The purpose of this study was to examine the current health status of a sample of Scottish youth in relation to physical fitness. A sample of 76 children aged 10.2 ± 0.56 years had indices of fatness, physical activity, cardio-respiratory fitness and muscular fitness assessed. A high percentage of participants were found to have unhealthy levels of cardio-respiratory fitness and explosive strength (82.9% and 81.6%, respectively). A positive (β = 0.242) although weak (R² = 0.39) overall relationship was observed between physical activity and cardio-respiratory fitness, though was stronger in the boys than the girls (R² = 0.725 vs. R² = 0.347). The data suggests that interventions improving physical activity participation, weight status and physical fitness are essential prior to adolescence in order to improve health and well-being.

**KEY WORDS:** Health, Overweight, Fitness testing, Fitness levels.
INTRODUCTION

The increasing prevalence of obesity is now considered a global concern (48). Throughout the Western world, obesity is the 5th leading risk factor for mortality (48) with the prevalence of poor weight status in youth appearing to increase for all ages (13, 28). Within the United Kingdom (UK), obesity levels have doubled in the last twenty-five years with 20-25% of youth presently having a Body Mass Index (BMI) which classifies them as overweight (6). Within Scotland, the percentage is even greater with recent figures suggesting that approximately 33% of children aged between 7 and 11 years are overweight (43).

Regular participation in physical activity is known to reduce the risk of obesity (37) and the likelihood of developing chronic diseases such as; cardiovascular disease (CVD), hypertension and type II diabetes (2, 13, 37). Nonetheless and despite the well-established benefits of being active, youth are increasingly adopting sedentary lifestyles (5) with many failing to achieve minimal activity guidelines (11, 47). Recent findings in Scottish populations suggest a worrying trend with 30-35% of Scottish youth aged between 2 and 15 years seemingly unable or undesiring to meet minimal activity guidelines for health (43) of one hour of moderate to vigorous physical activity per day (47). The importance of achieving daily physical activity recommendations for health is expressed by Ortega and colleagues (35), who found that Swedish youth who achieved daily physical activity recommendations were at decreased risk of CVD risk factors compared to those who did not achieve recommended levels of physical activity.

It has been argued that physical fitness is a more significant marker of health status in youth than physical activity (20, 35, 36), although both are known to be associated with future cardiovascular disease (CVD) risk in adulthood (34). Increasing physical activity participation has been associated with increased cardio-respiratory fitness and reduced risk of CVD in youth (7, 33). While it is known that healthy levels of cardio-respiratory and muscular fitness are linked to a healthier cardiovascular profile during childhood and adolescence and tend to track into adulthood (7, 13, 33, 34), limited evidence exists on the physical fitness status of Scottish youth. Physical fitness is not a single concept but rather consists of several individual interrelated and measurable constructs representing most of the bodies functions (muscular, cardio-respiratory, motor, metabolic and morphological) (34). Unsurprisingly, measures of physical fitness are now considered to be important markers of health status, CVD risk and early mortality (7, 13, 34). Thus, the purpose of this pilot investigation was to evaluate the physical fitness status of Scottish youth as they move into secondary school education. The findings here may reveal important clues as to whether the physical activity guidelines proposed in Scotland are achieving their desired aims of improving the health status of young individuals.
METHODS

Subjects

A sample of 76 children (36 boys and 40 girls) aged 10.2 ± 0.6 years were randomly selected from a primary school in the West of Scotland. Information concerning the aims of this study and their involvement was provided to participants and their parents/guardians. Only participants who returned both the consent and consent forms were eligible to participate. Participants were informed that they were free to withdraw from this study at any time and without explanation. All data collected was kept anonymous. Ethical approval for this study was granted by the University of the West of Scotland’s Ethics Committee.

Physical Measures

Stature and mass were measured barefoot while wearing light clothing. Stature was measured to the nearest 0.1cm using a portable Seca stadiometer (Seca Ltd. Brimingham UK). Mass was recorded to the nearest 0.1kg using a Seca 880 digital scale (Seca Ltd. Brimingham UK). Both instruments were calibrated prior to assessments to ensure accuracy of measurement. BMI was calculated as weight/height² (kg/m²). Participants were categorized as either obese, overweight or normal weight according to International BMI cut-off values (8, 9).

The 20m multi-stage fitness test (MSFT) was used to assess cardio-respiratory fitness and was performed in accordance with standard procedures (25). Briefly, participants were instructed to run back and forth in a straight line between cones set 20m apart while keeping in time with the audio signals from a CD. The initial speed was 8.5 km/h and increased by 0.5 km/h every level. Participants were encouraged to keep going for as long as possible. The test was terminated when the participant failed to reach the 20 m mark coincident with the audio signal on two consecutive occasions or when the participant stopped due to volitional fatigue. The last test stage completed was recorded for each participant. Maximal oxygen uptake (VO₂max) was then estimated using the Barnett et al equation (4):

\[
VO₂\text{max} = 24.4 - 5.0 \times G - 0.8 \times A + 3.4 \times S
\]

Where A is the age of the participant, G is gender (0 = male, 1 = female) and S is the final speed (S = 8 + 0.5 x last stage completed).

