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Physical Activity Variety, Energy Expenditure, and Body Mass Index

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Abstract

Objectives—To examine if physical activity (PA) variety was associated with moderate- to vigorous-intensity PA (MVPA) energy expenditure and body mass index (BMI) at 18 months during an obesity intervention.

Methods—Participants with 10 minutes/week of MVPA at 6 months and complete PA data were included. Participants were classified into Variety (N = 30), 2 different activities/week, or Less Variety (N = 65), only 1 activity/week.

Results—Weekly MVPA-related energy expenditure was higher for Variety than Less Variety (3674.7 ± 1934.6 kcal/week vs 2197.3 ± 1841.4 kcal/week, $p < .05$) at 18 months, with no difference in BMI.

Conclusions—Greater weekly PA variety during obesity treatment was related to greater 18-month MVPA energy expenditure.

Keywords

variety; physical activity; maintenance; weight loss

Increasing moderate- to vigorous-intensity physical activity (MVPA) is a standard component of adult lifestyle intervention for obesity treatment.^{1,2} Increasing MVPA assists with achieving the negative energy balance needed for weight loss. Additionally, high levels

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Human Subjects Statement

The protocol was approved by the Institutional Review Board at The Miriam Hospital in Providence, RI, and at the University of Tennessee, Knoxville, TN. This trial was registered at Clinical-Trials.gov (NCT00328744).

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

of MVPA are associated with long-term weight loss maintenance.³ For example, participants in the National Weight Control Registry (NWCR), the largest longitudinal study of successful weight loss maintainers, report an average weekly expenditure from MVPA of $2,621 \pm 2,252$ kcal.⁴ Long-term follow-up from lifestyle interventions also has reported that participants who are most successful at weight loss maintenance report activity levels similar to those of NWCR participants.^{5,6}

Unfortunately, even in those individuals who engage in MVPA to assist with weight loss, the majority do not engage in MVPA at levels recommended for successful weight loss and long-term weight loss maintenance.⁷ Kruger and colleagues examined leisure-time physical activity (PA) in those trying to lose weight from data collected in the National Health Interview Survey.⁷ Slightly more than half of those who reported using PA as a weight loss strategy met the 1998 National Institutes of Health minimal recommendation of 150 minutes/week of MVPA.⁷ Furthermore, less than half of those who included MVPA as part of their weight loss strategy met the lowest end (200 minutes/week) of the 2001 American College of Sports Medicine recommendation of 200–300 minutes/week of MVPA to facilitate long-term weight loss maintenance.³ Thus, new strategies are needed to aid overweight and obese individuals who are trying to lose weight with increasing MVPA.

Increasing the total volume of MVPA can be achieved by engaging in a limited number of activities multiple times during the week (ie, walking 5 times per week), a strategy that focuses on increasing frequency of MVPA, and/or by engaging in many different activities less frequently during the week (ie, once per week performing walking, biking, swimming, running, and dancing), a strategy that focuses on increasing PA variety.⁸ Whereas PA guidelines emphasize frequency, it is not clear what role PA variety may play in total volume of MVPA achieved as research in this area is limited.⁹ Two laboratory studies with children and adults have found that providing access to a greater variety of PA options increases time spent in PA.^{10,11} Some,^{8,13–15} but not all,¹² observational studies have reported a positive relationship between the number of activities engaged in and PA. For example, in 9- and 10-year-old children, those who met PA guidelines reported a greater number of physical activities than those who did not meet guidelines.⁸ Two studies with adults of varying weight status have found that individuals who regularly perform at least 2 activities of moderate- to vigorous-intensity engage in more minutes of MVPA¹³ and are more likely to meet PA guidelines than those individuals who regularly perform only one activity of moderate- to vigorous-intensity.¹⁴ Finally, a study examining PA in adolescents reported that a reduction in the number of different activities engaged in during adolescence was a primary reason for the reduction in PA that is commonly reported to occur during adolescence.¹⁵

Although a limited number of studies suggest that a larger number of different physical activities performed is related to greater MVPA, no study has examined prospectively if continued engagement in a variety of physical activities over time in overweight and obese individuals actively trying to increase PA is associated with MVPA-related energy expenditure and body mass index (BMI). Thus, the purpose of this investigation was to conduct a secondary data analysis to examine the relationship between PA variety and self-reported energy expenditure from MVPA and BMI in overweight and obese individuals participating in an 18-month lifestyle obesity intervention. Only participants that self-

reported engaging in MVPA after 6 months of intervention were included in the analyses. Participants classified as having PA variety reported consistently engaging in at least 2 different physical activities per week at 6-, 12-, and 18-month follow-up, whereas participants who did not consistently report engaging in at least 2 different physical activities per week at the same time points were classified as having less PA variety. It was hypothesized that participants having PA variety would self-report higher weekly MVPA-related energy expenditure and have a lower BMI at 18 months than participants with less PA variety.

