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Use of Dietary Supplements to Build Muscle and Physical Activity in U.S. Adults

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Abstract **Background**: Dietary supplements are consumable products that contain ingredients intended to supplement the diet. Dietary supplements are marketed to the public for various reasons, including improving one's body weight profile, energy, nutrition, sleep, beauty, athletic performance, mental and physical health, and disease risk. The evidence supporting many of these marketing claims is sparse. Furthermore, the extent to which dietary supplement use for a specific purpose influences physical activity (PA) in adult populations is unknown. The aim of this study was to examine the association between dietary supplement use for gaining muscle and PA in U.S. adults. **Methods**: Adults 20+ years of age from the 2017-2020 (pre-pandemic, 3.2 years) National Health and Nutrition Examination Survey (NHANES) were used. Participants were categorized into one of three supplement groups: uses a supplement to build muscle (USBM), uses a supplement for other reasons (USOR), or non-supplement user (NSU). PA variables included work (VWPA, MWPA), recreational (VRPA, MRPA), transportation (TPA), sedentary time (SED), moderate-to-vigorous PA (MVPA), met PA guidelines status (METPA), and physical inactivity (PIA). ANOVA and regression analyses were used while controlling for age, sex, race, income, and BMI. **Results**: Bivariate analyses showed that USBM adults had significantly greater VRPA (*Mean* = 168.6 min/week vs. *Mean* = 65.8 min/week, *p* = .0034), MVPA (*Mean* = 481.3 min/week vs. *Mean* = 228.5 min/week, *p* = .0019), METPA (*Mean* = 53.9% vs *Mean* = 38.5%, *p* = .0071), and significantly lower PIA (*Mean* = 34.8% vs *Mean* = 45.7%, *p* = .0275), than their counterparts, respectively. In the fully adjusted model predicting MVPA, USOR (*b* = -203, *p* = .0055) and NSU (*b* = -252, *p* = .0006) groups had significantly less MVPA than USBM. Furthermore, in the fully adjusted model predicting METPA, USOR (OR = 1.38, 95% CI: 1.18 – 1.61) and USBM (OR = 2.44, 95% CI: 1.47 – 4.05) groups had significantly greater odds of METPA, as compared to NSU. Finally, the supplement group-by-sex interaction (*p* = .0290) indicated that males (*Mean* = 561.7, *SE* = 93.3 min/week) in the USBM group had significantly greater MVPA than all other supplement groups, including USBM group females (*Mean* = 244.1, *SE* = 49.8 min/week). **Conclusion**: Results from this study indicate that U.S. adults taking supplements to build muscle report significantly more recreational PA than other supplement or non-supplement users. Furthermore, males taking supplements to gain muscle report significantly more MVPA than all other adults taking and not taking supplements.

Keywords: *nutrition, supplements, physical activity, MVPA, epidemiology, population health*

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1. Introduction

The National Institutes of Health (NIH) and Federal Drug Administration (FDA) both use similar definitions for a dietary supplement and cite the Dietary Supplement Health and Education Act of 1994 (DSHEA). The main characteristics of a dietary supplement are that it is a non-tobacco product, intended to supplement the diet, contains one or more dietary ingredients, is intended to be taken by mouth, and is labeled as a dietary supplement [1,2]. Consumers of dietary supplements have been growing as a population, estimated at over half of all U.S. adults, and with sales projected to reach $60 billion by year 2025 [3]. Amazon alone is estimated to control $10 billion of those sales annually and is expected to be the largest supplier of dietary supplements by 2024 [4]. Many submarkets of these products exist, for example, retail sales of sports nutrition supplements are estimated to contribute to over 10% of total dietary supplement sales [5].

Dietary supplements are marketed to the public for various reasons, and a cursory review of any drug store supplement section would show claims for improving one's body weight, energy, nutrition, sleep, beauty, athletic performance, mental health, physical health, and disease risk. The extent to which these dietary supplement claims influence their purchase and use is not clear. However, personal motives for using dietary supplements include improving/maintaining overall health, bone and joint health, vision, cholesterol, heart health, energy, bowel health, and body weight [6]. Furthermore, motives for using dietary supplements among those interested in fitness or athletics include both fat loss and muscle mass gains [7,8].