Standard procedures for the standing board jump (SBJ) as explained in the EUROFIT handbook (14) were used to assess lower limb explosive
strength. Briefly, participants were instructed to jump a maximal horizontal distance from a static starting position. A two footed take off and landing position was used. Participants were instructed to swing their arms and bend their knees to provide a forward drive. The score was measured as the distance from the take-off line to the heel closest to the take-off line after the jump and was measured to the nearest 0.1 cm.

Physical activity levels were assessed using a valid and reliable Physical Activity Questionnaire for Children (PAQ-C) (Crocker 10, 24). Participants were asked to complete the questionnaire at home with help and guidance from their parent/guardian. The questionnaire involved participants recalling their physical activity participation from the previous week (previous seven days). Participation was scored on a scale of 1-5 and provided an indication of activity levels within this cohort. For this study, a score of less than 2.5 indicated low physical activity participation and a score of more than 2.5 indicated high physical activity participation.

Maturation status was estimated using the Tanner sexual maturation staging (45). Using average age maturation guidelines proposed by Strang and Stray, pubic hair growth was estimated for each participant according to age (46). For females and males under the age of 9.5 years, guidelines suggest pubic hair growth will be at Tanner stage 1. For females aged 9.5 to 14.5 years and males aged 9.5 to 13.5 years, guidelines suggest pubic hair growth to be at Tanner stage 2. These estimations were determined with parents doing a comparative to photographs and not assessed by the researchers.

All performance measures were obtained at the same time of day to minimise the effects of diurnal variation. In addition, all measures were collected after familiarisation trials, with no physical activity 24 hours prior to experimental data collection.

**Statistical data analysis**

Data was analysed using the Statistical Package for the Social Sciences (SPSS) version 17.0. The level of significance was set a priori at $P \leq 0.05$ throughout. Mean ± SD was calculated for all measurements. Bonferroni-adjusted $t$-tests for two independent means were used to assess differences between two means. Standardized coefficient regression models were used to determine the direction, significance and strength of the relationship between physical activity and cardio-respiratory fitness. The direction of the relationship was represented by a “$\beta$” value and an “$R^2$” value indicated the strength of the relationship.
RESULTS

Descriptive characteristics of this cohort are presented in Table 1. No significant differences ($p > 0.05$) were found between gender in age ($p = 0.06$), height ($p = 0.605$), weight ($p = 0.691$) and BMI ($p = 0.337$). The majority (78.9%) of participants fell into Tanner stage 2 for sexual maturation and the remaining 21.1% fell into Tanner stage 1. The percentage of obese participants was 12.9%. Almost double the amount of girls were obese than boys (15% and 8.4%, respectively). The percentage of overweight participants was 23.4% and was similar in both girls and boys (23.5% and 23.3%, respectively). The prevalence of low physical activity in all participants was 38.2% with boys reporting more activity than girls, 61.2% vs. 65%, respectively. No significant differences ($p > 0.05$) in physical activity levels between genders was noted though boys had significantly greater $p \leq 0.05$ cardio-respiratory and explosive strength levels than girls (Table 2).

Table 1. Descriptive characteristics of participants.

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Boys</th>
<th>Girls</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (n)</td>
<td>76</td>
<td>36</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>10.2 ± 0.56</td>
<td>10.3 ± 0.49</td>
<td>9.85 ± 0.59</td>
<td>0.06</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>138 ± 7.27</td>
<td>138 ± 6.56</td>
<td>138 ± 7.91</td>
<td>0.605</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>33.3 ± 9.23</td>
<td>32 ± 9.02</td>
<td>34.1 ± 9.51</td>
<td>0.691</td>
</tr>
<tr>
<td>BMI (kg m⁻²)</td>
<td>17.9 ± 3.57</td>
<td>17.4 ± 3.44</td>
<td>18.4 ± 3.69</td>
<td>0.337</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Activity status (n/%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High Physical Activity</td>
<td>28/ 38.2</td>
</tr>
<tr>
<td>Low Physical Activity</td>
<td>48/ 61.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tanner Stage: (n/%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16/ 21.1</td>
</tr>
<tr>
<td>2</td>
<td>60/ 78.9</td>
</tr>
</tbody>
</table>

Physical activity level was found to be positively, and significantly ($p \leq 0.05$) associated with cardio-respiratory fitness in all participants (Table 3). To further examine this relationship the sample was split into genders. Although a positive and significant association between physical activity
and cardio-respiratory fitness was seen for both genders, the relationship was stronger in boys than in girls (Table 3).

