South African Journal for Research in Sport, Physical Education and Recreation, 2014, 36(2): 105-114.
Suid-Afrikaanse Tydskrif vir Navorsing in Sport, Liggaamlike Opvoedkunde en Ontspanning, 2014, 36(2): 105-114.
ISBN: 0379-9069

SUDDEN CARDIAC ARREST RISK PROFILE IN A GROUP OF AMATEUR LEVEL BASKETBALL PLAYERS FROM THE UNIVERSITY OF THE WITWATERSRAND

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ABSTRACT

The purpose of this study was to screen a sample (N=31) of urban university amateur level basketball players for the risk of sudden cardiac arrest (SCA). A questionnaire (self-reported) and physical assessment was used to elicit SCA risk factors for the participants. The physical part of the questionnaire comprised measuring blood pressure, body mass index (BMI), glucose and cholesterol measurement, and performing electrocardiograms (ECG) on those with positive signs of SCA risk, such as angina, syncope and family history of SCA. Resting blood pressures (BPs) were significantly different between the genders; males (n=17) 120mmHg (IR: 25) vs. females (n=14) 103mmHg (IR: 10)), p<0.0001, whereas total cholesterol (4.2 vs. 4.5mmol.L-1, p=0.07) and blood glucose (5 vs. 4.4mmol.L-1, p=0.13) were similar. ECGs were performed on those that displayed Marfanoid characteristics, such as pectus carinatum deformity, scoliosis, skin striae, and symptoms of dural ectasia; however, there was no evidence of underlying abnormalities. Basketball players may theoretically appear to be in the phenotype of high risk individuals for SCA, however, males and females in this group of university basketball players showed varying signs of SCA risk, with the overall risk being reasonably low, albeit abnormalities were highlighted in some and Marfanoid characteristics were clearly evident in others.

Key words: Sudden cardiac arrest; Basketball players, Marfan syndrome; Urban; South Africa.

INTRODUCTION

Sudden cardiac arrest (SCA) and the possibility of sudden cardiac death (SCD) during sport is a devastating event, representing 75% of all fatalities in young sportspersons (Harmon *et al*., 2011). Despite its rarity, SCA always receives a great amount of media attention. There are varying reports on the incidence of SCD, and the exact magnitude of the problem remains elusive. For example, the annual incidence of SCD is reported to be between 0.5 and three per 100 000 sportspersons (Ferreira *et al*., 2010; Pelliccia *et al*., 2011; Pugh *et al*., 2012), however, this may be underestimated due to the varying definitions of SCD (Borjesson & Pelliccia, 2009; Pelliccia *et al*., 2011). Although the rate of SCD varies between studies, there appear to be some steadfast trends. These include that males are at a greater risk than females, and university sportspersons had twice the death rate when compared to their school

counterparts (Borjesson & Pelliccia, 2009). The incidence is estimated at being two to four times higher in sportspersons than non-sportspersons (Ferreira *et al*., 2010), due to the excessive demands placed on the heart during vigorous exercise (Corrado *et al*., 2003).

Most SCD cases in sportspersons have been attributed to silent disorders of the cardiovascular system (Montagnana *et al*., 2008). A wide range of underlying congenital cardiac conditions appear to be the cause of SCD in sportspersons. The most common cause is hypertrophic cardiomyopathy (Maron, 2003), and to a lesser extent, an aortic rupture or mitral valve prolapse, due to Marfan syndrome (McClain, 1989; Ferreira *et al*., 2010; Pelliccia *et al*., 2011). Although genetic cardiovascular diseases, such as Marfan syndrome are rare, they are frequently associated with increased risk of sudden death during exercise (Maron, 2010). Therefore, strategies to identify at-risk sportspersons, particularly tall sportspersons such as basketball players, are essential (Mendelson, 2011).

