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Friend Social Network Size Moderates the Association Between Age and Physical Activity Across Adulthood

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ABSTRACT

International Journal of Exercise Science 17(5): 1068-1082, 2024. Both physical activity and social network size decline as people age. However, limited research has examined if social network size and contact frequency differentially influence physical activity across the adult lifespan. This study aimed to assess if these social network characteristics moderated the relationship between age and physical activity level across adulthood. Multiple regression analyses were conducted to examine the main-effect association between age, past-week physical activity, and past-year physical activity, as well as the moderating effect of social network characteristics (i.e., friend network size, friend contact frequency, relative network size, and relative contact frequency) on age-physical activity associations. The results revealed that friend network size had moderated associations between age and past-week physical activity ($\beta = -7.03$; $p = .025$, $f^2 = 0.13$) and past-year physical activity ($\beta = -585.52$; $p = .017$, $f^2 = 0.15$). Specifically, adults who were older and had smaller friend networks performed more minutes of moderate–vigorous physical activity (MVPA) over the past week and past year; on the other hand, adults who were younger and had larger friend networks performed more minutes of MVPA over the past week and past year. Relative network size, friend contact frequency, and relative contact frequency did not moderate the relationship between age and past-week physical activity and past-year physical activity. These findings suggested that building friend networks throughout adulthood may help promote active living across the adult lifespan.

KEY WORDS: Aging, exercise, social network structure

INTRODUCTION

Physical activity contributes to healthy aging (16) by improving muscle mass and bone health, increasing cognitive performance, and reducing cardiometabolic risk factors (4). The Physical Activity Guidelines for Americans recommend that adults do at least 150 minutes of moderate-intensity exercise per week or 75 minutes of vigorous-intensity exercise per week exercise, or an equivalent combination of both (51). Despite the established benefits of physical activity, less than a quarter of adults meet the physical activity targets and more than a third of adults

routinely do no leisure-time physical activity at all (51). Further, there is an increasing proportion of adults failing to meet the recommended physical activity guidelines as age increases (52). For example, 25.4% of middle-aged adults 50–64 years, 26.9% of older adults between 65–74 years, and 35.3% of those aged 75 years and older do not meet the guidelines (53). A study conducted across 146 countries found that the prevalence of physical inactivity among adults 80 years or older is more than double that of younger adults aged 18–29 years (55% versus 19%) (40).

Multiple ecological models, including the Social Networks for Activity Promotion (SNAP) Model and Ecological Model of Active Living, have shown that social network characteristics, such as network size and frequency of contacts with others, may contribute to explaining variation in levels of physical activity (37–39, 41, 44). Prior literature has shown that adults with larger social networks and better social support tend to engage in more physical activity. For example, a study conducted among 14,595 young adults between the ages 24–32 found that individuals with larger social networks accumulated higher physical activity levels relative to those with smaller networks (17). Similarly, a systematic review showed that more physical activity-related support from family and friend networks corresponded to higher physical activity levels among adults aged over 60 (28). Additionally, social network characteristics change throughout adulthood, as people age (2, 56), and may contribute to variation in physical activity across the adult lifespan. For example, a review of 277 studies with longitudinal and cross-sectional designs concluded that social network size decreases throughout adulthood (56) potentially contributing to fewer social contacts and lower participation in social events as adults age (15, 23, 32, 56).

Despite variations in social network characteristics as people age, little research has explored whether social network size and contact frequency exert different effects on physical activity levels across the adult lifespan. To address this research gap, the current study aimed to investigate the moderating effect of social network size and contact frequency on the relationship between age and physical activity levels. Understanding the influence of these social network characteristics on physical activity for adults of varying ages could help inform the design of future physical activity interventions tailored to varying age groups and help promote active living.