METHODS

Participants

Participants included in this secondary data analysis were from an 18-month randomized controlled trial examining the influence of a dietary variety prescription, which limited the variety of sweet and salty energy-dense foods consumed, on weight loss maintenance during a standard lifestyle obesity intervention. The primary outcomes from this trial have been described previously.¹⁶

Between July 2006 and August 2008, potential participants were recruited through newspaper advertisements, flyers, and posters and phone-screened for eligibility in Providence, RI and Knoxville, TN. The eligibility criteria included an age of 21 to 65 years and a BMI (kg/m^2) between 27 and 45. Individuals were excluded if they could not walk 2 blocks; reported a heart condition, chest pain during periods of activity or rest, or loss of consciousness on the Physical Activity Readiness Questionnaire;¹⁷ were taking weight-loss medications or participating in a weight-loss program; had undergone bariatric surgery; were pregnant, lactating, or, 6 months postpartum or planned to become pregnant during the time frame of the investigation; and were consuming > 5 different types of sweet and/or salty energy-dense foods (ie, cookies, chips).

Eligibility criteria for the secondary data analyses included having complete measures at 0, 6, 12, and 18 months for self-reported PA, and measures of diet and BMI at 0 and 18 months. Participants not engaging in at least 10 minutes of MVPA per week at 6 months, the completion of the most intensive part of the intervention, were considered to be inactive. Inclusion of these participants in analyses would have reduced the mean volume of self-reported weekly energy expenditure from MVPA due to a floor effect. Thus, the secondary data analysis only included participants reporting that they were engaging in at least 10 continuous minutes of MVPA per week at 6 months. A total of 204 participants were randomized into the trial, but 2 were withdrawn from the study due to becoming pregnant during the 18-month intervention. Of the remaining 202 participants, 95 participants met the additional eligibility criteria for the secondary data analyses. There were no significant ($p > .05$) differences in age, BMI, sex, race, ethnicity, education, marital status, and daily energy intake at baseline between participants who were included in the secondary data analysis compared to those who were not included. As expected, baseline self-reported weekly energy expenditure from MVPA was significantly greater in participants included in the secondary data analysis as compared to those participants who were not included (1632.7 ± 1627.5 kcal/week vs 544.5 ± 744.3 kcal/week, $p < .001$). Baseline self-reported number of

different activities engaged in per week at moderate- to vigorous-intensity level was also significantly greater in participants included in analyses versus those not that were not included (1.3 ± 1.2 vs 0.4 ± 0.8 , $p < .001$).

Study Design

Participants were classified into 2 groups: (1) participants who self-reported engaging in 2 different physical activities per week at 6, 12, and 18 months (Variety: $N = 30$); and (2) participants who self-reported engaging in only 1 PA per week at 6, 12, or 18 months (Less Variety: $N = 65$). The number of different physical activities a participant was engaging in was determined via self-report from the Paffenbarger Physical Activity Questionnaire,¹⁸ using guidelines that have been used previously (see Physical activity in Measures). Only activities representing structured exercise that were performed at a moderate- to vigorous-intensity in episodes of at least 10 minutes were used in determining variety of physical activities. Primary dependent variables were self-reported weekly energy expenditure from MVPA and BMI at 18 months.

