
44	No	No	No	No	No
45	No	No	No	No	No
46	No	No	No	No	No
47	No	No	No	No	No

48	No	No	Sometimes	No	No
49	Yes	No	Sometimes	No	No

Table 5: Cardiovascular Family History of Learners

Learner	Has any relative under the age of 50 years died from a heart problem.	Are you aware of any close relative, under the age of 50 years that has a heart disability.	Do you have any specific knowledge of known heart conditions in family members, eg Hypertrophic cardiomyopathy, Marfan syndrome, Long QTS.
1	No	No	No
2	No	No	No
3	No	No	No
4	No	No	No
5	No	No	No
6	Grandparent died of heart attack	No	No
7	No	No	No
8	No	No	No
9	Grandparent died of heart attack	No	No
10	No	No	No
11	No	Mom has cardiac rhythm abnormality.	No
12	No	No	No
13	Dad had heart attack at 50yrs, still alive.	No	No
14	No	No	No
15	No	No	No
16	No	No	No
17	No	No	No
18	No	No	No

19	No	No	No
20	No	No	No
21	No	No	No
22	No	No	No
23	No	No	No
24	No	No	No
25	No	No	No
26	No	No	No
27	No	No	No
28	No	No	No
29	No	No	No
30	No	No	No
31	No	No	No
32	No	No	No
33	No	No	No
34	No	No	No
35	No	No	No
36	No	No	No
37	No	No	No
38	No	No	No
39	No	No	No
40	No	No	No
41	No	No	No
42	No	No	No
43	No	No	No
44	No	Dad had heart attack at 52 yrs,still alive.	No

45	No	Dad has heartburn.	No
46	No	No	No
47	No	No	No
48	No	No	No
49	No	No	No

Table 6: Basic Physical Examination

Learner	Heart murmur (auscultation should be performed in supine and standing positions or with valsalva manoeuvre, specifically to identify murmurs of dynamic left ventricular outflow tract obstruction.	Femoral pulses to exclude aortic coarctation.	Physical stigmata of Marfan syndrome.	Brachial artery blood pressure (sitting position) preferably taken in both arms. (Left Arm)
1	No	No	No	71/35 – 128/66
2	No	No	No	137/74
3	No	No	No	138/84
4	No	No	No	127/61
5	No	No	Yes, in Father	125/59
6	No	No	No	136/77
7	No	No	No	134/74
8	No	No	No	132/76
9	No	No	No	142/70 – 134/72
10	No	No	No	116/74
11	No	No	No	133/74
12	No	No	No	134/77
13	No	No	No	139/82
14	No	No	No	139/66
15	No	No	No	136/87
16	No	No	No	136/81
17	No	No	No	118/72
18	No	No	No	130/70
19	No	No	No	128/78

20	No	No	No	136/75
21	No	No	No	135/79
22	No	No	No	117/77
23	No	No	No	133/88
24	No	No	No	108/68
25	No	No	No	125/77
26	No	No	No	133/70
27	No	No	No	133/83
28	No	No	No	118/75
29	No	No	No	132/76
30	No	No	No	122/59
31	No	No	No	132/77
32	No	No	No	132/81
33	No	No	No	120/77
34	No	No	No	116/72
35	No	No	No	114/75
36	No	No	No	137/76
37	No	No	No	135/62
38	No	No	No	133/71
39	No	No	No	136/74
40	No	No	No	154/84 – 142/71
41	No	No	No	139/91
42	No	No	No	131/74
43	No	No	No	141/88 – 135/77
44	No	No	No	134/78
45	No	No	No	138/78
46	No	No	No	132/62

47	No	No	No	114/68
48	No	No	No	130/84
49	No	No	No	134/82

The results for positive symptoms for the cardiovascular history:

Do you experience chest pain or discomfort, when exercising.	**Have you ever collapsed, fainted or felt like fainting during exercise.**	**Do you get short of breath or tired, during exercise, that appears out of keeping with the amount of exertion.**	**Are you aware whether or not you have a heart murmur.**	**Do you have high blood pressure.**
7	4	19	0	0

On further analysis a total of 4 learners scored positive on more than one symptom, but in all 4 learners the maximum was two symptoms. This means that a total of 26 learners had a positive cardiovascular history.

The results for the positive family cardiovascular history:

Has any relative under the age of 50 years died from a heart problem.	**Are you aware of any close relative, under the age of 50 years that has a heart disability.**	**Do you have any specific knowledge of known heart conditions in family members, eg Hypertrophic cardiomyopathy, Marfan syndrome, Long QTS.**
0	1	0

There were a total of 5 learners that gave a positive family history for heart attacks but in 4 of the cases the age of the family member was over 50 years. The fifth case was not a cardiac symptom.

The 1 positive family history was on the mothers side where the history was of atrial fibrillation. The corresponding learner did give a positive cardiovascular history for sometimes feeling like fainting during exercise but the rest of the learners PPSP was normal.

The results for the basic physical examination:

Heart murmur (auscultation should be performed in supine and standing positions or with valsalva manoeuvre, specifically to identify murmurs of dynamic left ventricular outflow tract obstruction.	**Femoral pulses to exclude aortic coarctation.**	**Physical stigmata of Marfan syndrome.**	**Brachial artery blood pressure (sitting position) preferably taken in both arms. (Left Arm)**
0	0	1	2

There was one learner that reported his father had Marfans Syndrome. This learner was unaware whether he has Marfans Syndrome and was also not aware whether he had ever been formally examined for the characteristic stigmata of this condition. There were no obvious musculoskeletal or ocular findings suggestive of Marfans. . On the demographics the learner had a height of 171cm (compared with a n=166.9cm) and a weight of 52.5kg (compared with a n=60.5) and had a body mass index calculated at 17.9 (compared with a n=21.6).