The number of participants failing to meet recommended levels for healthy cardio-respiratory fitness is displayed in Figure 1. A large percentage of participants reported unhealthy cardio-respiratory fitness levels (82.9%) although the boys appeared to have a lower percentage of unhealthy cardio-respiratory fitness levels (77.8%) than the girls (87.5%). Figure 2 displays the proportion of participants reporting unhealthy levels of explosive strength. A large percentage of participants were associated with unhealthy explosive strength levels (81.6%). Although boys presented a higher mean value of explosive strength than girls, similar results were observed in failure to meet cut off levels in both groups.

<table>
<thead>
<tr>
<th>Table 2. Independent T-test for measures of physical fitness and physical activity within gender. Means and standard deviation provided.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys (n = 36)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td><strong>Cardio-respiratory fitness (20MSFT)</strong> (mL · kg⁻¹ · min⁻¹)</td>
</tr>
<tr>
<td><strong>Explosive strength (SBJ) (m)</strong></td>
</tr>
<tr>
<td><strong>Physical activity (PAQ-C score)</strong></td>
</tr>
</tbody>
</table>

*Note *= Significance p ≤ 0.05

**DISCUSSION**

The main finding of the study indicates that the majority of youth studied possessed poor health in relation to physical fitness, obesity and physical activity participation. Other important findings of this study are that gender differences exist in measures of physical fitness and that physical activity may not directly affect levels of cardio-respiratory fitness, particularly in girls.

Physical activity is well known to help in the prevention of developing
risk factors of CVD such as; obesity, hypertension, type II diabetes and low physical fitness (34, 40). The present data indicates that over 60% of participants reported low levels of physical activity, a finding much greater than that seen in the 2010 Scottish Health Survey (43). In that study, one third of Scottish youth included were identified with inadequate levels of physical activity. The present finding, if extrapolated across the whole of Scotland, suggests that nearly twice as many youth are inactive as proposed by the Scottish Executive. Furthermore, youth in this study are less physically active than Danish, Flemish, Portuguese, Spanish, Swedish and Estonian youth (3, 32, 33, 35, 39), where on average one out of three youth were associated with low physical activity participation. This is a disturbing finding as participation in regular physical activity or achieving adequate levels of physical activity is widely accepted to track into adulthood and reduce the risk of adulthood obesity and CVD (15, 30, 34). It might therefore be suggested that the youth in this study are at higher risk of becoming obese adults and of developing current and future CVD than proposed by the Scottish Executive and their European equivalents, as a result of having low physical activity participation.

Table 3. Standardized coefficient regression analysis ($\beta$), standard error of estimate (SEM), significance ($P$ value) and Adjusted $R^2$ for Physical activity and Cardio-respiratory fitness in gender.

<table>
<thead>
<tr>
<th></th>
<th>$n$</th>
<th>$\beta$</th>
<th>$P$ value</th>
<th>Adjusted $R^2$</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>76</td>
<td>0.242</td>
<td>0.092</td>
<td>0.39</td>
<td>0.496</td>
</tr>
<tr>
<td>Boys</td>
<td>36</td>
<td>0.856</td>
<td>0.000*</td>
<td>0.725</td>
<td>0.278</td>
</tr>
<tr>
<td>Girls</td>
<td>40</td>
<td>0.603</td>
<td>0.000*</td>
<td>0.347</td>
<td>0.438</td>
</tr>
</tbody>
</table>

Note *– significance when $p \leq 0.001$

Low physical activity or reduction in physical activity has been associated with increased risk of childhood overweight and obesity (21). Unsurprisingly, results of the study presented here revealed similar trends in overweight and obesity levels to low physical activity levels, with approximately 40% of participants being classed as either overweight or obese. This finding reveals that two out of five youth in this study were in these categories, a finding slightly higher than reported in the 2009 Scottish health survey, where only one third of 2 to 15 year olds were classed as overweight/obese (43). Furthermore, the prevalence of overweight and obesity
in this study is substantially higher when compared to studies of Swedish (33) and Flemish youth (7) where the prevalence of overweight and obesity was only 12.6% and 7.4%, respectively. This comparison suggests that Scottish youth may be four times more likely to be overweight or obese by BMI standards than other European youth. Furthermore, girls in this study were almost twice as likely to be classified as obese than boys, strongly suggesting that girls are more at risk of becoming obese adults and developing future CVD than their male counterparts (15, 30).

