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Original Research

Decline in Physical Activity after Age 35 Increases the Risk of Obesity, Insulin Resistance, and Diabetes: A Cross-sectional Analysis of the MIDUS Study

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Abstract

Objective: To investigate the impact of changes in physical activity from young adulthood (ages 20–35 years) to middle age (ages ≥35 years) on the prevalence of obesity, insulin resistance, and diabetes.

Research design and methods: Data were analyzed from 1,395 participants in the Midlife in the United States (MIDUS) study, including biomarker subsamples. Participants reported their physical activity levels during young adulthood and currently (≥ 20 min, three times per week). Participants were categorized as persistently active, increased, decreased, or persistently inactive. Obesity was defined as body mass index (BMI) ≥ 30 kg/m^2, insulin resistance by HOMA-IR ≥ 2.8, and diabetes by self-reported diagnosis. Multivariable logistic regression was used to assess associations.

Results: Participants with decreased or persistently low physical activity levels were significantly more likely to have obesity (OR 2.29 and OR 2.03, respectively), insulin resistance (OR 1.88 and OR 1.79, respectively), and diabetes (OR 1.79 and OR 1.73, respectively) compared to persistently active subjects. After adjusting for covariates, including age, income, and alcohol consumption, increased activity did not exhibit a significant protective effect compared to persistent activity.

Conclusions: A decline in physical activity after the age of 35 years is associated with higher risks of obesity, insulin resistance, and diabetes. Health promotion programs targeting the maintenance of regular physical activity in adulthood may reduce these risks. Further longitudinal studies are needed to confirm these findings and address limitations, including sample diversity and missing data.

Keywords: Diabetes, Exercise, Insulin resistance, Obesity, Physical activity

Introduction

Obesity and diabetes are critical health concerns in the United States. Since the 1980s, obesity prevalence has steadily increased. According to National Health and Nutrition Examination Survey (NHANES) data, the age-standardized prevalence of obesity in adults rose from 33.7% in 2007–2008 to 39.6% in 2015–2016 [1]. Notably, this increase was significant in adults aged 40 years and those ≥60 years. Diabetes prevalence has also increased, with total diabetes prevalence (diagnosed and undiagnosed) affecting 14% of the United States adult population in 2010, and this percentage is projected to rise to 21%–33% by 2050.

Physical activity has benefits that may help prevent chronic diseases such as obesity and diabetes [2]. Regular exercise is critical for maintaining a healthy and normal body weight. All healthy adults aged 18–65 years are recommended to engage in moderate-intensity aerobic (endurance) physical activity for at least 30 min daily, 5 days per week, or vigorous-intensity aerobic physical activity for at least 20 min daily, 3 days per week [3]. A systematic review showed that physical activity lowered type 2 diabetes incidence by 26% and cardiovascular disease mortality by 23% [4].

Physical activity often varies along with life stages. Age-related decline in physical activity throughout adolescence has been well documented [5] Micklesfield *et al.* reported that the large majority of males (72%) and females (85%) experienced decreased physical activity during adolescence [6], which may pose health risks later in life. Reduction in physical fitness from childhood to adulthood has been linked to greater body adiposity [7], abdominal obesity [8], and insulin resistance [9] in young adulthood. However, data on how changes in physical activity from young adulthood to middle age impact obesity, insulin resistance, and diabetes are limited.

Therefore, this study aimed to investigate changes in physical activity levels from young adulthood (aged 20–35 years) to middle age (aged ≥35 years) using a large dataset and examine its relationship with obesity, insulin resistance, and diabetes.

Methods

Data and study population

This study is a cross-sectional analysis based on secondary data from the Midlife in the United States (MIDUS) study. The sample was drawn from the second wave of the National Survey of Midlife in the United States (MIDUS 2) and the MIDUS refresher, an expansion of the MIDUS project. The MIDUS [10] project, started in 1995, is a collaborative, interdisciplinary survey on physical health, psychological well-being, and social responsibility during midlife. The baseline sample included 7,108 non-institutionalized, English-speaking adults aged 25–74 years from the United States, collected through random-digit dialing. Data were gathered via phone interviews and self-administered questionnaires.

