



## Physical Activity and Sedentary Behavior Patterns Across Weekdays and Weekend Days in Youth With Multiple Sclerosis and Controls

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**Background:** This study quantified and compared weekday and weekend patterns of device-measured physical activity (PA) and sedentary behavior between youth with pediatric multiple sclerosis (MS) and controls for the purpose of informing future PA behavior change interventions.

**Methods:** Participant data were obtained from 3 ongoing observational studies, and the sample included 40 participants with pediatric MS and 41 controls. Light PA (LPA), moderate to vigorous PA (MVPA), and sedentary behavior data were collected using activity monitors (ActiGraph LLC) over 1 week. The main analysis involved a 2-way mixed factor analysis of variance with group as a between-subjects factor (pediatric MS vs control) and day as a within-subjects factor (weekday vs weekend day).

**Results:** There was no group by day interaction from the analysis of variance for percentage of activity monitor wear time spent in LPA, MVPA, or sedentary behavior. There was no effect of group for LPA, MVPA, or sedentary behavior. There was an effect of day of week on percentage of day spent in LPA, MVPA, and sedentary behavior.

**Conclusions:** These results suggest that youth with pediatric MS and controls were less physically active and more sedentary on weekends than on weekdays, but there were no differences between groups in PA and sedentary behavior overall or by day of the week. Physical activity interventions may be more successful by initially targeting weekend day activity. *Int J MS Care. 2022;24:8-12. doi:10.7224/1537-2073.2020-056*

**P**ediatric multiple sclerosis (MS) is a chronic demyelinating disease of the central nervous system occurring in persons younger than 18 years.<sup>1,2</sup> The hallmark features of pediatric MS include higher lesion burden, higher annualized relapse rates, and younger onset of irreversible disability compared

with adult-onset MS.<sup>3-5</sup> Youth with MS further present with fatigue, depression, and progressive cognitive impairment.<sup>6,7</sup> There has been a recent focus on lifestyle approaches for symptomatic management in this population as in the general population.<sup>8</sup>

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Physical activity (PA) is a promising strategy for managing the consequences of pediatric MS.<sup>9,10</sup> Cross-sectional evidence suggests that higher rates of vigorous PA are associated with reduced T2 lesion volume, depression, anxiety, fatigue, and annualized relapse rates in pediatric MS.<sup>10,11</sup> However, youth with MS engage in low levels of PA—less than 10 minutes per day of moderate PA and less than 1 minute per day of vigorous PA.<sup>12</sup> These estimates are far below the recommendations for youth by the US Centers for Disease Control and Prevention (eg,  $\geq 60$  minutes per day of moderate to vigorous PA [MVPA]).

There are no published estimates of rates or patterns of sedentary behavior for pediatric MS, but youth generally engage in high rates of sedentary behavior.<sup>13-15</sup> Sedentary behavior is on the opposite end of PA on the activity continuum and has been defined as any activity with minimal movement and low energy expenditure.<sup>16</sup> Sedentary behavior may also influence the consequences of pediatric MS, as it has been associated with negative health consequences in healthy pediatric populations (eg, obesity, poor self-esteem)<sup>17</sup> and impaired mobility and high blood pressure in adults with MS.<sup>18,19</sup> Of note, PA and sedentary behavior are discussed as 2 distinctly independent and modifiable health behaviors that may influence the symptomatic burden in youth with MS and could be targeted in behavior change interventions.<sup>10</sup>

The examination of patterns of engagement in PA and sedentary behavior is an important step in the development of behavior change interventions.<sup>20</sup> Indeed, youth may benefit most from interventions targeting specific time frames of physical inactivity or sedentarism (eg, weekend days vs weekdays) because the lowest levels of PA may provide the greatest opportunity for change and benefit.<sup>20,21</sup> The delivery of interventions that target periods in which PA is particularly low, or sedentarism is particularly high, may provide the greatest opportunity to elicit change as interventions targeting overall activity regardless of periods may have limited effectiveness.<sup>22</sup> There is some research indicating that youth without chronic disease are more active on weekdays than on weekend days<sup>20,23</sup> and are more sedentary on weekend days than on weekdays.<sup>24</sup> We are unaware of research that has examined these types of weekly patterns using device-measured estimates among youth with MS.

