Associations between Intersecting Sociodemographic Characteristics and Device-Measured Physical Activity among Children and Adolescents living in the United States

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Abstract

Background: Research has shown that sociodemographic characteristics explain some of the disparities in physical activity among children and adolescents, yet potential interactions between these characteristics have received limited attention. This study explored the intersectionality of gender, race/ethnicity, parental education, and household income in relation to device-measured physical activity volume and intensity in a nationally representative sample of US children and adolescents.

Methods: This cross-sectional study used data from three cycles of the US National Health and Nutrition Survey (2011-2012; 2012 National Youth Fitness Survey; 2013-2014). A total of 6,116 participants (49% female; weighted N=50,304,823) between 3 to 17 years of age wore an accelerometer on their non-dominant wrist for 7 days. Monitor-independent movement summary units were used to represent physical activity volume and intensity. A Social Jeopardy Index was created to represent increasing levels of intersecting social disadvantages based on combinations of gender, race/ethnicity, parental education, and household income-to-poverty ratio tertiles. Generalized linear regression models were computed.

Results: The results showed social disadvantages become increasingly evident among children and adolescents during the most intense 60 minutes of daily physical activity (B=-48.69 ± 9.94 SE, $p <$ .001), but disparities in total volume were not observed (B=34.01 ± 44.96 SE, p = 0.45).

Conclusions: Collectively, our findings suggest patterns of physical activity engagement may differ based on sociodemographic characteristics – socially disadvantaged children and adolescents appear to accumulate activity at lighter intensities. Collecting contextual information about device-measured physical activity behavior represents an important next step for gaining insight into these sociodemographic differences.

Background

Physical activity is widely regarded to be an important contributor to the physical and mental health of children and adolescents.[1–3] Despite a well-established evidence base and continued calls to action,[4] global estimates indicate roughly 80% of youth do not meet the public health recommendation of one hour of moderate-to-vigorous physical activity (MVPA) on average each day.[5] Among high-income countries with strong behavioral surveillance systems, evidence indicates the children and adolescents living in the United States are among the least active. For example, findings from the 2016-2017 National Survey of Children's Health indicated that 25.9% of children and 17.4% of youth met the physical activity guidelines.[6] Data from the 2015-2017 Youth Risk Behavior Risk Surveillance System demonstrated a similar trend, although guideline adherence among youth was slightly higher at 26.6%.[7] Taken together, it is clear that further research is needed to better understand why so many children and youth are missing out on the array of favorable benefits that physical activity behavior is known to confer for health.

One area of research that has received considerable attention for its role in physical activity behavior among children and youth is social determinants of health.[8] A systematic review of reviews examining correlates of child and adolescent physical activity behavior has demonstrated consistent associations with sociodemographic variables such as gender, household income, parental education, and race/ethnicity with physical activity behavior.[9] Specifically, results generally showed that boys are more active than girls, children who identify as White tend to be more active than other racial/ethnic groups, and positive associations exist between socioeconomic status indicators (e.g., household income, parental education) and physical activity. In the context of the United States, physical activity patterns observed from the 2019 cycle of the Youth Risk Behavior Risk Surveillance System align with the trends observed by Sterdt et al.[9] in that combined aerobic and muscle strengthening guideline adherence is roughly 13% higher for males than females, and notable disparities were observed across for race/ethnicity with White youth tending to report the highest rates of guideline adherence.[6] Whereas research to date has for the most part examined social determinants independently, more recent work has begun to consider how certain combinations of these variables when viewed through an intersectionality lens, may confer additive disadvantages that produce disparities in physical activity engagement. This is referred to as a multiple jeopardy effect.[10]

Intersectionality is a theory based on the premise that multiple social statuses intersect with one another to create complex social hierarchies wherein individuals will experience varying degrees of social (dis)advantages based on their sociodemographic attributes.[11] Although existing studies are limited, previous research has showcased how different combinations of social disadvantages – or intersections – influence physical activity behavior.[12–14] To date, however, only one study has examined these relationships using a multiple jeopardy index that encompassed four levels of potential discrimination or oppression. In their study of Brazilian adults, Mielke et al.[10] found that the highest rates of sufficient leisure time physical activity were among White men who had the highest education and income. Conversely, sufficient leisure time physical activity was lowest among women who identified as non-White and had the lowest education and income. Perhaps most noteworthy is that identifying with an increasing number of social disadvantages was inversely associated with sufficient leisure time physical activity in a dose-response manner. Given that physical activity behavior tends to track reasonably well from childhood into adulthood,[15] it is critically important that we understand how intersecting social (dis)advantages may influence physical activity behavior early in the life course. Such knowledge has the potential to inform socio-culturally targeted approaches to intervention design and delivery, which has been proposed to have a strong potential for reaching sub-groups at greatest risk for poor health outcomes.[16]

Although Mielke and colleagues[10] demonstrated convincing evidence regarding potential negative impacts that intersecting social disadvantages can have on physical activity behavior, a shortcoming of their work was the use of self-reported physical activity measures, which have the potential to introduce social desirability bias and recall errors.[17] Device-based measures of physical activity such as accelerometry are one potential alternative to address these limitations related to measurement error. While not without limitations, these devices are able to capture physical activity – regardless of purpose, context or intensity – over the course of a whole day. Most research measuring physical activity using accelerometry has operationalized time spent engaging in different physical activity intensities using absolute intensity cut points, which are prone to misclassifying physical activity intensity at the individual level.[18,19] In response, there have been calls to use raw acceleration data to generate alternative metrics that describe directly measured physical activity[20] – one such metric is Monitor-Independent Movement Summary (MIMS) units.[21] Investigating whether multiple intersecting social disadvantages have additive negative effects on whole day device-measured physical activity behavior among children and adolescents would address a current knowledge gap and could yield important findings for public health promotion strategists.