Intervention

This investigation implemented a standard lifestyle obesity intervention, which contained 3 components: (1) a cognitive behavioral intervention; (2) a diet prescription; and (3) a PA prescription. The 3 components are designed to assist participants with developing a healthy lifestyle to achieve a weight loss of 10%.^{1,2} The 18-month intervention consisted of 48 group meetings lasting 60 minutes each. These meetings occurred weekly from month 1 to month 6 and then twice a month from month 7 to month 18. Sessions covered lessons on behavioral and cognitive skills (self-monitoring, stimulus control, problem-solving, preplanning, goal setting, cognitive restructuring, social support development, and relapse prevention) to help with changing dietary and PA behaviors and were modeled after lessons used in Look AHEAD.¹⁹ Participants were instructed to consume a standard energy- and fat-restricted diet (1200 to 1500 kcal/day, 30% energy from fat). Participants also were instructed to increase MVPA gradually to 40 minutes/day, 5 times/week, and given a goal of 10,000 steps per day.²⁰

The primary objective of the trial was to examine the influence of a novel dietary prescription that limited the number of different sweet and salty energy-dense foods (ie, cookies, chips) consumed during an 18-month lifestyle obesity treatment intervention. Thus, participants were randomized to one of 2 conditions, a condition that limited the consumption of the number of these energy-dense foods to only 2, or to a second condition that did not have a limit. All other aspects of the 2 conditions were identical. A complete description of the intervention and the 2 conditions has been published previously.¹⁶

Measures

Dependent measures were collected in a research setting by trained research staff blinded to the randomization assignment.

Demographic characteristics and anthropometric measures—Basic demographic information (ie, sex, age, and education level) was obtained by self-report at baseline only.

Height, without shoes, was measured to the nearest millimeter at entry into the trial using a stadiometer, and weight was measured to the nearest 0.2 lb with a calibrated digital scale at 0 and 18 months while the participants were wearing light street clothes with no shoes. BMI was calculated as weight in kg/height in meters².

Dietary intake—Overall energy intake was assessed by 3 random (2 weekdays and 1 weekend day) 24-hour dietary recalls collected by phone over a one-week period at 0 and 18 months. Trained interviewers blinded to the intervention and intervention assignment, from the Cincinnati Center for Nutritional Research and Analysis, conducted the 24-hour dietary recalls. Each 24-hour recall was completed by using the Nutrition Data System Software for Research developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN. Participants were given 2-dimensional food shapes to help with estimating portion sizes. Daily energy intake was calculated as the means over the 3 days of recall.

Physical activity—Self-reported PA was assessed by using the Paffenbarger Physical Activity Questionnaire.¹⁸ This questionnaire yields estimates of the total energy expended in all self-reported physical activities per week based on flights of stairs climbed per day, city blocks walked per day, and frequency and duration of any sports and recreational activities performed within a typical week. The intensity of sports and recreational activities was determined using the Paffenbarger coding scheme. The Paffenbarger Physical Activity Questionnaire has been shown to be significantly correlated with an objective measure of PA.²¹

Guidelines developed by Bond et al¹³ were used to determine PA variety. For walking city blocks to be counted as a structured activity, participants had to report walking at least 12 blocks per day (equivalent to walking 1 mile at a moderate intensity). Treadmill walking reported as a sports and recreational activity was not distinguished as a separate activity from walking 12 blocks/day. Climbing stair flights, walking < 12 blocks/day, and moderate-to-vigorous intensity sports and recreational activities that were performed for < 10 minutes were not considered structured activities and were not counted towards the PA variety total. PA variety was determined by summing the number of self-reported moderate-to-vigorous-intensity activities meeting the above criteria. PA variety per week was determined at 6, 12, and 18 months and participants self-reporting engaging in 2 activities at all time-points were classified as Variety and those reporting only one activity at any time point were classified as Less Variety.

Statistical Analyses

Differences in baseline characteristics between the 2 PA variety groups were examined by using chi-square and independent t-tests for nominal and interval/ratio data, respectively. Paired t-tests were conducted to examine changes in daily energy intake, self-reported weekly energy expenditure from MVPA, and BMI from 0 to 18 months in all participants. To determine if differences in daily energy intake occurred between the groups at 18 months, an analysis of covariance (ANCOVA), with initial randomized intervention group, age, sex, race, and baseline daily energy intake as covariates, was conducted. To examine the number

of different self-reported PA weekly activities and the primary dependent variable of self-reported weekly energy expenditure from MVPA at 18 months, ANCOVAs, with initial randomized intervention group, age, sex, race, and baseline self-reported PA weekly activities or baseline self-reported weekly energy expenditure from MVPA as covariates, were conducted. For examining BMI at 18 months, an ANCOVA, with initial randomized intervention group, age, sex, race, and baseline BMI, was conducted. Analyses were conducted by using SPSS Statistics for Windows (version 20.0; SPSS, IBM Corp, Armonk, NY). The alpha-level was set at .05. Reported effect sizes, Cohen's d, occurring between the 2 groups were calculated using G Power.²²