The MIDUS 2 [11] (2004–2006) was the first longitudinal follow-up of MIDUS 1, whereas the MIDUS refresher [12] is a sample expansion of the MIDUS project. The Biomarker Project of each wave aimed to collect comprehensive biological assessments of a subsample of MIDUS respondents, thus facilitating analyses that integrated behavioral and psychosocial factors with biological regulation. The biomarker project included data from blood specimens, self-administered questionnaires, and physical examinations. In this study, the MIDUS 2 biomarker project [13] and MIDUS refresher biomarker project [14] data were used for analysis. The inclusion criteria were those aged ≥ 35 years who answered the following two questions about physical activity in the self-administered questionnaires.

1. Between ages 20–35 years, how many years did you participate in regular moderate-level physical activity?

   Moderate-level physical activity is defined here as activity that causes your heart rate to increase slightly and typically makes you work up a sweat (e.g., leisurely sports like light tennis, slow or light swimming, low-intensity aerobics, golfing without a power cart, brisk walking, or mowing the lawn with a walking lawnmower).

2. Do you currently engage in regular exercise or activity of any type for ≥ 20 min at least three times a week?

   Here, "regular exercise or activity" refers to activities requiring at least light-level physical effort, such as light housekeeping like dusting or laundry, and including activities like bowling, archery, easy walking, golfing with a power cart, or fishing.

In the MIDUS 2 (n = 1,255) and MIDUS refresher biomarker projects (n=863), 537 and 160 participants, respectively had missing responses to the questions above. The final sample included 1,395 participants **(Figure 1)**.

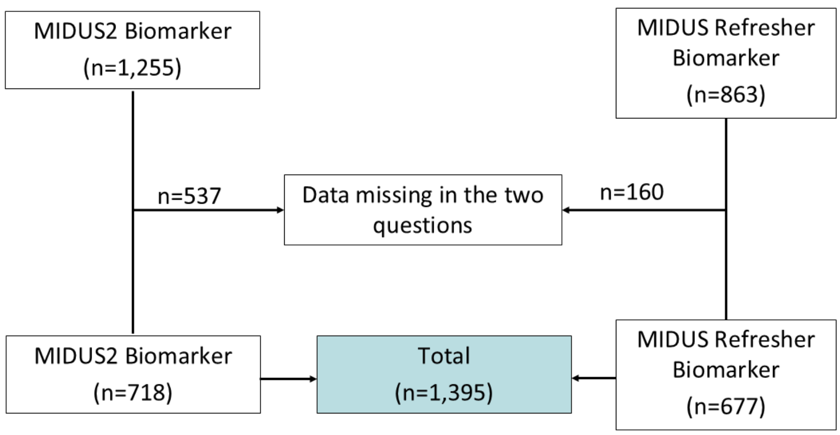

Figure 1. Participant flow diagram showing data availability in the MIDUS2 and MIDUS Refresher Biomarker datasets.

Outcome variables

Obesity: Body mass index (BMI) was calculated as a participant's weight in kilograms (kg) divided by height in meter squared (m^2). Obesity was defined as a BMI ≥ 30 kg/m^2.

Insulin resistance: Insulin resistance was estimated using a homeostatic model assessment for insulin resistance (HOMA-IR). HOMA-IR was calculated using the following formula: fasting insulin (mU/L) × fasting glucose (nmol/L) / 22.5. Insulin resistance was defined as HOMA-IR ≥ 2.8 [15].

Diabetes: Diabetes was characterized by recording the response of "Yes" to the question "In the past 12 months, have you experienced or been treated for any of the following - DIABETES OR HIGH BLOOD SUGAR?"

Predictor variable

Physical activity change: The participants were categorized into four groups: persistently active, increased, decreased, and persistently inactive. The four categories were defined based on physical activity levels from ages 20–35 years and current physical activity. The definitions of changes in physical activity are shown in **Table 1**. For example, participants who had engaged in moderate-level physical activity for 15 years at ages 20–35 years and were currently active were categorized into the persistently active group.

Covariates

Covariates included age, sex, race/ethnicity (White, Black, Asian, or other), marital status (married, separated, divorced, widowed, or never married), education (high school or lower, some college, bachelor's degree, or graduate degree), income (<US$25K, US$25–US$75K, or >US$75K; per year), and alcohol consumption. Alcohol consumption was assessed using the following question: "During the past month, how often did you drink alcoholic beverages on average? Would you say every day, five or six days a week, three or four days a week, one or two days a week, or less than one day a week?"