Based on prior research, we first conducted preliminary analysis on the main effect associations between age, social network characteristics, and physical activity outcomes. We then hypothesized that social network characteristics would moderate the age-physical activity association. Specifically, we hypothesized that larger social networks and more frequent network contact would help attenuate age-related declines in physical activity over the past-week and the past-year (17, 28, 44).

METHODS

Participants

This cross-sectional study was conducted as part of a larger measurement validation study that took place over a period of four months between November 2020 to February 2021. A power analysis revealed that a sample of 200 participants would enable us to detect a small to medium effect size with a Cohen's *d* of 0.4 (43,54), statistical power of 0.80, alpha = 0.05, and a two-tailed test. Stratified random sampling was used to ensure inclusion of diverse age groups in this study. This study received approval from the Institutional Review Board at Pennsylvania State University. Prior to data collection, all participants provided informed consent by completing an online form. This research was carried out fully in accordance to the ethical standards of the *International Journal of Exercise Science* (35).

The study recruited participants through CloudResearch (https://www.cloudresearch.com), an online research platform connected to Amazon Mechanical Turk (MTurk). MTurk serves as an online crowdsourcing platform where researchers post Human Intelligence Tasks (HITs) as job assignments, and eligible MTurk workers (18 years of age or older) can complete these tasks for compensation. MTurk workers are assigned an Amazon Turk Worker ID, which is a unique identifier for volunteers who choose to register on the platform as workers to do various tasks in exchange for financial compensation. These volunteer workers have demographic characteristics similar to the overall internet population in the United States (US) (34). Each HIT includes a job title, description, compensation amount, and estimated completion time. MTurk workers meeting the criteria of a minimum approval rating of 90% and completing at least 100 HITs were considered eligible to participate in the study. MTurk data has been shown to be valid and reliable across a wide range of tasks and participant populations (29, 34, 46).

To be included in this study, participants were required to meet the following inclusion criteria: being ≥ 18 years of age, having proficiency in responding to written questions in English, having a minimum residency duration of six months at their current address, and being able to provide a valid Amazon Turk Worker ID for future communication. Additionally, participants were required to fall into one of two categories: "physically active" or "physically inactive." Consistent with the Physical Activity Guidelines for Americans, the definition of "physically active" encompassed engaging in at least 150 minutes per week of regular moderate–vigorous physical activity for at least one year and engaging in at least two different modes of physical activity such as strength training and another activity like walking or running (51). On the other hand, "physically inactive" referred to individuals who engaged in 60 minutes or less of regular moderate–vigorous physical activity per week for at least one year. The classification of participants was based on three brief and validated questionnaires (8, 11, 12, 25).

Individuals who met any of the following criteria were excluded from the study: pregnancy, difficulty walking three city blocks or having another medical condition restricting engagement in physical activity, residing in an institutionalized setting, being homeless, planning to move or relocate within the upcoming month, or providing an Amazon Turk Worker ID that had previously been recorded or received.

In addition, participants were recruited for the study based on the criteria established for the larger validation study. Specifically, individuals were selected from the states categorized as the "most" active and the "least" active in the US. These classifications were determined by the proportion of adults in each state who met the aerobic and muscle-strengthening guidelines between 2011 and 2019, as assessed by the Behavioral Risk Factor Surveillance System (7). The states considered the "most" active included Alaska, California, Colorado, Connecticut, District of Columbia (DC), Hawaii, New Mexico, Utah, Vermont, Washington, and Wyoming. The states classified as the "least" active were Alabama, Arkansas, Indiana, Kentucky, Louisiana, Mississippi, Missouri, North Dakota, Oklahoma, Tennessee, and West Virginia.