Pre-participation screening of student sportspersons is important to detect 'silent' cardiovascular abnormalities, or identify asymptomatic sportspersons with underlying genetic diseases (Maron, 2003). Screening is supported by the American Heart Association (AHA) and should include history taking and physical examination (Maron *et al*., 2007), although both these have limited sensitivity to detect asymptomatic conditions (Asif *et al*., 2013). A positive response in the history taking is an indication for further cardiovascular examination and electrocardiogram (ECG) (Maron *et al*., 2007). International debate surrounds the routine use of the 12-lead ECG test in sport pre-screening. For example, it is routinely used in Europe (Corrado *et al*., 1998), as it is deemed sensitive enough to detect or raise suspicion of the cardiovascular condition underlying SCD. Furthermore, approximately 75 to 95% of hypertrophic cardiomyopathy (HCM) patients will present with abnormal ECG findings (Maron, 2002). On the other hand, the AHA does not recommend the use of ECG as a feasible test in large scale screening (Maron *et al*., 2007). Although current evidence for the use of ECG in screening is contrasting (Pugh *et al*., 2012), it has been promoted as a practical and cost effective test (Maron *et al*., 2007; Wheeler *et al*., 2010; Asif *et al*., 2013) that is an important way to reduce the risk of SCD (Corrado *et al*., 2006; Ferreira *et al*., 2010).

PURPOSE OF STUDY

The aim of this study was to assess the risk of sudden cardiac arrest and sudden cardiac death of university basketball players. It is recommended that sportspersons at risk of SCD should be screened, and basketball has one of the highest incidences of SCD when compared to other sport (Subasic, 2010; Harmon *et al*., 2011). Likewise, the prevalence of Marfanoid characteristics may be relatively high in basketball players, as the attraction for tall stature and long extremities may provide an advantage in the game, and draw from a population at risk of Marfan's syndrome. Therefore, cardiac screening may be particularly pertinent in this population.

METHODOLOGY

Study design

This study used a descriptive, cross sectional study design using risk profiling to assess basketball players for sudden cardiac arrest risk and screen for Marfanoid characteristics.

Sample

A sample of university enrolled basketball players (N=31) were asked to volunteer to participate in the study, aged between 19 and 25 years (mean age 22±4.24) from the University of the Witwatersrand. These amateur level sportspersons trained regularly and competed against other South African universities. They were informed of the study objectives and what was expected of them in the data collection process.

Ethical clearance

The data was treated with strict confidentiality and ethical clearance was granted by the Human Research Ethics Committee of the University of the Witwatersrand (M110441).

Measures

Anthropometric and blood pressure measures

Standard methods for anthropometry (stature [using a Seca stadiometer] and body mass [using a Seca digital weighing scale]) and blood pressure (BP) measurements were followed (Armstrong, 2006). For the latter, participants were seated and rested for 5 minutes prior to brachial BP measurement. Waist and hip circumferences were measured using an inelastic, but flexible tape to the nearest centimetre and resting heart rate was obtained using the carotid artery pulse (Armstrong, 2006). Body mass index (BMI) and waist-to-hip ratios (WHR) were calculated (Armstrong, 2006).

Blood analyses

The Accu-Chek Instant Plus (Roche Diagnostics GmbH, Mannheim, Germany) system was used to measure serum total cholesterol and blood glucose levels. All standard product procedures were followed (Roche Diagnostics, 2012).

Questionnaire

The questionnaire was formulated predominantly from the pre-participation examination model developed by Fédération Internationale de Football Association (FIFA, 2012). It comprises self-reported and measured sections on personal and family history of cardiac risk in order to determine sportspersons risk profile for SCA and SCD, whereby having at least 3 risk factors indicated risk of SCA and increased probability of SCD on-field (FIFA, 2012; Gradidge, 2012). Specific items extrapolated risk factor information on the incidence of exertional chest pain or discomfort, syncope or near syncope, excessive, unexpected or unexplained shortness of breath or fatigue related to exercise, previous finding of a heart murmur or increased systemic blood flow, and further family history of specific occurrence of certain conditions (Marfan syndrome, HCM, and long QT syndrome), a history of premature death, a disability resulting from a cardiovascular disease in close relatives who are younger than 50 years of age (Ferreira *et al*., 2010).

