THE PREVALENCE OF METABOLIC SYNDROME AND CARDIOVASCULAR DISEASE RISK FACTORS AMONGST SCOTTISH ETHNIC MINORITY ADOLESCENTS

ABSTRACT

Background: Metabolic syndrome (MS) is increasingly becoming common with a quarter of adults estimated to have MS; however MS in children is not as well explored. MS is known to contribute to future health risks such as cardiovascular disease (CVD) and therefore it is vital to recognize this growing problem as soon as possible. This study estimated the prevalence of MS and CVD risk factors in Scottish ethnic minority adolescents. **Methods:** 48 subjects of Pakistani-British and Indian-British ethnicity took part in this study. Participants were classified as having MS according to both the NCEP ATP III and IDF criteria's, while identification of CVD risk factors were based on established thresholds. **Results:** The prevalence of MS in this present study was ***16.67***% while CVD risk factors were present in a large majority of participants. Elevated blood pressure, increased WHR and weight were among the typical CVD risk factors present in the participants, while novel markers such as C-reactive protein (CRP) was raised in a large proportion of participants and ***32.5%*** exceeded fibrinogen (Fg) thresholds. Dietary analysis revealed that consumption of foods high in fat, and specifically high in saturated fats, was shockingly high, with ***>70%*** of participants exceeding the recommended quantities. **Conclusions:** The prevalence of MS and several CVD risk factors in this relatively small group was high. Scottish ethnic minority adolescents have an unhealthy diet and are not characteristically physically active.

KEYWORDS: METABOLIC SYNDROME · NCEP ATP III · IDF · CARDIOVASCUALR DISEASE · ETHNIC MINORITY

The cluster of risk factor that are now referred to as the metabolic syndrome were first described in principle by Dr. Jean Vague 1956[34], who demonstrated that abdominal obesity increased the likelihood of type II diabetes, atherosclerosis and gout (inflammatory arthritis). However, it wasn't until 1988 when G.M Reaven and colleagues delivered the famous Banting lecture titled; Role of insulin resistance in human disease, that the "constellation of abnormalities" were said to be caused by the underlying mechanism of insulin resistance [10, 26]. The metabolic syndrome has developed from a cluster of risk factors to an entity where several definitions are now available [10, 17]. The predominantly used criterions in recent literature are that of the IDF and the NCEP ATP III, however, there is no one set criterion to diagnose MS as ethnic, gender and age variances simply do not allow it [11, 18, 20]. Kolsgaard et al 2008 [18] successfully illustrated that the prevalence of MS was significantly higher in Norwegians of an ethnic background as compared to the indigenous Norwegians. The study demonstrated a prevalence of MS at 20.8% for the indigenous group compared to the significantly higher 30.6% prevalence of MS in the ethnic minority group. Studies have also shown the prevalence of MS to strongly increase with age. Hildrum et al 2007 [11], showed prevalence of MS to increase from 11% in the 20-29 age groups, to a significantly higher 47.2% in the 80-89 age groups. Further studies have illustrated complications in correctly diagnosing MS in adolescents due to the onset of puberty; lipid levels drastically change, behavioral patterns differ, increases in both blood pressure and percentage body fat (%BF), fluctuations in insulin secretion and insulin resistance [14, 35]. Although these crucial alterations make it difficult to define cut-off points in order to diagnose MS, it is widely accepted that the advancement of MS closely ties in with the onset of puberty [5, 14, 22, 35].

The world health Organization (WHO) [37] has estimated that 45 million children under the age of 5 were overweight, and have projected 700 million adults to be obese by 2015. Studies have shown in clinical populations that approximately 30% of overweight children are diagnosed with MS [7] and are at a significant risk of developing type II diabetes[2, 6, 7, 8, 13,14, 15, 16]. The IDF [38] estimates that a quarter of the world's adults have MS, and those diagnosed with MS are at a five-fold increased risk of developing type II diabetes. Diabetes is another growing epidemic and alongside obesity a major economic drain. WHO estimates that there are 3.2 million deaths annually attributed to diabetes mainly due to increased CVD risk [19, 30, 37]. The MS is also reported in several studies to increase the risk of mortality from CVD by 3-4 folds [19] hence, the increasing prevalence of MS is a cause of great concern as CVD is the number one cause of death globally and by 2030 it is estimated that 23.6 million people will die from CVD [37].

