ACSM PRE-PARTICIPATION HEALTH SCREENING GUIDELINES: A UK UNIVERSITY COHORT PERSPECTIVE

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ABSTRACT

Purpose: Pre-participation health screening is recommended to detect individuals susceptible to serious adverse cardiovascular complications during exercise. Although expert opinion and best available scientific evidence have informed recent modifications, there remains limited experimental data to support or refute current practice. We therefore aimed to quantify the impact of change to the ACSM pre-participation health screening guidelines on risk classification and referral for medical clearance in a large cohort of undergraduate university students. **Methods:** Participants attended the laboratory on a single occasion to undergo pre-participation health screening. Information concerning health status was obtained via self-report questionnaire and objective physiological assessment with all data recorded electronically and evaluated against ACSM screening guidelines (9th and 10th Edition). **Results:** Five-hundred and fifty-three students completed the study. The 9th Edition screening guidance resulted in eighty-two (15%) subjects classified as high-risk, almost one quarter (24%) classified as moderate-risk, and almost two-thirds (61%) classified as low-risk. In comparison, the updated 10th Edition screening guidance resulted in a significant reduction in those previously classified as either high-risk (5%) or moderate risk (2%), respectively. The majority of subjects (93%) were therefore cleared to begin a structured exercise programme. Taken together, approximately one-third (32%) fewer medical referrals were required when applying the updated 10th Edition guidance (χ^2 (4) = 247.7, P<0.001). **Conclusion:** The updated ACSM 10th Edition pre-participation screening guidance reduces medical referrals by approximately one-third. These findings are in keeping with previous reports and thus serve to consolidate and justify recent modification - particularly when applied to young adult or adolescent populations. The findings and arguments presented should be used to refine and inform future guidance.

Key words: ACSM, Exercise, Health, Physical Activity, Pre-participation, Screening.

INTRODUCTION

Regular physical activity and structured exercise training are widely accepted to promote health and well-being in addition to lowering the risk of developing chronic disease such as cardiovascular disease (CVD), diabetes mellitus and cancers across the lifespan (1). However, despite recognition of health benefit (i.e. reduced morbidity and mortality) (2), a large proportion (~30%) of the global population remain sedentary (3, 4). On this basis, and to reduce healthcare costs attributed to sedentary living (5), the World Health Organisation (WHO) have recently targeted a reduction in physical inactivity over the next decade as a key global health priority (6-9).

The American College of Sports Medicine (ACSM) currently advise completing at least 30 minutes of moderate intensity activity 5 days per week, or 20 minutes of vigorous intensity activity 3 days per week to optimise and maintain health (10). However, prior to initiating an exercise programme, irrespective of age, it is recommended that pre-participation health screening is conducted to detect individuals susceptible to serious adverse cardiovascular complications; i.e. sudden cardiac death and/or acute myocardial infarction during or post exercise (10).

Historically, pre-participation health screening, as described in the 9th Edition and previous versions of the ACSM Guidelines to Exercise Testing and Prescription focused on: (a) risk stratification calculated according to CVD risk factors and (b) the presence of signs or symptoms of and/or history of cardiovascular, pulmonary, renal, liver or metabolic disease. This approach permitted recommendations concerning suitability to commence exercise or the requirement for further clinical assessment (i.e. referral to a physician to obtain medical clearance) (11).

More recently, however, it has been acknowledged that employing this approach may contribute to excessive medical referrals thereby placing unnecessary burden on healthcare infrastructure, and equally, may create a barrier to physical activity and exercise engagement (12). In an attempt to simplify guidance, and address these concerns, a panel of experts convened by the ACSM published modifications to the pre-participation health screening criteria in 2015 (subsequently incorporated in the 10th Edition of the Guidelines for Exercise Testing and Prescription) (10). Accordingly, screening guidance currently centres on: (a) current level of physical activity, (b) the presence of known cardiovascular, metabolic, or renal disease (or signs or symptoms of these diseases), and (c) the desired intensity of the exercise bout / programme (10).