Protocol

The study link posted on MTurk provided a brief header describing the study, and after reviewing the online consent information, participants were given the option to provide their implied consent online. Those who consented were directed to complete a screening form lasting approximately 5–10 minutes, using a REDCap survey link (24). If participants completed the screening form and met the eligibility criteria, they were directed to complete an online questionnaire focused on the social environment, which took approximately 20 minutes. Eligible participants received an email with a REDCap link to the questionnaire, using their worker ID, within 24 hours. Participants were given a maximum of seven days to complete the questionnaire, and they received up to three email reminders to encourage their completion. Participants received $0.50 as compensation for completing the screening form and $1.50 for completing the questionnaire on the social environment. To verify survey completion and provide compensation, participants were given a unique code to copy and paste into the CloudResearch platform.

To ensure data quality, attention check questions were included in the surveys (47). These questions, blinded to respondents, involved providing age in the screening form and year of birth in survey 1, with the expectation that the difference between the two measures should not exceed one year. Additionally, the worker ID was cross-checked across all surveys, with the requirement that it should be identical for consistency. To automate the process, a syntax program was developed in SPSS to scan all the surveys for responses to the attention check questions. Participants who did not pass any of the attention check items were not included in the analyses.

Participants self-reported their biological age as the independent variable, which was measured as a continuous variable.

To capture a more comprehensive estimate of activity levels, the study assessed both past-week and past year total physical activity minutes as the dependent variables.

The National Center for Health Statistics (NCHS), a division of the Centers for Disease Control and Prevention (CDC), conducts the annual National Health Interview Survey (NHIS) (8). This survey covers multiple health-related topics, including physical activity, and offers a reliable

and valid assessment of moderate–vigorous physical activity and strength training over a one-week timeframe across various age groups (8, 48). For our analyses, the outcome variable was the total duration (in minutes) of moderate–vigorous activity performed within a one-week period.

The Chasan-Taber Physical Activity Questionnaire (CT-PAQ) evaluates the duration, frequency, and intensity of physical activities performed throughout an individual's lifetime (11, 12). For this study, a modified version of the CT-PAQ was employed to evaluate participants' physical activity over the past year. The CT-PQ has shown strong reliability (11) and concurrent validity across diverse adult age groups, as demonstrated by its correlation with activity scores derived from the questionnaire and physical activity log scores (12). The outcome variable analyzed in this study was the total number of weekly minutes engaged in moderate–vigorous activity over a one-year period.

The Berkman–Syme Social Network Index (SNI) was utilized to measure social network size and frequency of social contact (5) as the moderator variables. The SNI has shown acceptable psychometric properties across diverse adult age groups; test-retest reliability (α = 0.64–0.70) and construct validity (14,50). Participants were asked to select one of the following options to indicate their social network size: "None", "1 or 2", "3–5", "6–9", or "10 or more," which represents the number of close friends and relatives. These responses were then scored as 0 for having ≤ 2 friends or ≤ 2 relatives, and 1 for all other scores, following established procedures (30). Similarly, the frequency of social contact, specifically the monthly contact with those close friends or relatives, was scored as 0 for having ≤ 2 friends or ≤ 2 relatives, and 1 for all other scores (30). Higher scores indicate greater size of social network and increased frequency of social contact.

The analyses were adjusted for gender, ethnicity, race, education, and high/low active states, as these variables have been established as factors associated with age and physical activity (7, 22, 45, 55). To account for variations in COVID-19 severity across the various states measured, we included the COVID-19 seven-day case rate per 100,000 people as a continuous covariate in the analyses (9).

Statistical Analysis

Statistical analyses were conducted using SPSS Version 27 (IBM Corp., Armonk, NY, USA) with significance levels set at $p < 0.05$. Sample characteristics were evaluated using descriptive statistics. The Shapiro–Wilk test was used to assess the normality of the variables. Pearson's correlation was employed to examine the associations between study variables. Variables demonstrating high correlation ($r > 0.90$; indicating multicollinearity), as well as those that showed no correlation with the independent variable (age) or dependent variables (past-week or past-year physical activity) were not included in the models for hypothesis-testing (49). Predictor variables were mean centered prior to analyses. We conducted preliminary analyses of main effect associations between predictors of age, social network characteristics, and physical activity outcomes.