The continuing epidemic of obesity and related health issues has been alarmingly pronounced in Scotland, with Glasgow, Scotland's largest city, having been named as Britain's "fattest" city on several occasions and with the Scottish capital, Edinburgh closely following at second position [39]. Not only has this had a devastating effect on quality of life but it has been a serious economic exhaust. According to the Scottish health survey, the total cost of obesity to the Scottish society in 2007/2008 exceeded £457million [31]. The same report estimated the prevalence of children aged 2-15 to be overweight at 31.7% with 15.1% of them diagnosed to be clinically obese [31]. These figures are further aggravated when adults (16+) are concerned, 65.1% considered overweight with 26.8% of them clinically obese [31]

This large scale crisis in Scotland can be partly explained by an unhealthy diet and low levels of physical activity [31] (PA); the Scottish health survey, estimated that in the year 2009, only 65% of children were meeting the PA recommendations. The benefits of PA are well documented within current literature, illustrating the preventative role of PA on CVD, obesity, diabetes [2, 22, 33, 37] and studies in the adult population have demonstrated the prevalence of MS is less common amongst a regularly active group as compared to a sedentary group of individuals [3]. The survey also outlined the poor eating habits of Scottish children; in 2008/2009 only 1 in 7 children were eating the recommended five or more portions of fruit and vegetables. It also presented data on the dietary quality index (DQA) of children aged 2-15. The DQI uses fruit and vegetable consumption data along with measures based on food and drink items consumed. A score between 0-100 is calculated based on selection of items, with a high score indicating a healthy diet. The mean score for children aged 2-15 was 47.5, demonstrating the poor diet of Scottish youth. Several studies have detailed the implications of a poor diet; a diet rich in saturated fats and sugars greatly increases the risk of CVD and diabetes [2, 9, 12, 37].

The global epidemic of obesity, diabetes and cardio vascular diseases, particularly in the young has led to increased concern and interest in the correct diagnosis and prevention of MS. Intervention at an early stage of development of MS would greatly reduce the chances of type II diabetes onset and future CVD issues.

This study aims to estimate the prevalence of MS and cardiovascular disease risk factors in Scottish EM adolescents using both the modified NECP ATP III and IDF criterions. Secondary aims were to gain an overview of health status of the Scottish EM adolescents and to assess the use of both criterions in diagnosing ethnic minority groups.

METHOD/PROTOCOL

Subjects

A group of 48 Scottish ethnic minority adolescents (30 females and 22 males, 16±2 years of age) from the city of Glasgow participated in this study. Participants were recruited with the aid of the existing Scottish ethnic minority sports association (SEMSA) database of ethnic minority children, visits to community and religious centers (Sikh Gurudwara's, Hindu Mandir's and Islamic Mosque's). Key community figureheads were approached in-order to seek support and advice on how best to get good participation levels. Members of the research team and SEMSA then visited the possible participants and discussed their involvement in the project while fully explaining test protocols and any risks and discomforts they may experience during testing procedures. All participants were assured full anonymity and informed of their right to withdraw from the study at any point. Information sheets, participant and parent/guardian consent forms were distributed and only those volunteers were permitted to participate who had returned the completed consent forms. Participants were instructed to maintain their daily routines and not to change their dietary and lifestyle habits other than prescribed. The experimental protocol was approved by the University of the West of Scotland ethics committee.

Anthropometric and physiological measures

Weight was measured in normal daily clothing without shoes to the nearest 0.1kg using calibrated electronic weighing scales (Seca 880, Digital Scales, Seca Ltd, Birmingham, UK). Height without shoes was measured to the nearest 1mm (Seca Stadiometer, Seca Ltd). Body mass index (BMI) was calculated; $\mathbf{weight(kg)/height(m)^2}$. Skinfold measurements were taken in pairs at both the triceps brachii (upper arm) and triceps surae (Calf) using Harpenden skinfold callipers (John Bull, British Indicators Ltd, Bedfordshire, UK) and following standard procedures. A third measurement was taken only if the first two varied by more than 1mm. From the recorded skinfold measurements percentage body fat (%BF) was estimated with sex-specific equations;

$$\mathbf{Males}: \%\mathbf{BF} = .\mathbf{735} \times (\mathbf{triceps} + \mathbf{calf}) + \mathbf{1}$$
$$\mathbf{Females}: \%\mathbf{BF} = .\mathbf{610} \times (\mathbf{triceps} + \mathbf{calf}) + \mathbf{5.1}$$

Although their remains much debate as to which method and/or equation is suitable for predicting %BF in adolescents, Rodriguez et al 2005 [25] suggest that the slaughter equations are relatively accurate and are an cost effective method as compared to others for field research. Hip circumference (HC) was measured at the widest point between the buttocks and the iliac crest. Waist circumference (WC) was measured at the midpoint between the lower ribs and iliac crest. Both circumference measurements followed standard procedures. In order to gain a perspective on the index of relative fat distribution, waist-to-hip ratio (WHR) was calculated. Participants were allowed to sit at rest for 10 minutes to allow for acclimatization before blood pressure was taken. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured with an automated BP monitor (Omron Healthcare UK Ltd, Milton Keynes, UK). The cuff was placed tightly on the upper left arm with the participant comfortably seated and three measurements were taken at 1 minute intervals. The average of the second and third measurements was used for analysis. All anthropometric measurements were carried out with males and females in separate rooms and by a female practitioner for female participants in order to comply with ethnic minority values.