Although expert opinion and best available scientific evidence have informed these modifications, there remains limited experimental data to support or refute current practice, particularly when applied to young adult (i.e. <40 years) or adolescent populations (13). This is important given pre-participation health screening is recommended within universities and colleges (notably across exercise science courses and sports teams), and as part of inductions to gymnasia and fitness centres around the globe.

The primary aim of this study was therefore to quantify the impact and examine the implications of change to the ACSM pre-participation health screening guidelines on risk classification and referral for medical clearance in a large cohort of UK-based undergraduate university students. A secondary aim was to evaluate the requirement for widespread screening in this context by characterising the prevalence of CVD risk and signs/symptoms or history of non-communicable disease. We hypothesised that the updated 10th Edition guidance would reduce the percentage of medical referrals whilst providing a cost-effective and time-efficient approach to pre-participation health screening in young adult populations.

METHODS

Study population and experimental design

Six-hundred and five undergraduate university sport and exercise science students were enrolled into the study between 2015-17. In accordance with the Leeds Beckett University (UK) local pre-exercise risk assessment and risk management policy, all participants attended the laboratory on a single occasion to undergo pre-participation health screening. Information concerning health status was obtained via self-report questionnaire and objective physiological assessment with all data recorded electronically. In accordance with ACSM 9th Edition guidance (described below) - a finger-prick capillary blood sample was obtained for the assessment of blood glucose and total cholesterol for subjects who presented with ≥1 CVD risk factor. All testing was conducted by trained personnel and evaluated against ACSM pre-participation screening guidelines (9th and 10th Edition). Data were analysed retrospectively by two independent reviewers (OP and AS) to complete risk classification and determine screening outcome. All tests and procedures were approved by the local research ethics committee (IRB ethics ID: 50858) and all subjects provided written informed consent (Figure 1).

Pre-participation health screening guidance

9th Edition

The ACSM 9th Edition algorithm classifies individuals according to risk; i.e. low, moderate, and high. Screening outcome is determined based on the sum of CVD risk factors; i.e. age, family history of heart disease, smoking status, physical activity, obesity (based on BMI and/or waist circumference), dyslipidaemia, dysglycaemia and resting blood pressure values, and presence or absence of signs or symptoms, or known cardiovascular, *pulmonary*, renal, liver or metabolic disease with recommendations for medical clearance based on the desired intensity of exercise (Figure 2A).

10th Edition

The ACSM 10th Edition algorithm classifies individuals as physically active or inactive according to the level of exercise or physical activity engagement over the past 3 months (defined as planned, structured physical activity of at least 30 min duration at moderate intensity on at least 3 days per week). Screening outcome is determined based on presence or absence of known cardiovascular, metabolic, or renal disease and presence or absence of signs or symptoms of these conditions with recommendations for medical clearance based on the desired intensity of exercise (Figure 2B).

Risk stratification and screening outcome (9th vs. 10th Edition)

To allow a direct comparison of guidance, risk stratification and screening outcome was classified as (a) low-risk (colour code: green) (i.e. medical clearance not necessary), (b) moderate-risk (colour code: yellow) (i.e. medical clearance only required for vigorous exercise), (c) high-risk (colour code: red) (i.e. medical clearance recommended prior to any physical activity) (Figure 2).

Statistical analysis

Referral percentages were calculated and stratified with cross-tabulation conducted to compare screening outcome. Independent t-tests (continuous variables) and Chi-squared tests (categorical variables) were employed to evaluate between group (sex) differences. All other data were reported descriptively according to prevalence of CVD risk factors, signs and symptoms of disease and prior history of non-communicable disease. Data were analysed using SPSS Statistics statistical software package Version 24 (SPSS Inc., Chicago, IL). $P<0.05$ was considered statistically significant. Data are reported as mean ± SD unless otherwise stated.

RESULTS

Study population

Of the 605 subjects recruited to this study, 553 (male n = 393) completed the study, while 52 (male n = 43) were excluded from the analysis due to incomplete datasets. Subjects' clinical characteristics are presented in Table 1.