Statistical analysis

Descriptive characteristics were presented as means and standard deviations for continuous variables and frequencies and percentages for categorical variables. We assessed associations of obesity, insulin resistance, and diabetes with the predictor variable and covariates using chi-square tests for categorical variables and Student's t-tests for continuous variables. Variables with p-values <0.20 in univariate analyses were entered into the multivariable logistic regression model. The significance threshold was set at 0.05. All statistical analyses were performed using R (version 4.0.3).

Patient and public involvement statement

This study represents a secondary data analysis from the Midlife in the United States (MIDUS) study. Given this approach, patients and the public were not directly involved in the design or implementation of our research. However, our findings aim to contribute to public health improvements by highlighting how changes in physical activity levels affect obesity, insulin resistance, and diabetes risk. These insights may help shape more effective health promotion strategies for the general population.

Results

Demographic data for all measures are presented in **Table 2**. The mean age of the participants was 55.8 years, and 45.1% were male. Most participants were white (87.9%), with a small percentage of ethnic minorities. Obesity, insulin resistance, and diabetes rates were 59.9%, 47.0%, and 13.2%, respectively. Of the participants, 44.5% reported engaging in moderate-level physical activity for 11–15 years between ages 20 and 35, and 77.9% currently engage in regular exercise for at least 20 min three times per week. The percentages of changes in physical activity across the categories persistently active, increased, decreased, and persistently inactive were 36.9%, 41.0%, 12.5%, and 9.5%, respectively.

Table 3 shows the results of univariate analysis for obesity. The proportion of participants with obesity was higher in the decreased activity and persistently inactive groups than in the persistently active and increased activity groups. Age, race/ethnicity, education, income, alcohol consumption, and physical activity change were statistically significantly associated with obesity. Logistic regression (**Table 6**) revealed that the decreased activity and persistently inactive group had a higher obesity risk than the persistently active group (decreased group: odds ratio (OR) 2.29 [95% confidence interval (CI): 1.52–3.46], p<0.001; persistently inactive group: OR 2.03 [95% CI: 1.29–3.20], p=0.002).

Table 1. Definition of physical activity change.

Categories in physical activity change	Aged 20–35, the number of years participated in regular physical activity at a moderate level?	Do you engage in regular exercise or activity of any type for 20 min or more at least three times/week?
Persistently active	11–15 years	Yes
Increased	0–10 years	Yes
Decreased	11–15 years	No
Persistently inactive	0–10 years	No

Table 2. Demographic data.		
Variables	**Mean ± SD or frequency (%)**	
Age (years)	55.8	±11.3
Sex		
Male	596	(45.1)
Female	727	(54.9)
Race/ethnicity		
White	1,021	(87.9)
Black	55	(4.7)
Asian	7	(0.6)
Others	78	(0.7)
Marital status		
Married	814	(58.4)
Separated, divorced, or widowed	234	(16.8)
Never married	114	(8.2)
Missing	233	(16.7)
Education		
High school or lower	422	(30.3)
Some college	415	(29.7)
Bachelor	325	(23.3)
Graduate	233	(16.7)
Income		
<US$ 25K	469	(33.6)
US$ 25K–US$ 75K	396	(28.4)
>US $75K	188	(13.5)
Missing	342	(24.5)
Alcohol consumption		
<1 day/week	319	(22.9)
1–4 days/week	289	(20.7)
5–7 days/week	168	(12.0)
Missing	619	(44.5)
Obesity		
Yes	600	(56.9)
No	795	(43.1)
Insulin resistance		
HOMA-IR >2.8	656	(47.0)
HOMA-IR <2.8	726	(52.0)
Missing	13	(0.9)

Diabetes		
Yes	184	(13.2)
No	1,211	(86.8)
Physical activity (ages 20–35 years)		
11–15 years	621	(44.5)
0–10 years	774	(55.5)
Physical activity (current)		
Yes	1,087	(77.9)
No	308	(22.1)
Physical activity change		
Persistently active	515	(36.9)
Increased	572	(41.0)
Decreased	175	(12.5)
Persistently inactive	133	(9.5)

Table 3. Univariate analysis for obesity.