Electrocardiogram

Resting 12-lead ECG was performed (Schiller AT 6 ECG machine [Schiller AG], Switzerland) on the 10 participants that had 3 or more identified risk factors based on responses in the questionnaire. The ECG recorder was calibrated before testing, and this was done by recording the standard 1-mV deflection per centimetre. The time base was also standardised and the paper speed set at 25mm/sec. Electrodes were placed and connected in the customary fashion (Armstrong, 2006). The participants were requested to lie quietly in the

supine position while the resting ECG was recorded. If any abnormalities were observed, the researchers were obliged to refer to a specialist cardiologist for further evaluation.

Marfanoid characteristics

Participants were assessed for Marfanoid characteristics by a medical practitioner according to the Ghent criteria, including skeletal, visual and cardiovascular investigations (De Paepe *et al*., 1996).

Analysis of data

The analyses were done using Statistica version 10 (Tulsa, USA). Descriptive statistics were used to describe the sample, cardiac risk profile and the incidence of Marfanoid characteristics. Participants were divided into gender groups for comparison and differences were determined using Student t-tests for normative data, otherwise Mann-Whitney U tests were performed. Data were reported as mean±SD or median (inter-quartile range), and where appropriate normalised by logged for analyses. A multiple linear regression model determined whether independent variables were associated with total risk of sudden cardiac arrest. The independent variables were systolic blood pressure, diastolic blood pressure, fasting glucose, total cholesterol, Marfanoid characteristics, flu-like symptoms, and dyspnoea. The level of significance was set at 5%.

RESULTS

University enrolled basketball players (N=31), 17 males and 14 females aged between 19 and 25 years (mean age 22±4.24), from the University of the Witwatersrand amateur level basketball team volunteered for this study.

***TABLE 1*: CHARACTERISTICS: MALE AND FEMALE BASKETBALL PLAYERS**

Parameters	Male (n=17)	Female (n=14)	p-value
Resting heart rate (bpm)	69.2±12.6	80.3±15.7	0.050*
Systolic blood pressure (mm Hg)	120 (25)	103 (10)	0.001**
Diastolic blood pressure (mm Hg)	78.2±9.8	71.7±7.3	NS
Total cholesterol (mmol.L-1)	4.2 (1.3)	4.5 (0.6)	NS
Fasting glucose (mmol.L-1)	5.0 (1.0)	4.4 (1.0)	NS
BMI (kg.m-2)	23.7 (3.5)	21.7 (3.8)	NS
WHR	0.77±0.04	0.68±0.03	0.001**

Data expressed as Mean±SD or Median (interquartile range) Mean age= 22±4.24 N= 31
BMI= Body Mass Index WHR= Waist-to-Hip-Ratio NS= No significant difference

Resting heart rates were significantly different, 69.2±12.6 vs. 80.3±15.7 bpm (p=0.04) respectively, which may reflect usual gender differences in these competitive basketball players (Table 1). Average stature was 1.84m±0.1 for males vs. 1.68m±0.1 for females. Total cholesterol, fasting glucose and BMI were similar between the genders, however, WHR was significantly different (p<0.0001), a difference which is indicative of normal growth development variation between the genders, as well as their natural adiposity depot sites.

***TABLE 2*: GENDER: PREVALENCE OF CARDIOVASCULAR DISEASE OR RISK FACTORS IN MALE AND FEMALE BASKETBALL PLAYERS**

Disease or physiological condition	Male (n=17)	Female (n=14)
Hypertension (SBP>=140mm Hg; DBP>90mm Hg)	29%	14%
Overweight (BMI>=25kg.m^{-2})	24%	7%
Obesity (BMI>=30kg.m^{-2})	12%	7%
Hypercholesterolaemia (>=5mmol.L^{-1})	24%	28%
Hyperglycaemia (>=5.6mmol.L^{-1})	17%	7%

Note: Differences were not significant between the male and female participants.