To examine the hypotheses on the moderating effects of social network characteristics (friend social network size, friend social network contact frequency, relative social network size, and relative social network contact frequency), two multiple regression analyses were conducted with past-week (i.e., NHIS moderate–vigorous) and past-year (i.e., CT-PAQ moderate–vigorous) physical activity as the two dependent variables in separate models. Participant age was included as one of the independent variables in all models. An interaction term was included in each regression model to examine the moderating influence of social network characteristics on the association between age and physical activity outcomes. The interaction term was created by multiplying age by each social network characteristic variable; age*friend network size, age*friend contact frequency, age*relative network size, age*relative contact frequency. The effect sizes of the parameter estimates for significant interactions in the moderation analyses were determined using Cohen's f-squared classification, with small effect size ($f^2 = 0.02$), medium effect size ($f^2 = 0.15$), and large effect size ($f^2 = 0.35$) (13). To identify a moderating effect, the interaction term must be significant at $p < 0.05$. Figure 1 illustrates a graphic depiction of the multiple moderation model that was examined for each regression analysis. All models were adjusted for gender, race/ethnicity, state-based physical activity level, and COVID-19 rates.

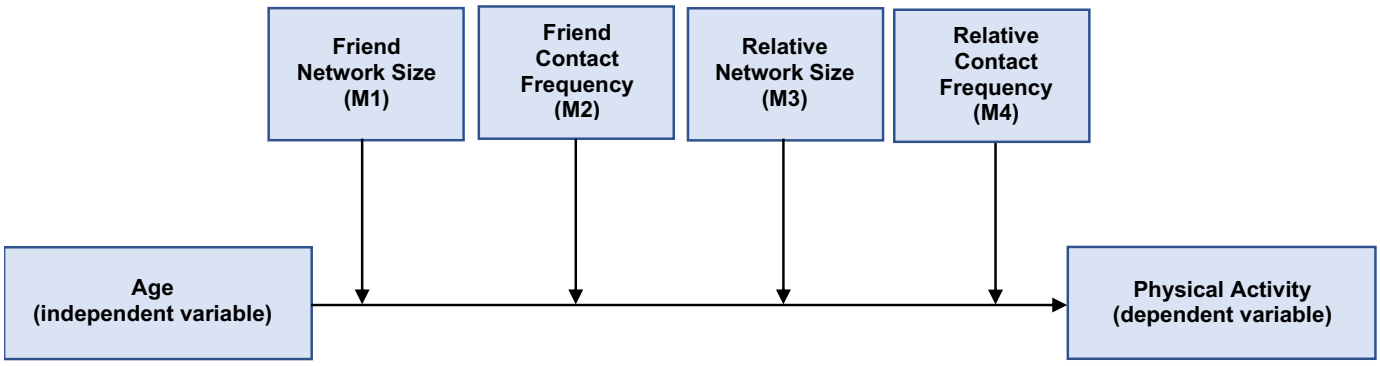

Figure 1. Conceptual illustration of multiple moderation model in the relationship between age and physical activity. "M" = Moderator.

RESULTS

Table 1 shows descriptive characteristics of the 205 participants included in the analyses. The majority of the participants were female (62.93%), White (85.37%), non-Hispanic/Latino (96.59%), and married (46.83%). Participants' ages ranged from 19 to 79 years with a mean age of 40.98 (SD = 12.89). Participants' education, income, health status, and physical activity levels varied widely. As shown in Table 2, preliminary analysis of the main effects revealed that age was significantly associated with both past-week ($\beta = 4.36$; $p = .003$) and past-year physical activity ($\beta = 303.12$; $p = .002$). Similarly, friend network size had significant main effects on both past-week ($\beta = 40.59$; $p = .005$) and past-year physical activity ($\beta = 2860.93$; $p = .006$). However, friend contact frequency (past-week: $\beta = 83.46$; $p = .377$; past-year: $\beta = 7257.07$; $p = .112$), relative network size (past-week: $\beta = -59.72$; $p = .268$; past-year: $\beta = -4022.59$; $p = .202$), and relative

contact frequency (past-week: β = 32.67; p = .310; past-year: β = 3909.64; p = .413) were not significantly associated with either past-week or past-year physical activity.

