

# **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 (9<sup>th</sup> and 10<sup>th</sup> Edition). **Results:** Five-hundred and fifty-three students completed the study. The 9<sup>th</sup> 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 10<sup>th</sup> 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 10<sup>th</sup> Edition guidance ( $\chi^2(4) = 247.7, P < 0.001$ ). **Conclusion:** The updated ACSM 10<sup>th</sup> 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.

## 1 INTRODUCTION

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

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

17 Historically, pre-participation health screening, as described in the 9<sup>th</sup> Edition and previous  
18 versions of the ACSM Guidelines to Exercise Testing and Prescription focused on: (a) risk  
19 stratification calculated according to CVD risk factors and (b) the presence of signs or  
20 symptoms of and/or history of cardiovascular, pulmonary, renal, liver or metabolic disease.

21 This approach permitted recommendations concerning suitability to commence exercise or the  
22 requirement for further clinical assessment (i.e. referral to a physician to obtain medical  
23 clearance) (11).

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

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

40 The primary aim of this study was therefore to quantify the impact and examine the implications  
41 of change to the ACSM pre-participation health screening guidelines on risk classification and  
42 referral for medical clearance in a large cohort of UK-based undergraduate university students.

43 A secondary aim was to evaluate the requirement for widespread screening in this context by  
44 characterising the prevalence of CVD risk and signs/symptoms or history of non-communicable  
45 disease. We hypothesised that the updated 10<sup>th</sup> Edition guidance would reduce the percentage  
46 of medical referrals whilst providing a cost-effective and time-efficient approach to pre-  
47 participation health screening in young adult populations.

## 48 **METHODS**

### 49 **Study population and experimental design**

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

### 63 **Pre-participation health screening guidance**

#### 64 ***9<sup>th</sup> Edition***

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

72 **10th Edition**

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

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

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

86 **Statistical analysis**

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

## 94 **RESULTS**

### 95 **Study population**

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

### 99 **Comparison of risk stratification and screening outcome**

100 The 9<sup>th</sup> Edition screening guidance resulted in eighty-two (15%) subjects classified as high-  
101 risk, one-hundred and thirty five (24%) classified as moderate-risk, and three hundred thirty  
102 three (61%) classified as low-risk. In comparison, the updated 10<sup>th</sup> Edition screening guidance  
103 resulted in twenty-seven classified as high-risk (5%) and thirteen classified as moderate risk  
104 (2%), respectively. All subjects originally classified as moderate risk according to 9<sup>th</sup> Edition  
105 guidance were re-classified as low risk when applying the 10<sup>th</sup> Edition guidance. The remaining  
106 five hundred and thirteen (93%) were therefore cleared to begin a structured exercise  
107 programme in accordance with the 10<sup>th</sup> edition of the ACSM's Guidelines for Exercise Testing  
108 and Prescription. Taken together, almost one-third (32%) fewer medical referrals were required  
109 when applying the updated 10<sup>th</sup> Edition guidance ( $\chi^2(4) = 247.7, P < 0.001$ ) (Figure 3A).

### 110 **High-risk re-classification**

111 Of the eighty-two subjects (15% of all participants) originally classified as high-risk, twenty-  
112 seven (5%) remained the same and required referral for medical clearance due to a sign and/or  
113 symptom of cardiovascular, metabolic or renal disease. Thirteen subjects (16%) were re-  
114 classified as moderate risk due to being physically active and having known cardiovascular,  
115 metabolic or renal disease but also being asymptomatic. Forty-two subjects (51%) were re-  
116 classified as low-risk due to guidance modification concerning pulmonary and liver (Figure  
117 3B). Specifically, thirty-eight subjects (46%) diagnosed with asthma, one subject (1%)

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

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

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

#### 129 **Blood sample analysis ( $n = 135$ )**

130 One hundred and thirty-five subjects (male:  $n = 102$ ) (24%) presented with  $\geq 1$  CVD risk factor  
131 and therefore provided a capillary blood sample in accordance with 9<sup>th</sup> Edition screening  
132 guidance. Of these, only five subjects (4%) presented with dyslipidaemia and only two subjects  
133 (1%) presented with dysglycaemia. In contrast, the other one hundred and twenty-eight subjects  
134 (95%) (1 CVD risk factor) were confirmed as low-risk following determination of normal  
135 resting blood lipid and glucose profiles (Table 3).