The degree to which dietary supplement use, in general adult populations, influences physical activity (PA), is also less understood. Some data show that knowledge and awareness of certain dietary supplements are positive correlates of PA in adults [9]. Among college students majoring in a sports-related science, using dietary supplements, such as vitamins, minerals, and amino acids, has shown to be a predictor of PA [10]. In middle-aged and older populations, dietary supplement use has shown to be positively associated with vigorous-intensity PA [11]. Despite these associations, data examining muscle building supplement use and PA relationships in the general adult population are sparse. Therefore, the aim of this study was to examine the association between dietary supplement use for gaining muscle and PA in U.S. adults.

2. Methods

Study design

Data for this study came from the 2017 to March Pre-pandemic 2020 National Health and Nutrition Examination Survey (NHANES) [12]. Because the coronavirus of 2019 interrupted the 2019-2020 NHANES cycle, the 2019-2020 data were not considered complete for use. Consequently, the incomplete 2019-2020 NHANES cycle was combined with the 2017-2018 NHANES cycle to create a 3.2-year nationally representative pre-pandemic cycle. Just as in previous years, the current NHANES is a survey of noninstitutionalized civilian residents of the US. The survey collects data from individuals using personal interviews, standardized physical examinations, and laboratory tests.

Assessment of study variables

Variables computed for this study have been explained elsewhere [12]. Briefly, nine different PA variables were used and include vigorous work-related PA (VWPA), moderate work-related PA (MWPA), transportation-related PA (TPA), vigorous recreational PA (VRPA), moderate recreational PA (MRPA), sedentary time (SED), moderate-to-vigorous PA (MVPA), met PA guidelines (METPA) and physically inactive (PIA). Both work-related PA variables were assessed by asking participants if they engaged in paid or unpaid work, household chores, or yard work for at least 10 minutes continuously. VWPA questions asked about vigorous-intensity activities that cause large increases in breathing or heart rate and included examples like carrying or lifting heavy loads, digging or construction work. MWPA questions asked about moderate-intensity activities that cause small increases in breathing or heart rate and included examples such as brisk walking or carrying light loads. Units for both work-related PA variables were minutes per week (min/week).

TPA was assessed by asking participants if they walk or bicycle to and from places (e.g., school, shopping, or work) for at least 10 minutes continuously and also had units of min/week. Both recreation-related PA variables were assessed from questions that asked participants to exclude work-related and transportation-related PA and include sport, fitness and recreational activities engaged in for at least 10 minutes continuously. VRPA asked about vigorous-intensity activities that cause large increases in breathing or heart rate and included examples like running or basketball. MRPA asked about moderate-intensity activities that cause small increases in breathing or heart rate and included examples like brisk walking, bicycling, swimming, or volleyball. Both recreational PA variables had min/week units. SED was assessed using a single question asking participants how much time they usually spend sitting on a typical day, including school, home, transportation, and work, and excluding sleep. SED units were in minutes per day (min/day). MVPA was computed from both VRPA and MRPA by adding MRPA plus two times VRPA and used units of min/week. METPA was computed from MVPA and categorized participants as either ‘0’ for < 150 min/week of MVPA or ‘1’ for 150+ min/week of MVPA. Finally, PIA was also computed from MVPA where participants with 0 min/week were categorized as ‘1’ for being physically inactive or otherwise ‘0’ for not being physically inactive.

A dietary supplement use variable was created and used as the primary predictor variable. Participants were asked for the reason or reasons they take (or reason or reasons a doctor or other health professional told them to take) a dietary supplement. Over 38 different reasons were recorded and for this study participants were categorized into one of three supplement use groups: 1) a participant that uses a supplement because they want to build muscle (USBM), 2) a participant that uses a supplement for other reasons (USOR) than to build muscle, or 3) a participant that is a non-supplement user (NSU).

