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The Sustained Athlete Fitness Exam – Outcomes of U.S. National Senior Games Athletes

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ABSTRACT

Background/Objectives: Physical fitness screening measures for older athletes are lacking in clinical and research arenas. This study aims to define the Sustained Athlete Fitness Exam (SAFE), a comprehensive tool developed using age and sex-based normative data from U.S. National Senior Games athletes, and to investigate any SAFE differences by age, sex, sport, or exercise volume.

Methods: This cross-sectional study engaged 4,659 U.S. National Senior Games athletes (mean age 67.65, SD 9.12, 59.1% female). Athletes completed health history questions and physical performance measures addressing subscales of: cardiovascular, muscular, flexibility, and balance. Subscale scoring applied age and sex norms from the study population. Outcomes were compared by age-group, sex, sport, and exercise volume.

Results: All 22 National Senior Games sports were represented in the study population. Health histories revealed low rates of chronic conditions with 28.5% reporting none. Median weekly cardiovascular and resistance exercise volumes were 240 and 30 minutes, respectively. Of the 20 points possible on the SAFE, scores ranged from 2 (0.2%) to 20 (.8%) with a median of 13. SAFE scoring demonstrated minimal differences by age-group or sex and aligned predictably by sport. Higher exercise volumes were associated with superior SAFE composite scores with nearly all subscales following this trend.

Conclusion: The SAFE, and associated norms, offer population-specific comparisons previously unavailable for older athletes with a tool able to address multiple domains of physical fitness while avoiding ceiling and floor effects.

Significance/Implications: These finding provide the opportunity to improve assessment, treatment, preventative medicine, and training support to a growing demographic.

Key Words: Masters Athlete, Normative Data, Screening, Prevention, Health Promotion

KEY POINTS

1. The SAFE screens older athlete cardiovascular, muscular, flexibility, and balance fitness.
2. Athletes reporting higher exercise volume had higher scores.
3. SAFE scoring limits influence from age and sex.

BACKGROUND

Sport participation opportunities for older athletes have increased in recent years, (Hoffman et al., 2010; Medic et al., 2019) with concomitant improvements in population-specific athletic performance. (Akkari et al., 2015; Stiefel et al., 2014) Older athletes are increasingly acknowledged as "exemplars of successful aging" (Geard et al., 2017) as they continue to challenge conventions of age-related limitations.

Numerous outcome measures allow quantification of physical performance in the general population of older adults, with normative values that guide interpretation for healthcare providers, though it is clear that these norms are less discriminating when applied to the older athlete (Fien et al., 2017; Glenn et al., 2015; Jordre et al., 2021a; Jordre & Schweinle, 2020a; Jordre et al., 2013; Jordre et al., 2016). With healthcare models geared toward disease or decline, some older athletes report disappointment with providers who appear naive to their unique needs (Shapero et al., 2016). Creation of population-specific thresholds to guide fitness screening in older athletes provides opportunities for improved prevention, health promotion, and continued sport engagement in this disparate subset of older adults.

Physical fitness testing of older athletes at the U.S. National Senior Games has been ongoing for over a decade via a research protocol previously known as the Senior Athlete Fitness Exam, and now as the Sustained Athlete Fitness Exam (SAFE). The SAFE utilizes a battery of clinically-relevant, standardized measures to screen cardiovascular, muscular, flexibility, and balance fitness (Jordre & Schweinle, 2020b). Progressive analyses have informed refinement of the SAFE to measures which are relevant and suitably challenging for this population (Jordre et al., 2016). Jordre et al. have identified associations in older athletes between SAFE measures and cardiovascular disease (2021a), diabetes (2021a), low bone density (2021c), and falls (2016). Sport-specific investigations by these same authors have demonstrated associations between

SAFE measures and athletic performance outcomes, (2021b; 2019) in addition to discernable within-population differences by competitive sport (2023; 2020; 2017a; 2017b). Jordre et al. initially quantified older athlete outcomes on individual SAFE measures by comparison with community-dwelling normative values (2021a; 2013; 2020a), and then progressed to use of the protocol's population-specific norms in aggregate (Jordre & Schweinle, 2020b). As data from the SAFE protocol has grown, representation in each age and sex category has become appropriate for more detailed scoring. Thus, the purpose of this study is to present the SAFE, a novel screening tool of physical fitness for older athletes, with associated normative values and scoring thresholds delineated by age-group and sex, and to describe the association of SAFE subscales and composite scores by age-group, sex, competitive sport, and exercise volume.

METHODS

This cross-sectional study recruited older athletes (N=4,659, mean age 67.65 SD 9.1, 59.1% female) to participate in a health history questionnaire and a battery of physical fitness measures known collectively as the SAFE. Recruitment covered seven successive National Senior Games events (2011, 2013, 2015, 2017, 2019, 2022 and 2023) via advertisements and word-of-mouth in the athlete village. Athletes received notification in advance of participation opportunities via e-mails distributed by the NSGA (National Senior Games Association). Testing took place in the athlete village, where athletes congregated between sporting events or on non-competition days. Inclusion criteria were consistent with NSGA participation requirements and included state-level qualification, registration to compete in the national games for the corresponding year, and age 50 or above in the same year. Prior to recruitment of participants, the study was approved by the Institutional Review Board's Office of Human Subjects Protection of the primary author, (nos. 2011.089, 2014.138, IRB-22-63) and athletes provided informed consent before taking part.

Physical measures were conducted by licensed physical therapists, physical therapist assistants, or supervised students of each. Testers received prior instruction and on-site training before conducting measurements, and they were monitored for method and accuracy. The primary investigator, a physical therapist, was onsite for all data collection.

Age, sex, and competitive sport were collected at consent. Health history variables were collected via interview through 2019 and subsequently via electronic platforms. Athletes were instructed to report health conditions only if they had been diagnosed by a healthcare professional.

Measures within the SAFE tool consisted of common screening measures chosen by virtue of their clinical relevance, minimal equipment requirements, ease of application, and demonstrated reliability (Barber et al., 2014; Clapis et al., 2008; Franchignoni et al., 1998; Kolber et al., 2012; Krause et al., 2011; Munoz-Bermejo et al., 2021; Norkin & White, 2009; Ross et al., 2008; Springer et al., 2007) and validity (Reidpath et al., 2012; Ross et al., 2020; Srikanthan et al., 2009; Tiernan et al., 2023; Vaishya et al., 2024; Yuan et al., 2021) in older adults. One novel measure, the Foam-Pillow Posture Test (Jordre et al., 2015), was included and is described below. A comprehensive summary of testing methods utilized for each measure can be found in Appendix 1.

SAFE Measures by Subscale

Cardiovascular Fitness Subscale (C-Fit) measures have been described previously (Jordre et al., 2021a) and included: blood pressure via electronic cuff, body mass index (BMI) via measured height and weight, waist circumference (WC), and waist-to-hip ratio (WHR). Heart rate and pulse oximetry were measured but were not scored.

Muscular Fitness Subscale (M-Fit) measures quantified muscular power (M-Fit *Power*) via maximal walking speed (MWS) (Jordre et al., 2016) and the five times sit-to-stand test (5xSTS) (Jordre et al., 2013), while muscular strength (M-Fit *Strength*) was quantified by handgrip dynamometry (Jordre & Schweinle, 2020a).

