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Health-Promoting Behaviors and Their Associations With Factors Related to Well-Being Among Former National Football League Players: An NFL-LONG Study

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Context: Understanding former professional football players' engagement with health-promoting behaviors (physical exercise, high-quality diet, and good sleep hygiene) will be helpful for developing lifestyle interventions to improve their feelings of well-being, a relatively understudied facet of health among this population.

Objective: Examine associations among health-promoting behaviors and subjective outcomes related to well-being among former National Football League (NFL) players.

Design: Cross-sectional.

Setting: Online or hard-copy survey.

Patients or Other Participants: Former NFL players.

Main Outcome Measure(s): Self-reported health-promoting behaviors (exercise frequency, diet quality, and sleep duration and disturbance) and factors related to well-being (Patient-Reported Outcomes Measurement Information System - Meaning and Purpose [MP], Self-Efficacy, and Ability to Participate in Social Roles and Activities [SRA]). Multivariable linear regression models were fit for each well-being-related factor with health-promoting behaviors as explanatory variables alongside select demographic, behavioral, and functional covariates. Models were fit for the full sample and separately for individual age groups: <30 years, 30 to 39 years, 40 to 49 years, 50 to 59 years, 60 to 69 years, and 70+ years.

Results: A total of 1784 former NFL players (aged 52.3 ± 16.3 years) completed the survey. Lower sleep disturbance was associated with better MP (β [standard error] = –0.196 [0.024]), Self-Efficacy (β [standard error] = –0.185 [0.024]), and SRA (β [standard error]= –0.137 [0.017]) in the full sample and almost all the individual age groups. More frequent moderate-to-vigorous exercise was associated with higher MP (β [standard error] = 0.068 [0.025]) and SRA (β [standard error] = 0.151 [0.065]) in the full sample and with better MP, Self-Efficacy, and SRA among select middle-aged groups (between 40 and 69 years old). Diet quality, resistance training exercise frequency, other wellness activity frequency, and sleep duration were not associated with well-being-related factors in the full group, and sparse significant associations were observed in individual age group models.

Conclusion: Lower sleep disturbance and more frequent moderate-to-vigorous exercise frequency may be important targets for improving overall health and well-being among former NFL players.

Key Words: physical activity, diet quality, sleep hygiene, health-related quality of life

Key Points

- Health-promoting behaviors differed across the adult lifespan in former professional American football players.
- More frequent moderate-to-vigorous exercise participation and less disturbed sleep were positively associated with multiple factors related to well-being, and the strength of association differed across age groups.
- Modifiable behaviors may be important clinical targets for improvement of overall health and well-being among former athletes, such as National Football League players.

There are many health benefits associated with engagement in health-related behaviors like exercise, dietary intake, and sleep among former athletes.[1–4] Despite these known benefits, former athletes may change their relationships with these behaviors after discontinuing structured sport participation.[5] Low engagement in healthy exercise, diet, and sleep behaviors following athletic careers may result in changes to health status across multiple domains, such as cardiovascular disease and associated risk factors,[1,6] depression,[7–9] cognitive impairment,[10–12] and dementia,[10,11,13] and these health-related behaviors are known modifiers of self-reported well-being.[2,14]

Well-being has been described by the World Health Organization as a positive state similar to health, related to a "sense of meaning and purpose," social conditions, and "capacity for action," including self-efficacy.[15] Specifically among former American-style football players, participation in regular physical exercise, higher diet quality, and sleeping $\geq$6 hours per night have been associated with better self-reported cognitive function and fewer mood-related symptoms.[2–4] However, evidence is lacking among former professional athletes such as these regarding other important aspects related to well-being, including subjective meaning and purpose, self-efficacy, and ability to participate in social roles and activities. Additionally, little is known about patterns of engagement in exercise, diet, and sleeping behaviors as former players age and whether the associations of these behaviors with well-being differ in former athletes of different ages. Although the risks for many noncommunicable diseases increase as people age, including those for cardiovascular disease and dementia, subjectively reported factors related to well-being (eg, self-efficacy) do not necessarily change consistently with increasing age.[16,17] Specific therapeutic targets and approaches are essential for clinicians treating former athletes, such as former National Football League (NFL) players who may be concerned about their long-term health and well-being as they age.[18] A deeper understanding of health-promoting behaviors across the adult lifespan in these athletes and how they relate to factors of well-being is an important step in developing tailored treatments such as exercise prescription, dietary intake patterns, and sleep hygiene strategies that meet their health needs.

This study aimed to describe participation in exercise, diet, and sleep behaviors among former NFL players and to examine the associations between these health-promoting behaviors and outcomes related to well-being across age groups. Outcomes in this study include the Patient Reported Outcomes Measurement Information System (PROMIS) Meaning and Purpose, Self-Efficacy, and Ability to Participate in Social Roles and Activities inventories.[19–21] The PROMIS item banks were rigorously designed through qualitative and quantitative approaches to avoid measurement bias across a number of constructs and regardless of gender, age, race, education, language, and method of administration.[22] The specific tools used in this study were developed using advanced statistical approaches to assess each specific construct domain in healthy individuals as well as those with chronic health conditions.[19–21,23] Findings from this study are meant to inform clinical assessments of exercise, diet, and sleep to provide clinical targets for improving health and well-being in former athletes and determine if these targets differ across adulthood.

METHODS

This cross-sectional study is part of the "Neurologic Function Across the Lifespan: A Prospective, LONGitudinal, and Translational Study for Former National Football League Players (NFL-LONG)" study. Participants self-administered an online- (Qualtrics, SAP America, Inc) or paper-based questionnaire between January 2019 and early April 2020. The Institutional Review Boards at the University of North Carolina at Chapel Hill and the Medical College of Wisconsin approved this study. Informed consent was required by all participants before accessing the electronic questionnaire; written informed consent was obtained on the first page of the hard-copy version.

Participants

Former NFL players who played at least 1 NFL season were eligible to participate in this study.[2] Individual NFL teams, former players representing individual team alumni associations, and former players in the NFL Legends community were contacted and offered participation via hard-copy mailing through an NFL Legends partner to the entire NFL Legends community ($n = 15\,025$) and via electronic mail to an overlapping sample through the same NFL Legends partner ($n = 11\,645$). Hard-copy questionnaires were distributed in the fall of 2019 and electronic communications were sent in 3 waves, including spring 2019, summer 2019, and spring 2020. All questionnaire respondents were screened by a member of the study team to determine their eligibility to participate.