Demographic covariates of age, sex, race, and income were used in this study. Age was used as a continuous variable, ranging from 20 years to 80+ years. Sex included males and female. Race/ethnicity was used as a categorical variable and included White, Black, Hispanic, and Other groupings. Lastly, income was used as a continuous variable and computed as a ratio of the family income to poverty, ranging from 0 to 5. A final control variable, body mass index (BMI), was used to adjust for behavioral health differences. BMI was assessed by first measuring participant height and weight using a digital stadiometer and digital floor scale, respectively. A final BMI variable was then computed by dividing a participant’s weight (kg) by height (m^2).

Statistical analyses

Descriptive statistics were computed for all study variables overall and across dietary supplement groups and included means, standard errors (SEs), and 95% confidence intervals (CIs). Analysis of variance (ANOVA) was used to compare study variables across supplement groups along with unadjusted post-hoc t tests. The chi-square test of independence was additionally used for both categorical PA variables, albeit, results were the same. Multiple regression was used to examine supplement group differences in MVPA with models of varying adjustments. Similarly, logistic regression was used to examine supplement group differences in the probability of METPA in models with different adjustment variables. All SEs were adjusted for the NHANES sampling design, *p*-values were reported as 2-sided and statistical significance set at $p < 0.05$.

3. Results

Table 1 contains descriptive statistics for the PA variables overall and indicates approximately 38.9% (95% CI: 36.1% - 41.7%) of adults METPA with 45.4% (95% CI: 42.8% - 48.1%) classified as PIA, leaving approximately 15.7% (95% CI: 14.3% - 17.1%) of adults accumulating an insufficient amount of PA each week. Table 2 contains results for the mean comparisons of PA across two supplement groups and shows that USBM adults had significantly greater VRPA (*Mean* = 168.6 min/week vs *Mean* = 65.8 min/week, *p* = .0034), MVPA (*Mean* = 481.3 min/week vs *Mean* = 228.5 min/week, *p* = .0019), METPA (*Mean* = 53.9% vs *Mean* = 38.5%, *p* = .0071), and significantly lower PIA (Mean = 34.8% vs Mean = 45.7%, *p* = .0275), than their counterparts, respectively. Table 3 shows similar results, with the additional classifications of USOR and NSU and highlights USOR engaging in significantly less VWPA (*Mean* = 167.5, *SE* = 12.7 min/week) and more SED (*Mean* = 367.4, *SE* = 5.3 min/week) than USBM and NSU. Additionally, NSU engaged in significantly more MWPA (*Mean* = 448.8, *SE* = 26.7 min/week) and PIA (*Mean* = 50.8%, *SE* = 1.2% min/week) than USBM and USOR.

Table 4 displays the multiple regression models examining the associations between supplement use and MVPA. In the unadjusted model, USOR (*b* = -259.1, *p* = .0017) and NSU (*b* = -244.1, *p* = .0023) groups had significantly less MVPA, as compared to USBM. However, in the demographics adjusted model predicting MVPA, USOR (*b* = -211.8 *p* = .0038) and NSU (*b* = -263.1, *p* = .0003) groups had significantly less MVPA, as compared to USBM, highlighting the changed effects of adding demographic variables as a covariates.

Table 5 displays the logistic regression models examining the associations between supplement use and METPA. All three models indicated a similar pattern with the fully adjusted model showing that USOR (OR = 1.38, 95% CI: 1.18 – 1.61) and USBM (OR = 2.44, 95% CI: 1.47 – 4.05) had significantly greater odds of METPA, as compared to NSU. Figure 1, lastly, shows the fully adjusted least squares means of MVPA across supplement group and sex. The supplement group-by-sex interaction (*p* = .0290) indicated that males (*Mean* = 561.7, *SE* = 93.3 min/week) in the USBM group had significantly greater MVPA than all other supplement groups, including USBM group females (*Mean* = 244.1, *SE* = 49.8 min/week).