Comparison of risk stratification and screening outcome

The 9th Edition screening guidance resulted in eighty-two (15%) subjects classified as high-risk, one-hundred and thirty five (24%) classified as moderate-risk, and three hundred thirty three (61%) classified as low-risk. In comparison, the updated 10th Edition screening guidance resulted in twenty-seven classified as high-risk (5%) and thirteen classified as moderate risk (2%), respectively. All subjects originally classified as moderate risk according to 9th Edition guidance were re-classified as low risk when applying the 10th Edition guidance. The remaining five hundred and thirteen (93%) were therefore cleared to begin a structured exercise programme in accordance with the 10th edition of the ACSM's Guidelines for Exercise Testing and Prescription. Taken together, almost one-third (32%) fewer medical referrals were required when applying the updated 10th Edition guidance (χ^2 (4) = 247.7, P<0.001) (Figure 3A).

High-risk re-classification

Of the eighty-two subjects (15% of all participants) originally classified as high-risk, twenty-seven (5%) remained the same and required referral for medical clearance due to a sign and/or symptom of cardiovascular, metabolic or renal disease. Thirteen subjects (16%) were re-classified as moderate risk due to being physically active and having known cardiovascular, metabolic or renal disease but also being asymptomatic. Forty-two subjects (51%) were re-classified as low-risk due to guidance modification concerning pulmonary and liver (Figure 3B). Specifically, thirty-eight subjects (46%) diagnosed with asthma, one subject (1%)

diagnosed with cystic fibrosis, one subject (1%) diagnosed with interstitial lung disease, and two subjects (2%) diagnosed with liver disease were reclassified as low-risk (Table 2).

CVD risk factors, signs and/or symptoms and history of disease

Prevalence of family history of CVD, physical inactivity, obesity (based on BMI and waist circumference thresholds), dyslipidaemia and dysglycaemia were not different between sexes (P>0.05). In contrast, smoking status (χ^2 (1) = 9.172, p=0.002) and evidence of hypertension (χ^2 (1) = 5.995, p=0.014) were higher in males. Descriptive statistics and prevalence data for CVD are provided in Table 3. Signs and/or symptoms of disease were not different between sexes (P>0.05). For the majority of diseases, no difference was observed between sexes (P>0.05). Descriptive statistics and prevalence data for signs and/or symptoms and history of non-communicable disease are provided in Table 2.

Blood sample analysis (*n* = 135)

One hundred and thirty-five subjects (male: *n* = 102) (24%) presented with ≥1 CVD risk factor and therefore provided a capillary blood sample in accordance with 9th Edition screening guidance. Of these, only five subjects (4%) presented with dyslipidaemia and only two subjects (1%) presented with dysglycaemia. In contrast, the other one hundred and twenty-eight subjects (95%) (1 CVD risk factor) were confirmed as low-risk following determination of normal resting blood lipid and glucose profiles (Table 3).

DISCUSSION

In support of our hypothesis, the present study provides the first experimental evidence to confirm that when employing the revised ACSM 10th Edition pre-participation screening guidance, almost one-third (32%) fewer university students were referred for medical clearance. The implications of our findings can be considered two-fold: firstly, reducing the impact of unnecessary or excessive medical referrals on primary healthcare infrastructure (i.e. cost, time and resource), and secondly, reducing barriers to exercise and physical activity engagement. The latter is of particular importance given the strong association between exercise engagement in early life and physical activity status across the lifespan (14).

The majority of research to date investigating pre-participation health screening has primarily evaluated individuals considered to be at 'heightened' risk of cardiovascular complications during exercise (i.e. mid-adult or elderly age-groups) (13, 15). For example, a recent retrospective analysis by Whitfield and colleagues compared referral patterns between the ACSM 10th Edition guidance with previously validated (and widely implemented) pre-participation questionnaires (i.e. AAPQ and PAR-Q) in a large representative sample (n = 6785) of United States adults (13). Similar to the present study, it was found that the 10th Edition guidance resulted in significantly fewer (~38%) medical referrals. The sample size of this comparative analysis is clearly a study strength, however it is important to acknowledge that several symptoms contributing to the ACSM guidance were not assessed, with all adults aged 40-years or older (13).