RESULTS

Baseline demographics between the 2 groups are shown in Table 1. There were no significant differences between the groups in age, BMI, race, ethnicity, education, daily energy intake, self-reported number of different physical activities per week, and self-reported weekly energy expenditure from MVPA. Participants were aged 52.5 ± 8.8 years, had a BMI of 34.4 ± 4.6 kg/m², and 91.6% of participants were white, 100% were non-Hispanic, 78.9% were married and 84.2% had some college education. Daily energy intake was 1956 ± 484 kcal. The self-reported number of different weekly physical activities was 1.4 ± 1.3 per week and the self-reported weekly energy expenditure from MVPA was 1632.7 ± 1627.5 kcal/week. There was a significant difference between the groups for sex, with the Variety group having a greater percentage of men than the Less Variety group (66.7% vs 40.0%, $p < .05$).

When changes were examined across time in all 95 participants, significant ($p < .001$) differences occurred between 0 to 18 months for daily energy intake, self-reported weekly energy expenditure from MVPA, and BMI. Daily energy intake decreased (1956 ± 484 kcal vs 1537 ± 450 kcal), self-reported weekly energy expenditure from MVPA increased (1632.7 ± 1627.5 kcal/week vs 2673.9 ± 1986.7 kcal/week), and BMI decreased (34.4 ± 4.6 kg/m² vs 30.3 ± 4.8 kg/m²) from 0 to 18 months. There was no significant difference between the groups in daily energy intake at 18 months ($d = 0.14$). At 18 months the self-reported number of different physical activities engaged in per week and self-reported weekly energy expenditure from MVPA was significantly ($p < .05$) different between the groups, with Variety reporting higher amounts than Less Variety (Table 2). The effect size for self-reported weekly energy expenditure from MVPA between the groups was $d = 0.78$, a medium to large effect size.²² Table 2 shows BMI at 18 months was lower for Variety than Less Variety, but was not significantly different between the groups. The effect size for BMI at 18 months between the groups was $d = 0.23$, a small effect size.²²

DISCUSSION

Whereas previous research has found that having access to or engaging in a variety of different activities increases time spent in PA and is related to meeting PA guidelines,^{8,10,11,13–15} no previous investigation has prospectively examined whether continued engagement in a variety of physical activities is related to higher MVPA levels and lower BMI within the context of obesity treatment. Results of this study indicated that

Variety participants who consistently reported engaging in at least 2 different physical activities per week from 6 to 18 months self-reported more weekly energy expenditure from MVPA at 18 months than Less Variety participants who did not report consistently engaging in at least 2 different physical activities per week from 6 to 18 months. At 18 months, the difference in self-reported weekly energy expenditure between the groups was 1478 kcal/week, which over time, could influence BMI. However, there was no difference in BMI at 18 months between the 2 groups.

The finding that consistent PA variety was related to greater self-reported energy expenditure from MVPA may be explained by a number of physiological and psychological factors. For example, when the same activity is performed consistently, there is increased risk of injury due to overuse/repetitive motion and less time for recovery, which could reduce MVPA.^{11,23} Thus, engaging in a variety of activities may prevent the occurrence of these physiological barriers and enhance MVPA. Additionally, research based on the behavioral economics indicates that motivation to engage in an activity is enhanced when individuals can choose from a variety of physical activities versus only one activity.^{24,25} Finally, potentially engaging in a greater number of activities for MVPA may decrease the rate of habituation in performing MVPA. Habituation occurs when there is a decrease in response to a stimulus with repeated presentations of the stimulus, with the decrease being unrelated to other non-psychological explanations such as fatigue.²⁶ A change in MVPA cues (eg, greater variety) should produce a recovery of engaging in PA. For example, engaging in a variety of activities has been associated with greater MVPA due to enhanced enjoyment^{11,27} and/or decreased boredom.^{23,28} It is important to note that it is unclear from this investigation if the variety needs to occur within the same MVPA episode or can occur across several days to be related to increased MVPA. Importantly, this investigation does suggest that consistently engaging in a variety of physical activities was related to achieving high-levels of MVPA at 18 months. Future research is needed to investigate potential mechanisms that underlie the relationship between PA variety and long-term engagement in MVPA.