This study examined weekday and weekend patterns of PA and sedentary behavior based on accelerometry in youth with MS compared with controls. We anticipated that youth with MS would engage in less PA behavior and more sedentary behavior than controls, as has been

described in previous studies,<sup>11</sup> and that these differences would extend to both weekend days and weekdays. We further expected youth with MS to engage in less PA behavior and more sedentary behavior on weekend days than on weekdays.

## Methods

Participants with MS were recruited through neuroinflammatory clinics at the Hospital for Sick Children and the Children's Hospital of Philadelphia. Those with pediatric MS were eligible for inclusion if they were younger than 18 years at the time of symptom onset and at the time of baseline testing, had a confirmed diagnosis of MS according to international diagnostic criteria,<sup>25</sup> had an Expanded Disability Status Scale score less than 4.0, and were fluent in English. Youth with MS were excluded if they were unable to communicate in English, had experienced a relapse within 30 days, or were unable to understand instructions and/or tolerate PA.

Controls were recruited by advertisement at the same hospitals, in the local community, or by word of mouth. Controls were eligible for inclusion in this study if they were younger than 18 years, had no personal history of MS, and had no known history of disease or disability.

Participant data were collated from 3 ongoing observational studies conducted through the aforementioned hospitals. Each study was approved by the local ethics panel. All participants or a legally authorized adult provided written informed consent or assent as appropriate. Basic demographic information (ie, age and sex) and disease-specific information, including disease duration (time since diagnosis), number of total relapses, and disability level, were collected from medical records of participants with pediatric MS. The Expanded Disability Status Scale was performed within 1 month of questionnaire completion and accelerometry.

Accelerometry data were collected using ActiGraph GT3X activity monitors (ActiGraph LLC) because these devices have been validated for use in pediatric samples.<sup>26</sup> The ActiGraph accelerometer measures acceleration of the body during human movement, and the accelerometer signal is converted into units called activity counts that reflect volumes and patterns of sedentary behavior and PA levels. Participants wore the accelerometer over the nondominant hip during waking hours for 7 consecutive days except when engaged in water-based activities. We defined a valid day as wear time of at least 600 minutes ( $\geq 10$  hours), and participants with at least 1 day of valid accelerometer data were included in the present analysis.<sup>27</sup>

Accelerometry data were analyzed using ActiGraph software version 6.13.3. Adolescent-specific cutpoints were used for categorizing sedentary (<800 activity counts per minute), light PA (LPA; 800-3199 activity counts per minute), and MVPA ( $\geq 3200$  activity counts per minute) engagement.<sup>26</sup> ActiGraph analyses provide estimations of sedentary behavior, LPA, and MVPA in minutes per day and in percentage of wear time per day. We report descriptive data related to PA and sedentary behavior in both minutes per day and

**Table 1. Descriptive Information**

Characteristic	Pediatric MS group (n = 40)	Control group (n = 41)	Significance
Sex, male/female	6/34	8/33	.60 <sup>a</sup>
Age, years	16.3 ± 1.4	15.9 ± 1.3	.12 <sup>a</sup>
EDSS score	1.5 [1.0-3.0]	NA	NA
Disease duration, y	2.3 ± 2.3	NA	NA
Annualized relapse rate	2.7 ± 2.5	NA	NA
Valid days	5.5 ± 1.5	5.3 ± 1.8	.72 <sup>a</sup>
Activity monitor wear time, min			
Weekday	827.8 ± 101.7	835.4 ± 111.8	.75 <sup>a</sup>
Weekend day	780.1 ± 136.3	779.4 ± 126.8	.98 <sup>a</sup>
Activity behavior, mean, min/%			
Sedentary	739/91	725/88	0.13/0.57 <sup>b</sup>
LPA	64/8	78/10	0.51/0.58 <sup>b</sup>
MVPA	12/1.5	15/1.7	0.22/0.21 <sup>b</sup>

EDSS, Expanded Disability Status Scale; LPA, light physical activity; min, minutes per day; MS, multiple sclerosis; MVPA, moderate to vigorous physical activity.

Note: Unless otherwise indicated, values given as number, mean ± SD, or median [range].

<sup>a</sup>P value.