136 **DISCUSSION**

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

145 The majority of research to date investigating pre-participation health screening has primarily  
146 evaluated individuals considered to be at 'heightened' risk of cardiovascular complications  
147 during exercise (i.e. mid-adult or elderly age-groups) (13, 15). For example, a recent  
148 retrospective analysis by Whitfield and colleagues compared referral patterns between the  
149 ACSM 10<sup>th</sup> Edition guidance with previously validated (and widely implemented) pre-  
150 participation questionnaires (i.e. AAPQ and PAR-Q) in a large representative sample ( $n =$   
151 6785) of United States adults (13). Similar to the present study, it was found that the 10<sup>th</sup>  
152 Edition guidance resulted in significantly fewer (~38%) medical referrals. The sample size of  
153 this comparative analysis is clearly a study strength, however it is important to acknowledge  
154 that several symptoms contributing to the ACSM guidance were not assessed, with all adults  
155 aged 40-years or older (13).

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

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

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

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

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

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

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

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

### 223 **Methodological considerations and future research**

224 Despite our encouraging findings, it is important to recognise and consider potential limitations  
225 to the updated 10<sup>th</sup> Edition guidance. For example, current policy stipulates clearance to engage  
226 in ‘vigorous intensity exercise’ defined as  $\geq 60\%$  aerobic capacity. Whilst evidence indicates  
227 that the absolute risk of cardiovascular complications during high-intensity exercise is low, the  
228 relative risk of sudden cardiac death and/or acute myocardial infarction during or post exercise  
229 increases (irrespective of age, current physical fitness or functional capacity) when  
230 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.

252 **TABLE FOOTNOTES**

253

254 **Table 1.** Subject clinical characteristics.

255 **Table 2.** Signs and symptoms and history of non-communicable disease (ACSM 9<sup>th</sup> and 10<sup>th</sup>  
256 Edition).

257 **Table 3.** Cardiovascular disease risk factors (ACSM 9<sup>th</sup> Edition)

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261 **FIGURE LEGENDS**

262 **Figure 1.** Schematic detailing experimental design.

**ACSM 9<sup>th</sup> 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<sub>2</sub>R) on at least 3 day of the week for at least 3 months

Obesity: Body mass index  $\geq 30 \text{ kg.m}^2$  or waist circumference >102cm for men and >88cm for women

Hypertension: Systolic blood pressure  $\geq 140 \text{ mmHg}$  and/or diastolic  $\geq 90 \text{ mmHg}$ , confirmed by measurements on at least two separate occasions, or on anti-hypertensive medication

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

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

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

**\*\*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 or 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 10<sup>th</sup> 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

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265 **Figure 2.** 9<sup>th</sup> (A) and 10<sup>th</sup> 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<sub>2</sub>R; 3 - <6 METS “An intensity that causes noticeable increases in heart rate and breathing”

**Vig ex:** Vigorous intensity exercise; ≥60% VO<sub>2</sub>R; ≥6 METS. “An intensity that causes substantial increases in heart rate and breathing”

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269 **Figure 3A.** Screening outcome according to 9<sup>th</sup> and 10<sup>th</sup> Edition ACSM pre-participation  
270 health screening guidance.

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**ACSM 9<sup>th</sup> 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 10<sup>th</sup> 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%)

272

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

**ACSM 10<sup>th</sup> 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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289 All authors were involved in the conception, design of the study, acquisition of data, drafting  
290 and critical revision of manuscript and final approval of the version to be published. The results  
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292 **GUARANTOR STATEMENT**

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

295

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

297

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