Physical activity questionnaire and daily food consumption diary

All participants completed a validated physical activity questionnaire for adolescents (PAQ-A) on day of testing. The protocol required participants to recollect their PA patterns from the previous seven days. Although the PAQ-A does not provide specific analysis of PA behaviors it provides a reliable estimation of PA and consequently been used successfully by several studies. Completion of the questionnaire would require no longer than 30 minutes and thus could be completed while participants rested before metabolic measurements were taken. Daily food consumption was monitored with a validated, self-report diary (Food Standards Agency, 2002) and a food frequency questionnaire. The collected data was analyzed using nutritional analysis software by Health options (Nutri Check, Health Options, Cirencester, Gloucester, UK). While completing the food consumption diaries participants were instructed to be as detailed as possible and to continue their normal eating and drinking habits.

Metabolic measurements

All participants arrived on days of testing after an overnight fast. All blood samples were collected between 9:00am and 11:00am by a team of qualified phlebotomists, experienced in pediatric sampling techniques. Participants were instructed to sit at rest for at least 30 minutes before blood sampling to control fro plasma volume shifts. The samples were allowed to clot and immediately centrifuged at 4,000rpm for 10 minutes. The blood samples were analyzed for insulin, glucose, adiponectin triglycerides (TG), total cholesterol (TC), high-density lipoprotein (HDL-C), low-density lipoprotein (LDL-C),fibrinogen (Fg), interleukin-6 (IL-6) and high-sensitivity C-reactive protein (CRP). All blood analyses were performed using standard procedures as used in similar studies. TC and TG were measured with the use of enzymatic methods (Randox, Antrim, UK) and a Camspec M107 spectrophotometer (Camspec, Leeds, UK). Concentration of HDL-C was determined after precipitation of very low density and low-density lipoproteins by the addition of phosphotungstic acid in the presence of magnesium ions. The Friedewald formula was used to calculate LDL-C;

$$\mathbf{L = C - H - Kt}$$

Where L is LDL-C, C is TC, H is HDL-C, K is a variable constant and t is TG.

Glucose was measured by the glucose oxidase method (Randox, Antrim, UK) and analyzed using a Camspec M107 spectrophotometer (Camspec, Leeds, UK). Plasma insulin was analyzed using easily available immunoassay kits (ALPCO, Salem, NH) and a Camspec M107 spectrophotometer (Camspec, Leeds, UK). Fg concentration was analyzed by equivalent immunoassay kits (ALPCO, Salem, NH) and a MRX microplate reader (Dynatech laboratories, MA). Concentrations of IL-6, CRP and TG were all calculated with specific ELISA kits (R&D Systems, Abingdon, UK) and a MRX microplate reader (Dynatech laboratories, MA).

Definition of Metabolic syndrome

Due to a relatively small sample size and the uncertainty of which of the several criterions are suitable, both the predominant criterions used in similar studies are used; the modified NECP ATP III and IDF. According to the NECP ATP III criterion, the existence of an three of the following 5 factors is required for a diagnosis of MS; abdominal obesity (WC ≥ 102cm, 88cm for men and women respectively, but for ethnic minorities WC ≥ 90cm, 80cm for men and women respectively); hypertriglyceridaemia (TG ≥ 1.7mmol/L); low HDL-C (HDL-C ≤ 1.03mmol/L, 1.29mmol/L for men and women respectively); elevated BP (SBP ≥ 130mmHg and/or DBP ≥ 85mmHg); impaired fasting glucose (glucose ≥ 5.6mmol/L). Whereas the modified NECP criterion places equal emphasis on each of the five risk factors the IDF criterion requires the presence of abdominal obesity and any two of the other four risk factors which are identical to those provided by the modified NCEP to enable a diagnosis of MS. This is a potential flaw in the criterion as several studies have shown that due to ethnic differences and other factors abdominal obesity is not always present in all cases thus omitting potential MS patients [21, 24]. This provides further justification in using both criterions. For both criteria's, the recommended Asian cut-off values were used, as the study focused on Scottish ethnic minority groups. However, the IDF does have its advantage when diagnosing adolescents and children [36, 38]. The modified NCEP criterion does not provide further cut-off points with regards to child WC whereas the IDF criterion provides instructions to use the 90th percentile values for child WC and to use the adult cut-offs if lower. This again provides further rationale for the use of both the predominately used criterions.