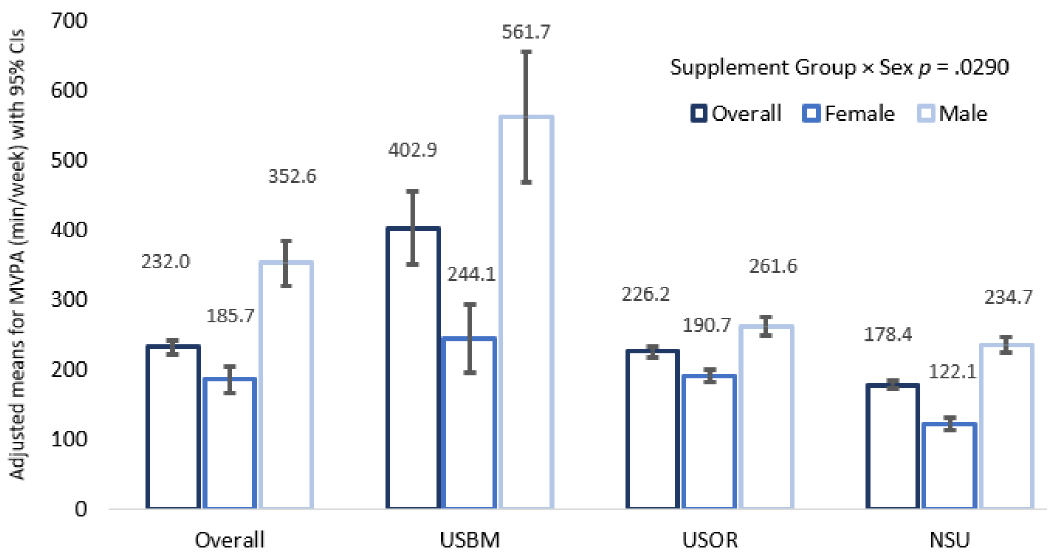

Figure 1. Fully adjusted least squares means of MVPA across supplement group and sex, NHANES 2017-2020 (pre-pandemic)

Table 1. Descriptive statistics for study variables in adults 20+ years of age, NHANES 2017-2020 (pre-pandemic)

PA Variable	*N*	*Mean*	*SE*	*LL*
VWPA (min/week)	8,516	237.99	13.92	209.32
MWPA (min/week)	8,503	392.06	18.36	354.25
TPA (min/week)	8,526	58.02	3.72	50.36
VRPA (min/week)	8,537	68.54	4.20	59.89
MRPA (min/week)	8,531	98.13	3.36	91.21
SED (min/day)	8,469	354.35	4.70	344.67
MVPA (min/week)	8,527	235.33	9.71	215.33
METPA (1=yes, 0=no)	8,527	.389	.014	.361
PIA (1=yes, 0=no)	8,527	.454	.013	.428

Note. PA is physical activity. SE is standard error. LL is lower limit of the 95% confidence interval (CI) estimating the mean. UL is upper limit of the 95% CI estimating the mean. VWPA is vigorous work-related PA. MWPA is moderate work-related PA. TPA is transportation-related PA. VRPA is vigorous recreational PA. MRPA is moderate recreational PA. SED is sedentary time. MVPA is moderate-to-vigorous PA. METPA is met PA guidelines. PIA is physically inactive.

Table 2. Descriptive statistics for study variables by two supplement groups in adults 20+ years of age, NHANES 2017-2020 (pre-pandemic)

	Supplement Group						
	USBM			Not USBM			*t*
PA Variable	*N*	*Mean*	*SE*	*N*	*Mean*	*SE*	*p*
VWPA (min/week)	262	319.31	56.49	8,246	235.75	13.38	.1082
MWPA (min/week)	262	348.32	42.36	8,234	393.32	18.50	.2917
TPA (min/week)	263	101.10	45.35	8,255	56.85	3.33	.3310
VRPA (min/week)	263	168.58	32.93	8,266	65.76	3.87	**.0034**
MRPA (min/week)	263	144.13	23.81	8,260	96.87	3.41	.0613
SED (min/day)	260	316.40	24.33	8,203	355.40	4.67	.1157
MVPA (min/week)	263	481.29	75.21	8,256	228.52	9.03	**.0019**
METPA (1=yes, 0=no)	263	.539	.052	8,256	.385	.014	**.0071**
PIA (1=yes, 0=no)	263	.348	.047	8,256	.457	.013	**.0275**

Note. PA is physical activity. SE is standard error. USBM indicates using a dietary supplement to build muscle. VWPA is vigorous work-related PA. MWPA is moderate work-related PA. TPA is transportation-related PA. VRPA is vigorous recreational PA. MRPA is moderate recreational PA. SED is sedentary time. MVPA is moderate-to-vigorous PA. METPA is met PA guidelines. PIA is physically inactive. ANOVA p-value is for the one-way analysis of variance.