<sup>b</sup>Cohen *d*.

percentage of wear time. We opted a priori to conduct the main analyses using the percentage of wear time estimates because we anticipated differences between weekday and weekend day device wear time and possibly differences in wear time between the pediatric MS and control groups.

Data analysis was conducted using SPSS Statistics for Windows, version 27 (IBM Corp). Descriptive statistics are reported as mean ± SD unless otherwise noted. Independent-samples *t* tests and  $\chi^2$  analyses examined possible differences in age and sex between those with pediatric MS and controls. The main analysis involved a 2-way mixed factor analysis of variance with group (pediatric MS vs control) as a between-subjects factor and day (weekday vs weekend day) as a within-subjects factor.

Cohen *d* effect sizes were generated for between-group differences in weekday and weekend day PA and sedentary behavior. Effect sizes are interpreted such that 0.2, 0.5, and 0.8 were considered small, medium, and large effects, respectively. Significance was determined a priori as  $P \leq .05$  for all analyses.

## Results

One or more valid days of accelerometry data were available for 40 youth with MS (34 girls and 6 boys) and 41 controls (33 girls and 8 boys). The mean ± SD age of the sample was 16.3 ± 1.4 years for youth with MS and 15.9 ± 1.3 years for controls. There was no difference in the distribution of sex ( $P = .60$ ) or age ( $P = .12$ ) between groups. Youth with MS had a mean ± SD disease duration of 2.3 ± 2.3 years, a mean ± SD annualized relapse rate of 2.7 ± 2.5, and a median disability

level of 1.5 (range, 1.0-3.0). Summary data are presented in **Table 1**.

There was no group × day interaction for percentage of activity monitor wear time spent in sedentary behavior ( $F = 0.9$ ,  $P = .34$ ). There was no effect of group for sedentary behavior ( $F = 3.66$ ,  $P = .06$ ). There was a significant main effect of day of week ( $F = 16.2$ ,  $P < .01$ ) on percentage of day spent in sedentary behavior (weekday: 89%, weekend day: 91%). Descriptive data are provided in **Table 2**.

There was no group × day interaction for percentage of activity monitor wear time spent in LPA ( $F = 1.2$ ,

**Table 2. Analysis of Variance Results**

Activity behavior and analysis	P value
Sedentary	
Group: pediatric MS vs control	.06
Time: weekday vs weekend day	<.01 <sup>a</sup>
Group × time	.34
LPA	
Group: pediatric MS vs control	.06
Time: weekday vs weekend day	.01 <sup>a</sup>
Group × time	.28
MVPA	
Group: pediatric MS vs control	.50
Time: weekday vs weekend day	<.01 <sup>a</sup>
Group × time	.92

LPA, light physical activity; MS, multiple sclerosis; MVPA, moderate to vigorous physical activity.

<sup>a</sup>Statistically significant.

**Table 3. Weekday Vs Weekend Activity Between Groups**

Activity behavior	Pediatric MS group (n = 40)	Control group (n = 41)	Cohen <i>d</i>
Weekday activity, %			
Sedentary	90.0 ± 3.8	88.3 ± 4.7	0.40
LPA	8.2 ± 2.7	9.6 ± 4.1	0.40
MVPA	1.8 ± 1.7	2.1 ± 1.6	0.20
Weekend activity, %			
Sedentary	92.4 ± 4.5	89.7 ± 4.8	0.58
LPA	6.8 ± 3.8	9.2 ± 4.7	0.60
MVPA	0.8 ± 1.5	1.1 ± 1.4	0.20

%, percentage of activity monitor wear time; LPA, light physical activity; MS, multiple sclerosis; MVPA, moderate to vigorous physical activity.

Note: Values are given as mean ± SD.

$P = .28$ ). There further was no effect of group for LPA ( $F = 3.64$ ,  $P = .06$ ). There was a significant main effect of day of week ( $F = 6.17$ ,  $P = .01$ ) on percentage of day spent in LPA (weekday: 9%, weekend day: 8%). Descriptive data are provided in Table 2.