In contrast to this approach, for the first time, our study provides a direct comparison of screening methods (i.e. ACSM 9th vs. 10th Edition) applicable to younger age-groups (i.e. young adult and adolescent populations). It is our view, that the data from the present study should therefore be interpreted to consolidate previous findings and interpreted to support

recent modification and inform potential revisions to future ACSM guidance. Taken together, the simplicity, cost-effectiveness and short time-frame to complete and obtain a screening outcome when applying the 10th Edition guidance provides strong justification to employ widespread screening (irrespective of age) prior to beginning an exercise programme.

The lower proportion of referrals and change to screening outcome in the present study is attributable to guidance modification concerning: (a) evaluating physical activity engagement, (b) removal of pulmonary and liver disease from screening outcome, and (c) discounting CVD risk factors (10). Of the eighty-two subjects that were originally classified as high-risk according to 9th Edition guidance, twenty-seven (15%) remained unchanged due to reporting a sign and/or symptom of cardiovascular, metabolic or renal disease. However, thirteen (16%) (presenting with known cardiovascular, metabolic or renal disease and asymptomatic) were re-classified to moderate risk due to physical activity either meeting or exceeding current recommendations (10). As the absolute and relative risks of acute cardiovascular events during exercise are known to be very low in asymptomatic individuals (16-18), re-classification and clearance to begin moderate intensity exercise (40-60% aerobic capacity) is certainly logical when applied to physically active individuals (irrespective of disease status).

It is important to note that self-report physical activity data acquired through consultation and questionnaire has previously been reported to provide poor validity and reliability when compared to device-based measures of human movement (e.g. pedometers and accelerometers etc.) (19). Indeed the most comprehensive appraisal of the literature to date concluded that self-report frequently results in both an over and under-estimation of physical activity (20). These findings therefore have important ramifications for risk assessment when employing 10th Edition guidance in the context of health screening and exercise prescription. Although the prominence of physical activity in the 10th Edition positively contributes to the observed

reduction in medical referrals, limitations associated with self-report should be considered during consultation. To optimise the accuracy of estimated daily physical activity, what constitutes 'planned, structured physical activity' should be clearly defined, and it is our view that supplementary or follow-up questions should be considered and encouraged moving forward.

The decision to no longer automatically refer those with pulmonary disease had a significant impact on screening outcome. As evidenced by our findings, of those previously classified as high-risk, almost half (49%) were re-classified as low-risk when discounting pulmonary disease (asthma: 95%, cystic fibrosis: 2.5% and interstitial lung disease: 2.5%). In support of this modification, it is worth noting that pulmonary disease is not associated with an increased risk of cardiovascular complications during exercise, rather, long-term physical inactivity, due to fear of provoking exertional breathlessness or exacerbation, is more likely to increase the relative-risk of an adverse cardiovascular event in this population (21). The overall prevalence of asthma (~7%) in our cohort is in keeping with current UK estimates (~8%) (22). It is important to acknowledge however that asthma is a complex disease consisting of several variants with unique underlying pathophysiology (23). In the context of pre-participation health screening, asthma sub-type and clinical control status should also be considered before granting clearance to commence vigorous or maximal intensity exercise. Caution is therefore advised when screening individuals predisposed to exercise-induced asthma, or those with severe, uncontrolled, or difficult to treat airways disease (24). Irrespective of this recommendation, the reduced referral pattern should help to deter physical inactivity in pulmonary disease patients. Indeed, the importance of regular exercise and physical activity in the context of pulmonary rehabilitation is well-established (25, 26).

Perhaps unsurprisingly liver disease was only found to have a minor impact on screening outcome in our young adult population. However, considering the growing global epidemic of obesity and associated metabolic disease (largely attributed to modifiable lifestyle factors such as diet, alcohol consumption, and physical inactivity), it is likely that a similar reduction in referral proportions related to liver disease would be observed when applied to older or ageing populations (27). Similarly, for the most part, the prevalence of CVD risk factors in our cohort was relatively low (<5%) with no difference observed between sexes.