One learner collapsed during the PPSP, he has blood pressure measured at 71/35 mmHg and was managed as a vagovagal episode. He complained of feeling dizzy just prior fainting. The learner responded well and a repeat blood pressure was 128/66 mmHg. He further reported that this has never happened to him before and that he had not eaten for the day and felt hot and flushed just prior to fainting. There were two learners that had a systolic blood pressure of greater than 140 mmHg. In

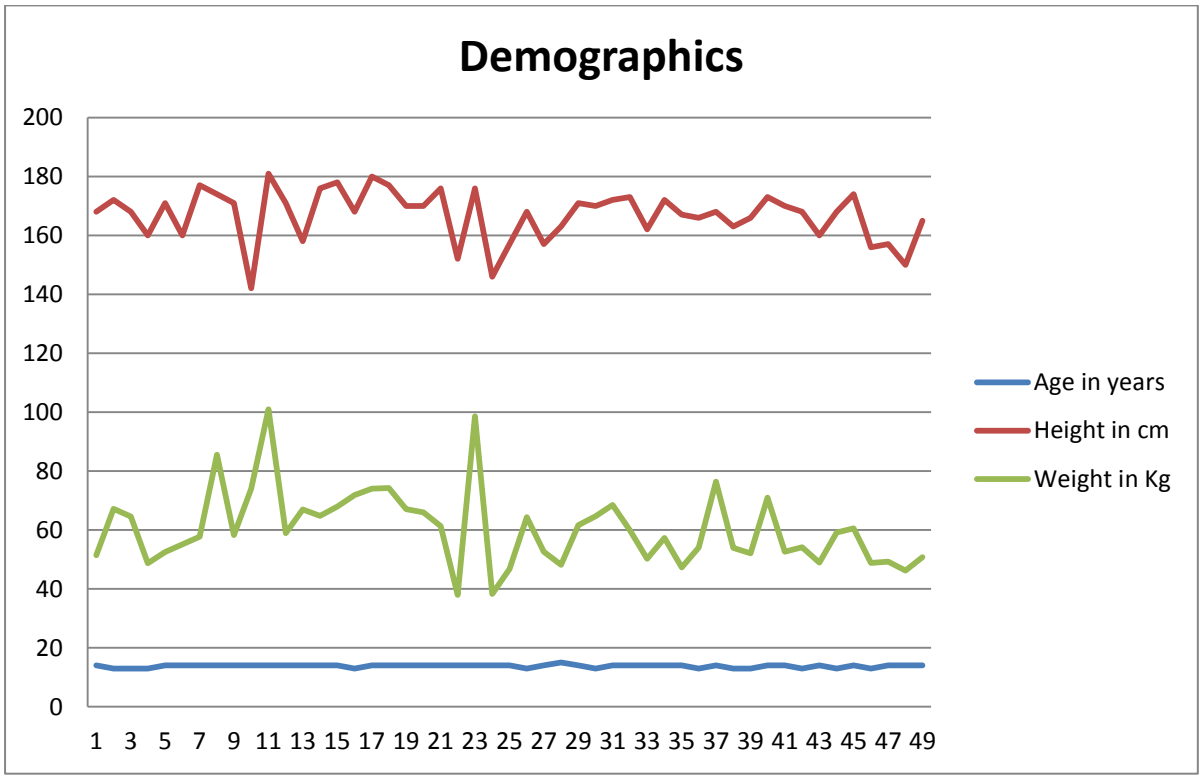
both instances a repeat blood pressure was taken standing up and in both learners the second blood pressure was within normal limits. One learner had an initial blood pressure of 154/84 mmHg with a repeat blood pressure standing of 142/71 mmHg, he reported not being aware of having any blood pressure medical history. On the rest of his screening he also was positive for a cardiovascular symptom of sometimes feeling short of breath when exercising.

If the AHA 12 point assessment is grouped together than a total of 27 out of the 49 learners would have been positive for the PPSP and required further evaluation. Of these 27, 26 would have been positive by only completing the medical history. Outside of the learner with the vasovagal episode, the family history and basic physical examination did provide any positives that were not already positive in the medical history component.

Category 2: Demographic data:

The additional demographic data that was recorded is shown below.

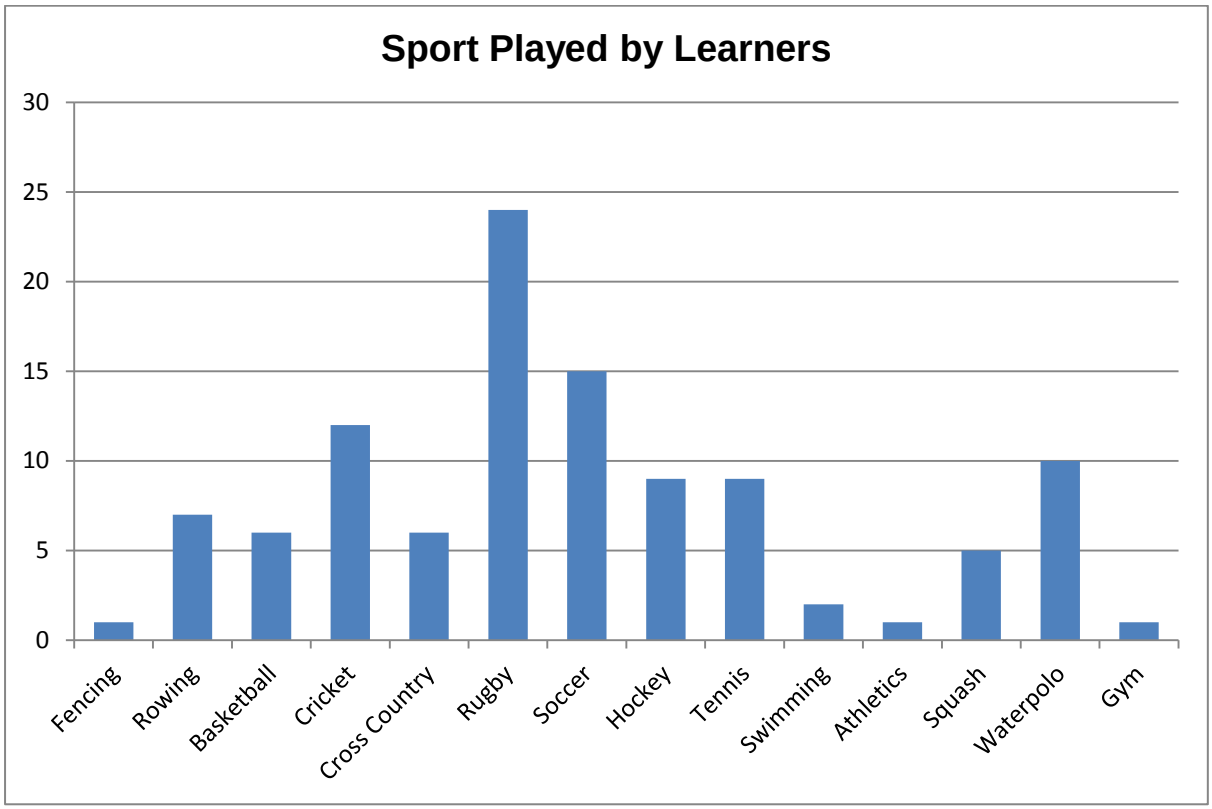
Graph 1: Demographic data



Demographic	Mean (n)
Age/years	13.8
Height/cm	166.9
Weight/kg	60.5

All of the learners, except one, reported playing sport and recorded that they participate in a number of sports, the ratio of the various sports played as a total reported is shown graphically below:

Graph 2: Sport Played by Learners

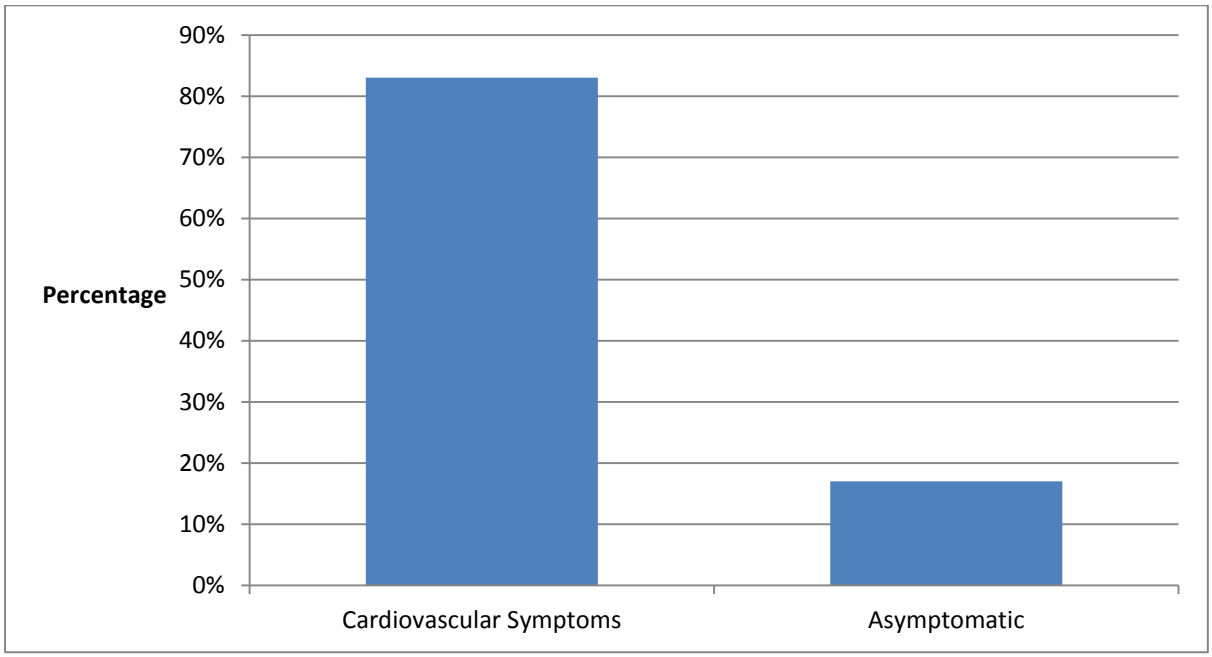


A number of the learners reported having a co-morbidity of asthma, 12 out of the 49 learners (24,5%), of these asthmatic learners 10 out of the 12 (83%) reported positive on cardiovascular history, and this was always due to:

Do you get short of breath or tired, during exercise, that appears out of keeping with the amount of exertion.

If these 10 were subsequently excluded from the overall 27 that were initially positive on the AHA 12 element PPSP, on the basis that the symptoms were more likely attributable to asthma rather than cardiac, then the overall number of positives changes from 27 to 17 out of 49 learners or 34.6%.

Graph 3: Percentage of Known Asthmatic Learners who were Positive on the Cardiovascular History.



The other co-morbidities reported were one learner who said he was anaemic, this learner reported a positive cardiovascular history for:

Have you ever collapsed, fainted or felt like fainting during exercise.

There was also one learner who was a Non-Insulin Dependent Diabetic, there PPSP was normal.

Category 3: Resting 12 lead ECG:

The table below documents the resting 12 lead ECG findings done in the supine position on all 49 learners. The criteria used are those determined by the ESC, any one finding is then considered positive.

Table 7: Criteria for a positive 12 lead ECG

P wave	**Yes or No**
• Left atrial enlargement: negative portion of the P wave in lead V1 ≥0.1mV in depth and ≥0.04s in duration;	0 Yes
• Right atrial enlargement: peaked P wave in leads II and III or V1 ≥0.25mV in	0 Yes

amplitude.	

QRS complex	**Yes or No**
• Frontal plane axis deviation: right ≥ +120 or left -30 to -90;	1 Yes
• Increased voltage: amplitude of R or S wave in standard lead ≥2mV, S wave in lead V1 or V2 ≥ 3mV, or R wave in lead V5 or V6 ≥ 3mv;	2 Yes
• Abnormal Q waves ≥0.04s in duration or ≥25% of the height of the ensuing R wave or QS pattern in two or more leads;	0 Yes
• Right or left bundle branch block with QRS duration ≥0.12s;	1 Yes
• R or R' wave in lead V1 ≥0.5mV in amplitude and R/S ratio ≥1.	0 Yes

ST – segment, T waves and QT interval	**Yes or No**
• ST segment depression or T wave flattening or inversion in two or more leads;	9 Yes
• Prolongation of heart rate corrected QT interval >0.44s in males and >0.46s in females.	1 Yes

Rhythm and conduction abnormalities	**Yes or No**
• Premature ventricular beats or more severe ventricular arrhythmias;	1 Yes
• Supraventricular tachycardias, atrial flutter or atrial fibrillation;	0 Yes
• Short PR interval (<0.12s) with or without 'delta' wave;	1 Yes
• Sinus bradycardia with resting heart rate ≤40 beats/min;	0 Yes
• First (PR≥0.21s), second or third degree atrioventricular block.	0 Yes

When calculated in total there were 16 positive findings but with overlap accounting for 4 learners, the total number of learners screened using the ESC criteria for resting 12 lead ECG was 12 out of 49 learners, or 24.5%.

Of these 12 learners, 9 were positive for:

ST segment depression or T wave flattening or inversion in two or more leads

If this criteria were to be removed from the ESC criteria on the basis of young athletes then the positive number of learners identified through resting 12 lead ECG would be 3 out of 49 or 6.1%.

Of the total of 12 learners that were positive using all the criteria, there was only one learner that did not have a corresponding positive AHA screening assessment. This means that the addition of the 12 lead ECG identified one further learner from the 49 that would require further evaluation, equivalent to 2%.

Category 4: Cost analysis:

The cost analysis that was done for the completion of this research is explained below:

The calculations were based on the PPSP having taken a total of 3 hours, and included the services of 5 registered nurses and 1 emergency medicine specialist. The hourly rate payable to the nursing staff was averaged at R200/hour and for the doctor R600/hour. These rates are based on the general fee structure payable in private independent practice.

