Fit and Tipsy? The Interrelationship between Cardiorespiratory Fitness and Alcohol Consumption and Dependence

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[1]Division of Research, The Cooper Institute, Dallas, TX; [2]School of Public Health, University of Haifa, Haifa, ISRAEL; [3]School of Social Work and Department of Psychiatry, Virginia Commonwealth University, Richmond, VA; [4]Department of Marketing, Faculty of Economics and Business, University of Groningen, Groningen, THE NETHERLANDS; and [5]True Health Initiative, Tulsa, OK

ABSTRACT

SHUVAL, K., D. LEONARD, K. G. CHARTIER, C. E. BARLOW, B. M. FENNIS, D. L. KATZ, K. ABEL, S. W. FARRELL, A. PAVLOVIC, and L. F. DEFINA. Fit and Tipsy? The Interrelationship between Cardiorespiratory Fitness and Alcohol Consumption and Dependence. *Med. Sci. Sports Exerc.*, Vol. 54, No. 1, pp. 113–119, 2022. **Purpose:** To examine whether higher levels of cardiorespiratory fitness are related to increased alcohol consumption and dependence among a large sample of adults attending a preventive medicine clinic. **Methods:** A cross-sectional study of 38,653 apparently healthy patients who visited the Cooper Clinic (Dallas, TX) for preventive medical examinations (1988–2019) and enrolled in the Cooper Center Longitudinal Study. The primary independent variable was cardiorespiratory fitness, based on a maximal treadmill test, and the dependent variables were alcohol consumption and dependence (self-reported). The relations between fitness category (low, moderate, high) and alcohol consumption (low, moderate, heavy) and suggested alcohol dependence (Cut down, Annoyed, Guilty, Eye opener score ≥2) among women and men were estimated via multivariable regression while adjusting for covariates (e.g., age, birth year cohort, marital status, and body mass index). **Results:** Women within the moderate and high fitness categories had 1.58 (95% confidence interval [CI], 1.32–1.91) and 2.14 (95% CI, 1.77–2.58) greater odds of moderate/heavy alcohol consumption, respectively, in comparison to their low fitness counterparts. Similarly, moderate and high fit men had 1.42 (95% CI, 1.30–1.55) and 1.63 (95% CI, 1.49–1.80) times greater odds of moderate-to-heavy alcohol consumption, respectively, in comparison to the low fitness group. In addition, among men who were heavy drinkers (but not women), higher fitness levels were related to lower rates of suggested alcohol dependence. Specifically, these men had 45.7%, 41.7%, and 34.9% proportions of clinically relevant alcohol problems across low, moderate, and high fitness categories (adjusted *P* for trend <0.001). **Conclusions:** Higher fitness levels are significantly related to greater alcohol consumption among a large cohort of adult patients. Interventions focusing on increasing fitness (via physical activity promotion) might consider concurrently aiming to reduce alcohol consumption. **Key Words:** CARDIORESPIRATORY FITNESS, ALCOHOL CONSUMPTION, ALCOHOL DEPENDENCE, PREVENTIVE MEDICINE

The benefits of engaging in health promoting physical activity have been well established (1). Numerous health benefits are gained by meeting physical activity guidelines, which necessitate participating in at least 150 min of moderate-intensity physical activity or 75 min of vigorous-intensity physical activity weekly or an equivalent combination (1). These benefits include reduced risk for numerous chronic diseases (e.g., type 2 diabetes, cardiovascular disease, some cancers) and lower risk for mortality from all-cause, cardiovascular disease and cancer (1–4). Habitually partaking in physical activity also leads to higher levels of cardiorespiratory fitness (henceforth "fitness"), which is a distinct component of cardiovascular health (5–7). In comparison, the relationship between alcohol consumption and morbidity, as well as mortality, is not as straightforward. Light (three or less drinks per week for women and men) and moderate levels of alcohol consumption (i.e., >3–7 and >3–14 weekly drinks for women and men, respectively, age 18–64 yr) are related to lower risk of coronary heart disease and cardiovascular disease mortality (8,9). In contrast, heavy alcohol consumption (>7 and >14 drinks a week for women and men, respectively, age 18–64 yr) is associated with increased risk for cardiovascular disease morbidity and mortality (8). In addition, there is established scientific evidence that any level of alcohol consumption (even light) can cause several cancers (10).