Data Collection

The General Health Survey was modified from prior versions with input from epidemiologists, athletic trainers, neuropsychologists, physicians, and other sports medicine professionals.[7,11] The present survey was updated from previous versions with more extensive and detailed queries of health history (eg, medical diagnoses), current health status (comorbidities, symptoms, and treatment), self-reported functioning (PROMIS measures across multiple domains), experiences related to the transition from playing football, and past and current concerns about their health. Five former NFL players critically reviewed the survey instrument and provided specific feedback to the study team to improve the questionnaire's flow and clarity. The study population historically consisted of predominantly non-Hispanic White/Caucasian- and Black/African-American-identifying men from across a wide range of socioeconomic statuses. Our study recruitment methods using paper and electronic formats were intended to reach and be accessible to all former NFL players. Participants selected and completed either the electronic or hard-copy questionnaire. A member of the study team was available via phone and email to address any questions or concerns regarding participation or completion of the survey, regardless of the mode of self-administration.

The present study instrument included demographic information, participation in selected health-related behaviors, and current self-reported functioning and well-being measures. Demographic information included age, race/ethnicity, body mass and height (which were used to calculate body mass index), and current relationship status (married or cohabitating, not married or cohabitating, or other relationship status). Behavioral information captured included frequencies of participation in moderate-to-vigorous physical activities, resistance training, other wellness activities, sedentary/sitting activities, screen-related activities, and alcohol intake. Self-reported functioning and well-being measures included validated inventories of items related to meaning and purpose, self-efficacy, ability to participate in social roles and activities, physical functioning, pain interference, and emotional support. Specific details for these items are described below.

Current Health-Promoting Behaviors: Exercise, Diet, and Sleep

Exercise and other wellness activity frequencies were reported as the number of days per week over the past 4 weeks that participants engaged in each type of activity. Moderate-to-vigorous aerobic exercise was defined as "exercise that increases breathing rate and heart rate (eg, jogging, cycling)," resistance training was defined as "resistance training or weight-lifting," and other wellness related activities were defined as "other wellness activities (eg, yoga, meditation)." No minimum session durations were required for any participant response.

The Rapid Eating Assessment for Participants-Shortened Version (REAPS) was used to assess diet quality.[24] The REAPS 16-item survey was validated in comparison to an established food frequency questionnaire (Pearson r correlation values of up to 0.516)[24] and a longer measure of dietary quality (r = 0.227),[25] and moderate internal consistency (Cronbach's α = 0.65)[26] has been recently reported. This instrument captures information about food consumption frequency by type (eg, whole grains, fruits, and processed meats) in an average week as well as meal preparation and willingness to make dietary changes to improve health via 5-point Likert scale from 1 (*very willing*) to 5 (*not at all willing*). Diet quality was calculated as the sum of each of the 13 scorable REAPS items, ranging from 13 (*worst*) to 39 (*best*).

Sleep duration was calculated as the average number of self-reported hours slept per night weighted by weekday and weekend nights when considering the past 4 weeks.[2] Sleep disturbance was self-reported using the PROMIS-29 Profile version 2.0 items related to sleep disturbance.[19] These items were each scored on 5-point Likert scales from *very poor* to *very good* in response to the item "My sleep quality was . . ." and from *not at all* to *very much* in response to "My sleep was refreshing," "I had a problem with my sleep," and "I had difficulty falling asleep." This 4-item sleep disturbance inventory has strong internal consistency (Cronbach's α of up to 0.88) across large groups of individuals with heterogenous demographic and health histories.[19] Individual item scores were summed and standardized as T-scores based on national normative data (mean $\pm$ standard deviation [SD] = 50 $\pm$ 10), with a higher T-score indicating more sleep disturbance (a less adaptive/worse outcome).

Self-Reported Well-Being: Meaning and Purpose, Self-Efficacy, and Social Participation

Factors related to well-being were measured via the PROMIS Adult Meaning and Purpose SF-4a,[20] PROMIS Adult Self-Efficacy SF-4a,[21] and the Ability to Participate in Social Roles and Activities 4-item scale from the PROMIS-29 Profile version 2.0.[19] Each scale consisted of 4 separate items rated on a 5-point Likert scale regarding the previous 7 days. Meaning and Purpose responses ranged from *not at all* to *very much* in response to items such as "My life has meaning." Self-Efficacy responses ranged from *I am not at all confident* to *I am very confident* in response to items such as "I can handle whatever comes my way." Social participation responses ranged from *never* to *always* in response to items such as "I have trouble doing all of the family activities I want to do." The summed items within each measure were standardized as T-scores based on national normative data (mean $\pm$ SD = 50 $\pm$ 10). Higher T-scores on each measure indicated more favorable outcomes, and scores of $\geq$60 may be interpreted as 1 SD better outcome scores than the general population, whereas the opposite is true for scores of $\leq$40.

Analysis Covariates

Covariates were selected a priori based on previous literature.[2,4,16,27–31] Demographic covariates included age, race/ethnicity (dichotomous; identified as White/non-Hispanic versus non-White), and current marital status (dichotomous; married/cohabitating with a partner versus not cohabitating). Behavioral covariates included current frequency of alcohol intake (ordinal; *never*, *monthly or less*, *2 to 4 times a month*, *2 to 3 times a week*, or *4 or more times a week*) and number of days/week spent sitting (ordinal; described as *at a desk*, *reading*, or *talking to friends*), and screen time (ordinal; defined as *looking at a screen to watch a show [television, computer, tablet, phone]*). Hours of weekly sitting and screen time were not calculable with the present data. Self-reported functioning covariates were Physical Function and Pain Interference domains from the PROMIS-29 Profile version 2.0 and the PROMIS Emotional Support SF-4a (Supplemental Tables 5–7, available online at http://dx.doi.org/10.4085/1062-6050-0537.23.S1).[19,30]

Self-reported lifetime concussion history was also considered as a covariate based on previous work with this same sample reporting statistically significant associations between concussion history and other self-reported measures of cognitive function, depression, anxiety, and emotional-behavioral dyscontrol.[2] A definition of concussion was provided to participants who were then asked to report the number of concussions they suspected they sustained on an ordinal level (0, 1, 2, 3 ...10+) in each level of football participation (before high school, during high school, during college, and during professional play) as well as from other sources (eg, military or motor vehicle accident). The sum of concussions reported across all categories was binned into 5 categories (0, 1 to 2, 3 to 5, 6 to 9, and 10+) to represent lifetime concussion history.