Variables	**non-Obesity**		**Obesity**		**p-value**
Age (years)	56.1	±11.7	55.4	±10.9	0.009
Sex					0.481
Male	339	(56.9)	257	(43.1)	
Female	428	(59.0)	298	(41.0)	
Race/ethnicity					<0.001
White	623	(61.1)	397	(38.9)	
Black	19	(34.5)	36	(65.5)	
Asian	7	(100)	0	(0.0)	
Others	45	(57.7)	33	(42.3)	
Marital status					0.28
Married	497	(61.1)	317	(38.9)	
Separated, divorced, widowed	135	(57.7)	99	(42.3)	
Never married	61	(54.0)	52	(46.0)	
Education					<0.001
High school or lower	228	(54.0)	194	(46.0)	
Some college	260	(62.8)	154	(37.2)	
Bachelor	205	(63.1)	120	(36.9)	
Graduate	101	(43.3)	132	(56.7)	
Income ($)					<0.001
<25K	277	(59.1)	192	(40.9)	
25-75K	234	(59.2)	161	(40.8)	

75K<	121	(64.4)	67	(35.6)	
Missing	162	(47.4)	180	(52.6)	
Alcohol consumption					<0.001
< 1 day/week	181	(56.7)	138	(43.3)	
1-4 days/week	173	(60.1)	115	(39.9)	
5-7 days/week	125	(74.4)	43	(25.6)	
Missing	315	(50.9)	304	(49.1)	
Physical activity (20-35yo)					0.018
10 years or less	418	(54.1)	355	(45.9)	
more than 10 years	376	(60.5)	245	(39.5)	
Physical activity (current)					<0.001
Yes	657	(60.5)	429	(39.5)	
No	137	(44.5)	171	(55.5)	
Physical activity change					<0.001
Persistently active	329	(63.9)	186	(36.1)	
Increased	328	(57.4)	243	(42.6)	
Decreased	75	(42.9)	100	(57.1)	
Persistently inactive	62	(46.6)	71	(53.4)	
Mean ± SD or Frequency (%)					

Table 4 shows that insulin resistance was more prevalent in the decreased and persistently inactive groups than in the persistently active and increased groups. All variables except marital status were significantly associated with insulin resistance. After adjusting for the significant predictors **(Table 6)**, insulin resistance risk was higher in the decreased and persistently inactive groups compared to the persistently active group (decreased group: OR 1.88 [95% CI: 1.23–2.88], p=0.004; persistently inactive group: OR 1.79 [95% CI: 1.13–2.50], p=0.013).

Table 4. Univariate analysis for insulin resistance.

Variables	**Insulin Resistance**				**p-value**
	No		**Yes**		
Age	55.2	±11.5	56.4	±11.1	0.007
Sex					<0.001
Male	277	(46.7)	316	(53.3)	
Female	426	(39.1)	295	(40.9)	
Race/ethnicity					0.007
White	568	(56.0)	446	(44.0)	
Black	18	(33.3)	36	(66.7)	
Asian	5	(71.4)	2	(28.6)	
Others	39	(50.0)	39	(50.0)	
Marital status					0.723
Married	438	(54.0)	373	(46.0)	

Separated, divorced, widowed	131	(57.0)	99	(43.0)	
Never married	61	(54.0)	52	(46.0)	
Education					<0.001
High school or lower	200	(47.8)	218	(52.2)	
Some college	235	(57.0)	177	(43.0)	
Bachelor	193	(59.6)	131	(40.4)	
Graduate	98	(43.0)	130	(57.0)	
Income ($)					<0.001
<25K	238	(51.0)	229	(49.0)	
25-75K	220	(55.8)	174	(44.2)	
75K<	119	(64.0)	67	(36.0)	
Missing	149	(44.5)	186	(55.5)	
Alcohol consumption					<0.001
< 1day/week	179	(56.5)	138	(43.5)	
1-4days/week	155	(54.6)	129	(45.4)	
5-7days/week	111	(66.5)	56	(33.5)	
Missing	281	(45.8)	333	(54.2)	
Physical activity change					<0.001
Persistently active	292	(57.0)	220	(43.0)	
Increased	308	(54.3)	259	(45.7)	
Decreased	66	(38.6)	105	(61.4)	
Persistently inactive	60	(45.5)	72	(54.5)	

Table 5 shows that the decreased activity and persistently inactive group had a higher percentage of diabetes patients than the persistently active and increased group. Age, race/ethnicity, education, income, alcohol consumption, and changes in physical activity were statistically significant in univariate analysis. **Table 6** shows that the decreased and persistently inactive groups had a higher diabetes risk than the persistently active group (decreased activity group: OR 1.79 [95% CI: 1.18–2.72], p=0.006; persistently inactive group: OR 1.73 [95% CI: 1.10–2.72], p=0.018).

Table 5. Univariate analysis for diabetes.