Flexibility Fitness Subscale (F-Fit) measures, described previously by Jordre et al. (2017b) included shoulder flexion active range of motion (AROM), ankle dorsiflexion AROM with knee extended, the modified Thomas test and the Foam-Pillow Posture Test (2015). The Foam-Pillow Posture Test identified athletes who were unable to maintain cervical spine neutral in supine with knees flexed and feet flat on the plinth. Those with observable cervical extension or an inability to rest the occiput on the plinth were provided a foam pillow to support their head and were recorded as a failure on the test. The Foam-Pillow Posture Test was validated by Jordre et al. (2015) within the SAFE protocol with findings that Wall-to-Occiput-Distance averaged 4 cm more for older athletes who failed the test when compared to those who passed.

Balance Fitness Subscale (B-Fit) measures were described by Jordre et al. (2016) and included a standardized single-leg stance position with two conditions; eyes closed (SLS-EC) and on foam (SLS-Foam) with times capped at 30 seconds.

SAFE Composite scores allowed a maximum of 20 points with four points possible on C-Fit, F-Fit and B-Fit subscales and eight points possible for M-Fit. M-Fit was divided into subsets; M-Fit *Power* and M-Fit *Strength* with four points allocated to each. Scored physical fitness measures and point distribution by measure and subscale are found in Table 1.

Statistical Analysis

For the purpose of analyses and development of normative data, athletes were assigned to eight age-groups: 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84, and 85+. A priori power analyses with G*Power (3.1.9.7) were utilized to determine the minimum sample size necessary for reliable normative data, and for sufficient power with MANOVA testing with 16 groups assuming a small effect size ($f^2(V) = 0.02$), a power of 0.80, and alpha of 0.01.

Descriptive statistics were used to describe the study population and to determine central tendencies. Athletes competing solely in archery, bowling, cornhole, disc golf, horseshoes, or shuffleboard, were combined into a single *leisure* category. Athletes competing in more than one sport were designated as *multisport* athletes, with the exception of those engaged in both track and field events, and those competing in either open-class powerwalk or a *leisure* sport in addition to their non-leisure primary sport. Flexibility outcomes were averaged for right and left sides to produce one continuous variable consistent with past methodology described by Soucie et al. (2011). The modified Thomas Test outcomes were designated as "pass" only if both right and left sides met the required threshold. Due to large standard deviations (SD) in exercise volumes, median scores were utilized to report central tendencies.

A MANOVA was conducted on all scored continuous variables, and Chi-Square tests were used for dichotomous variables to assess the influence of age-group and sex. Scoring for each SAFE measure was established via age-group and sex means, as statistically indicated by the aforementioned tests. Where possible, standard deviations informed ordinal scoring beyond dichotomous thresholds. One exception to this approach was C-Fit scoring which utilized combined age and sex groups for blood pressure and BMI and combined age groups for WC and WHR to align with contemporary clinical practice.

Kruskal-Wallis and Mann Whitney U tests were employed to compare SAFE subscale and composite scores by age-group, sex, competitive sport, and exercise volume. Dunn pairwise post hoc tests with Bonferroni adjustment were used to locate significant differences.

Missing data from the health questionnaire totaled 11.7% of all athletes, with 10.5% attributable to internet disruptions impacting electronic completion in 2022. Incomplete health history questionnaires were excluded from analysis. For physical measures, 14.9% of athletes were missing data on one or more measures as a result of; (1) an athlete opting out of a given measure in accordance with the IRB consenting process, (2) event scheduling interruptions preventing completion, (3) data entry errors resulting in biologically implausible metrics (i.e. height of 2555 cm) upon inspection of data, (4) data loss in 2022 due to internet disruptions, and (5) athletes who participated in 2011 where MWS was not included (N=243). Missing data was excluded at the level of individual measures for the generation of normative data. Athletes with missing data for a given subscale were excluded from relevant SAFE subscale and composite score analyses. Statistical analyses were performed with SPSS version 28.0, and alpha was set at <.01.

RESULTS

Study population

Of the 4,659 participating athletes, the mean age was 67.65 (SD 9.12), with 59.1% females (mean age 66.65, SD 8.97), and 40.9% males (mean age 69.10, SD 9.14). See Figure 1 for athlete age-group distribution by sex. A priori power analyses indicated a sample size of N=1,296 necessary for the development of reliable normative data for each measure and N=304 for MANOVA testing, indicating a more than sufficient sample size.

Health history

Complete health history and exercise volume results were provided by 88.3% of participating athletes (N=4,112). A total of 28.5% (N=1,170) reported having none of the queried conditions. These included a medical diagnoses of heart disease (coronary heart disease, myocardial infarct, heart failure), hypertension, hypercholesterolemia, stroke, Type 2 Diabetes Mellitus (T2DM), breathing problems (asthma, chronic obstructive pulmonary disease, sleep apnea), cancer (past or current), low bone density (osteoporosis or osteopenia), recent falls (in the past 12 months), or a joint replacement (hip, knee, or shoulder). The most common conditions reported were hypercholesterolemia (34.4%) and hypertension (27.6%). A total of 479 (11.6%) athletes reported a fall within the past year, and 192 (4.7%) reported a diagnosis of T2DM. Joint replacements were reported for the hip (N=145,3.5%), knee (N=252,6.1%), and shoulder (N=33,0.8%). A higher proportion of males reported heart disease (p<.001), hypertension (p<.001), stroke (p=.003), and

T2DM (p<.001). Females demonstrated a higher proportion of low bone density (p<.001), and falls (p<.001). See Table 2 for detailed health history prevalence by sex.

Exercise volume

Mean self-reported cardiovascular exercise volume was 297.96 minutes (SD=268.58, Md = 240, IQR 120-420). Self-reported resistance exercise volumes averaged 62.39 minutes (SD=109.55, Md = 30 minutes, IQR 0-90). Median exercise minutes for both modes were the same across sexes, and there were no significant differences by age-group for cardiovascular (H(7)=12.28,p=.09) or resistance (H(7)=11.95,p=.10) exercise volumes. A total of 312 athletes (6.7%) reported no regular cardiovascular exercise, while 1,692 athletes (41.1%) reported no regular resistance exercise.

Sport designations

All 22 of the competitive sports offered by the NSGA during the span of this study are represented in the study population, with the largest participation by volume being volleyball (N=578, 12.4%), multisport participation (N=549, 11.8%), and basketball (N=505, 10.8%). *Leisure* athletes comprised 6.6% (N=308) of the population. See Figure 2 for the distribution of participation by sport.

Comparisons by age-group and sex for individual physical performance measures

All scored measures for C-Fit were significantly different by age-group (p<.001) and sex (p<.001), with the exception of WC which demonstrated no significant difference by age-group (p=.31). On M-Fit measures, 5XSTS (p=.96) was not significantly different by sex while MWS (p<.001) and hand grip strength (p<.001) were higher for male athletes. All M-Fit measures were significantly different by age-group (p<.001), with higher scores achieved by younger groups. Within F-Fit measures, female athletes performed better on the Foam-Pillow Posture Test (χ^2=109.94, p<.001), shoulder flexion (p<.001), and the modified Thomas Test (χ^2=59.50,p<.001), while no significant difference was seen by sex for ankle dorsiflexion, (p=.58). By age-group, the Foam-Pillow Posture Test (χ^2=237.45,p<.001), shoulder flexion (p<.001), and ankle dorsiflexion (p<.001) all demonstrated a significant decline with advancing age, while the modified Thomas Test did not (χ^2=5.39,p=.61). Measures within B-Fit showed no significant differences by sex (SLS-EC, p =.64; SLS-Foam, p=.81), but differed by age-group for both SLS-EC (p<.001) and SLS-Foam (p<.001), with younger athletes demonstrating superior performance.