The amount payable by the medical funders for the performance of an ECG in independent private practice is R101.10 if the practitioner interpreting the ECG is a medical specialist and R77.80 if a general practitioner does the interpretation. This research was calculated based on interpretation by an emergency medicine specialist. There is also the physical cost of the electrodes and the paper for the ECG, this was paid for by the researcher and amount of R678 was paid in total.

There was a significant cost paid by the researcher for the envelopes and information leaflets, together with the informed consent and assent forms and the medical and family history questionnaire forms. This cost was calculated at R9.50

per learner to whom these were sent, for the purpose of this research, this was a total of 164 learners.

The costs that are not included, were the actual ECG machines, a total of 2 were sponsored for the PPSP by Welch Allyn. Also not included was the other equipment used for taking blood pressure measurements, height and weight.

Table 8: Cost Analysis

	Emergency Medicine Specialist consultation time at R600/hr	5 Registered Nurses consultation time at R200/hr	Envelope and paper costs for the 164 learners.	ECG interpretation fee as determined by Medical Funders for 49 learners	Cost of actual performance of an ECG, inlcuding paper and electrodes for 49 learners
Rand Value	**R 1 800**	**R 3 000**	**R 1 558**	**R 4 953.90**	**R 678**
Total					**R 11 989.90**
Total/Learner					**R 244.69**

CHAPTER 6: DISCUSSION

This chapter will review the subject of PPSP and the role that they play in preventing SCA in athletes through the detection of underlying cardiovascular conditions. The discussion will be organised according to each objective of the research.

6.1 The first objective

Document the findings of the Pre-Participation Screening Protocol done according to the American Heart Association guidelines that make use of the 12 point questionnaire for the screening of underlying cardiovascular risk factors that may predispose athletes to sudden cardiac arrest.

The learners were required to complete a medical history and family history. This was done without the presence of the researcher and in the presence of the parents/legal guardian. The AHA with the 12 point screening protocol advocates that any one positive score should result in further review and testing.

The number of learners that scored a positive on the AHA screening protocol was 27 out of 49 or 55.1%. This is a significant number but needs more interpretation and explanation. A number of the learners had an underlying history of asthma and were currently on treatment for asthma. Of the 12 learners that declared asthma as a co-morbidity, 10 were positive in the AHA protocol for the category of: ***Do you get short of breath or tired, during exercise, that appears out of keeping with the amount of exertion.***

Do you experience chest pain or discomfort, when	**Have you ever collapsed, fainted or felt like fainting during**	**Do you get short of breath or tired, during exercise, that appears out of keeping with**	**Are you aware whether or not you have a heart**	**Do you have high blood pressure.**

exercising.	exercise.	the amount of exertion.	murmur.	
7	4	19	0	0

The interpretation of shortness of breath during exercise as a symptom is more likely due to a respiratory condition, for example asthma, or in fact to poor conditioning of the athlete.[48] Even if this remains the more likely explanation there needs to be further documentation in order for the young athlete to pass the PPSP.

This may include the need for a specialist in Paediatrics or Paediatric cardiology to be present to elicit a more detailed history, ask about the time of onset of the shortness of breath and potentially may well require a trial of a bronchodilator therapy[44] to attempt to demonstrate that the cause is unlikely to be an underlying cardiovascular condition. This process, while adding additional cost to the PPSP, also places undue stress on the young athlete and the parents/legal guardian while such evaluations are made.

Bille et al, in the Lausanne Recommendations is not supportive of the AHA screening, in part, due to the simplicity of the questions. While this makes the AHA protocol readily implementable it is accepted that the number of false positives may be high. The Lausanne Recommendations routinely ask a more detailed participant history to elicit an underlying cardiovascular cause, as opposed to other respiratory conditions.

Campbell et al records that the American Academy of Pediatrics has acknowledged there is a wide variation in the physician interpretation of the symptoms potentially experienced by athletes and goes on to endorse the Paediatric sudden cardiac arrest risk assessment form that makes mention of a more detailed history. Campbell et al recorded a 7% dyspnoea positive during one screening program.

If some of the other positive findings on cardiovascular history are reviewed, a total of 7 learners out of 49 or 14.3% complained of: ***Do you experience chest pain or discomfort, when exercising.***

- Chest pain is a common presenting complaint to Paediatricians but is very rarely attributed to a cardiac cause.[48] When the chest pain occurs with intense exercise and with additional cardiovascular signs and symptoms, such as light-headedness, syncope or tachycardia then a cardiac aetiology becomes more likely and conditions such as CCAA should be sought and excluded.[49]
- Campbell et all recorded an 8% positive for chest discomfort.
- Maron et al in a study in Minnesota found that only 12 out of 134 athletes who had a cardiac arrest during exercise reported any symptoms immediately prior to the arrest. This included chest pain, dyspnoea or weakness.

4 of the learners or 8.2% gave a positive history of: ***Have you ever collapsed, fainted or felt like fainting during exercise.***

Syncope is common in teenagers but in most instances the cause is non-cardiac and related to heat, dehydration or stress and anxiety.[50] These precipitating factors need to be explored if the cardiovascular history is going to be cleared. The likelihood of a cardiac cause of the syncope is considered if there are further symptoms of chest pain or shortness of breath, that occur simultaneously during exercise.

The family history is best provided by the parents/legal guardians. Young athletes may not be aware of any potential cardiovascular pathology in immediate family members. The family history of sudden death or even syncope is found more commonly with the LQTS[50] and needs to be evaluated in detail as symptoms are often absent and clinical examination normal.

Heart murmur (auscultation should be performed in supine and standing positions or with valsalva manoeuvre, specifically to identify murmurs of dynamic left ventricular outflow tract obstruction.	**Femoral pulses to exclude aortic coarctation.**	**Physical stigmata of Marfan syndrome.**	**Brachial artery blood pressure (sitting position) preferably taken in both arms. (Left Arm)**
0	0	1	2

One learner gave a family history of Marfan Syndrome saying that his father had the syndrome confirmed. The learner was unaware whether he had ever been formally examined for Marfans Syndrome.

There are a number of systems affected in Marfans Syndrome; musculoskeletal with scoliosis and pectus excavatum, hyperextension at joints, eye findings such as myopia. The cardiac effects are typically mitral valve prolapse and aortic dilatation and cardiac complications are the cause of death in 80% of patients with Marfans Syndrome.[4]

The AHA 12 point history and physical examination has come under some scrutiny in the USA, not only for the complexity of interpreting the findings but through low sensitivities for identifying athletes with risks for underlying cardiovascular disease. In many instances the entire 12 points are not being covered and this further enhances the low sensitivity.[7] While the cost of performing the AHA 12 element PPSP is relatively low, cognisance needs to be given to a more detailed interpretation of the findings especially in light of co-morbidities and to pathologies that are often asymptomatic on history and examination, in particular hypertrophic cardiomyopathy and some of the channelopathies. Both of which would require and ECG as part of the PPSP to enable detection.