Data Processing and Statistical Analyses

To describe former NFL player's engagement in health-promoting behaviors, summary statistics were computed for the frequency of participating in exercise, diet quality, sleep duration, and sleep disturbance. Additionally, proportions of participants engaging in moderate-to-vigorous exercise ≥5 days/week as well as those engaging in resistance training ≥2 days/week were computed, with reference to physical activity guidelines from the Department of Health and Human Services in the United States, and proportions of participants sleeping between 7 and 9 hours/night were computed, with reference to recommendations provided by the American Academy of Sleep Medicine and Sleep Research Society.[32,33] Descriptive statistics were computed for the full study sample and for the following individual age subgroups: <30 years (n = 150), 30 to 39 years (n = 360), 40 to 49 years (n = 285), 50 to 59 years (n = 321), 60 to 69 years (n = 360), and 70+ years (n = 308). Multiple imputation methods were used to address missingness, similar to previous work (see Supplemental Material).[2] Summary scores, but not individual items, were imputed for the REAPS and PROMIS measures.

To measure the strength of the associations between health-promoting behaviors and well-being-related factors, we compared the effects of health-promoting behaviors on player self-reported Meaning and Purpose, Self-Efficacy, and Ability to Participate in Social Roles and Activities. Separate multivariable linear regression models were fit for each outcome, first in the full sample and separately within each individual age group, for a total of 21 models. We included frequencies participating in moderate-to-vigorous activities, resistance exercise, and other wellness activities, REAPS summary score, sleep duration, and sleep disturbance as the primary predictors of interest alongside the demographic, behavioral, and self-reported functioning and well-being covariates described above. Age was not included as a separate covariate in models within each individual age group. When fitting the regression models from the multiple imputation datasets, standardized z score values with a mean of 0 and SD of 1 were used for each predictor and outcome. Variance inflation factors were calculated to probe multicollinearity using a recommended cutoff point of 10.[34] Adjusted R^2 and standardized β coefficients (β) were calculated for each model, with a priori α set to .05. All analyses were performed with SPSS version 28.0.

RESULTS

A total of 1784 former NFL players responded to our survey and were included in this study as described in detail previously (Table 1).[2] On average, these participants reported playing 17.5 ± 4.5 years of football in their lifetime and had finished their professional football career 24.0 ± 15.6 years before their participation in this study. We distributed the web-based and hard-copy questionnaires to 15 025 individuals with email and/or mailing addresses on file but were unable to calculate an exact response rate as we do not have information on how many of those individuals received the distribution and were eligible for participation.

Current Health-Promoting Behaviors: Exercise, Diet, and Sleep

Overall, former players reported participating in approximately 3 days/week of moderate-to-vigorous exercise, 2 days/week of resistance training, and 1 day/week of other wellness activities (Table 2). Approximately 24% of all players reported participating in moderate-to-vigorous exercise ≥5 days/week, and 66% reported resistance training ≥2 days/week. Age-related trends for meeting these cutoffs were similar to the age-related trends observed in median weekly frequency of each exercise type (Table 2). The highest proportion of participants engaged in moderate-to-vigorous exercise ≥5 days/week was observed in former players aged 70+ years (28.3%), whereas the smallest proportion was observed in former players aged 40 to 49 years (20.9%). Conversely, the youngest age group of former players, those aged <30 years, reported the highest proportion of meeting strength training recommendations (79.5%), whereas former players aged 70+ years reported the smallest frequency (58.5%).

REAPS summary scores for diet quality were similar across age groups, with average scores near 28 for each individual age group (Table 2). Nearly half of the former players ate ≥8 ounces of meat per day, whereas about 20% had ≤2 servings of fruit and 2 servings of whole grain products per day (Table 3). Among REAPS items not included in the summary score, 82% indicated that they eat at home rather than eating out, and 80% reported a high degree of willingness to make changes to eating habits to be healthier (Table 3).

Average nightly sleep duration for this sample was just under 8 hours/night (Table 2). Former players between 30 and 49 years of age reported the lowest average number of hours/night of sleep (7.3), and those aged 40 to 49 years also reported the lowest frequency of sleeping between 7 and 9 hours/night (60.1%). The longest average nightly sleep duration was observed in the oldest former player group, those aged 70+ years, at 8.4 hours/night; however, the highest proportion of participants sleeping within the recommended range was observed in the participants <30 years old (72.9%; Table 2). Sleep disturbance T-scores approximated normative values (mean ± SD = 50 ± 10) in the full sample and for each separate age group (Table 2).

Associations of Health-Promoting Behaviors With Factors Related to Well-Being

Meaning and Purpose, Self-Efficacy, and Ability to Participate in Social Roles and Activities in our sample approximated normative values for the general population across all age groups (Table 1 and Figure).

Table 1. Sample Characteristics (n = 1784)[a]

	Full Sample With No Imputed Data n=1784	Full Sample After Multiple Imputation (Pooled) n=1784
Age, y, mean (SD)	52.3 (16.3)	52.3 (16.3)
Missing, n (%)	0 (0.0)	–
Body mass index, kg/m^2, mean (SD)	30.8 (4.6)	30.8 (4.6)
Missing, n (%)	17 (0.9)	–
Race/ethnicity, n (%)		
White/non-Hispanic	1041 (58.4)	1048 (58.6)
Non-White	732 (41.0)	736.4 (41.3)
Missing, n (%)	11 (0.6)	–
Relationship status, n (%)		
Married or cohabitating	1419 (79.5)	1419 (79.5)
Not married or cohabitating or other relationship status	365 (20.5)	365 (20.5)
Missing, n (%)	0 (0.0)	–
Frequency of alcohol use, n (%)		
Never	320 (17.9)	324.6 (18.2)
Monthly or less	351 (19.7)	359.2 (20.1)
2–4 times/mo	464 (26.0)	472.8 (26.5)
2–3 times/wk	350 (19.6)	356.0 (20.0)
4 or more times/wk	270 (15.1)	271.4 (15.2)
Missing, n (%)	29 (1.6)	–
PROMIS Meaning and Purpose T-score, mean (SD)	53.1 (10.9)	53.1 (11.0)
Missing, n (%)	44 (2.5)	–
PROMIS Self-Efficacy T-score, mean (SD)	49.8 (11.8)	49.8 (11.9)
Missing, n (%)	56 (3.1)	–
PROMIS Ability to Participate in Social Roles and Activities T-score, mean (SD)	51.3 (9.1)	51.3 (9.1)
Missing, n (%)	20 (1.1)	–
PROMIS Physical Function T-score, mean (SD)	45.5 (8.9)	45.5 (9.0)
Missing, n (%)	82 (4.6)	
PROMIS Pain Interference T-score, mean (SD)	56.3 (9.3)	56.4 (9.3)
Missing, n (%)	31 (1.7)	–
PROMIS Emotional Support T-score, mean (SD)	52.3 (9.4)	52.3 (9.5)
Missing, n (%)	48 (2.7)	–
Engagement in sitting activities (at a desk, reading, talking to friends), d/wk mean (SD)	4.6 (2.2)	4.5 (2.2)
Missing, n (%)	280 (15.7)	–
Time spent looking at a screen to watch a show (television, computer, tablet, phone), d/wk mean (SD)	5.8 (1.8)	5.8 (1.8)
Missing, n (%)	153 (8.6)	–

Abbreviations: PROMIS, Patient Reported Outcomes Measurement Information System; SD, standard deviation.