SAFE scoring

The SAFE tool can be viewed in Figure 3 with associated thresholds and scoring tables. Detailed normative values for all scored measures by age-group and sex can be found in Appendix 2 A-D. The combined mean(SD) for blood pressure was 135.02(19.09)/76.92(10.19)mmHg. In an effort to reflect the population-derived SD, and the non-diagnostic nature of the tool, while staying below internationally recognized thresholds for concern (Campbell et al., 2022), the threshold for blood pressure was set at <140/<90mm Hg for both sexes. The acceptable BMI range was set at 22.0-29.99kg/m^2, utilizing the combined mean (26.03kg/m^2) plus and minus one SD (4.32kg/m^2) and rounded for clinic utility. This range aligns with established levels of clinical concern related to low and high BMI in older adults (Porter Starr & Bales, 2015). Thresholds for WC and WHR reflect sex-specific study population means with ages combined. For measures within M-Fit *Power*, MWS was scored by age-group and sex means with two points allocated for meeting the mean and one for scoring within one standard deviation below the mean. The 5xSTS was scored in the same manner with sexes combined. For the M-Fit *Strength* subset, four points were allocated for meeting age-group and sex means for hand grip strength, with two points assigned for scoring within one SD below the mean. In F-Fit, both the Foam-Pillow Posture Test and the modified Thomas Test were scored as pass/fail. Thresholds for shoulder flexion aligned with age-group and sex means, and ankle dorsiflexion thresholds utilized age-group means alone.

One point was allocated for meeting the threshold bilaterally for each flexibility measure. In B-Fit, two points were allocated for meeting the age-group mean for both SLS-EC and SLS-Foam with sexes combined. Athletes scored zero on B-Fit measures if they did not meet the given threshold.

Aggregate SAFE subscale and composite scores

When applied to the study population, aggregate median scores for each subscale were C-Fit=2, M-Fit=6 (M-Fit *Power*=3; M-Fit *Strength*=4), F-Fit=3, and B-Fit=2. SAFE composite scores ranged from 2 (0.2%) to 20 (0.8%), with a median score of 13 (IQR 10-15), a mode of 13, and a mean(SD) of 12.49(3.40). SAFE composite score distributions appear in Figure 4.

SAFE subscale and composite scores by sex

Subscale scores did not differ significantly by sex for C-Fit (z=.37,*p*=.72), M-Fit (z=.72,*p*=.47), M-Fit *Power* (z=-.68,*p*=.49), M-Fit *Strength* (z=1.81,*p*=.07), or B-Fit (z=1.75,*p*=.08). There were statistically significant differences favoring female athletes on F-Fit (z=7.02, *p*<.001) despite median scores of 3 for both sexes. SAFE composite scores were significantly different across sexes (z=2.98, *p*=.003) with median composite scores of 12 and 13 for males and females, respectively.

SAFE subscale and composite scores by age-group

Scores across age-groups differed significantly on C-Fit (H(7)=75.07, *p*<.001) with athletes in age-groups 50-54 through 65-69 scoring a median of 3 while athletes in age-groups 70-74 through 85+ scored a median of 2. M-Fit (H(7)=8.10,p=.32), M-Fit *Power* (H(7)=5.65,*p*=.58), and M-Fit *Strength* (H(7)=6.30,*p*=.51) were not significantly different across age-groups. F-Fit (H(7)=45.14,p<.001), showed a statistically significant difference by age-group, despite median scores of 3 in every age-group, with younger athletes demonstrating higher scores. B-Fit (H(7)=105.68,p<.0001) was significantly different by age-group with a median score of 2 for age-groups 50-54 through 80-84 and a median score of 0 for those in the 85+ age-group. SAFE composite scores were significantly different across age-groups (H(7)=60.87,*p*<.001) with those aged 50-54 scoring a median of 14, those in groups 55-60 through 65-69 scoring 13, and groups 70-74 through 85+ scoring 12. Median scores by age-group and sex are found below the SAFE scoring tables in Figure 3.

SAFE Subscale and composite scores by sport

Significant differences by sport were seen for each fitness subscale (C-Fit H(18)=243.18, *p*<.0001; M-Fit H(18)=178.03, *p*<.0001; M-Fit *Power* H(18)=247.73, *p*<.0001; M-Fit *Strength* H(18)=161.54, *p*<.0001; F-Fit H(18)=93.11,*p*<.001; B-Fit H(18)=129.17, *p*<.0001), and SAFE composite scores (H(18)=222.86, *p*<.0001). The highest scoring sports in each subscale were; C-FIT: Cycling, M-FIT: Field Events, M-Fit *Power*: Racewalking, M-FIT *Strength*: Field Events, F-FIT: Swimming, and B-FIT: Triathlon. Track athletes achieved the highest SAFE composite scores. Figure 5 displays subscale rankings for all sport classifications with post-hoc comparisons for the top five ranked sports in each scoring category.

SAFE subscale and composite scores by exercise volume

Median exercise volumes by SAFE subscale are displayed in Figure 6. Significant differences were demonstrated in the volume of cardiovascular exercise reported for SAFE composite scores (H(18)=93.0, *p*<.001), and all subscales with higher scores associated with larger volumes of exercise; C-Fit (H(4)=98.25, *p*<.001), M-Fit (4)=14.02, *p*=.007), M-Fit *Power* (H(4)=24.84, *p*<.001), M-Fit *Strength* (H(2)=17.09, *p*<.001), F-Fit H(4)=38.81, *p*<.001, and B-Fit H(2)=21.95, *p*<.001). Significant differences in reported resistance exercise volumes with higher scores associated with larger volumes were found on SAFE composite scores (H18)=143.79, *p*<.001), C-Fit (H(4)=94.98, *p*<.001), M-Fit (H4)=61.50, *p*<.001), M-Fit *Power* (H(4)=77.86, *p*<.001), and B-Fit (H(2)=68.21, *p*<.001). M-Fit *Strength* (H(2)=6.06, *p*=.05), and F-Fit (H(4))=12.37, *p*=.02) subscales did not demonstrate significantly different resistance exercise volumes across subscale scoring.

DISCUSSION

The SAFE appears appropriately scaled for older athletes across a range of competitive sports, ages, and exercise habits. With fewer than 1% of this population scoring a perfect 20, and no athletes scoring zero, the tool appears to negate ceiling and floor effects. The large sample size supports stable normative data, accommodating of divisions by age and sex.

Health and exercise

The athletes in this study demonstrate a low prevalence of disease relative to their peers (Divo et al., 2014; Martin et al., 2024) with more than 25% reporting no chronic conditions or joint replacement history. They report high volumes of physical exercise, far surpassing the minimum guidelines established for older adults and distinguish themselves from general population trends (Watson et al., 2016). Notably, volumes of cardiovascular and resistance exercise remained relatively stable across age groups. Upwards of 93% of these athletes engage in regular cardiovascular exercise; evidence that the associated health benefits of this practice are well-appreciated in the population. In contrast, over 40% report no regular resistance exercise. With the multitude of health (Syed-Abdul, 2021) and sports performance benefits known to be associated with resistance exercise (Bull et al., 2020; Markov et al., 2023; Marques et al., 2023; Schroeder et al., 2019), this finding alone supports the need to remediate this disparity through targeted education and preventative care.

Findings related to age and sex

For individual measures within the SAFE, age moderated all scored measures except WC and the modified Thomas Test. Clinical trends support WC findings (Stevens et al., 2010) while modified Thomas Test outcomes were unexpected, with age-related differences potentially diluted by the pass/fail approach utilized for scoring. Further investigation is encouraged on this measure.