Leveraging available device-measured data from nationally representative samples of children and adolescents represents an excellent opportunity to improve our understanding of factors that contribute to the high rates of insufficient physical activity in the US. Therefore, the purpose of this study was threefold: 1) To investigate whether race/ethnicity, socioeconomic status (i.e., ratio of family income to poverty; highest level of parental education) and gender were independently associated with physical activity volume and intensity among a nationally representative sample of US children and adolescents; 2) Whether greater sociodemographic disadvantage (as per our Social Jeopardy Index) was inversely associated physical activity volume and intensity; and 3) If the relationship between sociodemographic disadvantages and physical activity was moderated by life stage (i.e., early childhood, childhood, adolescence). We hypothesized that 1) children and adolescents who are male, identify as non-Hispanic White, and live in households with higher income-to-poverty ratios and parents/caregivers who have achieved higher levels of education would engage in greater total volume and intensity of physical activity; 2) the Social Jeopardy Index would be inversely associated with physical activity volume and intensity; and 3) sociodemographic disadvantages would have greater negative effects on physical activity volume and intensity with increasing age.

Methods

Study Design and Participants

This cross-sectional study was a secondary analysis of pooled data from the 2011-2012 and 2013-2014 cycles of the National Health and Nutrition Examination Survey (NHANES) as well as the 2012 NHANES National Youth Fitness Survey (NNYFS). NHANES, including the NNYFS, is administered by the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention (CDC). Each cycle of NHANES involves collection of cross-sectional data using multistage probability sampling to recruit a nationally representative sample of the non-institutionalized US population for the purpose of capturing information to assess the health and nutritional status of individuals living in the US. The NNYFS was a supplement of NHANES that was conducted simultaneously during the second year of the 2011-2012 NHANES cycle in response to the need to collect data specific to physical activity and fitness levels of US children and adolescents between the ages of 3 to 15 years. Participants completed an in-person home interview to gather demographic, socioeconomic, and health-related information and visited a mobile examination center to complete physiological, behavioral, and anthropometric measurements. Protocols for NHANES and the NNYFS were approved by the NCHS ethics review board. A parent/caregiver provided informed consent for all participants under the age of 18 years and participants ages 7 to 17 years provided assent to participate in the mobile examination portion of the study. More information about NHANES (https://www.cdc.gov/nchs/nhanes/about_nhanes.htm) and the NNYFS (https://www.cdc.gov/nchs/nnyfs/about_nnyfs.htm) data collection procedures can be found on the CDC website. Complete preregistration details for this study can be found at https://osf.io/9dsfe.

Responses from 21,571 participants were available from the three cycles of data collection (*n* = 9,756 from 2011-2012 NHANES; *n* = 1,640 from 2012 NNYFS; *n* = 10,175 from 2013-2014 NHANES). Of the 21,571 NHANES participants, only 20,727 participated in the physical activity monitor portion of the study; those who did not were excluded. Participants were invited to wear a physical activity monitor in NHANES during 2011 if they were ≥ 6 years old, whereas children ≥ 3 years old were invited in the NNYFS and in NHANES from 2012 to 2014. Given the present study focused on children and adolescents, the sample was subset to only include participants between 3 to 17 years of age. Thus, a total of 6,116 children and adolescents between 3 and 17 years of age were included in this study (sample weighted *N* = 50,304,823), which included 834 young children (ages 3 to 5 years; weighted *n* = 7,147,966), 2,042 children (ages 6 to 9 years; weighted *n* = 15,269,284) and 3,240 adolescents (ages 10 to 17 years; weighted *n* = 27,887,573). Sampling weights were used to correct for any over- or under-representation of key groups so that the present sample was nationally representative.