6.2 The second objective

Perform and document the findings of a resting 12 lead ECG done and interpreted according to the European Society of Cardiology criteria for using the resting 12 lead ECG in order to identify an athlete at risk of sudden cardiac arrest.

The resting 12 lead ECG was performed in the supine position and done by a registered nurse. The criteria used for interpretation were those that are accepted by the European Society of Cardiology and if any one of the criteria was found then the ECG was considered positive and the athlete is required to have further evaluation, usually either by asking a cardiologist to interpret the ECG, if not already done, and then ultimately by echocardiography. A total of 12 learners or 24.5% had a positive ECG based on the ESC criteria.

The role of the ECG in a PPSP is one that is regularly debated, not only because of cost but also through the knowledge required to accurately interpret and limit the number of false positives.[35]

In Japan there is some evidence that in young athletes the T wave inversion can be considered normal and not representative of any risk of an underlying cardiovascular condition.[8] If this criteria was removed in this research then the number of positive ECG's would change from 12 to 3 out of 49 or from 24.5% to 6.1% respectively.

- "QRS voltage increases" is another one of the established ESC criteria that may need review. This ECG finding has been shown to occur in up to 40% of highly trained athletes and only in 2% of patients with HCM. In a number of reports the abnormality found on ECG is the "QRS complex voltage" and this is found in more than half the ECG's done.[51]

- Corrado et al emphasizes that for an ECG to be considered positive for potential HCM then more than one criteria for HCM should be present. These would include:
  - Increased QRS voltage
  - Abnormal Q waves in the inferior and or lateral leads
  - Down sloping ST interval
  - Inverted T waves in the precordial leads

  Abnormalities of QRS voltage often fall into the so called “grey zone” where it becomes difficult, even with 2D echocardiography, to distinguish between physiological and pathological hypertrophy of the heart.

  Isolated increases in QRS voltage account for more than half of the “abnormalities” in many reports but they do not give a clear indication of imminent SCD.

Where revised ECG criteria have been used in a sample of 1005 athletes the number of abnormal ECG’s was reduced from 292 to 110.[41] This still remains a significant 11% of competitors.

The ECG has to demonstrate a reduction in the incidence of sudden cardiac death if it is going to be routinely included in a PPSP. While the Corrado et al series appeared to prove this, some of the data from Israel through Steinvil et al has shown an equivocal incidence post introduction of a PPSP that included resting 12 lead ECG screening.[39] Steinvil et al has also put forward that the Corrado et al series would also show an equivocal incidence if the time periods were extended. Both studies had a small number of SCD that generated this finding and more information and research is needed to evaluate such an outcome.[35,39,40]

While the ECG remains expensive to perform and time consuming to analyse, there is a feeling amongst the participant and in particular when dealing with a young athlete, the parent or legal guardian that the PPSP has been done more comprehensively when an ECG has been performed.

The scientific nature of an ECG and the interpretation thereof is such that this must be the gold standard when screening for underlying cardiovascular pathology and risk. Chang et al has suggested that more use is made of the ECG in PPSP on the basis that the cost of interpretation and the false positives could be improved on, through technology and automated, computer analysis of the ECG.[46]

Even where ECG analysis is done, the medical history and basic medical examination still need to be included if a comprehensive screening program is mandated. Some of the underlying causes, CCAA and myocarditis, will have a normal ECG and rely on the cardiovascular history and examination to be excluded.

Screening of the young athlete, in the case of this research, grade 8 learners, is made difficult by the fact that the young heart may not be showing any signs of hypertrophic cardiomyopathy on the ECG and this is why many centres advocate the PPSP must done twice during a 5 year high school period.[48] Given that hypertrophic cardiomyopathy is the most common cause that justifies the ECG this makes it difficult to mandate in grade 8 learner screening. There are no clear guidelines presented that alter the criteria for a positive ECG based on age of the athlete.

6.3 The third objective

Compare the findings of cardiovascular risk factors as identified by using the American Heart Association protocol with those found by interpreting a resting 12 lead ECG according to the European Society of Cardiology guidelines.

The reason behind this objective was to try and see if there was any correlation between the medical history and examination and the ECG. The number of ECG positive findings was 12 out of 49, and the number of positive findings on the AHA 12 element PPSP was 26 out of the 49. These are the base figures without adjustment for T wave inversion on the ECG and for potential asthmatic symptoms on the AHA protocol respectively. Both of these adjustments would have significantly reduced the number of positives in both the ESC criteria and the AHA 12 element protocol.

The addition of the resting 12 lead ECG only added one further learner to the total.

Of the 12 positive ECG learners, 11 of them had a positive AHA protocol. ST segment depression or T wave flattening or inversion in two or more leads was the positive ECG criteria. This was not significant as the T wave flattening was looked for in any leads and not limited to the precordial leads. This learner had no T wave inversion involving the precordial leads and no other abnormalities suggestive of HCM.

While this may suggest that the ECG does not add further value, this would be in contrast to the study by Baggish et al where he showed that ECG analysis using the ESC criteria detected more than double the number of athletes at high risk for underlying cardiovascular pathology when compared to the medical history and physical examination alone. The study itself only had a sample of 510 athletes and 11 were identified as high risk through ECG against 5 with medical history and physical examination.[8,51]

There is no evidence or data to suggest a change to the PPSP where an athlete shows more than one positive finding. The AHA have been steadfast in their position that the 12 element screening protocol is considered positive if any **one** finding is positive. This would then mandate further assessment. Likewise the ESC considers any **one** of the identified ECG criteria as being enough to prompt further evaluation.

The likelihood of improving the sensitivity of the medical history and basic medical examination as well as decreasing the number of false positive ECG screenings is likely to be improved on, if multiple symptoms and ECG criteria were considered. There are currently no suggested guidelines for such interpretation

6.4 The fourth objective

Determine the comparative cost of these two particular screening programs.

The cost analysis done showed that the average cost per learner screened in this research was R244.69. This amount is comparable to a doctor's consultation in the independent private healthcare setting. While this may be reasonable for learners of parents/legal guardians who are able to financially send their children to an independent private school, the number of parents/legal guardians who are capable of this in the South African setting are in the minority. On a similar line, the number of people who can afford independent private health care, are also the minority.

The cost analysis done by Corrado et al was in the region of 30 Euros and in the USA it is estimated that the performance of an ECG alone would cost US$25.[35,44,46,47] These costs are in a similar category when comparing the cost of this research, although the absolute breakdown of how these cost are generated is not provided in the literature.