Table 2 presents the results of the multiple regression analysis for past-week and past-year physical activity. Similar moderation effects were observed for both past-week and past-year physical activity.

The first model for past-week physical activity indicated a significant interaction between age and friend network size (β = −7.03; p = .025, f^2 = 0.13), supporting the hypothesis that friend network size moderates the effect of age on past-week physical activity. Figure 2 presents the interaction effect, indicating that adults who were older and had a smaller friend network size performed more minutes of moderate–vigorous physical activity over the past week, whereas younger adults with a larger friend network size performed more minutes of moderate–vigorous physical activity over the past week. For example, a 70-year-old adult with a network size of 2 or fewer close friends, performed 63.57 more minutes of physical activity per week, on average, than a 70-year-old adult with a network size of 3 or more close friends. In contrast, a 19-year-old adult with a network size of 3 or more close friends performed 186.84 more minutes of physical activity per week, on average, than a 19-year-old adult with a smaller network size of 2 or fewer close friends. No significant moderation effects were observed between age and past-week physical activity for relative network size (β = −3.03; p = .183), friend contact frequency (β = 5.30; p = .154), and relative contact frequency (β = .04; p = .601).

Consistent with the first model for past-week physical activity, the second model for past-year physical activity showed that the interaction term for age and friend network size was significant (β = −585.52; p = .017, f^2 = 0.15), indicating that friend network size moderated the effect of age on past-year physical activity. As shown in Figure 3, adults who were older and had a smaller friend network size performed more weekly minutes of moderate–vigorous physical activity over one year, whereas younger adults with a larger friend network size performed more weekly minutes of moderate–vigorous physical activity over one year. For instance, a 70-year-old adult with a network size of 2 or fewer close friends, performed 102.62 more minutes of weekly physical activity over the past year, on average, than a 70-year-old adult with a network size of 3 or more close friends. In contrast, younger adults with a larger friend network size performed more weekly minutes of moderate–vigorous physical activity over one year. For example, a 19-year-old adult with a network size of 3 or more close friends performed 295.69 more weekly minutes of physical activity over the past year, on average, than a 19-year-old adult with a smaller network size of 2 or fewer friends. No significant moderation effects between age and past-week physical activity were observed for relative network size (β = −137.65; p = .278), friend contact frequency (β = 384.06; p = .117), and relative contact frequency (β = 90.04; p = .417).

Table 1. Sample characteristics.

Variable		*n* (%) or mean (SD)
Age (years), continuous		40.98 (12.89)
Gender[a]	Female	129 (62.93)
	Male	76 (37.07)
Ethnicity[b]	Not Hispanic/Latino	198 (96.59)
	Hispanic/Latino	7 (3.41)
Race[c]	American Indian/Alaskan Native	2 (0.98)
	Asian	14 (6.82)
	Black/African American	14 (6.82)
	White	175 (85.37)
Income[d]	< $30,000	46 (22.44)
	$30,000–$49,999	53 (25.85)
	$50,000−$69,999	40 (19.51)
	$70,000−$89,999	25 (12.20)
	$90,000−$109,999	18 (8.78)
	$110,000−$149,999	16 (7.80)
	≥ $150,000	7 (3.41)
Education[e]	High school/GED	25 (12.20)
	Some college	40 (19.51)
	2-year college degree	29 (14.15)
	4-year college degree	71 (34.63)
	Masters degree	31 (15.12)
	Doctoral degree	9 (4.39)
Marital Status[f]	Single/Never Married	66 (32.20)
	Married	96 (46.83)
	Divorced	22 (10.73)
	Separated	4 (1.95)
	Widowed	2 (0.98)
	Living with Partner	15 (7.32)
Met guidelines for moderate−vigorous physical activity per week (NHIS)[g]	≥ 150 minutes or ≥ 75 min of vigorous of physical activity	83 (40.49)
Met guidelines for moderate−vigorous physical activity per week over the past year (CT-PAQ)[h]	≥ 150 minutes or ≥ 75 min of vigorous of physical activity	82 (40.00)
Met guidelines for strength training[i]	≥ 2 times per week	98 (47.80)
Health Status[j]	Excellent	38 (18.54)
	Very Good	73 (35.61)
	Good	61 (29.76)
	Fair	30 (14.63)
	Poor	3 (1.46)