[a] Descriptive information as well as behavioral and self-reported functioning both before imputation of missing data and afterward. The multiple imputation procedure is detailed in the Supplement Material. Pooled frequency estimates from multiple imputations may not reflect whole numbers as a result of the pooling of data across imputation iterations.

Meaning and Purpose. In the full sample, more frequent moderate-to-vigorous exercise and less disturbed sleep were associated with greater Meaning and Purpose (Table 4). Among separate age groups, moderate-to-vigorous exercise was only associated with Meaning and Purpose among participants 50 to 59 years of age, and sleep disturbance was associated with all age ranges except <30 years of age. Longer sleep durations were also associated with lower Meaning and Purpose only among those 70+ years of age (Table 4).

Self-Efficacy. In the full sample, less disturbed sleep was associated with greater Self-Efficacy (Table 4). Among separate age groups, a higher-quality diet was associated with better Self-Efficacy among participants <30 and between 30 and 39 years of age, moderate-to-vigorous exercise was significant only among participants 40 to 49 years old, and sleep disturbance was significant among all age groups. Longer sleep durations were associated with lower Self-Efficacy only in those 70+ years of age (Table 4).

Ability to Participate in Social Roles and Activities. In the full sample, more frequent moderate-to-vigorous exercise and less disturbed sleep were associated with better Ability to Participate in Social Roles and Activities (Table 4). Within separate age groups, moderate-to-vigorous exercise among participants 40 to 49 and 60 to 69 years of age, sleep disturbance among all age groups except <30 years of age, and average nightly sleep among those 70+ years of age were all significantly associated with better Ability to Participate in Social Roles and Activities. Additionally, more frequent engagement in resistance training exercise was associated with better Ability to Participate in Social Roles and Activities only among participants ≤30 years of age (Table 4).

Sensitivity Analyses With Concussion History. Sensitivity analyses showed that the statistically significant health-promoting behavior predictors in each model did not change when concussion history was included (Supplemental Material).

DISCUSSION

In this large sample of former NFL players, we observed significant associations among modifiable, health-promoting

Table 2. Health-Promoting Behaviors Across the Lifetime[a]

	Range/Interpretation	Full Sample, Preimputation n=1784[b]	Full Sample, Postimputation n=1784	<30 Years Old n=150	30–39 Years Old n=360	40–49 Years Old n=285	50–59 Years Old n=321	60–69 Years Old n=360	70+ Years Old n=308
Moderate-to-vigorous exercise	0–7 days per week	3.0 (1.0, 4.0)	3.0 (2.0, 4.0)	3.0 (2.0, 4.3)	3.0 (1.7, 4.2)	3.0 (1.0, 4.0)	3.0 (1.8, 4.0)	3.0 (2.0, 4.9)	3.0 (1.9, 5.0)
Five or more days per week of moderate-to-vigorous exercise[c]	Dichotomous, yes/no, n (%)	395 (24.5%)	424.3 (23.8%)	36.8 (24.5%)	75.8 (21.1%)	59.5 (20.9%)	73.2 (22.8%)	91.7 (25.5%)	87.3 (28.3%)
Resistance training	0–7 days per week	2.0 (0.0, 3.0)	2.0 (1.0, 3.0)	3.0 (2.0, 5.0)	3.0 (1.4, 4.4)	2.0 (0.0, 3.1)	2.0 (0.0, 3.0)	2.0 (1.0, 3.0)	2.0 (0.0, 3.0)
Two or more days per week of resistance training[c]	Dichotomous, yes/no, n (%)	989 (65.7%)	1174.4 (65.8%)	119.3 (79.5%)	251.4 (69.8%)	177.1 (62.1)	207.3 (64.6%)	239.1 (66.4)	180.2 (58.5%)
Other wellness activities	0–7 days per week	0.0 (0.0, 0.0)	1.0 (0.0, 2.0)	0.7 (0.0, 2.0)	0.8 (0.0, 2.0)	1.0 (0.0, 2.0)	0.9 (0.0, 2.1)	1.0 (0.0, 2.1)	1.0 (0.0, 2.9)
Combined moderate-to-vigorous exercise and resistance training sessions[d]	0–14 sessions per week	5.0 (2.0, 7.0)	5.0 (3.0, 8.0)	6.0 (4.0, 8.0)	5.9 (3.4, 8.0)	5.0 (2.1, 7.0)	5.0 (3.0, 7.0)	5.0 (3.0, 8.0)	5.2 (2.9, 7.8)
Combined moderate-to-vigorous exercise, resistance training, and other wellness activities[e]	0–21 sessions per week	5.0 (2.0, 8.0)	6.3 (4.0, 9.0)	7.1 (5.0, 10.0)	6.8 (4.4, 9.4)	6.0 (3.1, 9.0)	6.2 (4.0, 9.0)	6.9 (4.0, 9.0)	6.8 (3.8, 9.7)
REAPS summary score	Summary score range 13–39, higher = better diet quality	28.0 (4.3)	28.0 (4.5)	27.9 (4.2)	27.9 (4.5)	27.8 (4.8)	28.0 (4.5)	28.4 (4.5)	27.8 (4.3)
Nightly sleep duration	Hours per night	7.7 (1.4)	7.7 (1.4)	7.8 (1.2)	7.3 (1.2)	7.3 (1.4)	7.5 (1.3)	7.9 (1.4)	8.4 (1.4)
Recommended sleep duration (7–9 hours/night)[c]	Dichotomous, yes/no, n (%)	1117 (62.6)	1167.7 (65.5)	109.4 (72.9)	238.2 (66.2)	171.4 (60.1)	207.9 (64.8)	236.1 (65.6)	204.7 (66.5)
Sleep disturbance	T-score, higher = more disturbed sleep	52.6 (6.5)	52.6 (6.7)	51.8 (5.9)	52.8 (6.5)	53.9 (7.0)	53.6 (7.2)	52.1 (6.7)	50.9 (5.9)

Abbreviation: REAPS, Rapid Eating Assessment for Participants (higher scores indicate better diet quality).