The United States Preventive Service Task Force recommends screening for unhealthy alcohol consumption and encourages providing brief counseling to those engaged in

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hazardous drinking (11,12). Similarly, the United States Preventive Service Task Force recommends physical activity counseling particularly to patients with cardiovascular disease risk factors, and to a lesser degree to those without (13,14). Other organizations, such as the American College of Sports Medicine in conjunction with the American Medical Association, call for physical activity to be regarded as a "vital sign," thereby assessing it routinely in primary care (15–17). This will enable identifying patients who are inactive and in need for effective counseling. Correspondingly, it is important to determine hazardous drinking patterns to promptly modify this maladaptive behavior, with the goal of improving health outcomes. Indeed, screening and surveillance of physical inactivity, fitness, and excessive drinking are important at clinical and population levels because it assists in planning, designing, and implementing pertinent intervention programs (18,19).

Interventions in primary care often emphasize promoting a positive health behavior (e.g., physical activity) (20) or decreasing a negative behavior (e.g., drinking) (21), without consideration of the possible interrelationship between the two. Positive health behaviors tend to cluster together, such as exercising and eating a healthful diet (when trying to lose weight), whereas light drinking (or abstaining from alcohol) is often not regarded as a health promoting behavior (22,23). Interestingly, studies examining the nexus of physical activity and alcohol consumption have found that participation in sports and other physical activities are related to increased drinking in college athletes and nonathletes alike (24). These studies, however, used self-reported measures of physical activity, which are subject to overreporting because of social desirability (25), and few studies have focused on community dwelling adults who could benefit from screening and behavior modification counseling by primary care providers in the clinical setting. This is of particular importance because over 80% of Americans visit a health care provider for a checkup annually, which is a key opportunity for preventive medicine lifestyle interventions (15,26,27). Thus, in the current study, we examine whether higher levels of objectively measured fitness are related to increased alcohol consumption and dependence, among a large sample of apparently healthy adults, attending a preventive medicine clinic. Study findings could illuminate existing interrelationships and provide insight into designing future interventions in primary care.

METHODS

The cross-sectional relationship of fitness (primary independent variable) with alcohol consumption and dependence (primary dependent variables) was examined among adults enrolled in the Cooper Center Longitudinal Study (CCLS). The CCLS aims to explore lifestyle behaviors (e.g., physical activity, fitness, diet) as they relate to chronic disease prevention (28). Cooper Center Longitudinal Study participants consist of patients who come to the Cooper Clinic (Dallas, TX) for preventive medicine examinations, which include fitness and laboratory testing, as well as an extensive medical questionnaire with items including alcohol consumption and physical activity. Patients interested in the CCLS opt into the study and provide written informed consent. Participants are primarily non-Hispanic White and well educated (28,29). The CCLS is reviewed and approved annually by The Cooper Institute Institutional Review Board, and this research received approval from the University of Haifa Institutional Review Board.

The present study sample began with 55,082 participants 20 yr or older who came to the Cooper Clinic (1988–2019), responded positively to a question on the medical history survey: "Do you drink alcoholic beverages (yes/no)" (i.e., current drinkers) and had complete information on all study variables. Of these, participants were excluded if they were pregnant (n = 50) or excluded if not apparently healthy; that is, had abnormal electrocardiogram (n = 4419); reported a personal history of myocardial infarction, stroke, or diabetes (n = 8450); were underweight (body mass index [BMI] < 18.5 $kg \cdot m^{-2}$) (n = 2751); or did not reach 85% of maximal heart rate during the treadmill examination (n = 759). These exclusion criteria resulted in 38,653 apparently healthy participants in the analytic sample.