***TABLE 3*: GENDER: PERSONAL AND FAMILY HISTORY OF KNOWN RISK OF SUDDEN CARDIAC ARREST OR SUDDEN CARDIAC DEATH**

Cardiac conditions	Males (n=17)	Females (n=14)	p-Value
Marfanoid characteristics	35%	0	**
Flu-like symptoms	53%	64%	NS
Dyspnoea	94%	43%	**
Dizziness	0	36%	*
Syncope	0	14%	NS
Hypertension	0	7%	NS
Heart murmur	0	7%	NS
Angina	6%	21%	NS
Palpitations	0	7%	NS
Medication managed cardiac conditions	0	0	NS
Hypertension – FH	6%	29%	NS
Stroke – FH	0	14%	NS
Arrhythmia – FH	0	14%	NS
Diabetes mellitus – FH	12%	14%	NS
SCD – FH	0	7%	NS

*p<0.01 **p<0.001 NS= Not significant FH= Family history

A number of the male group (35%) had positive signs for Marfanoid characteristics; however, when investigated further on ECG, none showed underlying signs of abnormalities. The prevalence of cardiovascular disease risk was determined. Only a small number had existent cardiovascular risk or conditions (Table 2). Based on whether participants had 3 or more positive SCA risk factors (data not shown), a total of 10 participants consented to having ECGs done. All were negative for HCM or other ECG abnormalities.

Family histories of SCA risk factors were evident in a few participants, but only 1 female had a family history of SCD. A small number (n=5) had a history of hypertension in their family, however, this is in contrast to the relatively low resting blood pressures seen in this population (Table 1). Females clearly had more risk factors than male basketball players. This was shown by cumulative calculation, but is noticeable in Table 3, which shows that the maximum number of risks in the male group was 5 versus 9 in the female group. All the SCA risk factors were placed into a multiple regression model. Hypertension (adjusted beta value [b]= -2.7, p=0.045), BMI (b= 16, p=0.02) and hypercholesterolemia (b= -1.6, p=0.04) were found to be associated with total SCA risk in this sample. Furthermore, in this population Marfanoid characteristics were found to be a good determinant of SCA risk profile.

DISCUSSION

It is well known that regular aerobic exercise provides cardio protective benefits, it does not however, preclude the risk of SCA in those sportspersons with underlying abnormalities. Although exercise-related SCA is rare, the unexpected and potentially catastrophic event in an otherwise healthy sportsperson has driven much research in the area of pre-screening and prevention. Young seemingly healthy sportspersons in high school and university are not excluded from the risk of SCA. The most common competitive sport at risk for SCA is basketball followed by football (Maron *et al*., 1996; Milani *et al*., 1996), making the pre-participation physical examination (PPE) for these sports particularly important.

The findings of the present study showed that a small number of participants had underlying non-communicable diseases (NCD), but only one participant knew of possible existent hypertension, whereas 26% had the condition. This reinforces the need to include PPE for all sportspersons as some may have cardiovascular abnormalities which they may not be aware of (Montagnana *et al*., 2008). The prevalence of obesity (10% versus 13% in males and females respectively) and hypercholesterolemia (10%) was similar to that of university sportspersons, however, it was only BMI that was shown to be a positive risk of SCA risk in the present study (adjusted beta value [b]: 16, p=0.02) (Bakkum *et al*., 2011). The association of obesity and cardiovascular disease is known; hence this result is not surprising. However, in this instance, some of the basketball players' BMI may have been lower than expected due to their elevated stature in relation to their body mass (Armstrong, 2006). The findings also showed conflicting evidence for risk of SCA with hypertension (adjusted beta, b= -2.7, p=0.045) and hypercholesterolemia (adjusted beta, b= -1.6, p=0.04) showing a negative correlation, such that with increases in hypertension and hypercholesterolemia, the risk of SCA decreases. The data, however, should be interpreted with caution as the small sample size may have produced unstable results in the multiple regression analysis.