Measures

Physical activity. Physical activity was measured using ActiGraph GT3X+ triaxial accelerometers sampled at 80 Hz frequency (ActiGraph Corp., Pensacola, FL, USA). The wear time period consisted of nine days during which participants were asked to wear the accelerometer on their non-dominant wrist for 7 full consecutive days (second to eighth day). The first (device pick-up) and last day (device return) of the wear period were only partial wear days and were therefore removed from our analyses. As per previous research,[22,23] two inclusion criteria were specified to be considered valid physical activity data in the present study: 1) a valid day was defined as having 1440 minutes of accelerometer data (i.e., 24 h) in which less than 5% of time was considered non-wear (i.e., < 72 minutes) and < 17 hours were recorded as sleep wear; and 2) a valid sample was defined as having ≥ 1 valid day. One day of data has been determined to be sufficient for generating stable group-level estimates of physical activity in population-level research.[23] Participant-level minute-by-minute MIMS units data were downloaded from the NHANES and NNYFS websites. MIMS units represent a universal acceleration summary metric that accounts for discrepancies in raw data among research and consumer devices. More information about MIMS units, including the algorithm used to process data and psychometric properties can be found elsewhere.[21] Custom R scripts were written to compute two physical activity metrics: volume (daily MIMS) and intensity (Peak-60 MIMS). Physical activity volume (daily MIMS) represented the total MIMS units accumulated within a day averaged across all valid days, whereas intensity (Peak-60 MIMS) represented the average of the highest 60 MIMS unit values recorded within a day, averaged across all valid days.

Sociodemographic variables. Sociodemographic information was collected from parents/caregivers during the interview portion of NHANES and the NNYFS. Variables included age (categorized into young children [3-5], children [6-9] vs. adolescents [10-17]), gender (male/female), racial/ethnic identity (categorized into non-Hispanic White; non-Hispanic Black; Mexican American; Other Hispanic; Other Race - including multi-Racial), highest level of parental/caregiver education, which was categorized into tertiles (college graduate or above; some college or associate degree; high school or less, GED or equivalent), and household income, which was used to calculate a household income to poverty ratio by dividing household income by the poverty guidelines specific to family size and geographic location for the survey year, which was then recoded into tertiles.

Social jeopardy index. To examine the influence of intersecting combinations of social (dis)advantages, we created a Social (or "multiple") Jeopardy Index as per Mielke and colleagues.[10] Each participant was assigned a score ranging from 0 to 6 based on the sum of their sociodemographic characteristics, with higher scores representing a greater amount of social disadvantage: gender (Male = 0; Female = 1); race/ethnicity (Non-Hispanic White = 0; Other = 1); ratio of family income to poverty (Top tertile = 0; middle tertile = 1; bottom tertile = 2), parental education level (College graduate or above = 0; Some college or associate degree = 1; High school or less, GED or equivalent = 2). By these metrics, the most socially advantaged children and adolescents (score = 0) were non-Hispanic White males living in households in the top tertile of the family income to poverty ratio and with a parent/caregiver who was a college graduate or more. Comparatively, the most socially disadvantaged (score = 6) were non-White females living in households in the bottom tertile of the family income to poverty ratio and with a parent/caregiver who was a high school graduate or less.

Data Analysis

All analyses were performed in R (version 4.3.0) and R Studio (version 2023.06.0, PBC, Boston, MA, USA) using the *mice,*[24] *miceadds,*[25] *survey,*[26] *and gtsummary*[27] packages. First, we inspected the data for missingness using the *mice* and *miceadds* packages. Data were considered missing at random and multiple imputation by chained equations was computed using the *mice* and *miceadds* packages to replace missing values. Multiple imputation is considered a best practice for handling missing data.[28] A total of 15 multiply imputed datasets were created as per recommendations to set m > 100 times the highest fraction of missing information (10% for physical activity).[29] Survey weighted descriptive statistics were computed for all variables using the *survey* and *gtsummary packages*.

To take the NHANES and NNYFS sampling plan into account, all analyses were conducted using the *survey* package and individual survey weights were divided by 3 (the number of survey cycles combined). For objective one, associations between each sociodemographic characteristic and physical activity (Daily MIMS and Peak-60 MIMS) were investigated using a series of generalized linear regression models. Unadjusted and adjusted analyses were computed, with simultaneous adjustment for each sociodemographic variable. Our primary analyses included race/ethnicity as a two-level variable (i.e., non-Hispanic White vs. Other) as per the Social Jeopardy Index,[10] but sensitivity analyses examining independent associations between sociodemographic characteristics and physical activity with a five-level race/ethnicity variable were also computed. For objective two, separate generalized linear regression models were computed to investigate associations between the Social Jeopardy Index and our two physical activity metrics (i.e., Daily MIMS and Peak-60 MIMS). To explore where potential differences in physical activity volume and intensity exist between specific intersecting sociodemographic characteristics, we calculated the means and 95% confidence intervals for each possible combination of the four sociodemographic characteristics (see Figure 1). For objective three, we computed a series of generalized linear regression models with an age (group: young children, children, adolescents) by Social Jeopardy Index interaction to identify the extent to which social disadvantages may affect physical activity volume and intensity across the early life stages. For all analyses, results from each of the multiply imputed datasets were pooled as per Rubin's Rules.[30] Statistical significance was set at $\alpha = 0.05$.