[a] Values represent median (interquartile range) or frequency n (%) for each item. Medians, interquartile ranges, and frequencies postimputation (in the full group and each age group) represent pooled data from across the 10 multiple imputation iterations. As such, these values in the pooled results may not be whole numbers.

[b] The number of missing responses from the initial (preimputation) data set for each behavior were moderate-to-vigorous exercise (n = 175; 9.8%), resistance training (n = 279; 15.6%), and other wellness activities (n = 649; 36.4%); REAPS summary score (n = 205; 11.5%); nightly sleep duration (n = 94; 5.3%); and sleep disturbance (n = 98; 5.5%).

[c] One hundred and fifty minutes per week of moderate-to-vigorous exercise (eg, 5 days at 30 minutes per session) and 2 days per week of resistance training are recommendations put forth by the US Department of Health and Human Services,[33] 7 to 9 hours of sleep is recommended by the American Academy of Sleep Medicine and Sleep Research Society,[34] and full-sample preimputation frequencies represent the proportion who reported meeting each criterion among those who responded to each item before imputation of missing data.

[d] Combined moderate-to-vigorous exercise and resistance training sessions were calculated as the sum of each individual category.

[e] Combined moderate-to-vigorous exercise, resistance training, and other wellness activities were calculated as the sum of each individual category.

Table 3. REAPS Individual Scored Item Responses[a]

	Usually/Often (Item Score = 1)	Sometimes (Item Score = 2)	Rarely/Never (Item Score = 3)	Does Not Apply to Me[b] (Item Score = 3)	Total Missing
Scored REAPS items: "In an average week, how often do you:", *n* (%)					
1. Skip breakfast?	524 (29.4)	447 (25.1)	767 (43.0)	NA	46 (2.6)
2. Eat <u>4 or more</u> meals from sit-down or take-out restaurants?	311 (17.4)	589 (33.0)	813 (45.6)	NA	71 (4.0)
3. Eat <u>less than 2 servings</u> of whole grain products or high fiber starches a day? Serving = 1 slice of 100% whole grain bread; 1 cup whole grain cereal like Shredded Wheat, Wheaties, Grape Nuts, high fiber cereals, oatmeal, 3–4 whole grain crackers, ½ cup brown rice or whole wheat pasta, boiled or baked potatoes, yuca, yams, or plantain	368 (20.6)	720 (40.4)	629 (35.3)	NA	67 (3.8)
4. Eat <u>less than 2 servings</u> of fruit a day? Serving = ½ cup or 1 medium fruit or ¾ cup of 100% fruit juice	392 (22.0)	783 (43.9)	549 (30.8)	NA	60 (3.4)
5. Eat <u>less than 2 servings</u> of vegetables a day? Serving = ½ cup vegetables or 1 cup leafy raw vegetables	286 (16.0)	785 (44.0)	656 (36.8)	NA	57 (3.2)
6. Eat or drink <u>less than 2 servings</u> of milk, yogurt, or cheese a day? Serving = 1 cup milk or yogurt, 1½–2 ounces cheese	575 (32.2)	604 (33.9)	546 (30.6)	NA	59 (3.3)
7. Eat <u>more than 8 ounces</u> (see sizes below) of meat, chicken, turkey, or fish <u>per day</u>?	870 (48.8)	617 (34.6)	213 (11.9)	40 (2.2)	44 (2.5)
Note: 3 ounces of meat or chicken is the size of a deck of cards or ONE of the following: 1 regular hamburger, 1 chicken breast or leg (thigh and drumstick), or 1 pork chop.					
8. Use <u>regular processed meats</u> (like bologna, salami, corned beef, hotdogs, sausage, or bacon) instead of low-fat processed meats (like roast beef, turkey, lean ham, or low-fat cold cuts/hotdogs)?	188 (10.5)	722 (40.5)	541 (30.3)	291 (16.3)	42 (2.4)
9. Eat <u>fried foods</u> such as fried chicken, fried fish, French fries, fried plantains, tostones, or fried yuca?	195 (10.9)	893 (50.1)	655 (36.7)	NA	41 (2.3)
10. Eat <u>regular potato chips, nacho chips, corn chips, crackers, regular popcorn, or nuts</u> instead of pretzels, low-fat chips or low-fat crackers, or air-popped popcorn?	305 (17.1)	836 (46.9)	380 (21.3)	222 (12.4)	41 (2.3)
11. <u>Add butter, margarine, or oil</u> to bread, potatoes, rice, or vegetables at the table?	495 (27.7)	764 (42.8)	485 (27.2)	NA	40 (2.2)
12. Eat <u>sweets</u> like cake, cookies, pastries, donuts, muffins, chocolate, and candies more than 2 times per day?	325 (18.2)	777 (43.6)	636 (35.7)	NA	46 (2.6)
13. <u>Drink 16 ounces or more</u> of nondiet soda, fruit drink/punch, or Kool-Aid a day? *Note: 1 can of soda = 12 ounces.*	173 (9.7)	382 (21.4)	1181 (66.2)	NA	48 (2.7)

Abbreviation: NA, not available; REAPS, Rapid Eating Assessment for Participants-Short Version.

[a] One or more REAPS items were missing for 205 total participants (11.5%). Among REAPS items not used for the summary score, 1461 participants (81.9%) responded *yes* to the item, "You or a member of your family usually shops and cooks rather than eating sit-down or take-out restaurant food;" 1474 participants (82.6%) responded *yes* to the item, "Usually feel well enough to shop or cook." In response to the question, "How willing are you to make changes in your eating habits in order to be healthier?" (rated from 1 [*very willing*] to 5 [*not at all willing*]), 980 participants (54.9%) selected 1, 456 (25.6%) selected 2, 226 (12.7%) selected 3, 64 (3.6%) selected 4, 21 (1.2%) selected 5, and 37 (2.1%) did not respond to this item.

[b] The *Does not apply to me* option is only provided for items 7, 8, and 10.

behaviors and multiple factors related to well-being. Specifically, sleep disturbance was associated with all self-reported outcomes across most age groups, and exercise, diet, and sleep behaviors were more sparsely associated with select age groups and outcomes. These findings may be important to inform interventions that improve health and well-being in former NFL players and other professional athletes.