Independent and dependent variables. The primary independent variable, fitness, was based on a maximal treadmill test during a clinical examination while adhering to the modified Balke protocol (28), as previously described (30). Based on the final treadmill speed and grade, which is correlated highly with maximal oxygen uptake (30–32), we computed maximal metabolic equivalent (METs), where 1 MET = 3.5 mL O_2 uptake/kg body weight/minute (29,33). In accordance with a standardized CCLS approach (30,34), participants' were categorized into age- and sex-specific quintiles and then grouped into the following three categories: 1) quintile 1, low fitness; 2) quintiles 2 and 3, moderate fitness; and 3) quintiles 4 and 5, high fitness. For analyses, the low fitness group was regarded the reference group. In addition, physical activity was based on questions pertaining to the frequency (sessions per week) and duration (on average) of activities in the three previous months (35). These included aerobic activities, such as walking, jogging, or running (36). The reported frequency and duration of activity were converted to minutes of activity per week and multiplied by an estimated MET value based on the Compendium of Physical Activities (37). This resulted in metabolic equivalent of task (MET) minutes per week ($MET \cdot min \cdot wk^{-1}$) for each participant. Based on the Health and Human Services Physical Activity Guidelines for Americans (1), three categories were constructed: 1) not meeting guidelines (<500 $MET \cdot min \cdot wk^{-1}$); 2) meeting guidelines (500–1000 $MET \cdot min \cdot wk^{-1}$); and 3) exceeding guidelines (>1000 $MET \cdot min \cdot wk^{-1}$).

The dependent variables consisted of current alcohol consumption and dependence (i.e., clinically relevant alcohol problems). In the medical history questionnaire, participants indicating that they consumed alcoholic beverages (i.e., current drinkers), were asked to specify the number of drinks per week of beer (12 oz), wine (5 oz), and hard liquor (1.5 oz) they consumed (28). Consistent with previous

research (9,28), current drinking was grouped into three categories for participants age 18 to 64 yr: 1) light drinking, three or less drinks per week; 2) moderate drinking, more than three to seven drinks per week (women) and more than three to 14 drinks per week (men); and 3) heavy drinking, more than seven drinks per week (women) and more than 14 drinks per week (men). Among study participants 65 yr or older, to adhere to American Geriatric Society and the National Institute for Alcohol Abuse and Alcoholism recommendations (38), moderate drinking was regarded as more than three to seven weekly drinks for both women and men, whereas heavy drinking was considered more than seven drinks a week for both sexes. Those participants at the heavy drinking level exceeded recommended weekly drinking guidelines (39).

In addition, alcohol dependence was assessed via participants' responses to the Cut down, Annoyed, Guilty, Eye opener (CAGE) questionnaire (40–42). This questionnaire, aimed at screening for clinically relevant alcohol problems, is designed for a clinical setting because of its brevity and focus on behavioral aspects of drinking to facilitate clinician–patient discussions (40). The CAGE questionnaire consists of four questions inquiring whether patients ever: 1) felt they needed to cut down on drinking; 2) felt annoyed by criticism pertaining to their drinking; 3) felt guilty about drinking; and 4) drank first thing in the morning (eye opener) (40,41). Total scores on the questionnaire range from 0 to 4, with a threshold of 2, indicative of suggested alcohol dependence (41). Subsequently, in the analyses, the total CAGE score was dichotomized into suggested dependence (score, ≥2) or no suggested dependence (score, <2) (43).

Covariates. The covariates, based on the literature (44–46), adjusted for in multivariable analyses, included the following: age, sex, marital status (married: yes/no), and BMI. In addition, based on reported age and date of examination, participants were placed into four birth year cohorts, because a cohort effect independent of age has been observed in the literature pertaining to drinking habits (47). Specifically, participants were placed into the following birth cohorts: Silent (born ≤1942), Baby Boomers (born 1943–1960), Generation X (born 1961–1981), and Millennials (born ≥1982) (48,49).