Results

Demographics. Demographic characteristics for the full sample and the age-based subsamples are presented in Table 1. Overall, the sample was on average 10 years of age and consisted of a balance of males (51%) and females (49%), with the majority identifying as non-Hispanic White (53%). Most participants lived in households with a parent/caregiver who graduated from high school or less (41%) yet were categorized into the highest tertile of the household income (42%). For the Social Jeopardy

Index, the most socially advantaged (8.5%) and disadvantaged (6.5%) groups were least represented, whereas all other groups had similar representation ranging from 15% to 18% of the sample. Missing data ranged from 0% for age, gender, and race/ethnicity to 10% for physical activity. In total, 90% of participants had valid physical activity sample, which consisted of an average of ~5 days of valid physical activity data and 1,235 minutes/day of valid wear time. Missingness for physical activity was associated with age (i.e., less missingness among children than young children and adolescents) as well as year of survey (i.e., less missingness in 2011-2012 NHANES and 2012 NNYFS than 2013-2014 NHANES).

Objective #1: Independent associations between sociodemographic characteristics and physical activity

The results of our unadjusted and adjusted generalized linear regression models examining associations between physical activity volume and intensity with sociodemographic characteristics can be found in Table 2. Sensitivity analyses examining all five race/ethnicity categories can be found in Supplementary Table 1. Our findings revealed significantly lower physical activity volume and intensity among females than males. Significantly higher physical activity volume and intensity were observed among children living in households with parents who graduated from college compared to those living in households with parents/caregivers who completed less education. In contrast, participants categorized into the highest household income tertile were found to engage in significantly lower physical activity volume compared to those classified into lower tertiles and significantly lower physical activity intensity compared to those in the lowest tertile. No racial/ethnicity differences in physical activity volume and intensity were observed.

Objective #2: Associations between social disadvantage and physical activity

Values for physical activity volume and intensity according to position on the Social Jeopardy Index for the full sample and stratified by age cohort are presented in Table 3. Estimates of the Daily MIMS and Peak-60 MIMS according to all potential combinations of sociodemographic characteristics are presented in Figure 1. The results of our generalized linear regression model for physical activity intensity demonstrated a significant inverse association with the Social Jeopardy Index (B = -48.68 ± 9.94 SE, p < .001) wherein children and adolescents who were considered more socially disadvantaged engaged in lower intensity movement in their most active hour. In contrast, a non-significant relationship was observed between physical activity volume and the Social Jeopardy Index (B = 34.01 ± 44.96 SE, p = .453).

Objective #3: Interactive effects of social disadvantage and age on physical activity

Given the categorical nature of our grouped age variable, young children (ages 3 to 5 years) were specified as the referent age group in our generalized linear regression models for physical activity volume and intensity. The results of our model for physical activity volume revealed a significant age by social disadvantage interaction for children (B = -182.75 ± 80.44 SE, p = .029), wherein physical activity volume declines with higher position on the Social Jeopardy Index to a greater degree among children ages 6 to 9 years compared to young children. Further, significant main effects of age were observed for children (B = 1388.65 ± 358.38 SE, p < .001) and adolescents (B = -3526.61 ± 425.13 SE, p < .001), which demonstrated that physical activity volume is highest among children, followed by young children, and lowest among adolescents. The main effect of social disadvantage (B = 67.14 ± 58.96 SE, p = .262) and interactive effect of social disadvantage for adolescents (B = 3.49 ± 88.85 SE, p = .969) were non-significant. For physical activity intensity, significant main effects of social disadvantage (B = -34.09 ± 16.22 SE, p = .042) and age for children (B = 399.61 ± 97.57 SE, p < .001) and adolescents (B = -509.22 ± 86.87 SE, p < .001) were observed. These results demonstrated that akin to physical activity volume, physical activity intensity was highest among children, followed by young children, and lowest among adolescents, and the Social Jeopardy Index was inversely associated with intensity. In contrast, the moderation effect of age on social disadvantage (i.e., interaction effects) were non-significant for children (B = -41.50 ± 22.21 SE, p = .069) and adolescents (B = -9.13 ± 19.45 SE, p = .641). Simply stated, age did not moderate the relationship between the Social Jeopardy Index and physical activity intensity.

Conclusions

The purpose of the present study was to investigate the influence of independent and intersecting social disadvantages as well as potential moderating effects of age on device-assessed physical activity volume and intensity among a nationally representative sample of children and adolescents living in the US. Using three cycles of pooled data from NHANES and the NNYFS, our results showed that males (versus females) and children with parents who graduated from college (versus less educational achievement) engage in greater physical activity volumes and intensities, whereas no racial/ethnic disparities were observed. Household income was inversely associated with physical activity volume in a dose-response manner, although for intensity a significant difference was only found between the highest and lowest income tertiles. When investigating the influence of intersecting sociodemographic characteristics via a Social Jeopardy Index, our results showed greater social disadvantages had a negative effect on physical activity intensity but not volume. Moderation analyses for age, however, demonstrated that intersecting social disadvantages have a significant negative influence on physical activity volume during childhood (i.e., between ages 6 to 9 years). Collectively, these findings address a critical knowledge gap within the body of literature investigating social determinants of health and have important implications for public health.