Variables	**non-Diabetes**		**Diabetes**		**p-value**
Age	55.3	±11.3	59.1	±11.0	0.021
Sex					0.570
Male	516	(86.7)	79	(13.3)	
Female	639	(87.9)	88	(12.1)	
Race/ethnicity					<0.001
White	920	(90.2)	100	(9.8)	
Black	40	(72.7)	15	(27.3)	
Asian	5	(71.4)	2	(28.6)	
Others	69	(88.5)	9	(11.5)	

Marital status					0.771
Married	723	(88.9)	90	(11.1)	
Separated, divorced, widowed	211	(90.2)	23	(9.8)	
Never married	100	(87.7)	14	(12.3)	
Education					<0.001
High school or lower	362	(85.8)	60	(14.2)	
Some college	376	(90.6)	39	(9.4)	
Bachelor	296	(91.4)	28	(8.6)	
Graduate	177	(76.0)	56	(24.0)	
Income ($)					<0.001
<25K	401	(85.5)	68	(14.5)	
25-75K	366	(92.4)	30	(7.6)	
75K<	173	(92.5)	14	(7.5)	
Missing	271	(79.2)	71	(20.8)	
Alcohol consumption					<0.001
< 1day/week	284	(89.0)	35	(11.0)	
1-4days/week	270	(93.4)	19	(6.6)	
5-7days/week	159	(94.6)	9	(5.4)	
Missing	498	(80.6)	120	(19.4)	
Physical activity change					<0.001
Persistently active	463	(90.1)	51	(9.9)	
Increased	505	(88.3)	67	(11.7)	
Decreased	131	(74.9)	44	(25.1)	
Persistently inactive	122	(84.2)	21	(15.8)	

Table 6. Logistic regression analysis for obesity, insulin resistance, and diabetes.

Variables	**Obesity**			**Insulin resistance**			**Diabetes**		
	OR	**(95%CI)**	**p**	**OR**	**(95%CI)**	**p**	**OR**	**(95%CI)**	**p**
Age	1.00	(0.99–1.01)	0.963	1.00	(0.99–1.02)	0.397	1.01	(1.00–1.02)	0.083
Sex (female vs. male)				0.40	(0.31–0.53)	<0.001			
Race/ethnicity									
Black vs. White	2.81	(1.58–5.12)	<0.001	2.75	(1.53–5.10)	<0.001	2.29	(1.28–4.21)	0.006
Asian vs. White	0.00	(0.00–0.00)	0.978	0.56	(0.08–2.82)	0.510	0.58	(0.08–2.80)	0.522
Others vs. White	1.06	(0.65–1.70)	0.824	1.21	(0.75–1.97)	0.436	1.18	(0.73–1.91)	0.490
Education									
Some college vs. ≤HG	0.73	(0.55–0.98)	0.035	0.73	(0.55–0.98)	0.037	0.77	(0.58–1.02)	0.068
Bachelor vs. ≤HG	0.81	(0.59–1.12)	0.200	0.77	(0.55–1.06)	0.106	0.77	(0.56–1.05)	0.104
Graduate vs. ≤HG	0.00	(0.00–0.00)	0.988	0.00	(0.00–0.00)	0.972	0.00	(0.00–0.00)	0.971

Income									
US$ 25–US$ 75K vs. <US $25K	1.01	(0.75–1.36)	0.935	0.77	(0.57–1.04)	0.085	0.90	(0.67–1.20)	0.469
>US$ 75K vs. <US$ 25K	1.02	(0.69–1.51)	0.920	0.57	(0.38–0.86)	0.007	0.75	(0.51–1.10)	0.140
Missing vs. <US$ 25K	1.08	(0.69–1.67)	0.729	1.01	(0.65–1.58)	0.958	1.03	(0.67–1.59)	0.900
Alcohol consumption									
1–4 days/week vs. <1 day/week	0.99	(0.70–1.40)	0.954	0.97	(0.68–1.38)	0.860	1.18	(0.84–1.66)	0.350
5–7 days/week vs. <1 day/week	0.51	(0.33–0.79)	0.002	0.58	(0.38–0.88)	0.011	0.72	(0.48–1.09)	0.121
Missing vs. <1 day/week	1.19	(0.87–1.62)	0.260	1.38	(1.01–1.90)	0.042	1.48	(1.09–2.01)	0.012
Physical activity (change)									
Increased vs. persistently active	1.27	(0.97–1.66)	0.088	1.20	(0.91–1.58)	0.190	1.07	(0.82–1.40)	0.610
Decreased vs. persistently active	2.29	(1.52–3.46)	<0.001	1.88	(1.23–2.88)	0.004	1.79	(1.18–2.71)	0.006
Persistently inactive vs. persistently active	2.03	(1.29–3.20)	0.002	1.79	(1.13–2.50)	0.013	1.73	(1.10–2.72)	0.018