Calculations are very specific for absolute costs but what is not explained is the cost that is incurred when further evaluation is required, especially when the PPSP yielded a false positive. There is data on the false positive rate of the ECG, as determined by the ESC criteria, to range between 9-40%.[14] This will then require, either a Cardiologist or specialist in Sports Medicine to review this ECG and see if they agree and the athlete should then be referred. This referral, almost always, then requires an echocardiogram.

The ECG is not the only modality that can incur extra costs. When the AHA 12 element screening protocol is used and requires a degree of interpretation to limit a positive finding that is more than likely not from a cardiovascular condition, the patient often has to be reviewed by a Paediatrician, particularly in the young athlete, with significant time spent taking a more detailed and thorough history and physical examination.

Most PPSP advocate that such screening should be done twice in an athlete's high school career[8], given the delayed presentation of symptoms and ECG changes for some of the underlying cardiovascular conditions. This would then repeat the costs in a 5 year period.

6.5 Conclusion

PPSP for SCA in young athletes is a complex topic that requires an understanding of the various cardiovascular aetiologies that may place the athlete at a higher risk of SCA during competition. These conditions can potentially be screened for but there is no clear and accepted process that such PPSP should follow.

The incidence of SCA is low, and while the media broadcasts those events that happen in athletes, there are potentially many more SCA's due to underlying cardiovascular pathology that occur in the non-athlete. Corrado et al[35] has data that shows a two fold increase in athletes but this is contested by Maron et al[36,37] who found no significantly higher incidence in the two groups. From a cost versus benefit ratio it is not possible to perform PPSP on all children. Estimates in the USA put this cost at US$2 Billion annually.[46]

The inclusion of a resting 12 lead ECG is supported by the ESC and not so by the AHA. Given the nature of the various underlying cardiovascular pathologies that should be screened for, it seems essential that the resting 12 lead ECG be included if the sensitivity of such PPSP is to be increased. Not all conditions are apparent on

the ECG alone but then not all conditions will reveal themselves on medical history and examination alone either.

The logistics of undertaking PPSP at a school going age with the requirements of informed consent from parent/legal guardian and learner assent are not to be underestimated. The confidentiality regulations that govern school learners make this administrative process ever more challenging.

When a PPSP does find an athlete positive, the current guidelines stipulate that only one criteria need be met, then there is an obligation to refer to a specialist and to undertake further, more costly investigations, in order to decide if the athlete is actually at any greater risk.

Young people compete in sport and are encouraged to do so, they achieve success again and again, and are driven to perform at a continual higher level. Undiagnosed cardiovascular pathology that precipitate a SCA is somehow more tragic in the athlete who is competing, and while the introduction of PPSP is not necessarily that simple; the medical profession and advancements in technology should be striving to ensure a decrease in this, albeit infrequent, but always tragic event.

6.6 Limitations

The researcher recognises some of the limitations in undertaking this research:

- The prevalence of underlying cardiovascular disease is low and requires high study volumes.
- The medical history and family cardiovascular history is often poorly provided by a young learner.
- The number of parents/legal guardians that provided informed consent may have been influenced to include a higher proportion of learners that had existing co-morbidities.

- In order to perform PPSP on school learners the process of obtaining permission and informed consent is not straight forward. In this research the meeting with the Headmaster of St Stithians Boys College, combined with the Director of Sport was easily arranged and the concept of the proposed research was welcomed. The detail of providing the necessary information to the parent/legal guardian and the learner is comprehensive and based on school policy could not be done directly with the parent/legal guardian.
- The sealed envelope containing the information leaflet and the respective informed consent and assent forms was handed to the grade 8 learner and he was required to open this and discuss with his parents/legal guardian. The responsibility was then left again with the grade 8 learner to ensure the return of the necessary documents. The number of returned forms was 50, from a total of 164, giving a 30.5% return percentage. This was a surprising and inordinately low percentage and possibly explained on a number of factors. 1 form was returned to the Division of Emergency Medicine at the University of the Witwatersrand. While this information was disclosed to the parent/legal guardian it was made very clear that the completed forms need to be returned to the Director of Sport or the researcher contacted directly.
- There was also the potential for apathy with both learner and parents/legal guardian alike, potentially on the basis of this not being compulsory and not perceived to be necessary. The fact that 28% that did return informed consent forms had some underlying medical condition suggests that a higher percentage of parents/legal guardians whose child/minor had such a condition were more likely to consent, on the basis that they were more concerned medically.

- In 2 cases the parents were in contact with the researcher after the PPSP had been done saying they had never actually received anything and were completely unaware of the proposed research. The policy of the school as determined by their constitution was such that the researcher was not permitted to contact the parent/legal guardian by any means and all communication had to take place through the school directly.
- The completing of the medical and family history questionnaire requires some time and interaction between parent/legal guardian and learner. This can be done absent from a medical person and this was the case in this research. This is advocated to lessen costs and decrease the time of the PPSP but comes with the added challenge of potentially having a number of learners that have marked a symptom positive when in fact on more careful questioning this could be excluded as not being suggestive of a cardiovascular condition.
- School time is a precious commodity and is utilised comprehensively at all levels, learners have direct curriculum requirements that cannot be interrupted. The extra mural activities of most learners is also extensive and finding a suitable time that can be allocated, even by the research being done on the school premises, was difficult. Ultimately a 3 hour allocation was agreed upon and this was utilised in full to do PPSP on the 49 learners that had consented. Had the full class of 164 learners consented then this time frame would have to be significantly extended and the logistics with examination space reviewed.

CHAPTER 7: REFERENCES

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Appendix 1: Adapted Medical History Questionnaire from the 12 Element AHA Recommendations for Pre-participation Cardiovascular Screening of Competitive Athletes.[35]

Personal history	Yes or No
6. Do you experience chest pain or discomfort, when exercising.	
7. Have you ever collapsed, fainted or felt like fainting during exercise.	
8. Do you get short of breath or tired, during exercise, that appears out of keeping with the amount of exertion.	
9. Are you aware whether or not you have a heart murmur.	
10. Do you have high blood pressure.	

Family History	Yes or No
4. Has any relative under the age of 50 years died from a heart problem.	
5. Are you aware of any close relative, under the age of 50 years that has a heart disability.	
6. Do you have any specific knowledge of known heart conditions in family members, eg Hypertrophic cardiomyopathy, Marfan syndrome, Long QT syndrome.	

Physical Examination	Findings
5. Heart murmur (auscultation should be performed in supine and standing positions or with valsalva manoeuvre, specifically to identify murmurs of dynamic left ventricular outflow tract obstruction.	
6. Femoral pulses to exclude aortic coarctation.	
7. Physical stigmata of Marfan syndrome.	
8. Brachial artery blood pressure (sitting position) preferably taken in both arms.	