To date, a considerable body of research has documented independent associations between sociodemographic characteristics and physical activity behavior among children and adolescents.[31] It should be acknowledged, however, that the majority of these studies have used self- or proxy-reports of physical activity or time in absolute intensities via accelerometry, both of which can introduce measurement error. Using device-based estimates of physical activity volume and intensity expressed using metrics based on directly measured accelerations therefore represented a major strength of the present study and allowed us to re-examine these relationships with less bias. Our findings for gender and parental education aligned with those from a systematic review of reviews by Sterdt et al.[9] which showed males are more active than females and parental education is positively associated with physical activity behavior. Racial/ethnic identity, on the other hand, was for the most part not found to be associated with physical activity volume or intensity in our two- and five-category models. These findings are in contrast to results from three systematic reviews which found children and adolescents who identify as non-Hispanic White are more active than those of other racial/ethnic backgrounds.[32–34] Given that these reviews only included studies up to 2003 and data for the present study was collected more recently, one possibility for this disparity in results is that over time racial/ethnic differences in physical activity levels have dissipated. It is also plausible that some of the racial/ethnic disparities observed in the past may be attributable to the self-reported nature of the data. For example, a study using self-reported physical activity data from the 2007 to 2016 NHANES found minority race/ethnicity was associated with less physical activity among adolescent females and household income was positively associated with adolescent physical activity.[35] These findings are in direct contrast to what we observed with accelerometry.

Perhaps most interesting among our models examining the independent influence of sociodemographic characteristics was the inverse association between household income and physical activity volume, in addition to children in the lowest tertile engaging in significantly more intense physical activity in their most active 60 minutes compared to those in the highest tertile. These findings contrast previous evidence from a systematic review in which positive relationships between family or household income-based metrics and physical activity were most commonly observed among samples of youth living in the US.[36] Yet only one of these studies used accelerometry, and a non-significant association was found between household income and average counts per minute, which is an indicator of general physical activity level.[37] Nevertheless, it is interesting that we found patterns of results in the opposite directions for parental education and household income. It is reasonable to postulate that parents who received a college education are more aware of the benefits of physical activity and therefore provide more physical activity support for their children, which is known to have a strong influence on physical activity behavior among children with and without chronic health conditions or disabilities.[38,39] For household income, the effect was strongest for physical activity volume, and previous work conducted in the US suggests this may be attributable to children of lower economic means having to rely on active transportation more often compared to their more affluent peers.[40] While there is partial coherence between our findings and the existing evidence base, a systematic review of sociodemographic correlates of device-measured physical activity behavior among children and adolescents is warranted. Such results would help improve our understanding of where potential social disadvantages may reside with more accuracy.

With a host of different indicators available to examine the influence of social disadvantage on physical activity behavior, it is clear that simply investigating independent associations can yield contrasting results. A composite metric that takes into consideration how social (dis)advantages intersect may therefore be more robust for making conclusions about associations with physical activity and permit capturing potential additive effects. In partial support of our hypotheses, we found that that physical activity intensity, but not volume, was inversely associated with greater social disadvantages via the Social Jeopardy Index in a dose-response manner. Simply stated, children who are considered increasingly more privileged (based on sociodemographic characteristics) engage in higher intensity movement during their most active hour. In light of the absence of an effect for total physical activity volume, our findings suggest socially disadvantaged children and adolescents accumulate a greater proportion of their total physical activity volume at lighter intensities. Given the nature of how physical activity was operationalized (i.e., MIMS units), it is challenging to interpret our findings in line with previous work which investigated guideline adherence among Brazilian adults.[10] Nevertheless, guideline adherence is based on time spent engaging in MVPA, which may better align with our intensity-based than our volume-based physical activity metric. This would ultimately demonstrate alignment with the inverse dose-response effects previously observed with increasing position on the Social Jeopardy Index.[10]

Although position on the Social Jeopardy Index was not associated with total physical activity volume among the full sample, a different pattern of results emerged when we examined whether age moderates this relationship. Specifically, we found that in comparison to young children (i.e., ages 3 to 5 years), physical activity volume was inversely associated with greater social disadvantage among children between the ages of 6 to 9, but not adolescents. In other words, additive social disadvantages have the greatest toll on physical activity volume during childhood. Although childhood was found to be the most physically active life stage in the present study, research has shown that physical activity begins to decline as early as seven years of age.[41] The present findings suggest such declines in physical activity may be partially attributable to social disadvantages. Childhood therefore represents an important time to ensure that children develop motor skills, confidence/motivation and positive affect towards being active as well as knowledge regarding the many benefits that physical activity confers, otherwise collectively known as physical literacy.[42] Research has shown that physical literacy predicts physical activity behavior.[43–48] Considering the amount of time children spend at school, in combination with the space and resources available, school-based initiatives in which physical education (P.E.) and recess have been reimagined such as the Zero Hour P.E. program that was implemented in Naperville, Illinois may be an ideal opportunity to promote the adoption and maintenance of physical activity behavior through targeting physical literacy.[49]

From a public health perspective, our findings pertaining to a non-significant relationship between the Social Jeopardy Index and physical activity volume are promising when considered in light of evidence from studies of adults using accelerometers that has suggested physical activity engagement – irrespective of bout duration, intensity, or frequency – provides favorable benefits for several health outcomes.[50] At the same time, other research has shown that engaging in higher intensity activities may be associated with even greater health benefits for youth,[2] which would suggest that those of greater social disadvantage may be missing out on some important health benefits. Determining effective strategies in which we get children of greater social disadvantage to engage in higher intensity activities should be prioritized considering trajectories of physical activity in childhood track reasonably well through adolescence and into adulthood.[15] Targeting groups at the greatest risk of engaging in insufficient amounts of physical activity could contribute to the *US Healthy People 2030* goal of increasing the proportion of children who do enough aerobic physical activity to 30%.[51] Collaborative efforts with implementation scientists may represent a promising approach to ensure socio-culturally targeted approaches to intervention design and delivery are optimized.