Table 3. Descriptive statistics for study variables by three supplement group in adults 20+ years of age, NHANES 2017-2020 (pre-pandemic)

	Supplement Group										
	USBM			USOR			NSU			ANOVA	
PA Variable	*N*	*Mean*	*SE*	*N*	*Mean*	*SE*	*N*	*Mean*	*SE*	*p*	*diff*
VWPA (min/week)	262	319.31	56.49	4,490	167.47	12.72	3,756	328.35	19.84	< .0001	USOR<USBM,NSU
MWPA (min/week)	262	348.32	42.36	4,486	352.43	22.33	3,748	448.84	26.73	.0137	NSU>USBM,USOR
TPA (min/week)	263	101.10	45.35	4,493	46.24	3.92	3,762	71.26	4.87	.0007	USOR<NSU
VRPA (min/week)	263	168.58	32.93	4,499	61.45	4.20	3,767	71.62	5.51	.0067	USBM>USOR,NSU
MRPA (min/week)	263	144.13	23.81	4,497	99.18	4.44	3,763	93.73	4.00	.0660	USBM>NSU
SED (min/day)	260	316.40	24.33	4,469	367.42	5.33	3,734	339.04	6.60	.0005	USOR>USBM,NSU
MVPA (min/week)	263	481.29	75.21	4,494	222.15	9.40	3,762	237.15	13.02	.0065	USBM>USOR,NSU
METPA (1=yes, 0=no)	263	.539	.052	4,494	.401	.016	3,762	.364	.015	.0002	USBM>USOR>NSU
PIA (1=yes, 0=no)	263	.348	.047	4,494	.420	.016	3,762	.508	.012	< .0001	NSU>USBM,USOR

Note. PA is physical activity. SE is standard error. USBM indicates using a dietary supplement to build muscle. USOR indicates using a dietary supplement for other reasons. NSU indicates not a dietary supplement user. VWPA is vigorous work-related PA. MWPA is moderate work-related PA. TPA is transportation-related PA. VRPA is vigorous recreational PA. MRPA is moderate recreational PA. SED is sedentary time. MVPA is moderate-to-vigorous PA. METPA is met PA guidelines. PIA is physically inactive. ANOVA p-value is for the one-way analysis of variance

Table 4. Multiple regression models examining the associations between supplement use and MVPA, NHANES 2017-2020 (pre-pandemic)

	Unadjusted				Demographics Adjusted				Fully Adjusted			
Parameter	*Estimate*	*Beta*	*SE*	*p*	*Estimate*	*Beta*	*SE*	*p*	*Estimate*	*Beta*	*SE*	*p*
Intercept	481.29	0.00	75.22	< .0001	687.44	0.00	74.73	< .0001	840.81	0.00	77.11	< .0001
Supplement Group												
USBM	ref				ref				ref			
USOR	-259.13	-0.31	73.92	.0017	-211.75	-0.26	66.39	.0038	-203.40	-0.25	67.01	.0055
NSU	-244.13	-0.29	72.01	.0023	-263.05	-0.32	63.43	.0003	-252.44	-0.31	64.00	.0006

Note. Unadjusted models only include the single supplement group predictor variable. Demographics adjusted models are adjusted for age, sex, race, and income. Fully adjusted models are additionally adjusted for body mass index (BMI). The intercept terms each represent the mean or adjusted mean MVPA. USBM indicates using a dietary supplement to build muscle. USOR indicates using a dietary supplement for other reasons. NSU indicates not a dietary supplement user