Discussion

This study examined the relationship between changes in physical activity levels in young adults (aged 20–35 years) and middle-aged adults (aged ≥35 years) and obesity, insulin resistance, and diabetes. Participants who had decreased physical activity levels and were continuously inactive were more likely to have obesity, insulin resistance, and diabetes than those who regularly exercised before and after the age of 35 years.

A decline in physical activity and persistent low fitness from young adulthood to middle age predicted obesity, insulin resistance, and diabetes in middle age or older. Previous studies support these findings, showing the protective effects of regular physical activity against overweight, obesity, and insulin resistance. However, most previous studies have focused on declines in fitness levels from childhood (or adolescence) to young adulthood and their impact on overweight or obesity [8,9,16], adiposity [7], insulin resistance [9], and the development of unhealthy habits such as smoking and saturated fat intake [17]. A Finnish study [18] on working-age adults found that continuous low physical activity and decreased activity levels over a 10-year period were strongly associated with significant body mass gains, whereas increased activity was associated with smaller weight gains. Our findings suggest that changes in physical activity levels between young adulthood and middle age may be critical not only in obesity development but also in diabetes incidence. Furthermore, this study showed that continued participation in regular physical activity could aid in obesity and diabetes prevention.

This study shows that continued participation in regular physical activity could aid in obesity and diabetes prevention. Therefore, health promotion programs that encourage maintaining physical activity levels are necessary. However, maintaining motivation for regular exercise is challenging for many adults. Addressing barriers to physical activity is crucial in developing effective programs. Salmon *et al.* identified significant barriers to physical activity among adults, including cost, fatigue, lack of time, and work and family commitments. These perceived barriers to physical activity were significantly associated with decreased physical activity and increased sedentary behavior [19]. Intrinsic motivational factors including mastery (getting better at an activity), physical fitness (being physically fit), affiliation (being with friends and engaging in activities with others), psychological state (improving psychological health), and appearance (maintaining or improving appearance and body shape) were associated with consistent physical activity [20]. Programs that help individuals identify their values and make physical activity more meaningful may improve adherence.

The strength of this study lies in its utilization of data from the MIDUS study, a widely recognized and comprehensive dataset that includes a diverse U.S. population. By categorizing participants based on their physical activity levels from young adulthood to middle age, we provide insights into the long-term impact of activity changes. The findings highlight the importance of maintaining consistent physical activity to prevent metabolic disorders, contributing to the development of targeted health promotion strategies.

This study has some limitations that should be considered when interpreting the results. First, the cross-sectional assessment of the current physical activity level when classifying physical activity changes before and after the age of 35 years. Current physical activity may not represent the physical activity level during the entire period after the age of 35 years. Longitudinal studies would provide a better understanding of the association between physical activity changes and obesity, insulin resistance, and diabetes. Second, the sample was predominantly white, limiting the generalizability of the results to ethnic minorities. Therefore, future studies should examine diverse populations to assess the external validity of these findings. Third, the presence of missing data for many participants in the MIDUS database may have introduced potential confounders. For example, smoking data were missing for >70% of participants, while alcohol intake data were missing for 44.4%, and income data were missing for 24.5%. These factors may have affected the results. Finally, information on whether the participants with diabetes had type 1 or type 2 diabetes was unavailable. However, this limitation likely did not significantly impact the results, as type 2 diabetes accounts for > 90% of adult diabetes cases in the United States [21].

Conclusion

This study shows that decreased physical activity after the age of 35 years is associated with obesity, insulin resistance, and diabetes. Health promotion programs aimed at maintaining physical activity levels in middle-aged individuals may help reduce the risk of these conditions.

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Author Contributions

Tomoya Sato is the sole author of this manuscript and was responsible for the study conception, design, data analysis, and manuscript writing. No other individuals contributed to this work in a manner that meets the ICMJE criteria for authorship.

Disclosure of Potential Conflict of Interest

The author has no conflicts of interest to disclose.

Compliance with Ethical Standards

This article does not contain any studies with human or animal subjects performed by any of the authors.

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