Although this study had several strengths such as the use of a nationally representative sample and accelerometry to directly measure physical activity behavior, it is not without limitations. First, accelerometry provides no contextual information pertaining to the types of physical activity that children and adolescents engaged in. This is important to note because leisure time physical activity has been shown to confer greater benefits for health compared to other domains such as occupational, transport and household activities.[52,53] Second, the physical activity metrics employed in the present study were informed by MIMS units, which are challenging to interpret from a public health recommendation standpoint. Finally, data for the present study were collected from 2011 to 2014 and therefore the pattern of results observed may not be reflected today. Some evidence suggests the COVID-19 pandemic exacerbated existing sociodemographic disparities in physical activity behavior,[54] making it reasonable to posit that the dose-response effect for physical activity intensity may be more pronounced now due to greater sport and recreational opportunity dropout among less privileged individuals.

In sum, evidence from the present study indicates that greater intersecting social disadvantages were associated with less intense physical activity among children and adolescents living in the US. It should be noted, however, that sociodemographic disparities in total physical activity volume were not observed among the full sample, yet moderation analyses revealed the influence of increasing social disadvantages was exacerbated during childhood. Moving forward, interventionists should consider sociodemographic-tailored strategies, particularly targeted towards children characterized by multiple intersecting social disadvantages, for the purpose of promoting the adoption and maintenance of physical activity behavior at a time when trajectories of behavioral patterns across the lifespan can be established.

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Table 1. *Descriptive statistics for the full sample and stratified by age group.*

	Full Sample (weighted N = 50,304,823)	Young Children (weighted n = 7,147,965)	Children (weighted n = 15,269,285)	Adolescents (weighted n = 27,887,573)
Age	10.1 (4.0)	4.0 (0.8)	7.5 (1.1)	13.2 (2.1)
Gender (male; %)	25,490,292 (51)	3,609,314 (50)	8,089,777 (53)	13,791,201 (49)
Race/Ethnicity (%)				
White	26,873,741 (53)	3,657,834 (51)	8,068,074 (53)	15,147,833 (54)
Mexican American	7,523,432 (15)	1,144,761 (16)	2,366,109 (15)	4,012,562 (14)
Other Hispanic	4,226,293 (8.4)	675,828 (9.5)	1,218,026 (8.0)	2,332,439 (8.4)
Black	7,046,396 (14)	1,000,188 (14)	2,063,797 (14)	3,982,411 (14)
Other	4,634,961(9.2)	669,354 (9.4)	1,553,279 (10)	2,412,328 (8.7)
Highest Level of Parental Education Tertiles (%)				
College graduate or more	14,408,944 (29)	2,090,444 (29)	4,627,059 (30)	7,691,441 (28)
Some college or associates degree	15,320,678 (30)	2,143,493 (30)	4,445,000 (29)	8,732,185 (31)
High school graduate or less	20,575,201 (41)	2,914,028 (41)	6,197,226 (41)	11,463,947 (41)
Household Income to Poverty Ratio Tertiles (%)				
1st (highest)	20,879,184 (42)	2,470,174 (35)	6,028,538 (39)	12,380,472 (44)
2nd (middle)	16,335,473 (32)	2,405,495 (34)	5,015,363 (33)	8,914,615 (32)
3rd (lowest)	13,090,166 (26)	2,272,296 (32)	4,225,384 (28)	6,592,486 (24)

Social Jeopardy Index (%)				
0 (most privileged)	4,279,616 (8.5)	548,355 (7.7)	1,597,211 (10)	2,134,050 (7.7)
1	8,035,348 (16)	890,563 (12)	2,180,759 (14)	4,964,026 (18)
2	8,906,317 (18)	1,440,652 (20)	2,610,223 (17)	4,855,442 (17)
3	9,078,588 (18)	1,121,623 (16)	2,830,913 (19)	5,126,052 (18)
4	9,133,561 (18)	1,450,387 (20)	2,563,198 (17)	5,119,976 (18)
5	7,613,851 (15)	1,166,172 (16)	2,382,325 (16)	4,065,354 (15)
6 (least privileged)	3,257,542 (6.5)	530,213 (7.4)	1,104,656 (7.2)	1,622,673 (5.8)
Valid Physical Activity Data (*n*)	45,131,448 (90)	5,967,314 (83)	14,319,930 (94)	24,844,203 (89)
Total Valid Days	4.92 (2.39)	4.78 (2.68)	5.58 (2.10)	4.60 (2.38)
Valid Weekdays	3.59 (1.77)	3.42 (1.98)	4.05 (1.54)	3.38 (1.78)
Valid Weekend Days	1.34 (0.81)	1.36 (0.84)	1.53 (0.73)	1.22 (0.83)
Total Valid min/day	1,235 (305)	1,151 (404)	1,290 (245)	1,226 (299)
Valid Wake min/day	801 (221)	717 (276)	839 (175)	802 (223)
Valid Sleep min/day	434 (124)	434 (162)	451 (103)	424 (122)
Valid Unknown min/day	39 (15)	32 (13)	35 (11)	44 (16)
Daily MIMS	17,973 (3,892)	19,722 (3,053)	20,389 (3,296)	16,201 (3,445)
Peak 60 MIMS	3,519 (771)	3,745 (619)	3,985 (693)	3,206 (693)