Statistical analysis. Characteristics of participants were summarized in total and by sex. The prevalence of light, moderate, and heavy drinking across low, moderate, and high fitness categories was summarized by sex and the unadjusted trends between the two ordinal variables was tested using Jonckheere–Terpstra statistics. Adjusted drinking level odds ratios (OR) for moderate and high versus low fitness were estimated using ordinal logistic regression. Specifically, partial proportional odds models were fit to higher versus lower levels of drinking. Consequently, there were separate logits for 1) light versus moderate and heavy drinking and 2) light and moderate versus heavy drinking, with the latter comparing those participants who adhered to versus exceeded weekly drinking recommendations. Odds ratios were adjusted for age, birth year cohort, marital status, and BMI. Adjusting for the decade of examination year (instead of birth year cohort) had little bearing on the primary estimates and was therefore not included in the models presented. Moreover, in a parallel analysis, self-reported physical activity replaced fitness as the exposure of interest (see Table, Supplemental Digital Content, Physical Activity and Alcohol Consumption among Women and Men, http://links.lww.com/MSS/C421). In addition, the prevalence of total CAGE score ≥2 across low, moderate, and high fitness categories was summarized by sex, and adjusted trends were tested using multiple logistic regression of the binary outcome. All analyses were programmed in SAS/STAT®, version 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Participants' mean age was 45.9 yr (SD = 9.5) with their age ranging from 20 to 86 yr. In addition, more than two thirds (71.7%) were men, 85.5% were married, and 82.4% were either Baby Boomers or Generation X. In addition, 43.1% of participants were in the low or moderate fitness category, whereas 47.8% were moderate and 10.5% were heavy alcohol drinkers. A total of 13.1% of participants received a CAGE score of 2 or higher, indicating suggested alcohol dependence. Furthermore, although, on average, participants were overweight (BMI: mean = 26.4 $kg \cdot m^{-2}$, SD = 4.3), BMI differed by sex. That is, women on average were of normal weight (BMI: mean, 24.1 $kg \cdot m^{-2}$; SD, 4.3), whereas men on average were overweight (BMI: mean, 27.3 $kg \cdot m^{-2}$; SD, 4.0). Finally, descriptive characteristics of participants stratified by sex appear in Table 1.

TABLE 1. Characteristics of study sample: CCLS 1988–2019.

Characteristics	Women (*n* = 10,922)	Men (*n* = 27,731)	All (38,653)
Age			
Mean (SD)	45.5 (10.0)	46.1 (9.3)	45.9 (9.5)
Birth cohort[a]			
Silent	12.5%	16.6%	15.5%
Baby Boomers	47.4%	50.5%	49.6%
Generation X	36.8%	31.1%	32.8%
Millennials	3.3%	1.7%	2.2%
Married	81.4%	87.1%	85.5%
BMI ($kg \cdot m^{-2}$), mean (SD)	24.1 (4.3)	27.3 (4.0)	26.4 (4.3)
Cardiorespiratory fitness[b]			
Low	6.6%	10.5%	9.4%
Moderate	26.9%	36.4%	33.7%
High	66.5%	53.1%	56.9%
Alcohol consumption[c]			
Light drinker	51.4%	37.8%	41.6%
Moderate drinker	44.0%	49.3%	47.8%
Heavy drinker	4.5%	12.9%	10.5%
CAGE score[d]			
0–1	89.1%	86.1%	86.9%
2–4	10.9%	13.9%	13.1%