Table 5. Logistic regression models examining the associations between supplement use and METPA, NHANES 2017-2020 (pre-pandemic)

	Unadjusted			Demographics Adjusted			Fully Adjusted		
Variable	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*
Supplement Group									
USBM	2.04	1.32	3.15	2.61	1.60	4.26	2.44	1.47	4.05
USOR	1.17	1.04	1.31	1.40	1.21	1.61	1.38	1.18	1.61
NSU	1.00	-	-	1.00	-	-	1.00	-	-

Note. Unadjusted models only include the single supplement group predictor variable. Demographics adjusted models are adjusted for age, sex, race, and income. Fully adjusted models are additionally adjusted for body mass index (BMI). USBM indicates using a dietary supplement to build muscle. USOR indicates using a dietary supplement for other reasons. NSU indicates not a dietary supplement user

4. Discussion

The purpose of this study was to examine the extent to which taking a dietary supplement for the purpose of gaining muscle is associated with PA in the general adult population. Results showed that those taking supplements to build muscle report greater amounts of recreational PA than other supplement or non-supplement users. Additionally, adults taking supplements to build muscle were more likely to comply with the current PA guidelines and less likely to be sedentary and inactive. This relationship was not observed for work-related or transportation-related PA outcomes. Furthermore, taking supplements to build muscle was associated with greater amounts of recreational PA even after adjusting for demographic variables and BMI. This signifies a robust association between taking supplements for this purpose and increased amounts of PA. Data supporting these specific findings in the published literature are sparse. However, it is known that a sizeable percentage (approximately 24%) of adults adopt both muscle strengthening activity as well as aerobic PA [14]. Therefore, a link may exist between dietary supplement use to build muscle and PA that is mediated by muscle strengthening activity. Another explanation for these results is that respondents could have included their muscle strengthening activity when asked about their recreational aerobic PA. Regardless of these propositions, further research is required to better understand the mechanisms behind this association.

Another finding worth noting is the significantly greater amounts of MVPA in adult males taking dietary supplements to build muscle. Males USBM had greater amounts of MVPA when compared to all other supplement and sex group combinations. To date, published data supporting this finding are scarce to nonexistent. However, as previously stated, muscle strengthening activity may play a mediating role between supplement use and PA in adults. Assuming this as a possible theory, we then also know that the prevalence of muscle strengthening activity is greater in males than in female [15]. This fact may provide indirect evidence to the mediating role of muscle strengthening activity in this relationship. Nevertheless, further research is also warranted to corroborate these results.

A strength of this study was its use of PA questions from the NHANES PA questionnaire module. The CDC specifically designs its questionnaires to target behaviors that contribute to morbidity and mortality in the U.S and are created by industry leading content experts. Another strength of this study was its use of a population-based survey representing pre-pandemic health status in U.S. adults. NHANES data represent the total noninstitutionalized civilian U.S. population residing in the 50 states and District of Columbia. Therefore, results from this study can be generalized to all noninstitutionalized adults 20+ years of age residing in the U.S.

A limitation in this study however was the use of cross-sectional data. Cross-sectional data cannot support and should not imply cause-and-effect relationships. Therefore, results from this study should not suggest that taking a supplement for the purpose of building muscle can necessarily change PA outcomes in adults. A randomized controlled trial should be conducted to address such cause-and-effect associations. Another limitation of this study is the use of self-report PA. That is, data from self-reported PA questionnaires have certain biases over more objective means of measurement such as accelerometers. However, the items used to assess the PA variables in this study came from the Global Physical Activity Questionnaire (GPAQ), which has adequate validity and reliability evidence supporting its use in this population. Ultimately, findings from this study should be interpreted with caution.

5. Conclusions

Results from this study indicate that U.S. adults taking supplements to build muscle report greater amounts of recreational PA than other supplement or non-supplement users. These findings remain robust after controlling for common demographic variables as well as BMI. Furthermore, males taking supplements to gain muscle report significantly greater amounts of MVPA than all other adults taking and not taking supplements. Further research is needed however to examine the extent to which muscle building supplements can influence recreational PA in adults.

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