Note: Values in table represent Means with Standard Deviations in parentheses or *n* with percentage of sample in parentheses.

563 **Table 2.** *Independent associations between physical activity volume and intensity with sociodemographic characteristics.*

Variables	Daily MIMS		Peak 60 MIMS	
	Unadjusted B (SE)	Adjusted B (SE)	Unadjusted B (SE)	Adjusted B (SE)
Gender (referent = males)				
Females	-386.43 (121.97)**	-388.12 (117.64)**	-326.44 (29.40)***	-324.68 (29.21)***
Race/Ethnicity (referent = non-Hispanic White)				
Other	-33.55 (164.32)	-212.45 (157.91)	-49.45 (31.20)	-40.42 (24.60)
Household Income Tertiles (referent = T3 [highest])				
T2	159.14 (184.62)	409.43 (194.50)*	-71.53 (39.23)	-4.10 (38.66)
T1 (lowest)	706.31 (169.19)***	1035.75 (192.74)***	-15.55 (39.37)	76.47 (37.69)*
Parental Education (referent = College graduate or more)				
Some college	-393.31 (217.26)	-628.88 (245.76)*	-157.44 (41.16)***	-154.92 (43.16)***
High school or less	-86.78 (182.91)	-497.83 (212.24)*	-131.68 (34.31)***	-146.28 (33.91)***

564 Note: Values in table represent Means with Standard Deviations in parentheses. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3. *Physical activity volume and intensity according to position on the Social Jeopardy Index*

	Social Jeopardy Index						
	0	**1**	**2**	**3**	**4**	**5**	**6**
Full Sample							
Daily MIMS	18,494	17,717	17,877	17,754	17,968	18,148	18,389
	(3,906)	(4,039)	(3,912)	(3,733)	(3,862)	(3,966)	(3,671)
Peak 60 MIMS	3,856	3,535	3,521	3,485	3,463	3,483	3,362
	(830)	(795)	(774)	(758)	(755)	(746)	(625)
Young Children							
Daily MIMS	19,871	19,699	19,654	19,111	19,855	19,985	20,145
	(3,082)	(2,992)	(3,044)	(2,948)	(3,217)	(2,843)	(3,167)
Peak 60 MIMS	3,937	3,830	3,759	3,634	3,749	3,721	3,636
	(710)	(576)	(584)	(625)	(664)	(600)	(496)
Children							
Daily MIMS	20,856	20,928	20,333	19,982	20,280	20,333	20,198
	(3,356)	(3,146)	(3,385)	(3,222)	(3,255)	(3,399)	(3,123)
Peak 60 MIMS	4,316	4,099	4,003	3,924	3,938	3,888	3,716
	(742)	(666)	(680)	(692)	(655)	(691)	(572)
Adolescents							
Daily MIMS	16,373	15,952	16,029	16,228	16,277	16,341	16,584
	(3,251)	(3,479)	(3,401)	(3,401)	(3,440)	(3,652)	(3,263)
Peak 60 MIMS	3,490	3,234	3,192	3,210	3,144	3,178	3,033
	(739)	(723)	(705)	(694)	(664)	(673)	(512)

Note: Values in table represent Means with Standard Deviations in parentheses. Higher scores on the Social Jeopardy Index represent greater social disadvantage.