[a]Silent generation were born in ≤1942, Baby Boomers: 1943–1960, Generation X (1961–1981), Millennials ≥1982.
[b]Treadmill times were categorized into age- and sex-specific quintiles and then grouped into low fitness; moderate fitness; high fitness. In women, the mean MET (SD) for low fitness was 6.6 (0.9), moderate fitness: 8.4 (0.9), high fitness: 10.9 (1.6). In men, the mean MET (SD) for low fitness was 8.5 (1.1), moderate fitness: 10.6 (1.1), and high fitness: 13.4 (1.8).
[c]Current drinking was grouped into three categories for participants age 18–64 yr: (1) light drinking: ≤3 drinks per week; (2) moderate drinking: >3–7 drinks per week (women) and >3–14 drinks per week (men); and (3) heavy drinking: >7 drinks per week (women) and >14 drinks per week (men). Among participants age ≥65 yr, moderate drinking was regarded as >3–7 weekly drinks for both women and men, whereas heavy drinking was considered >7 drinks a week for both sexes; light drinking remained the same as above.
[d]CAGE scores range from 0 to 4, with a threshold of 2 indicative of suggested alcohol dependence.

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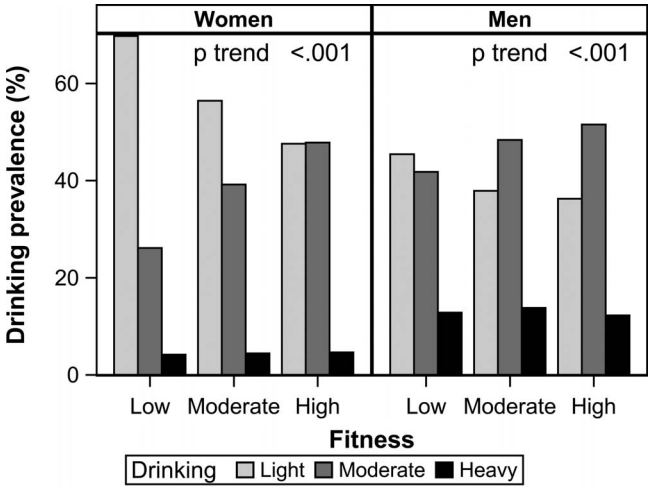

FIGURE 1—Prevalence of alcohol consumption by cardiorespiratory fitness among women and men: Cooper Center Longitudinal Study 1988–2019. Current drinking was grouped into three categories for participants age 18–64 yr: 1) light drinking: ≤3 drinks per week; 2) moderate drinking: >3–7 drinks per week (women) and >3–14 drinks per week (men); and 3) heavy drinking: >7 drinks per week (women) and >14 drinks per week (men). Among participants age ≥65 yr, moderate drinking was regarded as >3–7 weekly drinks for both women and men, whereas heavy drinking was considered >7 drinks a week for both sexes; light drinking remained the same as above. Treadmill times were categorized into age- and sex-specific quintiles and then grouped into low, moderate, and high fitness. Total participants, *N* = 38,653; women, *n* = 10,922; men, *n* = 27,731.

The prevalence of alcohol consumption by fitness category among women and men is depicted in Figure 1. In women, light drinking decreased whereas moderate drinking increased according to increasing fitness categories. Specifically, 69.8%, 56.4%, and 47.6% of women were light drinkers within the low, moderate, and high fitness categories, respectively. Conversely, 26.1%, 39.2%, and 47.8% of women were moderate drinkers within the low, moderate, and high fitness categories, respectively. In comparison, the prevalence of heavy drinking in women appeared similar across fitness categories, that is, 4.2%, 4.4%, 4.6% were heavy drinkers within the low, moderate, and high fitness categories, respectively. In men, similar trends were observed; that is, light drinking decreased (45.4%, 37.9%, 36.2%), moderate drinking increased (41.8%, 48.4%, 51.5%), and heavy drinking was similar across ordered fitness categories (12.8%, 13.8%, 12.2%), respectively. Trends for light and moderate drinking were statistically significant across fitness categories for both sexes (unadjusted *P* for trend <0.001).