Differences by sex were seen for all individual measures with the exception of 5XSTS, ankle dorsiflexion, and single-leg balance. This is consistent with past findings for 5XSTS (Vilarinho et al., 2024) and single-leg stance tests (Springer et al., 2007). While others have found sex-based differences in ankle dorsiflexion (Araki et al., 2023), no clear evidence was found to differentiate dorsiflexion scoring by sex for these athletes.

SAFE scoring largely attenuates the impact of age and sex seen on individual measures and should prove useful in future population-based comparisons. The 1-point difference in mean composite scores favoring female athletes may relate to the proportionally greater volume of female athletes evaluated, or that females in the study were on-average 2.45 years younger than males with differing health history trends. Conversely, in general-population studies of older adults, females have consistently underperformed on measures of physical performance when compared to males (Melsæter et al., 2022), a phenomenon likely related to the historic neglect of sex-based differences when scoring standardized measures (Sialino et al., 2019). The only sex difference found within SAFE subscales appeared in F-Fit, though the magnitude of this difference was small enough to not impact a difference in median scores.

Age-groups were minimally different across SAFE subscale and composite scores. C-Fit measures were not adjusted for age and resulted in lower scores for those aged 70 and older, and B-Fit scores were only moderated by age for the oldest, 85+ age-group.

Findings related to sport and exercise volume

SAFE subscale and composite scores by sport aligned largely with clinical expectations. Athletes competing in the most vigorous cardiovascular sports, such as cycling and road race, excelled on C-Fit, while athletes in sports demanding muscle strength or power, such as track and field, exceled on M-Fit and relevant subsets. Superior composite scores were seen in track athletes, triathletes and cyclists as compared to those engaged in golf, table tennis or sports of leisure. These differences provide early evidence of face validity for SAFE scoring methods.

When considering exercise volumes, SAFE subscale and composite outcomes reflected higher scores for athletes reporting higher exercise volumes. The lowest scores were associated with exercise volumes below population medians (240 minutes cardiovascular and 30 minutes resistance exercise). As such, the apparent impact of achieving even 30 minutes of weekly resistance exercise reaffirms the importance of this exercise mode, even for the seemingly fit older athlete.

The lack of difference seen on M-Fit *Strength*, as related to resistance exercise volume, was unexpected. However, a recent investigation of older weightlifters found a similar lack of association (Huebner et al., 2023). This may relate to several factors including, potential underappreciation or under-reporting by athletes of resistance exercise innate to their sport-specific training routines, confusion over what constitutes this exercise mode, or phenomena yet to be understood in this population.

Limitations

As an observational study one cannot contend that sport-engagement, specific sports, or even exercise volumes were the direct cause of any outcomes. However, the large sample provides greater confidence in these observations. The self-reported nature of exercise volume comes with innate limitations as athletes may have over or under-reported actual exercise practices and appear to have great variability in exercise volumes, thus necessitating the need to apply median values to avoid the potential influence of outliers. While testers were consistently trained and observed for accuracy in this protocol, the risk of measurement error is inherent in a field-side study of this nature. The authors depend on the established reliability and ease of application for each measure within the SAFE in addition to the large sample size and more stringent thresholds set for significance to attenuate variations between testers.

Clinical Implications

The SAFE and associated normative data fill a void for those who treat older athletes and seek assessment measures able to discern relevant fitness limitations and support meaningful interventions. Population health trends, exercise practices, and sport-specific findings provide greater insight into this population, free from speculation. With this, providers will be better equipped to anticipate and adjust to the care needs of these athletes. Integration of this simple screening tool could affect positive change for older athletes seeking improved care and those able to provide it.

CONCLUSION

These findings provide opportunities to quantify physical fitness with population-specific normative data in older athletes at the level of individual physical performance measures and with a composite screening tool, the SAFE. To these authors' knowledge, no equivalent tool exists. Age and sex-specific norms derived from this study will allow healthcare providers to assess older athletes at levels commensurate with their abilities as this population strives to sustain optimal health and sport performance outcomes.

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Competing Interest

The primary and secondary authors have secured copyright for the Sustained Athlete Fitness Exam (SAFE) tool to protect the integrity of their work. There is no fee to reproduce or utilize the tool at this time. The university of the primary author hosts an educational on-line course on the SAFE for a $25 fee, paid to the university and not to the authors. The course is not required to conduct the SAFE.

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Table 1

Physical performance measures and point allocation by SAFE subscales

Subscale		Points Allocated	Scored Measures (point contribution)
Cardiovascular Fitness		4	Blood Pressure (1) Body Mass Index (1) Waist Circumference (1) Waist to Hip Ratio (1)
Muscular Fitness	*Power*	4	Maximal Walking Speed (2) Five Times Sit to Stand (2)
	Strength	4	Handgrip Dynamometry (4)
Flexibility Fitness		4	Foam Pillow Posture Test (1) Shoulder Flexion AROM (1) Ankle Dorsiflexion AROM (1) Modified Thomas Test (1)
Balance Fitness		4	Single Leg Stance Eyes Closed (2) Single Leg Stance on Foam (2)
Composite SAFE score		20	

Note. SAFE, Sustained Athlete Fitness Exam; AROM, Active Range of Motion

Table 2

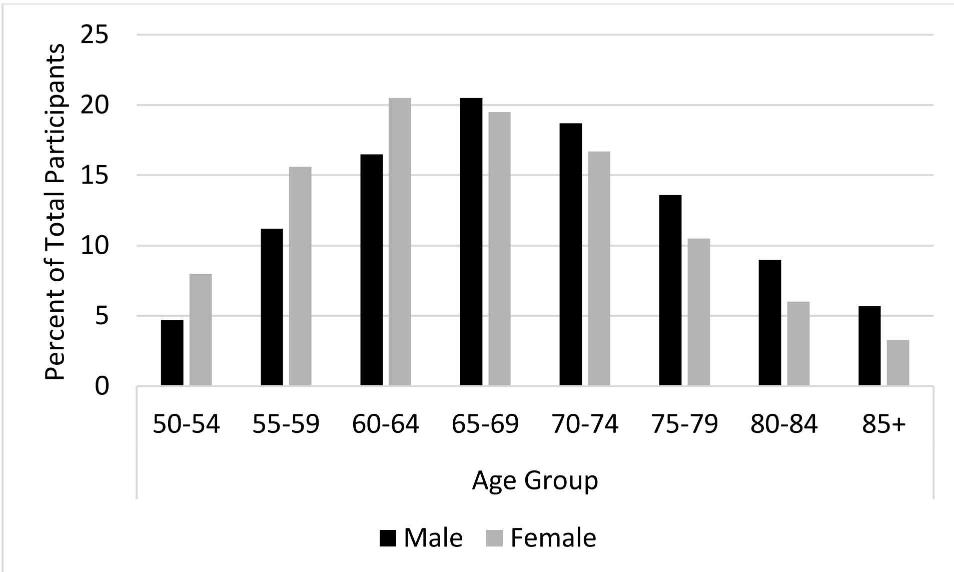
Health History of Participants

Health Condition	**Sex**	**N**	**%**
Heart Disease*	Male	264	15.7
	Female	189	7.8
	Combined	453	11.0
Hyperlipidemia	Male	603	35.8
	Female	813	33.5
	Combined	1416	34.4
Hypertension*	Male	534	31.7
	Female	601	24.8
	Combined	1135	27.6
Stroke†	Male	53	3.1
	Female	42	1.7
	Combined	95	2.3
Breathing Problems	Male	197	11.7
	Female	312	12.9
	Combined	509	12.4
Cancer	Male	394	23.4
	Female	518	21.3
	Combined	912	22.2
Type 2 Diabetes*	Male	104	6.2
	Female	88	3.6
	Combined	192	4.7
Low Bone Density*	Male	52	3.1
	Female	590	24.3
	Combined	642	15.6
Falls*	Male	150	8.9
	Female	329	13.6
	Combined	479	11.6
Total Hip	Male	72	4.3
	Female	73	3.0
	Combined	145	3.5
Total Knee	Male	101	6.0
	Female	151	6.2
	Combined	252	6.1
Total Shoulder	Male	16	1.0
	Female	17	0.7
	Combined	33	0.8
No Comorbidities or Joint Replacements	Male	483	28.7
	Female	687	28.3
	Combined	1170	28.5