The suggestion of excessive referrals in the past is supported by our data given the majority of our population (95%) who presented with ≥1 CVD risk factor (following the screening questionnaire and measurements of anthropometry and resting blood pressure) returned to low-risk following blood analysis (i.e. normal resting blood glucose and lipid profiles). Of concern, the incidence of smoking status (9%) and evidence of hypertension (14%) was high in males, which clearly has ramifications for long-term respiratory health (28) and the development of CVD and heightened relative risk of mortality in later life (29). Finally, the incidence of signs and/or symptoms or history of non-communicable disease was low when compared against current estimates from the global population (30).

Methodological considerations and future research

Despite our encouraging findings, it is important to recognise and consider potential limitations to the updated 10th Edition guidance. For example, current policy stipulates clearance to engage in 'vigorous intensity exercise' defined as ≥60% aerobic capacity. Whilst evidence indicates that the absolute risk of cardiovascular complications during high-intensity exercise is low, the relative risk of sudden cardiac death and/or acute myocardial infarction during or post exercise increases (irrespective of age, current physical fitness or functional capacity) when approaching maximal exercise. To further mitigate risk; in circumstances where individuals

231 are required to exercise to volitional exhaustion (e.g. maximal oxygen uptake testing), it may
232 be pragmatic to evaluate the accuracy of self-report information relevant to screening outcome
233 (e.g. physical activity status) on a case-by-case basis before granting clearance. Although we
234 recognise that ACSM pre-participation health screening guidelines are designed to detect
235 individuals susceptible to serious adverse cardiovascular complications, it is also important to
236 consider and rule-out other relevant conditions that may be made worse or increase the risk of
237 injury during exercise. In support of this concept, musculoskeletal injury was reported in
238 approximately 12% our cohort which would have remained undetected without requesting
239 further patient history. Finally, as with all screening criteria, a potential for false-positive or
240 false-negative outcome exists when employing current guidance. To provide evidence-based
241 recommendations and to justify benefit of widespread pre-participation health screening,
242 validation against objective diagnostic work-up in those referred for medical clearance, and
243 long-term follow-up of individuals cleared to exercise remains a research priority.

244 **Conclusion**

245 In summary, in a large cohort of UK-based undergraduate university students, we have
246 demonstrated that the ACSM 10th Edition guidance reduces medical referrals by
247 approximately one-third. These findings are in-keeping with previous reports and thus serve to
248 consolidate and justify recent modification - particularly when applied to young adult or
249 adolescent populations. In order to continue to optimise the health, well-being and overall
250 safety of individuals engaging in exercise, consideration of the findings and arguments
251 presented should be used to refine and inform future guidance.

TABLE FOOTNOTES

Table 1. Subject clinical characteristics.

Table 2. Signs and symptoms and history of non-communicable disease (ACSM 9th and 10th Edition).

Table 3. Cardiovascular disease risk factors (ACSM 9th Edition)

FIGURE LEGENDS

Figure 1. Schematic detailing experimental design.

ACSM 9th Edition:

*CVD risk factors

Age: men >45 years; women>55 years

Family history: myocardial infarction, coronary revascularisation, or sudden death before 55 year in father or other male first-degree relative or before 65 year in mother or other female first-degree relative

Cigarette smoking: Current cigarette smoker or those who quit within the previous 6-months or exposure to environmental tobacco smoke

Sedentary lifestyle: Not participating in at least 30 min of moderate intensity, physical activity (40% - <60% VO_2R) on at least 3 day of the week for at least 3 months

Obesity: Body mass index ≥30kg.m^2 or waist circumference >102cm for men and >88cm for women

Hypertension: Systolic blood pressure ≥140mmHg and/or diastolic ≥90mmHg, confirmed by measurements on at least two separate occasions, or on anti-hypertensive medication

Dyslipidaemia: Low-density lipoprotein (LDL) cholesterol ≥130mg.dL^{-1} (3.37mmol.L^{-1}) or high-density lipoprotein (HDL) cholesterol <40mg.dL (1.04 mmol.L^{-1}) or on lipid-lowering medication. If total serum cholesterol is all that is available, use ≥200mg.dL-1 (5.18 mmol.L^{-1})