The relationship between fitness (moderate and high vs low category) and alcohol consumption while adjusting for covariates, appears in Table 2. Ordinal logistic regression was used to distinguish higher from lower levels of alcohol consumption at the two possible breakpoints: 1) light versus moderate/heavy drinking, and 2) light/moderate versus heavy drinking. In women, participants within the moderate and high fitness categories had 1.58 (95% confidence interval [CI], 1.32–1.91) and 2.14 (95% CI, 1.77–2.58) times greater odds of moderate/heavy versus light drinking, respectively, in comparison to their low fitness counterparts. No significant relationships between fitness and alcohol consumption were observed when comparing heavy to light/moderate drinking levels in women. In men, individuals within the moderate and high fitness category had 1.42 (95% CI, 1.30–1.55) and 1.63 (95% CI, 1.49–1.80) times greater odds of moderate/heavy versus light alcohol consumption, respectively, in comparison to their low fitness counterparts. In addition, men within the moderate (but not high) fitness category had significantly greater odds of heavy (in comparison to light/moderate) drinking (OR, 1.15; 95% CI, 1.01–1.31). When examining the physical activity-alcohol relationship, as with fitness, meeting or exceeding activity guidelines was related to higher odds of moderate/heavy versus light drinking; however, findings differed somewhat when comparing heavy to light/moderate drinking (see Table, Supplemental Digital Content, Physical Activity and Alcohol Consumption among Women and Men, http://links.lww.com/MSS/C421).

In addition, the prevalence of a CAGE score of ≥2, by fitness and drinking categories among men and women, appear in Figure 2. In women, the prevalence of suggested alcohol dependence in heavy drinkers did not differ significantly across fitness levels. Specifically, the prevalence of suggested alcohol dependence in women who were heavy drinkers was 46.7%, 49.2%, and 47.6% across low, moderate, and high fitness categories, respectively (adjusted *P* for trend = 0.532). In comparison, in men who were heavy drinkers, there was significantly less suggested alcohol dependence across fitness categories. Specifically, the prevalence of suggested alcohol

TABLE 2. Cardiorespiratory fitness and alcohol consumption among women and men[a]: adjusted odds of higher vs lower levels of drinking[b].

	Alcohol Consumption[c]			
	Women (Heavy vs Light/ Moderate Drinking)	Women (Moderate/ Heavy vs Light Drinking)	Men (Heavy vs Light/ Moderate Drinking)	Men (Moderate/Heavy vs Light Drinking)
Cardiorespiratory Fitness[d]	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Moderate fitness (vs low)	0.99 (0.66–1.53)	1.58* (1.32–1.91)	1.15** (1.01–1.31)	1.42** (1.30–1.55)
High fitness (vs low)	0.99 (0.66–1.54)	2.14* (1.77–2.58)	1.04 (0.90–1.19)	1.63** (1.49–1.80)

*$P < 0.01$.
**$P < 0.05$.
[a]CCLS—1988–2020; total: *n* = 38,653; women: *n* = 10,922; men: *n* = 27,731.
[b]Multiple regression models were computed to examine the relationship between fitness (low, moderate, high) and alcohol consumption (heavy vs light/moderate, and moderate/heavy vs light) adjusting for age, birth cohort (Generation X and Millennials vs Boomers), marital status: married (yes/no), and BMI. Separate models were estimated for women and men.
[c]Current drinking was grouped into three categories for participants age 18–64 yr: (1) light drinking: ≤3 drinks per week; (2) moderate drinking: >3–7 drinks per week (women) and >3–14 drinks per week (men); and (3) heavy drinking: >7 drinks per week (women) and >14 drinks per week (men). Among participants age ≥65 yr, moderate drinking was regarded as >3–7 weekly drinks for both women and men, whereas heavy drinking was considered >7 drinks a week for both sexes; light drinking remained the same as above.
[d]Treadmill times were categorized into age- and sex-specific quintiles and then grouped into low fitness, moderate fitness, high fitness.