Note. N=4,112 (1,684 male, 2428 female) Numbers reflect participant self-report of conditions diagnosed by a medical provider. Breathing problems include: chronic obstructive pulmonary disease, asthma, sleep apnea. Cancer includes active or past cancer. Low bone density includes a diagnosis of osteoporosis or osteopenia. Total joint replacements reflect unilateral or bilateral. Pearson Chi Square significant for differences by sex *p<.001 † p<.01.

Figure 1

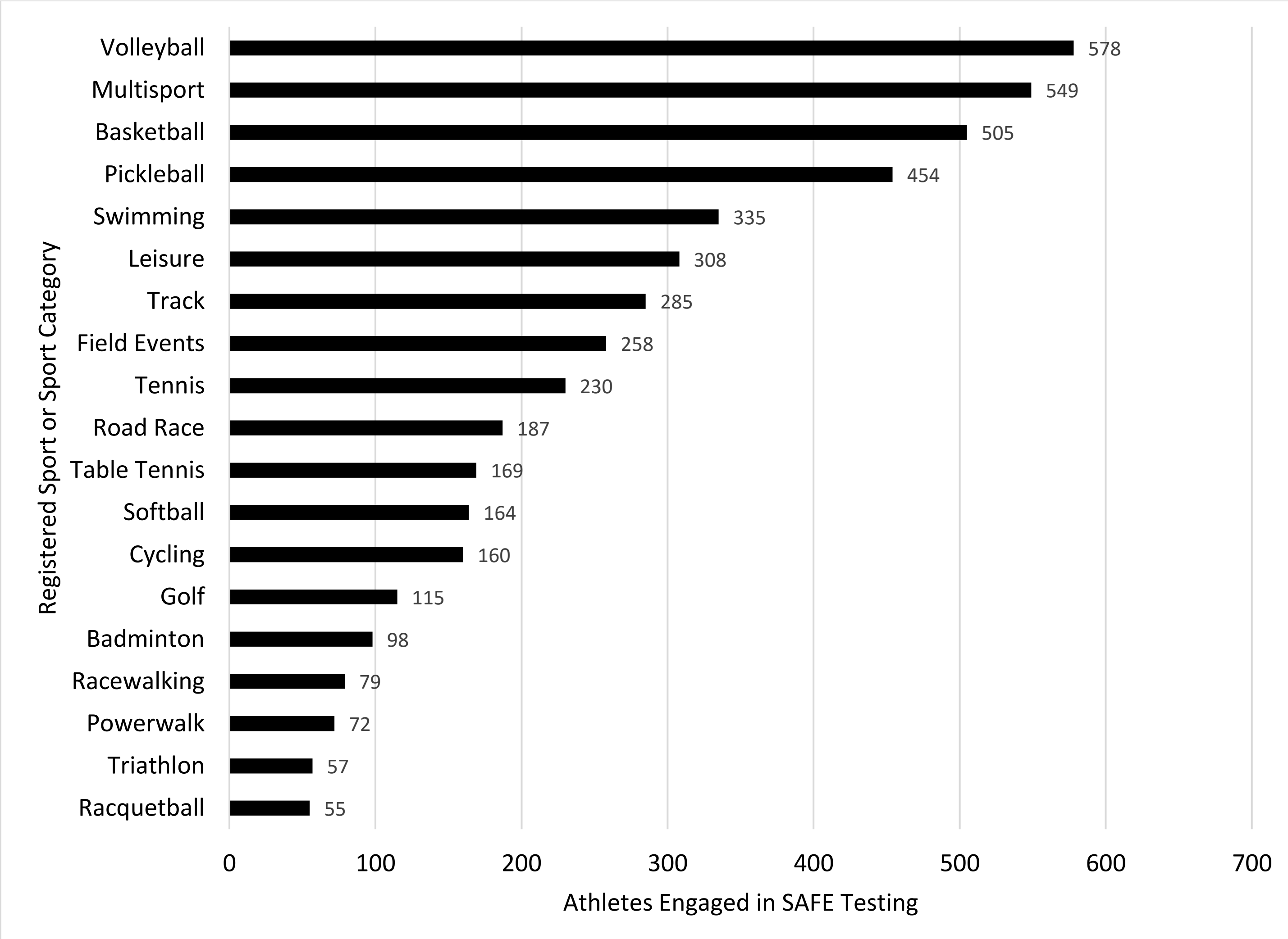
Distribution Of Participants by Age Group and Sex



Note. N=4,659 participants; 59.1% female, 40.9% male

Figure 2

Sport Designation of National Senior Games Athletes Tested on SAFE Measures



Note. N = 4,659. SAFE is the Sustained Athlete Fitness Exam. Multisport athletes are those competing in two or more sports with the exception of leisure sports, track with field events, or powerwalk. Leisure Sports include archery, bowling, cornhole, disc golf, horseshoes, and shuffleboard. Field Events include shotput, javelin, discus, hammer, high jump, triple jump, pole vault, and long jump. Track includes athletes competing in only track, with no field events. Road Race includes 5K or 10K running events. One athlete competing in the exhibition sport of Judo is not displayed.

SAFE 50+

SUSTAINED ATHLETE FITNESS EXAM

Athlete Age	
Male	Female
The SAFE is intended for use on athletic older adults	

Measure	Athlete Result	Goal	Goal met	
Heart Rate (bpm)		**60 - 100**	Y	N
% Oxygen Saturation		**≥ 95**	Y	N

Measure	Athlete Result	0 points		1 point		SCORE	
Blood Pressure (mmHg)		**> 139 / > 89**		**≤ 139 / ≤ 89**		0	1
Weight (kg)		See BMI chart / calculator					
Height (cm)							
*BMI (kg/m^2)		**< 22.0** or **≥ 30.0**		**22.0 - 29.99**		0	1
Measure	Athlete Result	0 points		1 point			
		Male	Female	Male	Female		
Waist Circumference (cm)		**> 95.0**	**> 84.0**	**≤ 95.0**	**≤ 84.0**	0	1
Hip Circumference (cm)		†Waist / Hip Circumference = Waist-to-Hip Ratio					
†Waist-to-Hip Ratio		**> 0.92**	**> 0.82**	**≤ 0.92**	**≤ 0.82**	0	1
CARDIOVASCULAR FITNESS SUBSCALE SCORE						4	

Measure	Athlete Result			Scoring	SCORE		
Max Walking Time (s)				‡10 m / Max Walking Time = Max Walking Speed			
‡Max Walking Speed (m/s)				Score using Max Walking Speed table	0	1	2
5 x Sit-to-Stand (s)				Score using 5 x Sit-to-Stand table	0	1	2
MUSCULAR - POWER					4		
Handgrip Strength (kg)	R		L	Score stronger side using Grip Strength table	0	2	4
MUSCULAR - STRENGTH					4		
MUSCULAR FITNESS SUBSCALE SCORE					8		