[a]Gender: 0 = Male, 1 = Female; [b]Ethnicity: 0 = Not Hispanic/Latino, 1 = Hispanic/Latino; [c]Race: 1 = American Indian/Alaskan Native, 4 = White; [d]Income: 1 = < $30,000 and 7 = ≥ $150,000; [e]Education: 1 = High school/GED, 6 = Doctoral Degree; [f]Marital status: 1 = Single/Never Married, 6 = Living with Partner; [g]Moderate−vigorous physical activity per week (NHIS): 0 = < 150 minutes or < 75 min of vigorous of physical activity, 1 = ≥ 150 minutes or ≥ 75 min of vigorous of physical activity; [h]Moderate−vigorous physical activity per week over the past year (CT-PAQ): 0 = < 150 minutes or < 75 min of vigorous of physical activity, 1 = ≥ 150 minutes or ≥ 75 min of vigorous of physical activity; [i]Strength training: 0 = < 2 times per week, 1= ≥ 2 times per week; [j]Health status: 1 = Excellent, 5 = Poor.

Table 2. Moderation analysis.

Variable	Past-Week Physical Activity[a] β (SE)	Past-Year Physical Activity[b] β (SE)
Age	4.36 (2.00)*	303.12 (153.14)*
Friend Network Size	40.59 (41.39)*	2860.93 (3168.42)*
Friend Contact Frequency	83.46 (52.98)	7257.07 (4055.82)
Relative Network Size	−59.72 (44.54)	−4022.59 (3410.17)
Relative Contact Frequency	32.67 (49.68)	3909.64 (3803.54)
Age x Friend Network Size	−7.03 (3.49)*	−585.52 (267.19)*
Age x Friend Contact Frequency	5.30 (4.41)	384.06 (337.96)
Age x Relative Network Size	−3.03 (3.13)	−137.65 (239.62)
Age x Relative Contact Frequency	.04 (3.70)	90.04 (283.14)
	Controls	
Gender	68.74 (35.53)*	6332.88 (2719.76)*
Race	26.43 (19.35)	2721.89 (1481.25)
Ethnicity	−8.72 (86.21)	−864.16 (6588.46)
State-Based Physical Activity Level	83.61 (34.10)	6925.90 (2610.26)
US COVID-19 7-Day Case Rate per 100,000	−.95 (.75)	−63.65 (57.36)

* $p < 0.05$. [a]Dependent Variable: NHIS Moderate–Vigorous Minutes in past week; [b]Dependent Variable: CT-PAQ Moderate–Vigorous Minutes in past year.