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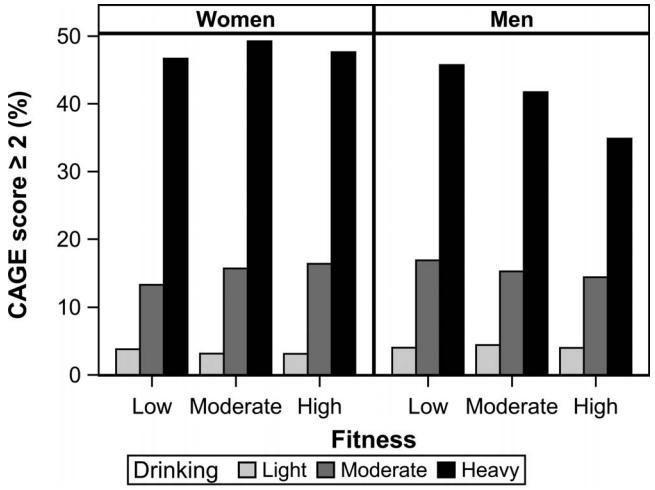

FIGURE 2—Prevalence of Suggested Alcohol Dependence by Cardiorespiratory Fitness and alcohol consumption among Women and Men: Cooper Center Longitudinal Study 1988–2019. A CAGE score ≥2 was regarded as suggested alcohol dependence. Among heavy drinkers, the CAGE score trends across fitness are significant for men ($P < 0.001$) but not women ($P = 0.358$). Current drinking was grouped into three categories for participants age 18–64 yr: 1) light drinking: ≤3 drinks per week; 2) moderate drinking: >3–7 drinks per week (women) and >3–14 drinks per week (men); and 3) heavy drinking: >7 drinks per week (women) and >14 drinks per week (men). Among participants age ≥65 yr, moderate drinking was regarded as >3–7 weekly drinks for both women and men, whereas heavy drinking was considered >7 drinks a week for both sexes; light drinking remained the same as above. Treadmill times were categorized into age- and sex-specific quintiles and then grouped into Low, Moderate and High Fitness. Total participants: $n = 38,653$; women: $n = 10,922$; men: $n = 27,731$.

dependence was 45.7%, 41.7%, and 34.9% for low, moderate, and high fitness categories, respectively (adjusted p for trend <0.001).

DISCUSSION

In the present study, we assessed the interrelationships between fitness and alcohol consumption and dependence among patients presenting at a preventive medical clinic. Study findings indicate that current drinkers with higher fitness levels exhibited an increased tendency for alcohol consumption. For example, highly fit women and men were ~2.1 and ~1.6 times, respectively, more likely to be moderate/heavy versus light drinkers in comparison to low fit women and men. When examining self-reported physical activity (rather than fitness) as the exposure, analysis showed similar patterns when comparing moderate/heavy versus light drinking across physical activity levels. These trends appear to reflect tradeoffs primarily between light and moderate drinking; heavy drinking was largely unchanged.

Previous research in the field has observed similar findings with regard to physical activity and alcohol consumption. For example, Werneck et al. (50) observed that Brazilian adults with higher levels of physical activity were more likely to consume alcohol on a weekly basis. In fact, a systematic review by Dodge et al. (51) concluded that three fourths of studies among nonstudent adults found that higher levels of physical activity were related to increased alcohol consumption. Although many of the reviewed studies were cross-sectional, limiting the ability to determine a temporal relationship, Conroy et al. (52) examined physical activity and drinking patterns over a 21-d period, finding that individuals consumed more alcohol on the same days when they were more physically active. Thus, present results, alongside prior evidence (51), indicate that those engaging in physical activity are also more likely to consume alcohol, although not necessarily at a level that exceeds drinking guidelines. This relationship could be explained by a psychological mechanism referred to as the "licensing effect," where achieving goals (e.g., running a 10-km race) could provide a "license" to indulge in an unhealthy behavior (e.g., drinking) as a rewarding mechanism (53,54). This psychological explanation, however, should be regarded as supposition, which warrants additional empirical examination in subsequent research, particularly because psychological variables were not available in the current data set. In addition, a study by Rockafellow and Saules (55) observed a significant relationship between participation in team sports and increased alcohol consumption among physically active college students. The present study, among primarily midage participants, was unable to determine whether participation in team sports is as an effect modifier in this relationship because this information was not available in the data set.