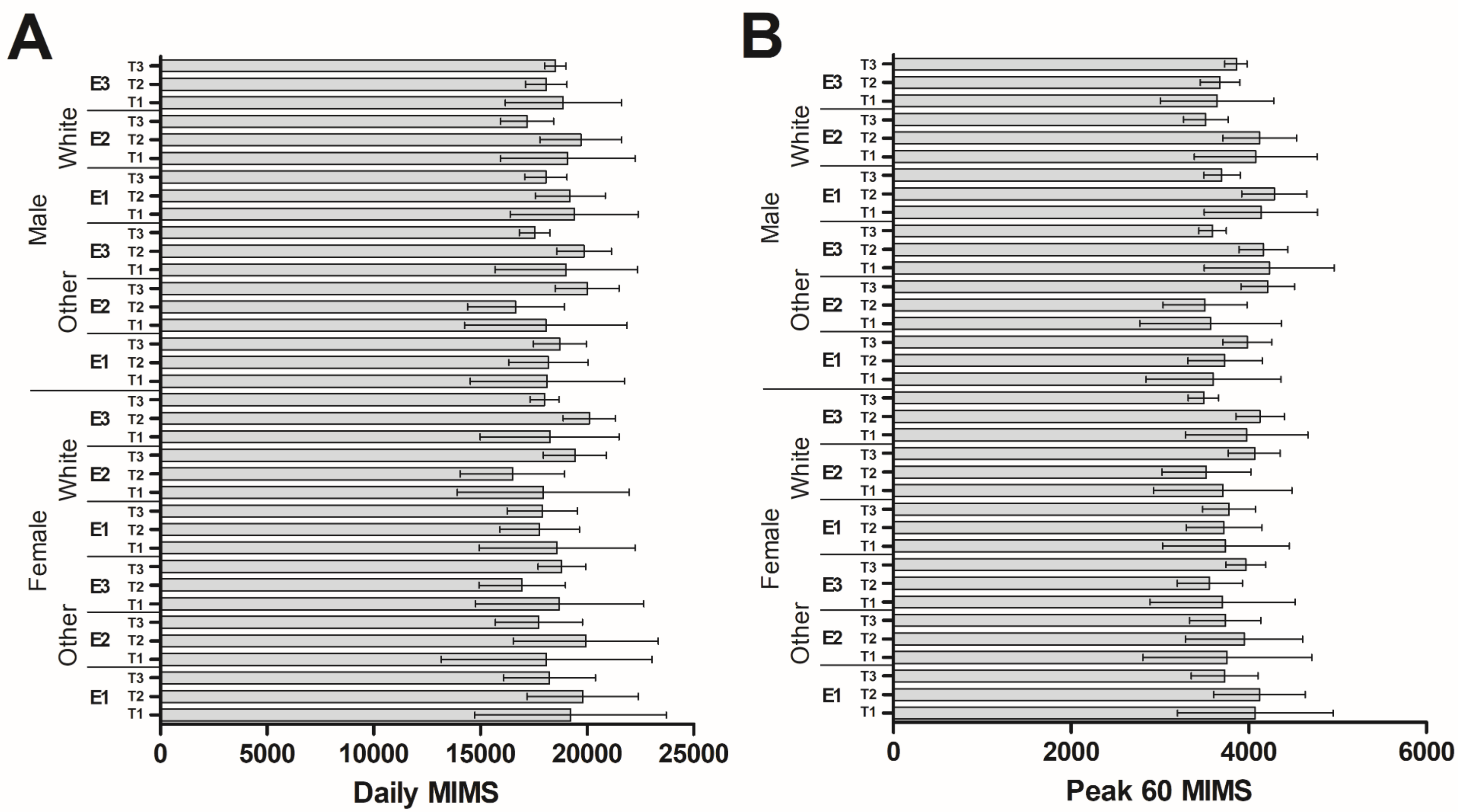

Figure 1. Estimates of the Daily MIMS and Peak 60 MIMS according to all potential combinations of sociodemographic characteristics. T3 = highest household income tertile, T2 = middle tertile, T1 = lowest tertile; E3 = College graduate, E2 = Some college, E1 = High school or less. Values presented are Means with 95% Confidence Intervals.

Supplementary Table 1. *Independent associations between physical activity volume and intensity with sociodemographic characteristics, including five levels of race/ethnicity.*

	Daily MIMS		Peak 60 MIMS	
Variables	**Unadjusted B (SE)**	**Adjusted B (SE)**	**Unadjusted B (SE)**	**Adjusted B (SE)**
Gender (referent = males)				
Females	-386.43 (121.97)**	-381.76 (116.04)**	-326.44 (29.40)***	-323.75 (28.94)***
Race/Ethnicity (referent = non-Hispanic White)				
Mexican American	53.34 (209.22)	-134.51 (207.42)	-24.85 (43.82)	-3.02 (34.57)
Other Hispanic	193.10 (248.54)	-25.43 (242.93)	-55.55 (44.04)	-47.45 (40.60)
Black	75.81 (207.21)	-53.83 (206.37)	-49.76 (37.58)	-32.10 (34.28)
Other	-548.09 (198.81)**	-639.28 (192.77)**	-83.40 (35.05)**	-90.07 (35.35)*
Household Income Tertiles (referent = T3 [highest])				
T2	159.14 (184.62)	395.38 (194.13)*	-71.53 (39.23)	-4.78 (38.56)
T1 (lowest)	706.31 (169.19)***	993.36 (193.44)***	-15.55 (39.37)	71.92 (37.55)
Parental Education (referent = College graduate or more)				
Some college	-393.31 (217.26)	-669.13 (248.81)*	-157.44 (41.16)***	-160.46 (43.33)***
High school or less	-86.78 (182.91)	-559.25 (224.51)*	-131.68 (34.31)***	-158.21 (36.46)***

Note: Values in table represent Means with Standard Deviations in parentheses. * $p < .05$, ** $p < .01$, *** $p < .001$