Measure	Athlete Result				0 points	1 point	SCORE	
Foam Pillow Posture test	Fail		Pass		Pillow needed	No pillow needed	0	1
Shoulder Flexion (°)	R		L		Score using Shoulder Flexion table		0	1
Ankle Dorsiflexion (°)	R		L		Score using Ankle Dorsiflexion table		0	1
Modified Thomas test (°)	R		L		< **0° (-)** (R or L) (thigh above horizontal)	≥ **0° (+)** (R and L) (thigh at / below horizontal)	0	1
FLEXIBILITY FITNESS SUBSCALE SCORE							4	

Measure	Athlete Result	Scoring	SCORE	
Single-leg eyes closed (s)		Score using Single-leg eyes closed table	0	2
Single-leg on foam (s)		Score using Single-leg on foam table	0	2
BALANCE FITNESS SUBSCALE SCORE			4	

SAFE results are based on comparison with National Senior Games Association athletes	**SAFE 50+ SCORE**	20

SAFE [50+] Scoring tables

Max Walking Speed (m/s)	0 points		1 point		2 points	
	Male	Female	Male	Female	Male	Female
50-54 yrs	< 2.0	< 1.9	2.0 - 2.3	1.9 - 2.2	≥ 2.4	≥ 2.3
55-59 yrs	< 2.0	< 1.9	2.0 - 2.3	1.9 - 2.2	≥ 2.4	≥ 2.3
60-64 yrs	< 2.0	< 1.8	2.0 - 2.3	1.8 - 2.1	≥ 2.4	≥ 2.2
65-69 yrs	< 2.0	< 1.8	2.0 - 2.2	1.8 - 2.1	≥ 2.3	≥ 2.2
70-74 yrs	< 1.8	< 1.7	1.8 - 2.1	1.7 - 2.0	≥ 2.2	≥ 2.1
75-79 yrs	< 1.7	< 1.7	1.7 - 2.0	1.7 - 1.9	≥ 2.1	≥ 2.0
80-84 yrs	< 1.6	< 1.6	1.6 - 1.9	1.6 - 1.8	≥ 2.0	≥ 1.9
85+ yrs	< 1.5	< 1.4	1.5 - 1.8	1.4 - 1.6	≥ 1.9	≥ 1.7

5 x Sit-to-Stand (s)	0 points	1 point	2 points
50-54 yrs	> 7.7	6.2 - 7.7	≤ 6.1
55-59 yrs	> 7.9	6.5 - 7.9	≤ 6.4
60-64 yrs	> 9.2	6.8 - 9.2	≤ 6.7
65-69 yrs	> 8.9	7.0 - 8.9	≤ 6.9
70-74 yrs	> 9.9	7.6 - 9.9	≤ 7.5
75-79 yrs	> 10.2	7.9 - 10.2	≤ 7.8
80-84 yrs	> 11.1	8.6 - 11.1	≤ 8.5
85+ yrs	> 13.8	10.0 - 13.8	≤ 9.9

Grip Strength (kg)	0 points		2 points		4 points	
	Male	Female	Male	Female	Male	Female
50-54 yrs	< 41	< 29	41 - 50	29 - 34	≥ 51	≥ 35
55-59 yrs	< 41	< 27	41 - 49	27 - 32	≥ 50	≥ 33
60-64 yrs	< 39	< 26	39 - 47	26 - 30	≥ 48	≥ 31
65-69 yrs	< 37	< 24	37 - 45	24 - 29	≥ 46	≥ 30
70-74 yrs	< 34	< 23	34 - 42	23 - 27	≥ 43	≥ 28
75-79 yrs	< 32	< 22	32 - 39	22 - 26	≥ 40	≥ 27
80-84 yrs	< 30	< 19	30 - 36	19 - 24	≥ 37	≥ 25
85+ yrs	< 25	< 18	25 - 32	18 - 21	≥ 33	≥ 22

Shoulder Flexion (°)	0 points (L or R)		1 point (L and R)	
	Male	Female	Male	Female
50-54 yrs	< 171	< 175	≥ 171	≥ 175
55-59 yrs	< 172	< 174	≥ 172	≥ 174
60-64 yrs	< 170	< 173	≥ 170	≥ 173
65-69 yrs	< 169	< 173	≥ 169	≥ 173
70-74 yrs	< 167	< 172	≥ 167	≥ 172
75-79 yrs	< 165	< 171	≥ 165	≥ 171
80-84 yrs	< 163	< 171	≥ 163	≥ 171
85+ yrs	< 161	< 163	≥ 161	≥ 163

Ankle Dorsiflexion (°)	0 points (L or R)	1 point (L and R)
50-54 yrs	< 8	≥ 8
55-59 yrs	< 8	≥ 8
60-64 yrs	< 8	≥ 8
65-69 yrs	< 7	≥ 7
70-74 yrs	< 7	≥ 7
75-79 yrs	< 6	≥ 6
80-84 yrs	< 5	≥ 5
85+ yrs	< 5	≥ 5

Single-leg eyes closed (s)	0 points	2 points
50-54 yrs	< 14.4	≥ 14.4
55-59 yrs	< 12.1	≥ 12.1
60-64 yrs	< 9.7	≥ 9.7
65-69 yrs	< 8.4	≥ 8.4
70-74 yrs	< 6.6	≥ 6.6
75-79 yrs	< 5.1	≥ 5.1
80-84 yrs	< 4.0	≥ 4.0
85+ yrs	< 3.6	≥ 3.6

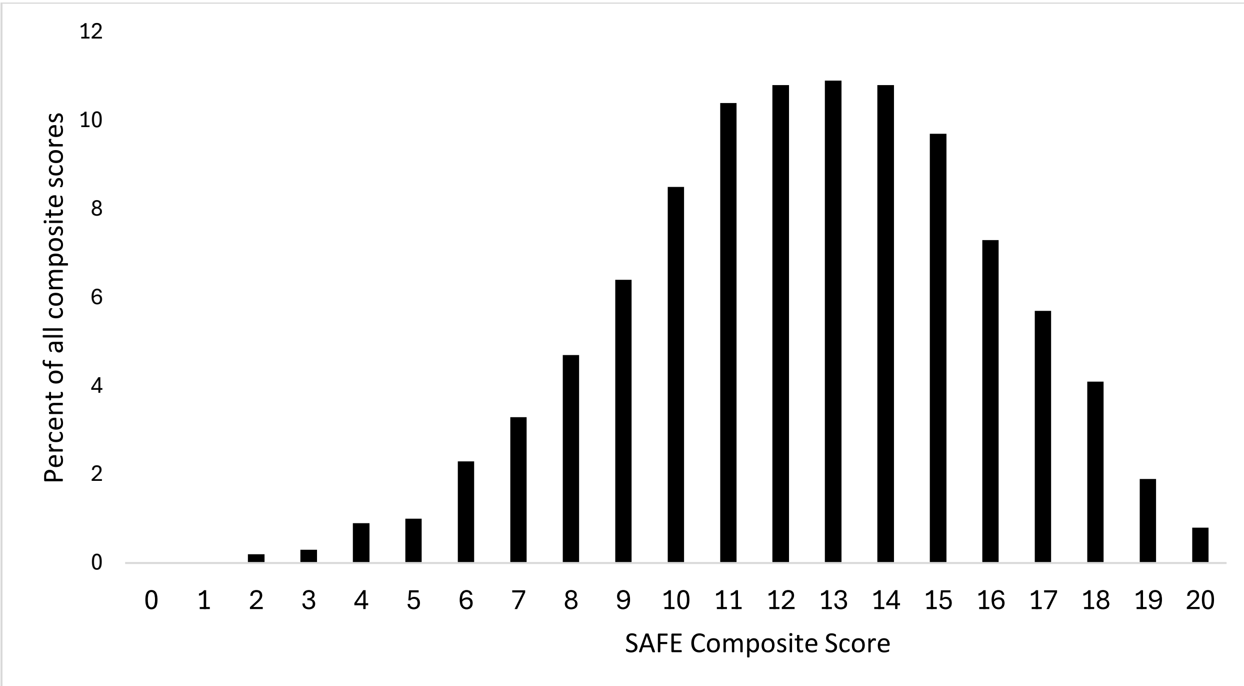
Single-leg on foam (s)	0 points	2 points
50-54 yrs	< 24.7	≥ 24.7
55-59 yrs	< 22.3	≥ 22.3
60-64 yrs	< 20.2	≥ 20.2
65-69 yrs	< 17.8	≥ 17.8
70-74 yrs	< 13.8	≥ 13.8
75-79 yrs	< 11.4	≥ 11.4
80-84 yrs	< 8.6	≥ 8.6
85+ yrs	< 5.1	≥ 5.1