Exercise and Other Wellness Activities

Overall, only 23.8% of all participants participated in ≥5 days/week of moderate-to-vigorous activity, whereas most former NFL players reported participating in moderate-to-vigorous exercise fewer than half of the days in each week. Study participants did not report duration of participation in each exercise session, so we cannot directly classify whether these former players were meeting recommendations for American adults regarding moderate-to-vigorous exercise: 150 to 300 minutes per week of moderate or 75 to 150 minutes of vigorous activity or equivalent combination.[32] Although this is a limitation of this study, our data suggest that many former NFL players may not have been meeting those recommendations, and this is something that should be evaluated more directly in clinical settings and future research to determine aerobic exercise engagement more specifically. Conversely, most players reported >2 days/week of resistance training, which is in line with current recommendations.[32] Taken together, these seminal data on exercise-related behaviors in former NFL players show that most players do not abandon exercise after their professional career has ended, and approximately one-quarter may

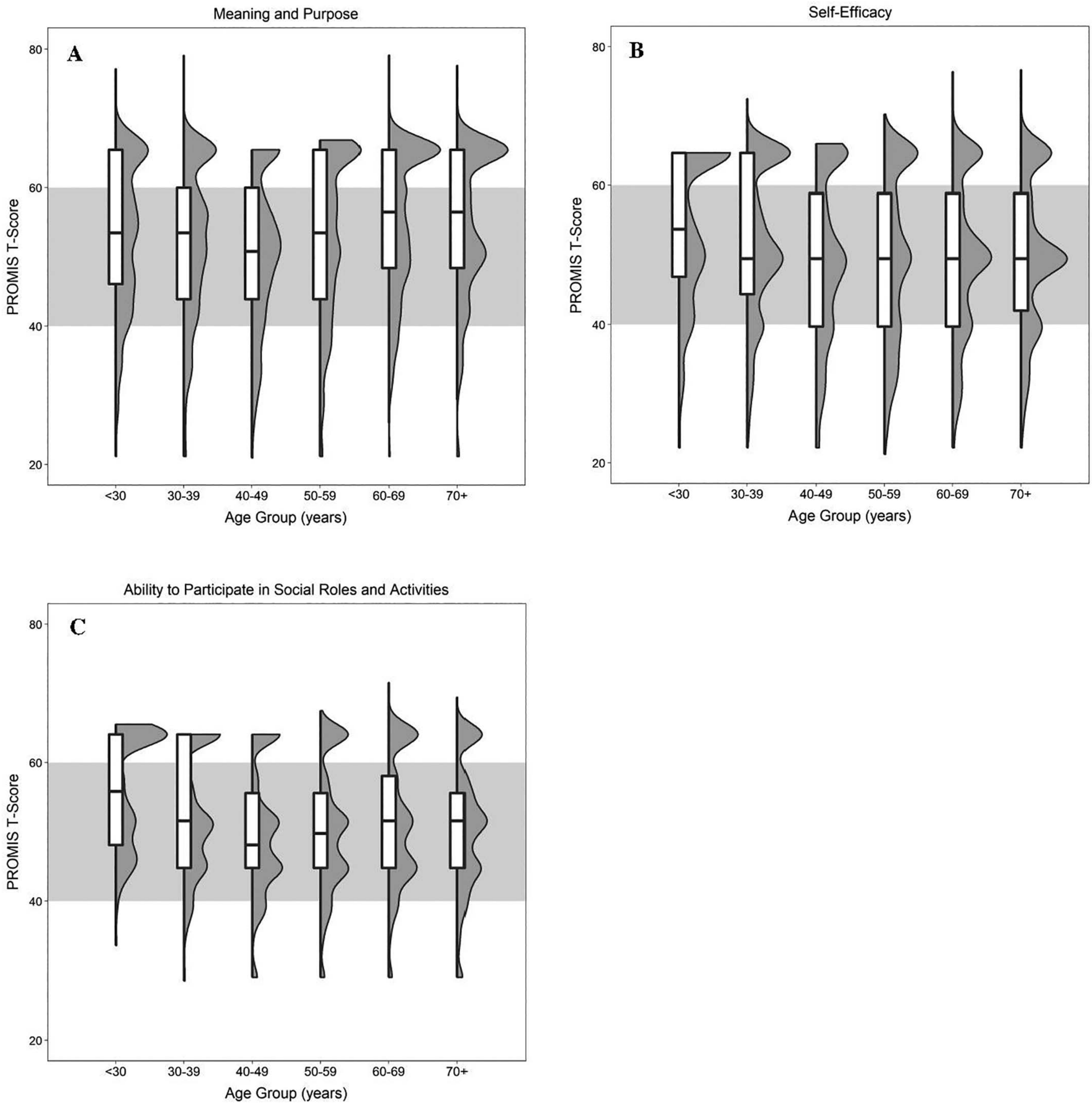

Figure. Factors associated with well-being by age group. Patient Reported Outcome Information System (PROMIS) measure T-scores are presented for each age group after multiple imputations for each of the following 3 primary outcome domains: Meaning and Purpose (A), Self-Efficacy (B), and Ability to Participate in Social Roles and Activities (C). Higher scores indicate better outcomes for all 3 measures. The box plots show the median and interquartile ranges, and the half-violin plots show the density of T-scores within each age group for each PROMIS domain. The gray rectangles highlight the area from 1 standard deviation below (T-score = 40) to 1 standard deviation above (T-score = 60) the normative population mean (T-score = 50).

still be highly engaged in aerobic and resistance training activities as evidenced by a median of 5 combined sessions per week. As a result, former players may be open to clinical exercise prescriptions and recommendations to improve their health and well-being.

Clinical and lifestyle interventions that help former NFL players engage in aerobic exercise activities may be important given findings from this study. More frequent moderate-to-vigorous exercise was associated with more adaptive (ie, better) outcomes among all of the well-being-related measures in our study, particularly among those between 40 and 59 years of age (Table 4). These findings suggest that moderate-to-vigorous exercise has a particularly meaningful relationship with well-being among former professional football players in these midlife years, despite negligible differences in weekly moderate-to-vigorous exercise participation between age groups. It is possible that former players in this age group have the most to gain from exercise in this period of

Table 4. Associations Between Health-Promoting Behaviors and Well-Being in Former National Football League Players