There was no group × day interaction for percentage of activity monitor wear time spent in MVPA ( $F = 0.01$ ,  $P = .92$ ). There was no effect of group for MVPA ( $F = 0.5$ ,  $P = .5$ ). There was a significant main effect of day of week ( $F = 24.1$ ,  $P < .01$ ) on percentage of day spent in MVPA (weekday: 2%, weekend day: 1%). Descriptive data are provided in Table 2.

There was a small effect of pediatric MS on weekday LPA ( $d = 0.40$ ) and a moderate effect on weekend day percentage of LPA ( $d = 0.60$ ) compared with controls. There was a small effect of pediatric MS on weekday percentage of MVPA ( $d = 0.20$ ) and weekend day percentage of MVPA ( $d = 0.20$ ) compared with controls. There was a small effect of pediatric MS on percentage of weekday sedentary behavior ( $d = 0.40$ ) and a moderate effect of pediatric MS on percentage of weekend day sedentary behavior ( $d = 0.58$ ) compared with controls. Effect sizes are presented in Table 3.

## Discussion

We quantified and compared patterns of PA and sedentary behavior across weekdays and weekends among participants with pediatric MS and controls. These results suggest that both groups were less physically active and more sedentary on weekends than on weekdays, and there were no differences between groups in PA and sedentary behavior overall or by day of the week. These results align with evidence from the general population indicating that youth engage in more sedentary behavior<sup>28</sup> and less

activity behavior on weekend days than on weekdays.<sup>29,30</sup> This may be attributed to the presence of fewer scheduled activities and more personal choice on weekends, together with preferences for inactive behaviors.<sup>28</sup>

This observation of higher sedentary behavior and lower PA on weekend days compared with weekdays provides information that may inform the development of PA interventions for youth with MS. These results suggest that interventions for adolescents with MS may be most effective by differentially targeting weekday and weekend day activity behaviors. For example, interventions that target specific periods of high sedentary behavior may effectively reduce sedentarism and increase activity as a direct consequence.<sup>31</sup> As such, the present results support the tailoring of PA interventions based on specific periods. Such interventions would benefit from future research that identifies specific strategies that may be most effective in promoting PA and reducing sedentary behavior on weekend days for those with pediatric MS as well as the effect of various seasonal factors influencing patterns of PA (eg, school extracurricular activities).

Neither PA nor sedentary behaviors differ significantly between youth with MS and controls, but we suspect that this might be a result of the small sample size and the resulting low statistical power. Inspection of effect size estimates suggested a small effect of pediatric MS on sedentary behavior and LPA on weekdays and a moderate effect of MS on sedentary behavior and LPA on weekends compared with controls. The overall estimates of LPA and MVPA were comparable with previously reported PA rates among youth with MS<sup>12</sup> wherein the sample significantly differed from controls. This finding suggests that pediatric MS may indeed have an effect on PA and sedentary behavior, but this effect may be less influential than the effect of day of week based on the present analysis. We further recognize that both groups in the present study engaged in low levels of PA and did not

## PRACTICE POINTS

- Physical activity (PA) interventions for youth with MS may be more effective by targeting specific time frames of activity.
- Youth with MS were similar to peers without chronic illness in time spent engaged in PA and sedentary behavior on weekdays and weekend days.
- Youth with MS engaged in lower levels of PA and higher levels of sedentary behavior on weekend days compared with weekdays.



meet recommended PA guidelines. This may be partially due to the documented decline of PA behavior and rise in sedentary behavior from childhood to adolescence.<sup>32</sup> Indeed, evidence suggests that the largest decline in activity behavior occurs in late adolescence,<sup>33</sup> and this highlights the importance of intervening before or during this critical phase of health behavior habit development.

There are several potential limitations of the present study. The comparison of 2 existing groups assumes that differences are associated with disease status rather than with other factors differing between groups (eg, family support or environmental accessibility). The small sample size and associated statistical power, along with low rates of PA in the sample, may limit our ability to identify actual differences between the pediatric MS and control groups.

In conclusion, overall youth with MS and controls engage in lower levels of PA behavior and higher levels of sedentary behavior on weekend days than on weekdays. Importantly, both samples spend a considerable amount of time in sedentary behavior and very little time in LPA or MVPA. Based on previous research outside of pediatric MS, behavior change interventions that differentially target PA or sedentary behavior on weekdays and weekends may promote healthy activity behavior among those with pediatric MS. □

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