SAFE [50+] Median Scores	50-54 yrs	55-59 yrs	60-64 yrs	65-69 yrs	70-74 yrs	75-79 yrs	80-84 yrs	85+ yrs
Male	**12**/ 20	**13** / 20	**13** / 20	**12** / 20	**12** / 20	**12** / 20	**12** / 20	**12** / 20
Female	**14** / 20	**13** / 20	**13** / 20	**13** / 20	**12** / 20	**12** / 20	**12** / 20	**12** / 20

SAFE [50+] Percentile Scores	25th	50th	75th
Male	**10** / 20	**12** / 20	**15** / 20
Female	**10** / 20	**13** / 20	**15** / 20

Figure 4

Distribution of Composite Scores on the SAFE



Note. Participants with complete SAFE composite scores depicted here include N=3,963. SAFE is the Sustained Athlete Fitness Exam. Mean age is 67.60 (SD 9.03); 41.1% Male (mean age 68.95, SD 9.03), 58.9% Female (mean age 66.67, SD 8.91). For SAFE composite scores, mean = 12.49 (SD 3.40), Median = 13.0, Mode = 13.0.

Figure 5

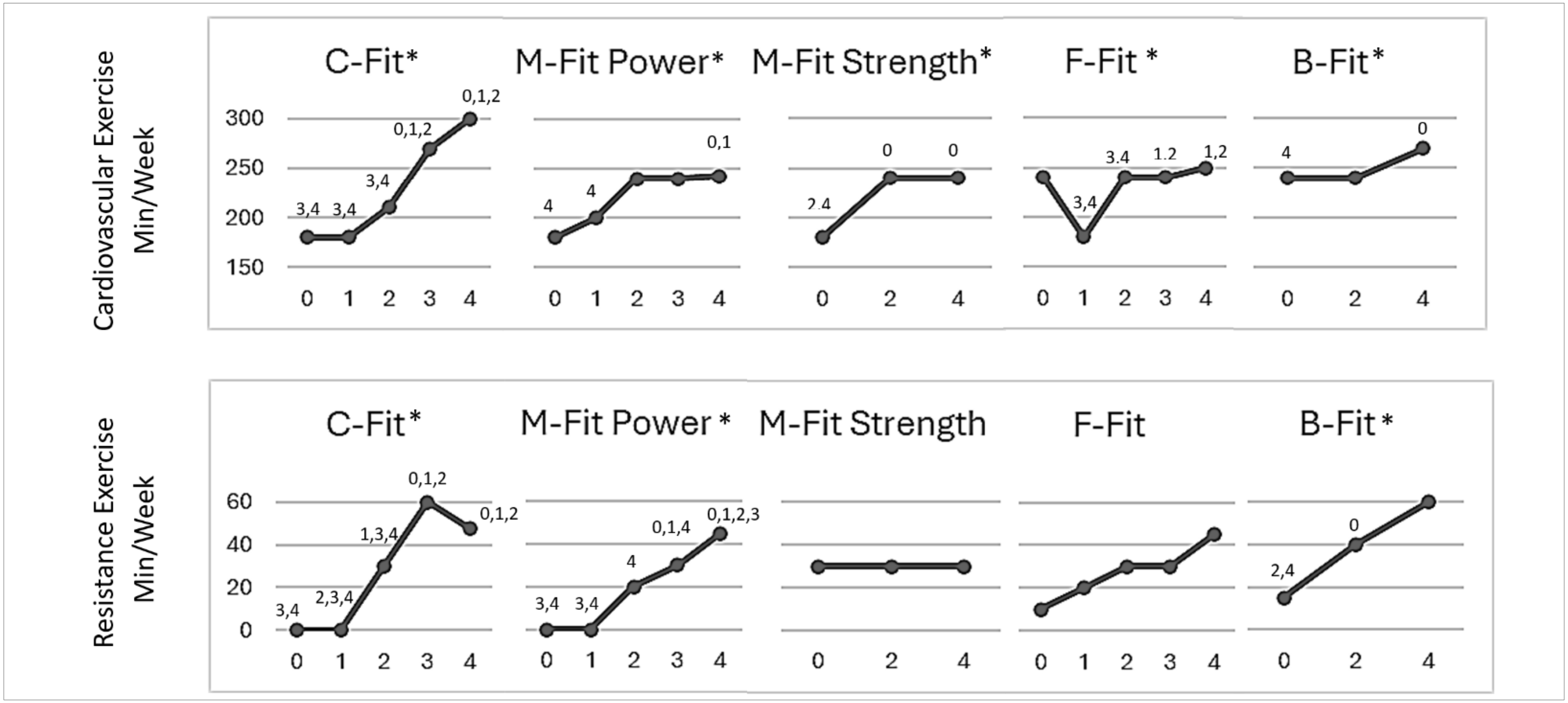
Sport Ranking by SAFE Subscale and Composite Scores