Findings from the current study demonstrate that 75% of these basketball players had three or more CV risk factors. This is similar to findings from a previous study done on university sportspersons in South Africa (Bakkum *et al*., 2011). Likewise, the present study found that cardiac risk factors were more common in females than males (Bakkum *et al*., 2011). Common self-reported symptoms found in the females included flu-like symptoms, dyspnoea, dizziness, and to a lesser extent syncope, angina, heart murmur and palpitations. Familial hypertension, stroke, arrhythmia and diabetes were more prevalent in the females. A family history of SCD, which represents a red flag indicative of further investigation

(Subasic, 2010), was reported by one female basketball player. Reported prodromal symptoms, such as syncope, angina and palpitations, have been found in 36% of SCD cases (Subasic, 2010). The current study showed that these warning signs were present in 42% of the females in this group, and 5% of the males.

The role of routine ECG testing in PPE has stimulated much debate in the sporting environment. Many argue that this diagnostic test can greatly increase the detection of those at risk, and therefore, reduce the incidence of SCD, which is a major reason for PPE in the first instance (Harmon *et al*., 2011; Asif & Drezner, 2012). On the other hand, it is a costly exercise and, coupled with its potential false positive outcomes, has caused it to be branded as inefficient (Maron, 2005). Although ECG screening has been advocated as feasible in developed countries, its routine use in resource scarce countries, such as South Africa, may not be achievable. Therefore, in the current study, only participants that had three or more positive risk factors were screened for underlying signs of abnormalities. The most common underlying cause of SCD in sportspersons is hypertrophic cardiomyopathy (HCM) (Cross *et al*., 2011), however, in screening for HCM in this population all ECG readings were negative. In a much larger study of football players, Schmied *et al*. (2013) found structural abnormalities in 5% of players. In a previous study, 10% of football players in South Africa presented with abnormal ECG readings (Gradidge, 2012). In the current study none of the ECG tests presented with abnormal findings, however, only 10 tests were done and may not be reflective of this population.

Another causative factor for SCA is Marfan syndrome, the heritable disorder of connective tissue, which may lead to the weakening of the walls of the aorta and other anatomical structures (Judge & Dietz, 2005). The prevalence of Marfan syndrome is likely to be high in a sport such as basketball due to added performance advantage of being tall. Not surprisingly, there was a high (35%) prevalence of positive signs for Marfanoid characteristics in this group. Although the prevalence thereof is reported to affect both males and females equally (Stout, 2009), the current study found all those with positive signs for Marfanoid characteristics were male. In addition, mitral valve prolapse and early aortic root dilation are common complications presenting in cardiac assessment of those with Marfan syndrome (Stout, 2009). In the current study, none of the players displayed abnormal ECG findings. For example, Kinoshita *et al.* (2000) found a small prevalence of aortic dilation (0.96%) in basketball players, and this was associated with features of Marfan syndrome (Kinoshita *et al*., 2000). Furthermore, it is estimated that 70% of those with Marfan syndrome will die of acute cardiovascular complications (Stout, 2009). Despite the normal ECG findings in this study, late complications, such as aortic root dilation, may progress rapidly, and these patients are recommended to have serial ECG assessments (Stout, 2009). Therefore, it remains important to take particular care in evaluating sportspersons participating in certain sports, such as basketball and volleyball, for signs of Marfan syndrome or Marfanoid characteristics, and the diagnosis confirmed for appropriate recommendations to be made (Pelliccia *et al*., 2005).

CONCLUSIONS

The risk of SCA was relatively low in this group of young, adult competitive basketball players, however, there were a number that had positive signs of risk and it is these

abnormalities that may place individual sportspersons at risk of SCD. Nevertheless, the sample was small and causality could not be determined in this cross sectional study of basketball players from the University of the Witwatersrand. The data validate the purpose and significance of the PPE screening and the use of ECG to exclude cardiomyopathy and other abnormalities aiding in reducing mortality. Furthermore, some of the basketball players had underlying cardiovascular and metabolic abnormalities, of which only one participant was aware, thus demonstrating the need for instigating PPE where it is not being done and continuing such a programme where one already exists. Future studies of SCA prevention in basketball players should explore PPE in order to justify its mandatory use in the sport.

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(Subject Editor: Prof Ernst Krüger)