Group	Adjusted R^2[a]	Diet Quality β (Standard Error)	Moderate-to-Vigorous Exercise β (Standard Error)	Resistance Training β (Standard Error)	Other Wellness Activities β (Standard Error)	Average Nightly Sleep Duration β (Standard Error)	Sleep Disturbance T-Score β (Standard Error)
Meaning and Purpose							
Full sample	.379	0.000 (0.022)	0.068 (0.025)[c]	0.021 (0.027)	–0.004 (0.022)	–0.029 (0.021)	–0.196 (0.024)[d]
<30 years old	.349	0.044 (0.079)	0.084 (0.099)	0.068 (0.083)	0.013 (0.083)	–0.029 (0.100)	–0.086 (0.090)
30–39 years old	.288	0.046 (0.052)	0.007 (0.061)	0.060 (0.062)	0.025 (0.057)	0.026 (0.055)	–0.194 (0.056)[d]
40–49 years old	.406	–0.009 (0.053)	0.104 (0.064)	–0.031 (0.065)	0.038 (0.052)	0.049 (0.053)	–0.161 (0.58)[c]
50–59 years old	.478	–0.006 (0.053)	0.138 (0.055)[b]	0.007 (0.058)	–0.056 (0.053)	0.026 (0.052)	–0.178 (0.049)[d]
60–69 years old	.375	–0.011 (0.044)	0.017 (0.053)	0.066 (0.056)	0.010 (0.044)	–0.046 (0.045)	–0.217 (0.051)[d]
70+ years old	.346	–0.055 (0.059)	0.058 (0.057)	–0.002 (0.061)	–0.051 (0.054)	–0.176 (0.051)[d]	–0.285 (0.069)[d]
Self-Efficacy							
Full sample	.370	0.035 (0.022)	0.041 (0.025)	–0.007 (0.026)	–0.006 (0.024)	–0.035 (0.021)	–0.185 (0.024)[d]
<30 years old	.414	0.190 (0.078)[b]	–0.130 (0.097)	0.001 (0.079)	0.046 (0.078)	–0.037 (0.091)	–0.263 (0.084)[c]
30–39 years old	.319	0.114 (0.046)[b]	0.021 (0.056)	0.015 (0.056)	–0.055 (0.053)	–0.004 (0.051)	–0.149 (0.051)[c]
40–49 years old	.434	–0.028 (0.054)	0.151 (0.065)[b]	–0.085 (0.066)	0.046 (0.055)	–0.014 (0.055)	–0.189 (0.060)[c]
50–59 years old	.444	–0.020 (0.049)	0.003 (0.052)	0.094 (0.058)	–0.001 (0.057)	–0.008 (0.051)	–0.194 (0.049)[d]
60–69 years old	.310	0.058 (0.046)	0.027 (0.061)	0.001 (0.060)	–0.024 (0.048)	–0.017 (0.047)	–0.185 (0.054)[d]
70+ years old	.278	–0.033 (0.060)	0.051 (0.063)	–0.056 (0.069)	–0.003 (0.052)	–0.135 (0.055)[b]	–0.185 (0.071)[d]
Ability to Participate in Social Roles and Activities							
Full sample	.652	–0.002 (0.016)	0.065 (0.018)[d]	0.020 (0.020)	–0.002 (0.020)	–0.027 (0.016)	–0.137 (0.017)[d]
<30 years old	.591	0.017 (0.057)	–0.066 (0.073)	0.188 (0.061)[c]	–0.046 (0.065)	0.110 (0.066)	–0.023 (0.065)
30–39 years old	.587	0.011 (0.039)	0.075 (0.045)	0.005 (0.046)	0.016 (0.040)	0.026 (0.039)	–0.127 (0.041)[c]
40–49 years old	.667	0.048 (0.039)	0.101 (0.049)[b]	–0.035 (0.050)	0.042 (0.043)	0.005 (0.040)	–0.206 (0.045)[d]
50–59 years old	.684	–0.024 (0.036)	0.068 (0.038)	0.038 (0.041)	0.015 (0.037)	–0.017 (0.038)	–0.128 (0.036)[d]
60–69 years old	.688	–0.047 (0.033)	0.093 (0.039)[b]	–0.017 (0.042)	–0.005 (0.036)	–0.028 (0.035)	–0.084 (0.037)[b]
70+ years old	.631	0.005 (0.044)	0.001 (0.045)	0.038 (0.049)	–0.063 (0.043)	–0.120 (0.038)[c]	–0.244 (0.052)[d]

[a] Adjusted R^2 is presented as the average value across the 10 dataset imputations. Models included the primary predictors presented in this table as well as demographic (age, race/ethnicity, and marital status), behavioral (frequencies of alcohol intake, prolonged sitting, and screen time), and functional (Physical Functioning, Pain Interference, and Emotional Support) covariates; however, age was not included in the models for separate age groups. β is the standardized β-weight, and standard errors are from the pooled linear regression models using predictor and response variable *z* scores.

[b] $P < .05$.

[c] $P < .01$.

[d] $P < .001$.

life, when they are also reporting worse functioning and well-being overall than their younger and older counterparts. For example, in recent work with an overlapping sample, former players between 40 and 59 years of age reported less adaptive (ie, worse) functioning than both younger and older players on measures of anxiety, depressive symptoms, and emotional-behavioral dyscontrol, and moderate-to-vigorous exercise participation was also associated with better outcomes across each of these measures.[2,17] In combination with previous work, our study supports the need to identify exercise intervention targets, such as engaging in more frequent moderate-to-vigorous aerobic exercise, as a strategy for improving well-being alongside the prevention of numerous noncommunicable disorders that commonly occur in mid-to-later life, including cardiovascular disease and dementia.[2–4] Clinicians treating patients in this population should also consider the roles that injury, surgery, and other comorbidity history play in affecting both engagement with exercise and feelings of well-being over time.

Diet Quality

Overall diet quality scores were relatively homogenous across age groups. Most participants reported that they usually/often or sometimes did not meet REAPS item benchmarks (Table 3). The lowest scoring item overall was related to frequent consumption of $\geq$8 ounces of meat per day, consistent with a prior study of former football players using a longer REAPS instrument.[3] We did not measure dietary preferences in this study, so we cannot speak to whether participants were following vegetarian, vegan, or other dietary patterns that intentionally limited consumption of meat. Still, responses for individual REAPS items in our study denote room for improvement in multiple domains of dietary intake. More than 80% of participants indicated that they would be willing to make changes in their eating habits to be healthier, and, therefore, dietary intervention could be a beneficial clinical target alongside exercise and sleep. There is no well-established threshold or screening criteria for REAPS summary scores to interpret "healthy" eating versus not healthy eating; however, the average summary score for former NFL players in our study (28.0 $\pm$ 4.3) was below average scores reported in generally healthy young adults (33.6 $\pm$ 3.1) and similar to scores reported in a sample of middle-aged individuals seeking weight-loss surgery (28.3 $\pm$ 4.0).[25,26] REAPS summary scores can be used as a starting point for identifying who may need specific improvements to dietary habits, as may be informed by addressing specific items within the REAPS questionnaire. Interventions centered on individual self-efficacy may promote healthy eating behaviors,[35] and this framework may benefit former NFL players such as those in our study who are willing to change their eating to improve their health.