Appendix 2: Criteria for a positive 12 lead ECG, as set out by the ESC[35,40]

P wave	Yes or No
• Left atrial enlargement: negative portion of the P wave in lead V1 ≥0.1mV in depth and ≥0.04s in duration;	
• Right atrial enlargement: peaked P wave in leads II and III or V1 ≥0.25mV in amplitude.	

QRS complex	Yes or No
• Frontal plane axis deviation: right ≥ +120 or left -30 to -90;	
• Increased voltage: amplitude of R or S wave in standard lead ≥2mV, S wave in lead V1 or V2 ≥ 3mV, or R wave in lead V5 or V6 ≥ 3mv;	
• Abnormal Q waves ≥0.04s in duration or ≥25% of the height of the ensuing R wave or QS pattern in two or more leads;	
• Right or left bundle branch block with QRS duration ≥0.12s;	
• R or R' wave in lead V1 ≥0.5mV in amplitude and R/S ratio ≥1.	

ST – segment, T waves and QT interval	Yes or No
• ST segment depression or T wave flattening or inversion in two or more leads;	
• Prolongation of heart rate corrected QT interval >0.44s in males and >0.46s in females.	

Rhythm and conduction abnormalities	Yes or No
• Premature ventricular beats or more severe ventricular arrhythmias;	
• Supraventricular tachycardias, atrial flutter or atrial fibrillation;	
• Short PR interval (<0.12s) with or without 'delta' wave;	
• Sinus bradycardia with resting heart rate ≤40 beats/min;	
• First (PR≥0.21s), second or third degree atrioventricular block.	

Appendix 3:

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Dr Peter Anderson

CLEARANCE CERTIFICATE	M111131
PROJECT	Sudden cardiac Arrest in School Athletes: Understanding the Role of Pre-Participation Screening
INVESTIGATORS	Dr Peter Anderson.
DEPARTMENT	Division of Emergency Medicine
DATE CONSIDERED	25/11/2011
M1111310DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 25/02/2012 **CHAIRPERSON** .....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Prof Efraim Kramer

DECLARATION OF INVESTIGATOR(S)
To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

Appendix 4: Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-partcipation Screening.

Dear Chairperson of Board of Governors

My name is Dr Peter Anderson, I am a registered Specialist in Emergency Medicine, currently sitting for a Masters in Science in Medicine in Emergency Medicine at the University of the Witwatersrand.

Having been a past pupil of St Stithians College I am aware of the sporting capability and emphasis that is placed on all pupils. This I endorse with enthusiasm; physical activity has been shown to be of significant benefit to health and well-being. You need look no further than the media advertising the “Let’s Play” concept.

The intention of this information leaflet is to highlight the topic of my intended research against this background, which is to primarily attempt to identify a program that may help reduce the incidence of sudden cardiac arrest, in the young athlete. There is well documented literature that if young athletes are subjected to what is called a pre-participation medical screening program, that any potential underlying heart problems may be identified and in so doing, significantly reduce the risk of what the medical world terms sudden cardiac arrest.

What follows below is the synopsis of this intended research

“Sudden cardiac arrest in young athletes is a tragic event that can potentially be reduced through the implementation of a pre-participation screening program. While the absolute contents of this program are debated, consensus does exist, that should such a program be implemented, a reduction in mortality will be found. The emphasis of any pre-participation screening is found in a history and basic physical examination, with or without routine electrocardiogram (ECG) testing. This is based on the understanding that 90% of sudden cardiac arrests are attributable to an underlying cardiac pathology

with the majority being hypertrophic cardiomyopathy. Debate continues around the cost effectiveness of such a program but there is no doubt that in a society that is promoting an active lifestyle and with the pressure of competitive sport at most schools, there is likely to be zero tolerance for not being able to screen for potentially lethal cardiac pathology. This research project aims to conduct a pilot pre-participation screening program at one Johannesburg high school, using a combination of both the American Heart Association and European Society of Cardiology Guidelines. The prevalence of findings will be documented and comparisons made between the two programs. Further a cost analysis will be done for each program, in order to determine the appropriateness of introducing such a screening program at school level in South Africa."

I must emphasize at this point that the incidence of such an event is rare, but obviously should be prevented by all possible means. It is my intention to undertake pre-participation medical screening in the form of a basic medical history questionairre and physical examination together with doing an electrocardiogram (ECG) on all grade 8 male scholars at the school. This process will be done by myself and a registered professional nurse will be doing the ECG on each pupil. The information will be kept strictly confidential and the writing up of my research will be in anonymous format. Any positive findings will be communicated to both scholar and parent or legal guardian in person by myself with the necessary referral advice to a cardiologist if needed.

The practicalities of such an assessment will involve the scholar having to undress to the waist, in order for the ECG and physical examination to be done. Further the scholar will be asked to complete a basic history questionnaire. Please also note that this research is being done on male scholars only, the justification being the

significant incidence in the literature supporting a male:female incidence of 5:1 to 9:1.

I must emphasize too, that this is being done for research purposes, and while the literature supports such screening, it is certainly not done at every school world-wide. My intention is for this process to be of benefit to both parent or legal guardian and scholar alike, as well as to the Sports Institute of St Stithians College.

There is no obligation to part take in this research.

This research project will be conducted under the auspice of the University of the Witwatersrand with full ethics committee clearance from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand.

All costs for this intended research will be borne by myself.

Should there be any queries, please do not hesitate to contact me directly or the ethics committee.

Dr Peter Anderson

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Human Research Ethics Committee of the University of the Witwatersrand.

Disclaimer

This research together with the findings thereof, be they positive or negative, is not meant to be taken as authoritative, especially in the setting of sudden cardiac arrest during exercise.

Appendix 5

Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-partcipation Screening.

Dear Parent

Hi! My name is Dr Peter Anderson, I am a registered Specialist in Emergency Medicine, currently sitting for a Masters in Science in Medicine in Emergency Medicine at the University of the Witwatersrand.

Having been a past pupil of St Stithians College I am aware of the sporting capability and emphasis that is placed on all pupils. This I endorse with enthusiasm; physical activity has been shown to be of significant benefit to health and well-being. You need look no further than the media advertising the “Let’s Play” concept.

The intention of this information leaflet is to highlight the topic of my intended research against this background, which is to primarily attempt to identify a program that may help reduce the incidence of sudden cardiac arrest, in the young athlete. There is well documented literature that if young athletes are subjected to what is called a pre-participation medical screening program, that any potential underlying heart problems may be identified and in so doing, significantly reduce the risk of what the medical world terms sudden cardiac arrest.