Together with observational research examining the intersection of physical activity and alcohol consumption, interventions aiming to reduce excessive alcohol consumption via physical activity promotion have been attempted with mixed success. For example, Kendzor et al. (56) found that encouraging physical activity (e.g., walking, cycling) during a treatment intervention for heavy drinkers, did not result in reduced alcohol consumption. Moreover, a recent systematic review by Thompson et al. (57) indicates that although some studies observed that physical activity markedly reduced alcohol initiation, others did not find that physical activity significantly affected alcohol consumption. The current study's results, reflecting behaviors of adults, indicate that higher levels of fitness are related to increased drinking, particularly moderate alcohol consumption. Thus, when designing interventions for this population, interventions focusing on increasing fitness (through physical activity promotion) might want to concurrently attempt to reduce alcohol consumption.

As expected, the present study finds that heavy alcohol consumption corresponds with a higher prevalence of suggested alcohol dependence (as measured by CAGE). Of interest, however, is an inverse relation between fitness categories and suggested alcohol dependence among men who are heavy drinkers, but not women who are heavy drinkers. That is, in men who are heavy drinkers, as fitness increased, the percentage of those with suggested alcohol dependence decreased. For example, men who drank heavily within the low fitness category had an approximately 1.3 times higher percentage of suggested alcohol dependence than their high fit counterparts (45.7% vs 34.9%, respectively). This finding warrants further investigation, including to determine the potential protective aspects of this relationship for men and why they did not generalize to high fit women. Previous research by Lisha et al. (58), in a large sample of US adults, found that physical activity was positively related to alcohol consumption but

not to severe forms of alcohol use disorders with no differences by sex.

The present study has strengths and limitations that should be considered when interpreting findings. Strengths of the study include the large sample size, the focus on adults attending a preventive medicine clinic with a valid alcohol dependence measure (CAGE), and the use of objective measurements of fitness instead of self-reported physical activity. Although fitness is a quantitative and direct consequence of habitual physical activity, it is also influenced by nonmodifiable factors (e.g., sex, age, genetics) (28,59). In the current study, we present findings for both the behavior (physical activity) and the physiological consequence of this behavior (fitness), which is a strength in the present study. The study's outcome (alcohol consumption), however, as with other epidemiological studies, is based on self-report, which could be subject to underreporting because of social desirability. In addition, inclusion of an explicit reference period (e.g., 12 months or 30 d) for alcohol consumption would improve its measurement (60). The study is also limited by its focus on a cohort consisting of predominantly White, highly educated participants with access to preventive medical care. As a result, these conclusions might not be applicable to a multi-ethnic and more economically diverse population. Moreover, the present study's focus on apparently healthy adults whose behaviors might not represent individuals with morbid conditions is an additional limitation. Finally, only an association, rather than a temporal and causal relationship, can be established between fitness and alcohol consumption because of the cross-sectional nature of the study (51).

CONCLUSIONS

In conclusion, the present study finds that objectively determined fitness is significantly related to higher alcohol consumption among a large sample of adults attending a preventive medicine clinic. This finding supports previous research examining the relationship between self-reported physical activity and alcohol consumption. Thus, preventive interventions among adults might need to focus not only on promoting physical activity but also on concurrently reducing alcohol consumption levels. These two behaviors appear to go hand in hand, and insights from behavioral science should be considered when employing interventions.

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The authors have no disclosures of potential conflicts of interest to report. The results of the present study do not constitute endorsement by ACSM. The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

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