Although self-reported weekly energy expenditure from MVPA at 18 months was different between the groups, BMI at 18 months was not different between the groups. Previous research has shown that high levels of PA are related to enhanced long-term weight loss and successful weight loss maintenance.⁴⁻⁶ This investigation found that the amount of self-reported weekly energy expenditure from MVPA in the Variety group was even greater than that reported by long-term successful weight loss maintainers in the NWCR (3675 ± 1935 kcal/week vs 2621 ± 2252 kcal/week).⁴ Most likely, the small sample size in this investigation hampered the ability to find statistical significance between the conditions in BMI at 18 months, as this was a small effect. As there was no significant difference between the groups in self-reported daily energy intake at 18 months, the lack of difference between the 2 groups in BMI at 18 months did not appear to be due to differences in energy intake. It would be important to ascertain if the greater amounts of self-reported weekly energy expenditure from MVPA are related to changes in other activities, such as reduced amounts of light PA and greater amounts of sedentary behavior, which could impact on BMI. Additionally, it would be important to follow up over a longer period of time to ascertain if the self-reported weekly energy expenditure from MVPA reported by the Variety group is maintained beyond the 18-month time frame. Finally, as both MVPA and diet were self-

reported in this investigation, to improve understanding of the relationship among PA variety, MVPA-related energy-expenditure, and BMI, future studies should be conducted with an objective measure of activity.

An additional limitation of this investigation is that the results cannot be generalized to healthy weight individuals and overweight and obese individuals who are not seeking obesity treatment. A major strength of this study includes examining the relationship between PA variety and energy expenditure from MVPA and BMI on a longitudinal, rather than cross-sectional basis.

Increasing the total volume of MVPA can be achieved by focusing on changing frequency of occurrence of MVPA and/or by increasing PA variety.⁸ This investigation found that overweight and obese participants reporting consistent weekly PA variety across a 12-month time frame during obesity treatment self-reported greater amounts of weekly energy expenditure from MVPA. Future research is needed to examine the effect of PA variety on increasing and maintaining MVPA, how potential increases in MVPA may be related to changes in light PA and sedentary behavior, and how these changes in activity may influence BMI outcomes in overweight and obese individuals seeking obesity treatment.

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Table 1Baseline Characteristics of Participants in the Variety and Less Variety Groups (M $\pm$ SD)

	Variety (N = 30)	Less Variety (N = 65)
Age (yrs)	51.3 $\pm$ 8.8	53.0 $\pm$ 8.8
BMI (kg/m²)	33.5 $\pm$ 4.4	34.8 $\pm$ 4.6
Sex (M/F) *	20/10	26/39
White (%)	93.3	90.8
Some college education (%)	96.7	89.2
Married (%)	80.0	78.5
Daily energy intake (kcal)	2087 $\pm$ 454	1882 $\pm$ 505
Number of different physical activities per week	1.7 $\pm$ 1.4	1.2 $\pm$ 1.3
Energy expenditure from MVPA (kcal/week)	1842.1 $\pm$ 1426.2	1351.5 $\pm$ 1606.4

*
p < .05.

Note.

BMI = body mass index

M/F = Male/Female

MVPA = moderate- to vigorous-intensity physical activity

Table 2

Self-reported Number of Different Weekly Physical Activities, Self-reported Weekly Energy Expenditure from MVPA, and BMI at 18 months in the Variety and Less Variety Groups (M $\pm$ SD)

	Variety (N = 30)	Less Variety (N = 65)
Number of different physical activities per week **	2.8 $\pm$ 0.7	1.6 $\pm$ 1.0
Energy expenditure from MVPA (kcal/week) *	3674.7 $\pm$ 1934.6	2197.3 $\pm$ 1841.4
BMI (kg/m ²)	29.5 $\pm$ 4.3	30.6 $\pm$ 5.0

*
p < .05.

**
p < .001

Note.

MVPA = moderate- to vigorous-intensity physical activity

BMI = body mass index