Rank	C-Fit (N=4474)	M-Fit (N=4204)	M-Fit – *Power* (N=4223)	M-Fit – *Strength* (N=4572)	F-Fit (N=4509)	B-Fit (N=4481)	SAFE (N=3963)
1	Cycling[1]	Field Events[1]	Racewalking[1]	Field Events[1]	Swimming[1]	Triathlon[1]	Track[1]
2	Roadrace[2]	Track[2]	Track[2]	Basketball[2]	Triathlon[2]	Track[2]	Triathlon[2]
3	Triathlon[3]	Racewalking[3]	Field Events[3]	Volleyball[3]	Volleyball[3]	Road Race[3]	Cycling[3]
4	Racewalking[4]	Cycling[4]	Cycling[4]	Golf[4]	Cycling[4]	Cycling[4]	Racewalking[4]
5	Badminton[5]	Volleyball[5]	Multisport[5]	Softball[5]	Softball[5]	Volleyball[5]	Volleyball[5]
6	Track	Multisport	Pickleball	Racquetball	Racewalking	Field Events	Field Events
7	Multisport	Racquetball	Powerwalk	Cycling	Multisport[1]	Golf	Multisport
8	Volleyball	Softball	Volleyball[2]	Racewalking	Field Events[1]	Powerwalk	Swimming[1]
9	Tennis	Golf	Road Race	Track	Track[1]	Multisport[2]	Road Race
10	Swimming[1,2]	Basketball	Triathlon	Multisport	Pickleball[1]	Pickleball[2]	Tennis
11	Pickleball[1,2]	Tennis	Tennis[2]	Leisure	Badminton	Racewalking	Badminton
12	Powerwalk	Pickleball[1]	Swimming[2]	Tennis	Powerwalk	Tennis[2]	Pickleball[1,5]
13	Field Events[1,2]	Triathlon	Softball[2]	Triathlon	Table Tennis[1]	Badminton	Powerwalk
14	Table Tennis[1,2]	Badminton	Badminton	Badminton	Basketball[1,3]	Swimming[2]	Softball[1]
15	Basketball[1,2,5]	Swimming[1,2,5]	Golf[2]	Pickleball[1,2,3]	Golf	Racquetball	Basketball[1,3,5]
16	Softball[1,2,3,4,5]	Powerwalk	Racquetball	Swimming[1,2,3]	Tennis[1]	Table Tennis[2]	Racquetball
17	Racquetball[1,2,5]	Road Race[1,2,4,5]	Basketball[1,2,3,4,5]	Powerwalk[2]	Leisure[1,3]	Softball[2]	Golf[1]
18	Golf[1,2,3,4,5]	Table Tennis[1,2,3,4,5]	Table Tennis[1,2,3,5]	Road Race[1,2,3,4,5]	Road Race[1,3]	Basketball[1,2,3,5]	Table Tennis[1,2,3,4,5]
19	Leisure[1,2,3,4,5]	Leisure[1,2,3,4,5]	Leisure[1,2,3,4,5]	Table Tennis[1,2,3,4,5]	Racquetball	Leisure[1,2,3,4,5]	Leisure[1,2,3,4,5]

Note. Subscale and composite scores were all significantly different by sport ($p<.001$). Sport rank corresponds to Kruskal-Wallis rank order. Gray data bars represent mean-rank magnitude. Dunn post hoc tests are represented for the top 5 ranked sports (1-5) in each subscale and reflect sports in the same subscale which are significantly different after Bonferroni correction, $\alpha < .01$. C-Fit-cardiovascular fitness subscale. M-Fit-muscular fitness subscale. M-Fit-Power-muscular power subset. M-Fit Strength-muscular strength subset. F-Fit-flexibility fitness subscale. B-Fit-balance fitness subscale and SAFE composite-total Sustained Athlete Fitness Exam score.

Figure 6

SAFE Subscales by Self-Reported Cardiovascular & Resistance Exercise Volume



Note. Cardiovascular and resistance exercise volumes are represented as population median values. *Depicts exercise volume significantly different across subscale on Kruskal Wallis testing ($p<.01$). Superscripts 1-4 reflect score values within the subscale with a significantly different exercise volume ($p<.01$) using Dunn pairwise post-hoc after Bonferroni correction. Fitness subscales include cardiovascular (C-Fit), Muscular (M-Fit), with power and strength subsets (M-Fit - *Power*, M-Fit – *Strength*,) flexibility (F-Fit), and balance (B-Fit).

Appendix 1

Sustained Athlete Fitness Exam – Testing Instructions

	Cardiovascular Fitness (C-FIT)
Blood Pressure & Heart Rate	Athlete sits quietly, feet flat, with left arm supported on an adjacent table. Utilize an Omron digital blood pressure monitor on the left upper extremity.
SpO2	Apply a pulse oximeter to the right hand, fourth digit during blood pressure.
Height	With athlete shoes removed, measure via stadiometer to the nearest .5 cm.
Weight	With athlete shoes removed, collect weight via digital scale to the nearest .5 kg.
BMI	Formula: Weight (kg)/{height(m)]^2
Waist Circumference	Athlete stands with feet together and arms slightly away from their side with abdominals relaxed. A light shirt may be worn but bulky clothing must be removed. With an inelastic tape measure, measure the most narrow aspect of the waist to the nearest .5 cm. If there is no obvious waist the level of umbilicus should be utilized.
Hip Circumference	Athlete maintains position for waist circumference. Measure the widest aspect of the hips to include the greatest excursion of the buttocks to the nearest .5 cm.
Waist-Hip Ratio	Formula: Waist circumference/hip circumference to the nearest .5 cm.
	Muscular Fitness (M-FIT)
Maximal Walking Speed	Athlete walks a 15-20 m path at their usual pace (untimed). Then instruct them to *"Walk back to where you started as quickly as you can without running."* Follow behind, allowing a minimum 2.5 m for acceleration & deceleration. Time the central 10 m of the course. Record speed as m/sec.
Five Times Sit to Stand Test	Athlete sits at the front of a standard chair, arms crossed over their chest, feet flat. Instruct athlete to *"Stand and sit as quickly as you can five times. I will start time on the word "go" and will stop when you return to sitting after the fifth stand."* Briefly demonstrate the test and then secure the chair for testing while timing on a digital stopwatch. Time is recorded to the nearest tenth of a second.
Grip Strength	Athlete sits with feet flat on the floor and test arm by the side, elbow bent to 90° gripping a handheld Jamar dynamometer set to position 2. Instruct the athlete to squeeze as tightly as possible 3-5 seconds. Allow a practice trial on the right and left. Record the second trial in kg to the nearest whole number and score the higher of the two hands.
	Flexibility Fitness (F-FIT)
Foam Pillow Posture Test	Position the athlete in supine on the plinth so that the heels extend off the end when knees are extended. Then instruct the athlete to bend their knees and place their feet flat. Athletes unable to lie flat or without obvious cervical extension to reach the plinth are offered an AirEx to support the head. Result is documented.
Shoulder Flexion	Athlete remains in the posture test position with instruction to reach the right arm overhead as far as possible. Active range of motion (AROM) is measured goniometrically with the fulcrum over the lateral aspect of the greater tubercle, the proximal arm parallel to the midaxillary line of the thorax and the distal arm along the lateral midline of the humerus. Repeat on the left side. Record AROM in degrees for each side.
Ankle Dorsiflexion	Athlete remains supine on the plinth but straightens the knees to allow the heels to extend just past the end of the plinth. Instruct the athlete to *"pull your toes up as far as you can"*. AROM dorsiflexion is measured goniometrically with the fulcrum over the lateral aspect of the lateral malleolus, the proximal arm in line with the lateral midline of the fibula and the distal arm parallel to the lateral aspect of the fifth metatarsal. A 90° position of the ankle is 0° with greater movement measured as positive and less as negative.
Modified Thomas Test	Athlete sits on the short end of the treatment table and lies back with left knee pulled to their chest to just flatten the lumbar lordosis. Athlete's opposite leg relaxes off the end of the plinth. Correct for abduction of the hip and measure goniometrically with the fulcrum at the greater trochanter of the hip, distal arm along the lateral midline of the femur, and proximal arm along the lateral midline of the trunk. Extension past 0° is recorded as positive while inability to extend to 0° is recorded as negative. Repeat for left leg.
	Balance Fitness (B-FIT)
Single Leg Stance Eyes Closed	With shoes removed, place a gait belt around athlete's waist and instruct them to stand with arms crossed over their chest on one leg with their eyes closed. Athletes choose their preferred stance leg and may switch between trials. Guard the athlete, and start timing once they have achieved the requested position. Time stops at 30 seconds OR if the athlete shifts their foot/hops, squeezes legs together, places opposite foot down or opens their eyes. Stopwatch time is recorded to the nearest tenth of a second with the best of 3 trials scored.
Single Leg Stance on Foam	The athletes steps onto a foam AirEx pad. Instruct the athlete to assume single leg standing with eyes open. All rules and scoring are identical to eye-closed.