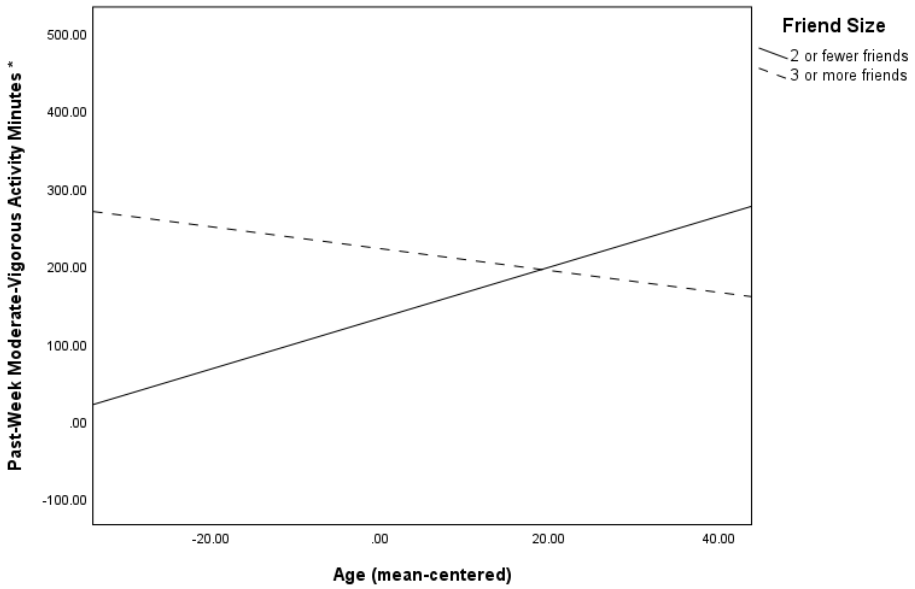

Figure 2. Graphic representation of the moderation of age by friend size on NHIS moderate–vigorous minutes of physical activity. All predictor variables were centered around the mean; thus, a negative value on the predictor axis indicates corresponding values less than the mean. *NHIS Moderate–Vigorous Minutes in past week.

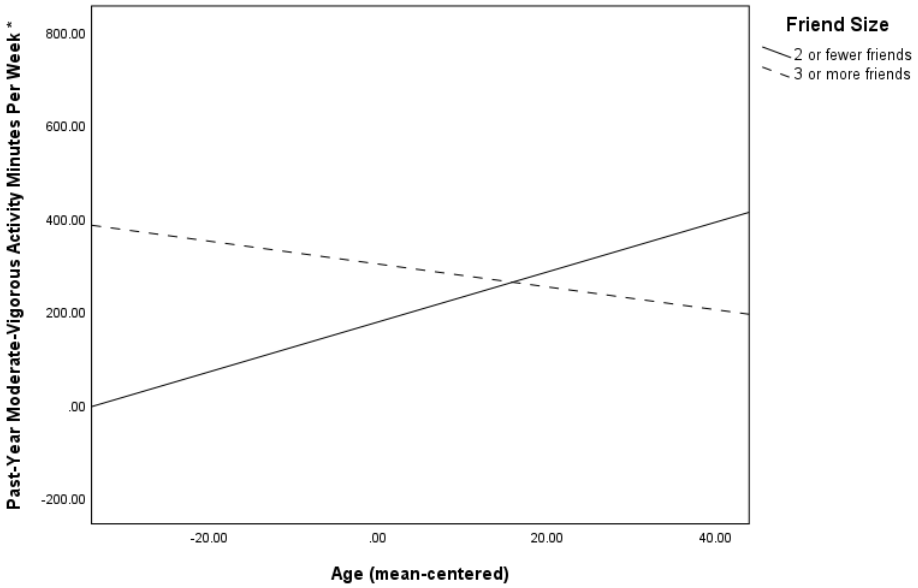

Figure 3. Graphic representation of the moderation of age by friend size on CT-PAQ moderate–vigorous minutes of physical activity. All predictor variables were centered around the mean; thus, a negative value on the predictor axis indicates corresponding values less than the mean. *CT-PAQ Moderate–vigorous Minutes in past year.

DISCUSSION

This study explored whether social network size and contact frequency moderate the strength of the relationship between age and physical activity. To our knowledge, this is among the first studies to examine the interaction of social network structural characteristics (i.e., social network size and social network contact frequency) with age in relation to past-week and past-year physical activity.