Criteria for CVD risk factors

Established blood and physical markers for assessing the risk of CVD were used in this study alongside novel markers,
C-reactive protein, Fibrinogen and Interleukin 6. For Blood pressure thresholds the 95th percentile for children according to the national institute of health report on blood pressure was approximated. Weight status was defined using BMI in the context of gender specific centers of disease control charts (CDC charts). WHR thresholds were defined as >0.9 for boys and >0.8 for girls.[40] The dietary thresholds implemented in this study were > 30 percent total fat and > 10 percent saturated fat, as per WHO [37] recommendations. Lipid and lipoprotein thresholds were determined according to NCEP 2002 [22], Thomas et al 2005, 2008 [32, 33] and Nousari et al 1999[23].

Statistical analysis

All data is presented as mean ± SD and was analyzed using Minitab 16. A P-value (P≤0.05) was considered to be significant throughout the data analysis. 2-sample t-test was carried out to observe any significant differences between male and female groups where appropriate.

RESULTS

This Study included a total of 48 subjects (22 boys and 26 girls) aged between 13-18 years with a mean age of 16.5 ± 1 year. The majority of the participants were of a Pakistani-British group (60.42%) with the Indian-British participants making up the rest of the cohort (***Figure 1***). ***Tables 1 and 2*** show the participant's anthropometric, physiological, dietary, physical activity, blood lipid and clinical characteristics according to gender.

The prevalence of MS in the cohort according to the NCEP ATP III criteria and IDF criteria was 16.67% with prevalence of 6.25% and 10.42% in the under 16 and over 16 age groups respectively (***Figure 2***). The prevalence of MS was greater in the male population with 4 males diagnosed from a group of 22 compared to the female population with 4 diagnosed from a group of 26 (***Table 3***).

Physical activity (PA) levels in both male (**2.52 ± 0.61**) and females (***1.91 ± 0.57***) were low but female PA levels were significantly lower (***P<0.01***) (***Table 1***). Dietary analysis shows that total fat % consumed is greater than recommended values in both males (***34.77 ± 5.50***) and females (***33.27 ± 4.93***) with no significant differences between them (***Table 1 and 5***). The % of saturated fat intake is also greater than recommended values for both male (***13.18 ± 3.49***) and female groups (***12.12 ± 2.67***) again with no significant differences amongst the two groups (***Table 1 and 5***). According to BMI used in conjunction with gender specific CDC charts, 18.75% of participants were overweight, 6.25% of who were classified as obese (***Table 4***). There was a significant difference (***p<0.01***) between boys and girls with regards to % body fat, ***23.37 ± 4.83 %*** and ***26.71 ± 3.02*** for boys and girls respectively (***Table 1***). WHR showed a significant difference (***P<0.01***) between the groups, ***0.84 ± 0.06*** and ***0.73 ± 0.10*** for males and females respectively (***Table 1***). Few significant differences (***P<0.05***) were recorded for blood lipids and lipoproteins though mean fasting glucose and CRP were significantly greater in the male group, while HDL-C was significantly greater in the female group and LDL-C was significantly lower in the female group (***Table 1***).

The percentage of participants who exceeded the published criteria thresholds for CVD risk factors is shown in ***Table 5***. It is remarkable that ***75***% of all participants consumed a diet that exceeds the recommended fat consumption thresholds, while ***72.92***% of all participants consumed a diet high in saturated fats. Furthermore, considering the relatively small sample size, a fair proportion of all participants were overweight, exceeded the WHR criterion and had elevated blood pressure. ***32.5***% of participants exceeded the fibrinogen thresholds while a large proportion had raised CRP levels.

DISCCUSION/CONCLUSIONS

The metabolic syndrome is well researched amongst the adult population, though the same cannot be said for children and adolescent groups. To my Knowledge this is the first study that has estimated the prevalence of MS and CVD risk factors amongst Scottish ethnic minority groups, making comparison to other studies difficult. However, from the limited literature available, the prevalence of MS (16.67%) in this current study was considerably greater than reported in other studies. Cook et al 2003 [7] reported that the prevalence of MS among 12-19 year old Americans was 4.2% while Khader et al 2010 [17] reported prevalence of MS in Jordanian children and adolescent to be 1.4% in participants aged between 10 and 16 years of age and 3.6% in participants aged 16 and 18 years of age. This agrees with current literature that the risk of metabolic disorders such as diabetes mellitus, insulin resistance and elevated CVD risk factors is greater in a south Asian population as compared to a Caucasian population [24]. Research groups in India and Pakistan [1, 28] have estimated prevalence of MS at 19.52% and 14.95% respectively which is in agreement with this study. Prevalence of MS was greater in older participants as has been shown throughout the literature available [11, 17].