Prediabetes: Impaired fasting glucose = fasting plasma glucose ≥100mg.dL-1 (5.55mmol.L^{-1}) and ≤125mg.dL^{-1} (6.94 mmol.L^{-1}) or impaired glucose tolerance test = 2 hour values in oral glucose tolerance test ≥140mg.dL^{-1} (7.77 mmol.L^{-1}) and ≤199mg.dL^{-1} (11.04mmol.L^{-1}) confirmed by measurements on at least two separate occasions.

Negative risk factors: High-density lipoprotein cholesterol ≥60mg.dL^{-1} (1.55mmol.L^{-1})

**Signs or symptoms of disease

Pain, discomfort in the chest, neck, jaw, arms, or other areas that may result from ischemia

Shortness of breath at rest or with mild exertion

Dizziness of syncope

Orthopnoea or paroxysmal nocturnal dyspnoea

Ankle oedema

Palpitations or tachycardia

Intermittent claudication

Known heart murmur

Unusual fatigue or shortness of breath with usual activities

***History of disease

Cardiovascular: Cardiac, peripheral vascular, or cerebrovascular disease

Pulmonary: Chronic obstructive pulmonary disease, asthma, interstitial lung disease or cystic fibrosis

Metabolic: Diabetes mellitus (types 1 and 2) or renal disease

ACSM 10th Edition:

†Participates in regular exercise

Performing planned, structured physical activity at least 30 min at moderate intensity on at least 3 days per week for at least the last 3 months

††Signs or symptoms of disease

At rest or during activity; includes pain, discomfort in the chest, neck, jaw, arms, or other areas that may result from ischemia; shortness of breath at rest or with mild exertion; dizziness or syncope; orthopnoea or paroxysmal nocturnal dyspnoea; ankle oedema; palpitations or tachycardia; intermittent claudication; known heart murmur; or unusual fatigue or shortness of breath with usual activities

†††History of disease

Cardiac, peripheral vascular, or cerebrovascular disease

Type 1 and 2 diabetes mellitus

Figure 2. 9th (A) and 10th Edition (B) ACSM pre-participation health screening algorithm(s).

Medical clearance: Approval from a healthcare professional to engage in exercise
Mod ex: Moderate intensity exercise; 40% - <60% VO_2R; 3 - <6 METS "An intensity that causes noticeable increases in heart rate and breathing"
Vig ex: Vigorous intensity exercise; ≥60% VO_2R; ≥6 METS. "An intensity that causes substantial increases in heart rate and breathing"

Figure 3A. Screening outcome according to 9th and 10th Edition ACSM pre-participation health screening guidance.

ACSM 9th Edition: red - medical clearance recommended (*n* = 82; 15%); yellow - medical clearance required for vigorous intensity exercise only (*n* = 135; 24%); green - medical clearance not required (*n* = 333; 61%).

ACSM 10th Edition: red - medical clearance recommended (*n* = 27; 5%); yellow - medical clearance required for vigorous intensity exercise only (*n* = 13; 2%); green - medical clearance not required (*n* = 513; 93%)

Figure 3B. Re-classification of high-risk individuals (*n* = 82) according to updated pre-participation health screening guidelines (ACSM 10th Edition).

ACSM 10th Edition: red - medical clearance recommended (*n* = 27; 33%); yellow - medical clearance required for vigorous intensity exercise only (*n* = 13; 16%); green - medical clearance not required (*n* = 42; 51%).

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The authors have no real or perceived conflict of interest in respect of this manuscript.

CONTRIBUTION STATEMENT

All authors were involved in the conception, design of the study, acquisition of data, drafting and critical revision of manuscript and final approval of the version to be published. The results of the study are presented clearly, honestly, and without fabrication or falsification.

GUARANTOR STATEMENT

OP and AS confirm full responsibility for the content of the manuscript, including data and analysis.

The results of the present study do not constitute endorsement by ACSM.

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