In a study of former football players by Hinton et al, better diet quality (higher REAP score) was positively associated with better outcome scores on crude, single-item measures of overall physical and mental health as well as fewer reported cognitive difficulties.[3] However, that study used a longer version of the instrument (31 items) than was used in our study (16 items), so we cannot directly compare summary scores between studies. In the present study, diet quality was significantly associated with better self-efficacy only among participants <40 years of age. It is possible that higher perceived self-efficacy in this sample influenced younger former players' choices to eat healthier. Alternatively, the ability to make healthy dietary intake choices, including financial freedom and access to a variety of foods, may support these players' feelings of self-efficacy.[35,36] Regardless, more information is needed as to why this pattern was observed in only the youngest age groups. Where dietary intake patterns such as the Mediterranean diet have been associated with reduced risks for numerous disease processes, there is little known about the effects of specific nutrients on subjective well-being.[37–40] It is reasonable to consider that because dietary intake is related to physical health status, better subjective well-being and related factors could be downstream effects of overall good physical health. Yet, the opposite may also be true that better subjective well-being facilitates engagement in health-promoting activities such as healthy eating. In this light, dietary intake is a valuable component of health and well-being. Dietary intake should be considered a readily modifiable intervention target in former football players.

Sleep Duration and Quality

Average sleep durations for all age groups were in accordance with current recommendations for healthy adults to obtain 7 to 9 hours of sleep/night.[33] Similarly, sleep disturbance scores approximated US norms across all ages.[19] Compared with the other age groups, former players aged 40 to 59 years reported the lowest proportions for meeting recommended sleep durations, and this coincided with the highest relative sleep disturbance scores. However, these differences were relatively small, particularly for sleep disturbance scores. Possible reasons for these age-dependent patterns could be familial (eg, number of young children) or vocational (eg, early building of a new career after professional football) or related to myriad other factors that were not measured in this study. Former players 70+ years of age were the only ones to report average sleep of more than 8 hours per night, and longer sleep durations were associated with worse outcomes in this group alone. In the general population, sleep duration generally declines with older age, where average nightly sleep durations appear to plateau around 7 hours/night after age 40.[41] We are unable to determine what specific factors are associated with the discrepancy between participants in our study and expected changes in the general population. One possible explanation could be the relative prevalence of mild cognitive impairment and dementia in former football players, which, although not included in the present study, also increase in prevalence with older age.[10–12,42–44] Mild cognitive impairment and dementia-related conditions are simultaneously related to longer sleep durations and worse health-related quality of life, potentially resulting from reduced independence in daily life, which are each related to measures of well-being.[45,46] More work is needed to understand the prevalence and effects of mild cognitive impairment and dementia-related conditions in former NFL players, particularly toward measuring their associations with other facets of health and well-being and identifying points for intervention. Monitoring clinical history and comorbidity in former football players may be essential for understanding and intervening on health-related behaviors like sleep in clinical practice. Our study findings support the premise that sleep duration and other facets of sleep hygiene are potentially actionable clinical targets to improve well-being in former football players.

Further Considerations

Comorbidities, injury history, and social-behavioral factors might be associated with both participation in health-promoting behaviors and self-reported factors related to functioning and well-being. However, health promotion and morbidity prevention strategies in clinical practice also need to account for the application of this knowledge in real-world settings, including factors that impede or support their implementation. Therefore, evaluation of barriers and facilitators for meeting established health-behavior guidelines and recommendations by former NFL players could help inform the implementation of interventions to improve health and well-being in this population, potentially including behavioral change approaches.[35,47]

Limitations

Despite our large sample size, the survey response was relatively low (a minimum response frequency of 1784/15 025 [11.9%]), and as a result, our findings may lack generalizability across all former NFL players.[2] Given the self-reported nature of the questionnaire, participants may have under-estimated/overestimated their engagement in health-promoting behaviors. Further, we can only make inferences on behaviors and factors related to well-being within the relatively narrow time frame antecedent to their completion of the study questionnaire. However, the health-promoting behaviors and well-being outcomes were reflective of the month preceding study participation and may therefore be a fair representation of the relationship in that frame. Importantly, some participants submitted their questionnaire to us in electronic or paper format during the first month after the coronavirus disease 2019 national emergency declaration (March 13, 2020), but we are unable to determine how many of those forms were actually completed within this timeframe. The decision to extract data for analyses was informed, in part, by drastic slowing of survey responses and the beginning of the pandemic. That said, there is not likely to be a meaningful proportion of participants who completed the questionnaire in this time frame compared with those who did not. Ultimately, it cannot be determined how this phase of the pandemic might have affected participants' engagement in exercise, diet, and sleep behaviors. Longitudinal studies are needed to understand the evolving nature of health, well-being, and behaviors in former NFL players over time. Future studies should use objective measures where possible (eg, actigraphy) and also account for medical diagnoses, disabilities, socioeconomic status, and other barriers and facilitators to meeting recommendations for health-related behaviors, such as personal (eg, chronic injury), interpersonal (eg, social support), and environmental (eg, presence of sidewalks in the community) factors.

CONCLUSIONS

Lower sleep disturbance and more frequent moderate-to-vigorous exercise frequency may represent important modifiable targets for improving overall health and well-being among former NFL players. Engagement in moderate-to-vigorous exercise may not match current recommendations for health maintenance and promotion and should be encouraged among former players. Responses to individual dietary intake questions suggest that many players are consistently making high-quality dietary choices, but there may still be room for improvement of overall dietary quality. Although most former players appear to be meeting sleep duration recommendations, disturbed sleep was associated with multiple factors related to well-being, and improvements in sleep quality may benefit former players of all ages.

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SUPPLEMENTAL MATERIAL

Supplemental Material. Supplemental Results.
Supplemental Table 1. Preimputation frequency of responses on the Patient Reported Outcomes Measurement Information System-29 Sleep Disturbance measure.
Supplemental Table 2. Preimputation frequency of responses on the Patient Reported Outcomes Measurement Information System Meaning and Purpose measure.
Supplemental Table 3. Preimputation frequency of responses on the Patient Reported Outcomes Measurement Information System Self-Efficacy measure.
Supplemental Table 4. Preimputation frequency of responses on the Patient Reported Outcomes Measurement Information System-29 Ability to Participate in Social Roles and Activities measure.
Supplemental Table 5. Preimputation frequency of responses on the Patient Reported Outcomes Measurement Information System-29 Physical Functioning measure.
Supplemental Table 6. Preimputation frequency of responses on the Patient Reported Outcomes Measurement Information System-29 Pain Interference measure.
Supplemental Table 7. Preimputation frequency of responses on the Patient Reported Outcomes Measurement Information System Emotional Support measure.
Supplemental Table 8. Sensitivity analyses: models with and without self-reported concussion history included.

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