Results of the moderation analyses indicated that the interaction between friend network size and age was significant, suggesting that friend network size moderates the relationship between age and both past-week and past-year physical activity. Specifically, younger adults with a larger friend network size had more physical activity, whereas older adults with a smaller friend network size had more physical activity. On the other hand, relative network size, friend contact frequency, and relative contact frequency did not moderate the association between age and either past-week or past-year physical activity. These findings partially supported our hypothesis that, as age increases, adults have a smaller social network structure when compared to younger adults. However, in our study, as age increases, adults with a smaller friend network size unexpectedly had higher physical activity.

Our unexpected findings suggest that as age increases, the quality of relationships may be more important than social network size for explaining variations in physical activity levels (28, 44). In contrast, among younger adults, social network size may be more important than the quality of relationships for influencing physical activity. This is consistent with previous literature indicating that younger adults may be most interested in expanding their social networks, whereas as age increases, adults may become more interested in maintaining relationships in

their existing social network (6, 10, 21, 31, 57). As priorities change throughout adulthood, values and responsibilities tend to shift which may explain the difference in social network size between younger and older adults (15, 32, 56). For example, evidence suggests that younger adults may initially build larger social networks but may gradually prune their social networks as they age to exclude those members who are less emotionally satisfying to interact with (19, 21). Moreover, as individuals age, they often lose people in their social networks due to deaths, relocation, or other life events which could also be a primary reason for smaller networks as age increases (56). These pruning efforts may result in more satisfying and supportive relationships with remaining close friends who may provide greater support for physical activity (21).

The present study adds to literature showing the importance of social network structure on physical activity (1, 3, 18, 28) by illuminating the differential effect of social network size on physical activity across the adult lifespan. Based on these findings, future interventions to increase physical activity may benefit from helping younger adults to grow their social networks with a wide range of contacts, while helping older adults to maintain their existing close friendships. It should also be noted that our finding that friends appear to be more important than relatives for promoting physical activity across the adult lifespan is consistent with some literature (20, 27). These studies suggest that friendships play a crucial role in motivating individuals to engage in physical activity through various mechanisms, including social support, companionship during exercise, and creating of opportunities for shared physical activity. Friendships, characterized by mutual interests and emotional closeness, may create an environment that fosters encouragement and accountability for maintaining an active lifestyle. However, it is important to acknowledge that our findings also diverge from other literature (26, 28). Thus, future researchers may benefit from conducting longitudinal studies to more comprehensively assess the influence of different network members (e.g., friends, relatives, coworkers, and neighbors) on physical activity across multiple life domains (e.g., home, leisure, work, transportation) (17, 28, 42).

A strength of this study is the inclusion of both past-week and past-year physical activity assessments, together with consistent findings across both assessments, which increases confidence in the reliability of study findings. Relative to prior studies (17, 28), our study also uniquely included adults with wide variation in age, which allowed exploration of moderation effects for social networks across a broad range of the adult lifespan. Limitations of this study include the use of cross-sectional data based on convenience sampling, along with self-report data that may be subject to recall bias. Additionally, we did not examine other potentially salient moderator variables in addition to social network structure, such as neighborhood walkability (36), and loneliness (33). Lastly, considering the time period of this study, COVID-19 quarantine or isolation may have influenced participants' physical activity levels, and future studies in the post-pandemic period should be conducted to assess the stability of our findings.

Our findings indicate that social network size may exert different effects on physical activity across the adult lifespan. Among younger adults, those with a larger network size of close friends performed more moderate–vigorous physical activity, whereas older adults with a smaller network size of close friends performed more moderate–vigorous physical activity.

Relative network size, friend contact frequency, and relative contact frequency did not moderate the relationship between age and past-week physical activity and past-year physical activity. Future interventions to increase physical activity may benefit from exploring the effects of helping younger adults to grow their friend network size, while helping older adults to improve the quality of their existing social ties.

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