Although, the prevalence of MS in children has been reported to be relatively low [17] it is not a similar story when considering overweight and obese adolescents where prevalence of MS is estimated at ~30% by cook et al 2003 [7] and at ~ 50% by Weiss et al 2004 [35]. This clearly indicates a significant role of obesity in MS.

Both criterions used to identify MS in this study were successful, though it must be noted that one subject was ‘missed’ by the IDF criteria as abdominal obesity was not a factor. This slight disagreement between the two criteria’s has been well documented by Pan et al 2008 [24] and Moy et al 2010 [21] both of whom state that the NCEP ATP III is more suited to diagnosing South Asians, due to variations in cardiometabolic factors and insufficient data on correctly diagnosing South Asians with abdominal obesity.

This study also documented the problem of obesity in the Scottish ethnic minority group, with 18.75% of participants classified as overweight. This can be explained by both the dietary analysis and PA levels; with >70% of participants consuming a diet high in saturated fats and with PA level means 2.42 and 1.91 for male and female groups respectively, the results confirm previous findings that a poor diet and physical inactivity are strongly related to obesity, and increase the likelihood of MS, diabetes and prevalence of CVD risk factors [3, 4, 9, 10, 13, 19, 30]. Behre et al 2011 [3] reported that MS was less common in male subjects who performed regular PA as compared to male subjects who led a sedentary lifestyle and Hooper et al 2001 [12] showed that reductions in dietary fat led to a 9% reduction in CVD mortality and a 16% reduction in cardiovascular events.

Furthermore, the prevalence of established CVD risk factors such as increased WHR and elevated blood pressure were common. According to several studies the distribution of body fat is vital in determining health status.[2, 40] It is reported that an 'apple' shaped body i.e. abdominal fat stores faces greater risk of MS, CVD and diabetes as compared to a 'pear' shaped body i.e. carrying more weight in the hips region [2, 40]. Moreover, elevated levels of novel blood marker CRP were present in a large proportion of participants. CRP is an acute-phase protein synthesized by the liver in response to signals released by lipocytes (fat cells) [2, 27, 32]. It is typically raised in response to inflammation and is reported to exaggerate ischemia hence its role as a key CVD marker. Studies in the adult population have reported CRP levels to be up to 35% lower in a physically active group compared to a sedentary group [32]. Along with elevated CRP levels, 32.5% of participants exceeded the fibrinogen thresholds. Fg is another novel blood marker which is becoming increasingly vital in the detection of CVD at an early stage. It is an acute-phase protein synthesized by the liver that plays a dominant role in the clotting of blood. It is suggested that elevated levels of Fg cause thickening of blood vessels and blood plasma to an extent where blood flow is drastically reduced and may result in sever stroke [2,22, 30, 33].

Regular physical activity is proven to reduce CVD risk factor and considering the age of participants involved in this study it is possible that with swift action development of further health issues can be prevented. Behavioural changes towards a more physically active lifestyle coupled with a healthy diet low in saturated fats should be the way forward for those diagnosed with MS and CVD risk factors in this Study.

In conclusion, the prevalence of MS in the Scottish ethnic minority group studied was high, with prevalence greater in the under 16 groups and male group. Several CVD risk factors are present in a large percentage of participants with consumption of saturated fats alarmingly high. The modified NCEP ATPIII criterion may be more suitable to determine MS in ethnic groups as compared to the IDF criterion.

Considering the age of participants involved in this study it is possible that with swift action development of further health issues can be prevented. Behavioural changes towards a more physically active lifestyle coupled with a healthy diet low in saturated fats should be the way forward for those diagnosed with MS and CVD risk factors in this Study.

POSSIBLE LIMITATIONS

The major limitation to this was low participation. During initial stages of recruitment it was noted that individuals were apprehensive of participation due to the requirement of blood sampling. Additionally, the individuals who did agree for blood sampling were uncomfortable during the drawing of blood samples and as a result adequate samples were not taken leading to missing blood lipid data. Although significant results were achieved it is possible that the results may be understated due to the small sample size. Furthermore, with the ethnic upbringing of the children it was advised by community figureheads, not to administer a questionnaire aimed at defining stage of puberty. As previous studies [5, 14, 22, 35] have shown that stage of puberty is important in the role and development of MS this was another limitation.

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