I must emphasize at this point that the incidence of such an event is rare, but obviously should be prevented by all possible means. It is my intention to undertake pre-participation medical screening in the form of a basic medical history questionairre and physical examination together with doing an electrocardiogram (ECG) on all grade 8 male scholars at the school. This process will be done by myself and a registered professional nurse will be doing the ECG on each pupil. The information will be kept strictly confidential and the writing up of my research will be

in anonymous format. Any positive findings will be communicated to you in person by myself with the necessary referral advice to a cardiologist if needed.

The practicalities of such an assessment will involve your son having to undress to the waist, in order for the ECG and physical examination to be done. Further your son will be asked to complete a basic history questionnaire. Please also note that this research is being done on male scholars only, the justification being the significant incidence in the literature supporting a male:female incidence of 5:1 to 9:1.

I must emphasize too, that this is being done for research purposes, and while the literature supports such screening, it is certainly not done at every school world-wide. My intention is for this process to be of benefit to both parent or legal guardian and scholar alike.

There is no obligation to part take in this research.

This research project will be conducted under the auspice of the University of the Witwatersrand with full ethics committee clearance from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand. **Ref M111131.**

All costs for this intended research will be borne by myself.

Should there be any queries, please do not hesitate to contact me directly or the ethics committee.

Dr Peter Anderson

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Disclaimer

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Appendix 6

Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-partcipation Screening.

Dear Scholar

Hi! My name is Dr Peter Anderson, I am a registered Specialist in Emergency Medicine, currently sitting for a Masters in Science in Medicine in Emergency Medicine at the University of the Witwatersrand.

Having been a past pupil of St Stithians College I am aware of the sporting capability and emphasis that is placed on all pupils. This I endorse with enthusiasm; physical activity has been shown to be of significant benefit to health and well-being. You need look no further than the media advertising the “Let’s Play” concept.

The intention of this information leaflet is to highlight the topic of my intended research against this background, which is to primarily attempt to identify a program that may help reduce the incidence of sudden cardiac arrest, in the young athlete. There is well documented literature that if young athletes are subjected to what is called a pre-participation medical screening program, that any potential underlying heart problems may be identified and in so doing, significantly reduce the risk of what the medical world terms sudden cardiac arrest.

I must emphasize at this point that the incidence of such an event is rare, but obviously should be prevented by all possible means. It is my intention to undertake pre-participation medical screening in the form of a basic medical history questionairre and physical examination together with doing an electrocardiogram

(ECG) on all grade 8 male scholars at the school. This process will be done by myself and a registered professional nurse will be doing the ECG on each pupil. The information will be kept strictly confidential and the writing up of my research will be in anonymous format. Any positive findings will be communicated to you in person by myself with the necessary referral advice to a cardiologist if needed.

The practicalities of such an assessment will involve you having to undress to the waist, in order for the ECG and physical examination to be done. Further you will be asked to complete a basic history questionnaire. Please also note that this research is being done on male scholars only, the justification being the significant incidence in the literature supporting a male:female incidence of 5:1 to 9:1.

I must emphasize too, that this is being done for research purposes, and while the literature supports such screening, it is certainly not done at every school world-wide. My intention is for this process to be of benefit to both parent or legal guardian and scholar alike.

There is no obligation to part take in this research.

This research project will be conducted under the auspice of the University of the Witwatersrand with full ethics committee clearance from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand. **Ref M111131.**

All costs for this intended research will be borne by myself.

Should there be any queries, please do not hesitate to contact me directly or the ethics committee.

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Disclaimer

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Appendix 7: Adapted Medical History Questionnaire from the 12 Element AHA Recommendations for Pre-participation Cardiovascular Screening of Competitive Athletes.

Personal history	**Yes or No**
11. Do you experience chest pain or discomfort, when exercising.	
12. Have you ever collapsed, fainted or felt like fainting during exercise.	
13. Do you get short of breath or tired, during exercise, that appears out of keeping with the amount of exertion.	
14. Are you aware whether or not you have a heart murmur.	
15. Do you have high blood pressure.	

Family History	**Yes or No**
7. Has any relative under the age of 50 years died from a heart problem.	
8. Are you aware of any close relative, under the age of 50 years that has a heart disability.	
9. Do you have any specific knowledge of known heart conditions in family members, eg Hypertrophic cardiomyopathy, Marfan syndrome, Long QT syndrome.	

Appendix 8:

CONSENT FORM-Board of Governors

Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-participation Screening

We, (name of Board of Governors) hereby grant permission for St Stithians College, Grade 8 male scholars to participate in the research project entitled:

Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-participation Screening

The procedures have been explained and we understand and appreciate their purpose. We have read and understand the attached information leaflet, **appendix 4**. The term procedure refers to a history taking and basic physical examination, together with a resting electrocardiogram (ECG).

I understand that the procedures form part of a research project, and may not provide any direct benefit to the scholar.

I understand that all experimental procedures have been sanctioned by the Human Research Ethics Committee of the University of the Witwatersrand.

This consent is subject to the assent of scholar and consent parent or legal guardian alike.

_____	_____	_____
Subject Name	Subject Signature	Date
_____	_____	_____
Investigator Name	Investigator Signature	Date

Appendix 9

CONSENT FORM-Parent

Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-participation Screening

I, (parent or legal guardian) of (name of scholar) hereby grant permission to (name of scholar) participating in the research project entitled:

Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-participation Screening

The procedures have been explained to me and I understand and appreciate their purpose, and the extent of my involvement. I have read and understand the attached patient information leaflet, **appendix 3A and appendix 4**. The term procedure refers to a history taking and basic physical examination, together with a resting electrocardiogram (ECG).

I understand that the procedures form part of a research project, and may not provide any direct benefit to my child.

I understand that all experimental procedures have been sanctioned by the Human Research Ethics Committee of the University of the Witwatersrand.

I understand that my child's participation is voluntary, and that they are free to withdraw from the project at any time.

_____	_____	_____
Subject Name	Subject Signature	Date
_____	_____	_____
Investigator Name	Investigator Signature	Date

Appendix 10

ASSENT FORM-Scholar

Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-participation Screening

I, (name of scholar) of hereby grant permission to participate in the research project entitled:

Sudden Cardiac Arrest in School Athletes: Understanding the Role of Pre-participation Screening

The procedures have been explained to me and I understand and appreciate their purpose, and the extent of my involvement. I have read and understand the attached patient information leaflet, **appendix 3B**. The term procedure refers to a history taking and basic physical examination, together with a resting electrocardiogram (ECG).

I understand that the procedures form part of a research project, and may not provide any direct benefit to me.

I understand that all experimental procedures have been sanctioned by the Human Research Ethics Committee of the University of the Witwatersrand.

I understand that my participation is voluntary, and that I am free to withdraw from the project at any time.

_____	_____	_____
Subject Name	Subject Signature	Date

_____	_____	_____
Investigator Name	Investigator Signature	Date