The relationship between physical activity and physical fitness is well documented (17-19,23). However, the literature remains unclear in respect to the amount of physical activity needed to elicit changes in cardio-respiratory fitness (37). A significant ($p = 0.000$) however weak ($R^2 = 0.39$) relationship between physical activity and cardio-respiratory fitness was observed in this study, supporting the finding of Kemper & Koppes, (23). This suggests that increasing physical activity may not be beneficial for improving cardio-respiratory fitness. On this note, a gender specific analysis of this relationship indicated that the female participants were the cause of this weak overall relationship as the male participants demonstrated a much stronger relationship than the females ($R^2 = 0.725$ and $R^2 = 0.347$, respectively). Suggesting that, increasing physical activity in the girls may not be beneficial for improving cardio-respiratory fitness, as higher levels of physical activity did not directly reflect high cardio-respiratory fitness in girls. Whereas, increasing physical activity in the boys may be beneficial for improving cardio-respiratory fitness. It would be worthwhile in later studies to examine and quantify the volume and intensity characteristics of the reported physical activity to further explore this discrepancy in previous and present data.

Cardio-respiratory fitness has been suggested to be the most important indicator of health in youth (34). A meta-analysis which reviewed the 20m MSFT results in over 100 studies involving 37 countries indicated European youth from Italy, Greece, Portugal, America, Brazil and Singapore reported the poorest levels of cardio-respiratory fitness on a worldwide perspective (34). These low levels of fitness are proposed to persist into adulthood (26). Supporting this view, four out of five (82.9%) participants in this present study possessed poor cardio-respiratory fitness which may associate them with future unhealthy cardiovascular outcomes. The majority of participants in this study are at risk of maturing into adulthood with poor cardio-respiratory fitness (26), resulting in an increased risk of future CVD (16, 39). Girls in this study presented a higher incidence of unhealthy cardio-respiratory fitness than males (87.5% and 77.8%, respectively). This result supports the findings of Mota et al., (29) who reported a higher prevalence of unhealthy cardio-respiratory fitness in Portuguese girls than boys (28% and 19%, respectively). Thus, girls may present a higher risk of developing future CVD than boys due to a higher prevalence of unhealthy cardio-respiratory fitness.
levels. This difference between genders could partially be explained by the fact that boys tend to participate in vigorous intensity physical activity more than girls (12, 41), resulting in greater improvements in cardio-respiratory fitness and lower associations with unhealthy cardio-respiratory fitness (1, 35).

**Figure 1:** Percentage of participants failing to achieve cut off values as proposed by The Cooper Institute (46) for cardio-respiratory fitness.

<table>
<thead>
<tr>
<th>Boys</th>
<th>Girls</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>77.8</td>
<td>87.5</td>
<td>82.9</td>
</tr>
</tbody>
</table>

**Figure 2:** Percentage of participants failing to achieve cut off values as proposed by The Committee of Experts on Sports Research (14) and ACSM (1) for explosive strength.

<table>
<thead>
<tr>
<th>Boys</th>
<th>Girls</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>83.3</td>
<td>80</td>
<td>81.6</td>
</tr>
</tbody>
</table>
Recently, the focus of muscular fitness has shifted from a sports performance focus (31) to a health related focus (16, 22, 27, 42). This present study indicates that 86.2% of the studied population sample demonstrated an unhealthy explosive strength level, meaning that four out of five youth in this study may be at additional CVD and metabolic risk. This finding may be due to the low physical activity participation rates among participants in this study. Martinez-Gmez et al., (27) found an association between total physical activity, physical activity intensity and muscular fitness. They found that low levels of total physical activity as well as low intensity physical activity reflect low levels of muscular fitness, whereas as high levels of total physical activity and vigorous intensity physical activity reflected higher levels of muscular fitness. Suggesting that participating in adequate levels of physical activity, more specifically vigorous physical activity, may be beneficial for achieving healthy muscular fitness.

CONCLUSION

The results of this study may indicate that overweight/obesity, low physical activity and unhealthy physical fitness levels of Scottish youth demonstrate a worryingly low health status compared with other European youth. A large number of subjects in this current study failed to achieve minimal criteria for health, indicative of an increased risk of current and future CVD risk factors. Results of this study indicated that girls in this study were more obese and less physically fit than the boys meaning that they are at a higher disease risk than boys, and are at a greater risk of retaining that risk and persistent low fitness into adulthood. Results also suggested that increasing physical activity levels may not directly or sufficiently improve cardio-respiratory fitness in all participants. This is especially apparent when considering this association in girls. These findings indicate that developing physical activity interventions to promote healthy and correct physical activity habits, reduce overweight/obesity and improve physical fitness, particularly in girls, requires more attention within the youth of Scotland.

REFERENCES


17. Gutin B, Barbeau P and Owens SL. Effects of exercise intensity on
23. Kemper HG and Koppes, LL. Linking physical activity and aerobic fitness: are we active because we are fit, or are we fit because we are active? Pediat Exerc Sci 18: 173-81, 2006.

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